MMED PART III

The Nervous System Effects of Occupational Exposure to Manganese - Measured as Respirable Dust - in a South African Manganese Smelter.

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Date: 13 August 2003

DECLARATION

I, Dr Taryn Young, hereby declare that the work on which this dissertation is based is original (except where acknowledgments indicate otherwise) and that neither the whole work nor any part of it has been, is being, or is to be submitted for the purposes of another qualification.

Signature: Signed by candidate **Date:** 13/8/2003

INDEX

Acronyms

ACGIH TLV	American Conference of Governmental Industrial Hygienists Threshold Limit Value
CEI	Cumulative Exposure Index
DPD	Danish Product Development test battery
HI	Harmonic Index
IEH	Institute for Environment and Health, United Kingdom
INT	Average Exposure Intensity
LOS	Total Length (years) of Service
LN	Luria-Nebraska test battery
MCEF	Mixed Cellulose-Ester Membrane Filter
MMT	Methylcyclopentadienyl Manganese Tricarbonyl
Mn	Manganese
NCOH	National Centre for Occupational Health, South Africa
SPES	Swedish Performauce Evaluation System
US-EPA Rfc	United States Environmental Protection Agency reference concentration
WHO NCTB	World Health Organisation Neuro-behavioural Core Test Battery

1. ABSTRACT

The analytic cross-sectional study of manganese exposure, using respirable dust (instead of inhalable dust) as the exposure metric, in relation to neuro-behavioural outcomes among a large number of ferroalloy workers, aimed to shed further light on associations between these outcomes, biological exposures, biological effect measures, atmospheric exposure intensity, and atmospheric cumulative exposure based on either the current job or across all exposed jobs.

Methods: Five hundred and nine production workers at a manganese (Mn) smelting works, comprising eight production facilities, and 67 external referents were studied. Exposure measures from personal sampling included the Mn content of respirable dust as an integrated cumulative exposure index (CEI) and as average intensity (INT). Biological exposure and biological effect measures included blood (MnB), urine (MnU) manganese and serum prolactin. Neuro-behavioural endpoints included items from the Swedish Nervous system Questionnaire (Q16), World Health Organisation Neurobehavioural Core Test Battery (WHO NCTB), Swedish Performance Evaluation System (SPES), Luria Nebraska (LN), and Danish Product Development (DPD) test batteries, and a brief clinical examination. Potential confounders and effect modifiers included age, educational level, alcohol and tobacco consumption, neurotoxic exposures in previous work, past medical history, previous head injury and home language. Associations were evaluated by multiple linear and logistic regression modeling.

Results: The arithmetic mean intensity of dust exposure was 0.105 mg/m^3 amongst the exposed with 30% having levels above the recommended 0.1mg/m^3. The average Mn levels in the blood and urine were 12.5µg/L and 10.5 µg/L respectively. There were significant correlations between respirable and inhalable Mn, MnB and MnU. Results from the large number of tests performed resolved into three groups. Group 1 showed differences between external unexposed referents and all the exposed and/or differences between internal low exposed referents and the rest of the exposed but no further exposure-response relationships. It included the Santa Ana from the WHO NCTB; Finger tapping with dominant hand and endurance tapping tests from the SPES; Left and right sided median frequency, Left and right sided dispersion around

the median frequency from the DPD tremor test; Luria Nebraska items 22R, 22L, 23L and questionnaire items depression, irritation and tiredness. Group 2 showed the presence of a more substantive exposure-response relationship. It consisted of only 4 tests, and included the WHO Digit symbol and digit span tests, subjects' perception that they had sex less often than normal, and the LN item 1R which had a step to a poorer score at high exposure. Group 3 contained the overwhelming majority of test results (almost all the questionnaire items, almost all the DPD tests - including sway and diadochokinesia - and the clinical test) for which exposure effects were either null or in a counterintuitive direction.

Conclusion: Neuro-behavioural effects based on respirable dust as the exposure metric and below the new occupational exposure limit (0.1mg/m^3 respirable Mn or less than category 4 when exposure is categorised) proposed by the IEH are few and unconvincing when appropriately adjusted and when the character of exposure-response relationships is closely examined.

2. INTRODUCTION

2.1 Literature review

There has been increasing interest in the chronic nervous system effects of long term occupational Manganese (Mn) exposures below the American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Value (TLV) for inhalable dust of 0.2mg/m^3 [ACGIH, 1996], and in environmental exposures at or above the United States Environmental Protection Agency reference concentration (US-EPA RfC) of 0.05µg/m^3 [IRIS, 1999] sparked by increasing use of the gasoline anti-knock additive Methylcyclopentadienyl Manganese Tricarbonyl (MMT) [US-EPA,1994] [Frumkin et al, 1996].

Manganese is an essential element for normal body processes. The estimated daily dietary intake is 2-5 mg per day. Other than through dietary intake, exposure can occur in both the occupational (e.g. manganese ore mining, manganese alloy production) and environmental (e.g. mining, toxic dump sites) settings [Mergler et al, 1997]. The primary occupational use is in the manufacture of steel (to impart hardness). It is also used in the production of dry-cell batteries, ceramics, matches, welding rods, fertilizers, and dyes. Occupational exposure, in comparison to environmental exposure, is at higher levels and more variable, but this is counterbalanced by the healthy worker effect (those in employment are generally healthier than the rest of the community). The primary route of entry in occupational settings is inhalation, however ingestion also plays a role.

Adverse health effects, from excess exposure, manifest mainly as neurological effects. It has been hypothesised [Mergler et al, 1999] that early neuro-functional alterations may be followed by sub-clinical abnormalities and ultimately clinically manifest neurological disease or manganism. Clinical manganism presents with extra-pyramidal dysfunction (similar to Parkinsonism) and neuro-psychiatric symptoms, and has not been reported at exposure levels below 5mg/m^3. Other clinical effects include respiratory, cardiovascular, reproductive and developmental toxicity [Frumkin et al, 1996]. Once neuro-toxic effects manifest clinically, damage is essentially irreversible [Iregren, 1994]. Therefore, focus has shifted to the early manifestations, as early detection is important for the prevention of ongoing exposure.

Iregren (1999) reviewed 13 studies of manganese exposed workers, showing mostly motor effects with tests for finger tapping, diadochokinesometry and Luria-Nebraska (LN) items, along with postural tremor and sway abnormalities. Pegboard, memory, reaction time and cognitive tests were less conclusive. More recently, Lucchini et al. (1999) found Mn effects with World Health Organisation Neuro-behavioural Core Test Battery (WHO NCTB) and LN tests in smelter workers at inhalable exposure intensity levels around 0.1mg/m^3. Mergler et al (1999) and Beuter et al (1999) found subtle neuro-behavioural effects and exposure-age interactions with environmental exposures measured as blood manganese (MnB). As part of the same study Bowler et al (1999) found mood effects, while Hudnell et al (1999) located these exposure-response relationships at environmental concentrations around the US-EPA RfC. Roels et al. (1999) in a prospective study, showed reversibility of effects below 0.1mg/m^3. These studies have raised concerns that the ACGIH TLV might be too high to protect against neuro-behavioural effects. On the other hand, no effects were found by either Gibbs et al. (1999) at occupational exposures averaging 0.18mg/m^3 total dust, or by Deschamps et al (2001), at exposures averaging below 0.15mg/m^3, over a 20-year period. Myers et al (2003) also evaluated a comprehensive range of endpoints, with levels of exposure (using inhalable dust) ranging from environmental to industrial, and found little convincing evidence for a continuum of effects from neuro-functional to sub-clinical to clinical.

Biological monitoring using blood and urine Mn have been reported as not being suitable exposure metrics because of high variability [Levy et al, 2003]. It has been hypothesised that systemic effects are more likely to be associated with the respirable fraction, which the UK Institute for Environment and Health (IEH) has recently recommended as the most biologically appropriate measure of exposure to airborne Mn for evaluating health effects. Based on three key studies by Roels et al (1992), Gibbs et al (1999) and Myers et al (2003) the IEH recommended occupational exposure limits as 0.1mg/m^3 respirable Mn. A supplementary limit of 0.5mg/m^3 inhalable Mn was also recommended as a safeguard, in case gastrointestinal absorption, subsequent to inhalation, is not insignificant. The latter is quite likely in the ferroalloy industry where most workers exposed to Mn work.[1]

[1] Personal communication with Prof J Myers, University of Cape Town.

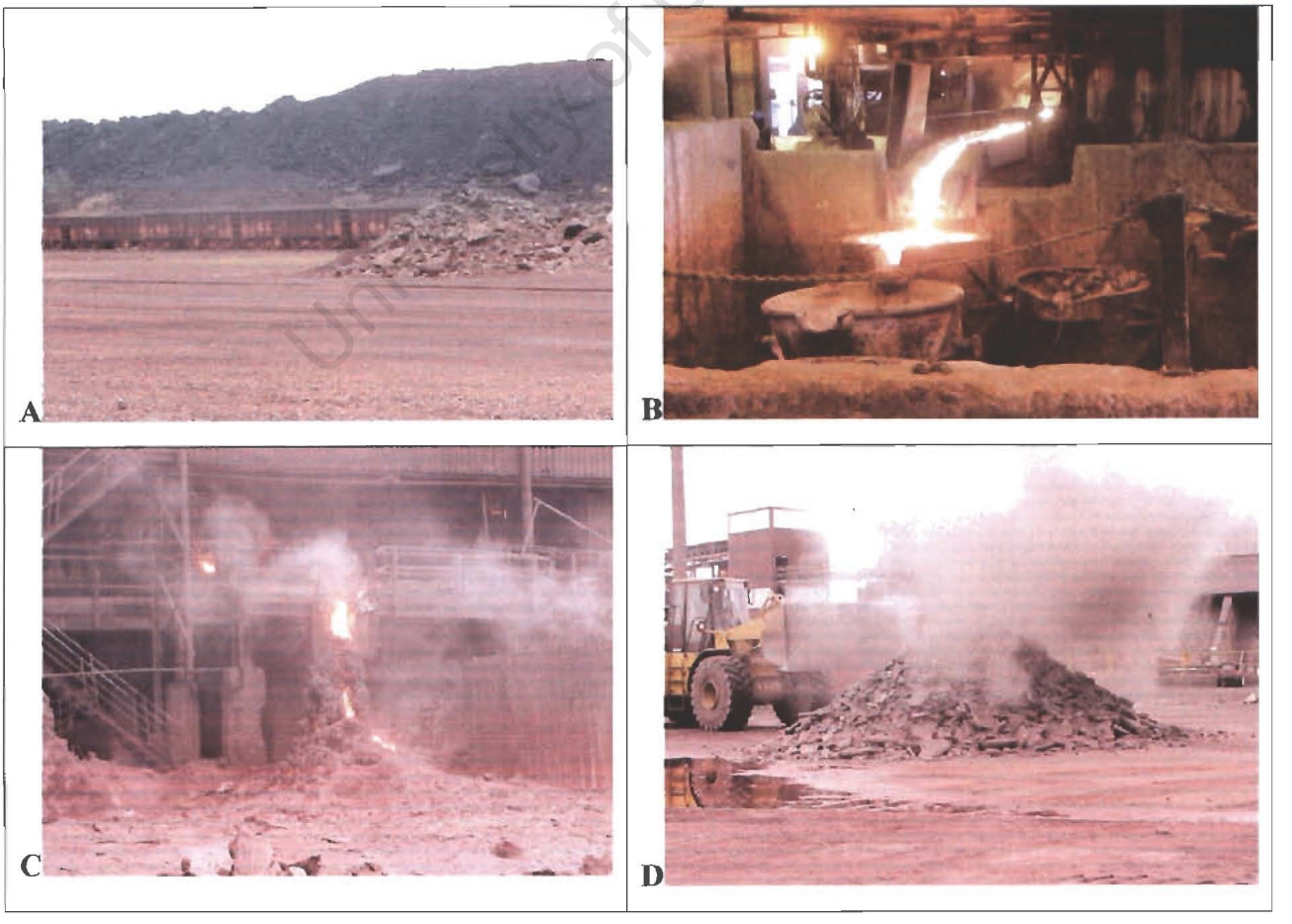
There is still insufficient scientific information relating to the neurobehavioural and indeed other effects of respirable Mn as very few studies have used respirable dust as the exposure metric [Gibbs et al, 1999]. More generally problems with the relatively few existing studies using inhalable dust as the metric include small numbers of exposed subjects, non standard possibly insensitive neurobehavioural tests, and relatively poor consistency across studies for exposure effects and especially for the character of exposure-response relationships.

This cross-sectional study of exposure, using respirable dust (instead of inhalable dust) as the exposure metric, in relation to neurobehavioural outcomes among large numbers of ferroalloy workers aimed to shed further light on associations between these outcomes and biological exposures, biological effect measures and atmospheric exposure in the form of intensity and cumulative exposure based on either the current job or across all exposed jobs. It was not possible in this study to meaningfully disentangle chronic from acute effects of manganese exposure and accordingly the relationship between the cumulative exposure index (CEI) an integrated intensity-duration exposure measure across jobs and a number of neurobehavioural endpoints was investigated. Selection of endpoints was based upon those reported in the state-of-the-art review of the scientific literature by Iregren (1999) which recommends that the test battery should include tests of motor function, response speed, memory and rating scales of mood and subjective symptoms.

This study sought to examine the hypothesis that exposure response analysis based on the respirable dust exposure metric for Mn would be more sensitive than that based on an inhalable exposure metric. An analysis of data from this study based on inhalable Mn did not find any convincing Mn effects [Myers et al, 2003]. As in the latter study "exposure-response relationship" denotes the existence of structure beyond a simple difference between external referents and all the exposed and/or between the internal referents and the rest of the exposed, while "continuity of response" denotes continuing incremental impairment in function as exposure increases. Scientific understanding of the impact of Mn exposure on function leads to the hypothesis that the exposure-response relationship should show no impact on function (or a threshold) at low exposures, given that Mn is an essential element in human nutrition, followed by a continuity of response at higher levels of exposure beyond that threshold.

2.2 Description of plant

The works includes eight production facilities - four plants, which are Mn smelters, and some non-Mn metals plants. Mn ore (containing from 30-50% Mn in various oxide states) arrives at the works from the company's two mines (Photo A). The Raw Materials section orders, receives, and supplies incoming ores, sinters, reductants (coal, coke), fluxes (slag and quartz) and, scrap steel to the various Mn and non-ferrous smelters. The Raw Materials section is also responsible for crushing and sorting furnace slag. Mn-containing ores arrive via rail car at the smelters. Raw materials and fluxing agents (coal, coke, Mn ore, and quartzite) are combined into the appropriate smelt balance, which is fed to furnaces. Smelting temperatures exceed 3000°C. As the Mn-containing ore is smelted, manganese oxides are reduced (e.g., Mn_3O_4, MnO_2, $\rightarrow$Mn) towards an elemental state. Molten ore loads are cleared from the furnaces by tapping (Photo B). Once the tap hole is open, molten Mn metal (and slag) flows from the furnace through a sand-filled runner, to ladles in the tap bays (Photo C). Slag is separated from the melt as it flows from one ladle to the next. The ore is cast in the casting bay where it is poured into "fines" beds. After cooling, the casts are removed with a front-end loader (Photo D). [NCOH Report, 2000]



2.3 Objectives

1. To determine the demographic characteristics of workers
2. To determine the level of worker exposure using respirable dust as the exposure metric
3. To determine the neuro-behavioural performance and other nervous system related outcomes for workers
4. To determine associations between exposure (exposure intensity and cumulative exposure) and outcome measures

3. METHODS

3.1 Study design

An analytic cross-sectional study was conducted where exposed and unexposed groups were studied at one point in time at which health outcomes were determined along with estimates of current and historical exposures. No other type of study could be done because of the absence of cases making prospective study designs inappropriate. Moreover, subjects could be selected in a way that maximised exposure contrast, which would increase the sensitivity of the study in detecting exposure-response relationships.

3.2 Study population & sample

Stratified random sampling was used to draw manganese (Mn) exposed subjects from one of eight production environments in a Mn smelting works in South Africa. Of 1380 production workers at the works, two hundred subjects were randomly selected in each of three subjectively determined exposure groups (i.e. within each strata each worker had an equal chance of being selected). Different plants or activities at the works were divided into notionally high (three Ferro- and Silico-Mn smelters), medium (one Ferro-Silicon smelter, raw and finished materials handling plants) and low (quality control laboratories, administration and security workers, and a chemical plant making no use of Mn) exposure groups. Maintenance workers with highly variable exposures were excluded. The low exposure group served as an internal referent group with no direct Mn exposure. High exposure based on the ambient levels of inhalable dust was considered to be above 2mg/m^3, medium between 2 and 0.1mg/m^3, and low exposure below 0.1mg/m^3. All of the plants were geographically located in a single works, and even the plant not directly using Mn received exposure from fugitive emissions in the works environment. Consequently, as a targeted sample, an external unexposed referent group (n 67) from an electrical fittings assembly plant without any direct or indirect Mn exposure was included in the study.

EXPOSURE

Full-shift personal breathing zone inhalable and respirable dust and fume samples were collected. Inhalable dust and fumes were collected on 25 millimetre (mm) 1.2-µm pore size mixed cellulose-ester membrane filter (MCEF) filter cassettes connected to Gilian® constant-flow personal sampling pumps and respirable dust and fumes were collected using 37 mm, 5-µm MCEF membrane filters mounted in standard three piece polystyrene filter cassettes and sealed with shrink bands [NCOH Report, 2000].

Representative exposure intensity estimates were obtained for all Mn exposed production jobs at all plants at the works and at the external referent plant by compiling a job-exposure matrix. The matrix was constructed using the different plants as columns and job categories as rows. All direct measures were entered first. However, not all workers had direct respirable dust measurements done therefore estimates were made in order to complete the matrix. Estimates were based on either workplace assessment impressions that certain job categories have similar exposures or by using conversion factors (Table 1) or by making interpolations based on an understanding of the production process (subjective occupational hygiene judgements). Conversion factors represent an average relationship between ambient inhalable and respirable dust concentrations for the different plants. Table 2 demonstrates the completed job-exposure matrix where the blue color is used for the direct measurements, green for the estimates and red for interpolations. Exposure data was normally distributed thus only arithmetic means are presented in Table 2.

Table 1: Conversion factors used to determine respirable dust levels from inhalable dust levels (Respirable dust = conversion factor * inhalable)

Plant	Conversion factor
Smelter 1	0.24
Smelter 2	0.04
Smelter 3	0.24
Materials Handling	0.15
Chemical plant	0.50
Administration	0.13
Laboratory	0.12
Security	0.11

Table 2: Job-exposure matrix (respirable dust in mg/m^3)

Legend: blue - direct measurements, green - estimates and red - interpolations

Arithmetic *respirable dusts (Mg/m3)*	Smelter 2	Chemical plant	Smelter 3	Smelter 1	Smelter 4	Ad valloy	Railway line	Hostel	Metal loys	Work service	Construction	Stores	MHD	Lab	All plant	Silos	Admin	Security	Phase 2	Base	Project
Tapper	0.3		0.51	0.18	0.01	0.3			0.3												
Sorter of stones	0.3																				
Driver of pegger	0.3			0.07																	
Maintenance, assistant mechanic, Mechanic, Assistant fitter, Builder	0.04	0.005	0.35	0.23	0.01		0.005			0.004	0.004	0.004	0.05				0.005				
Group leader	0.3	0.005	0.35	0.2	0.008								0.03			0.03	0.007				
Labourer	0.3	0.005	0.35	0.2	0.008	0.3	0.02	0.005	0.3	0.004	0.004	0.004	0.08	0.09	0.04		0.007		0.01	0.01	
Crane driver	0.08		0.5	0.5	0.03	0.08							0.02								
Cleaner	0.08		0.03	0.03				0.004				0.004	0.08				0.007				
Stoker				0.18	0.01				0.3												
Crane anchor	0.08		0.5	0.5																	
Cast floor worker			0.5	0.11																	
Process operator	0.08	0.003	0.07	0.07	0.01	0.08	0.01			0.01			0.08	0.04							
Cook								0.004													
Paste loader	0.3			0.15		0.3															
Supervisor	0.04	0.004	0.07	0.18	0.008							0.004	0.03	0.04							
Tippler driver				0.54																	
Loco driver	0.08									0.01			0.02								
Fireman					0.008																
Crane hooker				0.54	0.03																
Furnace operator	0.08		0.07	0.07	0.01																
Gasplant operator	0.08		0.07		0.01																
Storeclerk	0.03			0.03	0.003							0.004					0.007				
Manager		0.005		0.03	0.008																
Superintendent		0.005																			
HR officer				0.03	0.003								0.02								0.003
Driver	0.08	0.005	0.5	0.18	0.003					0.01		0.01	0.02				0.008	0.008			
Radio operator	0.3																				
Grinds ore						0.3															
Engineer		0.005	0.07	0.07	0.008																
X ray operator														0.04							
Lab analyst				0.07										0.04							
Casualty officer																	0.007				
Plant attendant	0.3	0.005			0.008								0.08								
Security																	0.007	0.004			
Cutter								0.004													
Production technician		0.005																			

A cumulative exposure index (CEI) in mg-years/m^3 respirable dust was calculated for each subject by summing the products of the average exposure intensity (using arithmetic means) for each job worked by the subject and the number of years this activity was performed. This was divided by total years of service (LOS) in the smelter works to yield a measure of average exposure intensity across all exposed jobs (INT) in mg/m^3.

BIOLOGICAL EXPOSURE AND BIOLOGICAL EFFECT MEASURES:

First voided urine specimens were brought in by subjects on the day of testing along with two weeks' growth of toenail clippings. Venous blood specimens were collected each day during the testing session between 12 noon and 2 pm, with precautions taken to avoid contamination. Specimens were kept on dry ice and sent immediately for analysis of blood manganese, urine manganese and serum prolactin levels to the National Centre for Occupational Health (NCOH) and the South African Institute for Medical Research laboratories, respectively.

Endpoints included items from the Swedish Nervous system Questionnaire (Q16), World Health Organisation Neuro-behavioural Core Test Battery (WHO-NCTB), Swedish Performance Evaluation System (SPES), Luria Nebraska (LN), and Danish Product Development (DPD) test batteries, and a brief clinical examination.

Questionnaire

Nervous system outcomes were measured by a battery of 46 questionnaire items drawn from the Swedish Q16 instrument [Axelson and Hogstedt, 1988], and the WHO-NCTB questionnaire [WHO, 1986] for autonomic nervous system symptoms, subjective symptoms referable to the nervous system, and neuro-psychiatric questions aimed at measuring mood. Dummy questions (ankle swelling and earache) were included to measure reporting bias. Information on potential confounders and effect modifiers including age, educational level, alcohol and tobacco consumption, neurotoxic exposures in previous work, past relevant medical history, previous head injury and home language was collected using a standardised questionnaire (Appendix 1).

Neuro-behavioural Test Battery

A neuro-behavioural test battery deemed most appropriate from a review of the literature included seven items (1, 2, 3, 4, 21, 22, 23) or 13 sub-items (left and right) testing motor function from the Luria-Nebraska battery [Golden et al., 1980]. Test results in integers were categorized into three scores ranging from zero for high performance to two for poorest performance. These scores were dichotomized grouping zero as a good score (0) and scores one and two together as a poor score (1).

The Benton Visual Retention Test for memory, Digit-Span and the Digit-Symbol tests for cognitive ability, the Santa Ana pegboard test for motor function were selected from the WHO NCTB. Finger tapping for the dominant and non-dominant hands and finger tapping endurance for motor function, and the simple reaction time tests were selected from the SPES battery [Iregren et al., 1996].

Danish Product Development (DPD) Test Batteries

A device produced by Danish Product Development [DPD, 1994] was used for quantitative neurometric testing comprising the Catsys test for dysdiadochokinesia, the Tremor test for resting tremor, and the Sway test on a force platform for postural sway. Eight Tremor Test parameters are derived from analysis of a tremor power spectrum, and include tremor intensity (m/s^2), median frequency (F50); standard deviation of F50 (sF50) indicating the degree of irregularity of tremor, and the Harmonic Index (HI) comparing the tremor spectrum with that of a single harmonic oscillation which has a HI = 1.00.

The Catsys system tests hand pronation/supination, finger tapping and auditory reaction time yielding 20 parameters. Subjects pronate and supinate or tap on a drum to a metronome at slow and fast rhythms. The time distance between each stimulus and response is measured. The maximum frequency at which rhythmical pronation/supination and tapping can be maintained is also measured. The Sway test was performed under four conditions – eyes open, no insulation under feet; eyes open, insulation; eye shut no insulation; and eyes shut with insulation [Despres et al., 2000]. For each test, a graph of sway in two dimensions is recorded and a composite variable created by the length of distance traveled by the stylus on the graph. One parameter is recorded for each condition.

Clinical Examination

A brief clinical examination was conducted testing the glabellar reflex, observing facial expression, gait and balance of the subject while walking backwards on a line. Gross abnormality of the limbs was also excluded.

The study was conducted over a period of one year from late 1999 to late 2000. Between five and eight subjects drawn from either morning (starting at 7am) or afternoon (starting at 2pm) shifts were seen each day. Four subjects were allocated to each of four testing stations viz. Questionnaire/examination, Swedish performance evaluation system (SPES), World Health Organisation Neuro-behavioural Core Test Battery (WHO NCTB) / Luria-Nebraska (LN) and Danish Product Development (DPD) simultaneously and rotated through the other testing stations. A trained neuro-behavioural psychologist served as the study coordinator, oversaw all the testing, and administered the SPES tests, while two other trained interviewers administered the DPD battery and the WHO/LN tests respectively. A single trained interviewer conducted all the questionnaire interviews and brief clinical examinations in the home language of the subjects, which included English, Afrikaans, isiXhosa, isiZulu and Sesotho.

There were no refusals to participate in the study although there were 80 refusals to provide blood samples on cultural grounds. Recruitment of subjects continued over the course of a year until the requisite number of subjects was obtained from each of the three gross exposure categories, viz. low, medium and high.

3.4 Ethics

The study was approved by the Research Ethics Committee of the Health Sciences Faculty of the University of Cape Town. Informed consent was signed by all participants. The tests are not harmful in any way. Strict rules of confidentiality protected workers from potential discrimination. Only group and not individual results were made available to stakeholders. Workers benefited by having access to a medical examination, by affected workers being referred to the NCOH Occupational medicine clinic for further investigation if necessary and by study results leading to greater control of potentially toxic exposures at work where appropriate.

A Research Reference Panel was set up with representatives of workers and their trade unions, management and researchers to oversee all aspects of the study and to assist the research team. The reference panel served as a conduit for stakeholder input to the research process. While the study was mostly funded by the company, independence of the researchers in planning and conducting the research, and in analyzing, interpreting and publishing the results was ensured in a research contract.

3.5 Data analysis

Data was analysed using STATA software (STATA 7, 2001). Two different types of exposure intensity and cumulative exposure measures were calculated, reflecting either lifetime exposure across all jobs or current job exposure - a cumulative exposure index (CEI) in mg-years/m^3 and a measure of average exposure intensity (INT) in mg/m^3. Univariate and bivariate data exploration was used to describe the atmospheric and biological exposure variables and explore their inter-relationships. Associations were evaluated by multiple linear and logistic regression modelling. Effects were adjusted throughout for age, years of schooling, smoking status, alcohol consumption, past job exposures to neurotoxins, previous head injury and home language.

The analysis plan for investigating exposureresponse relationships involved:

a) Comparing (adjusted for all potential confounders):
    i. External unexposed referents with all other subjects, and
    ii. Internal low exposed referents exposed at less than the lowest observed adverse effect level with the rest of the exposed.
b) Examining the overall exposure-response relationship between outcomes and exposure variables (cumulative, intensity) using smoothed plots with locally weighted robust regression, (see, e.g. Cleveland, 1979) for continuous outcomes, and frequency tables for categorical outcomes.
c) Further examination of the nature of the exposure-response relationship by examination of structure of the point estimates of effect across categories of exposure (CEI) adjusting for confounders.
d) Modeling the overall exposure-response relationship or trend using multiple linear or logistic regressions with continuous and categorical outcome variables respectively, and continuous exposure variables (CEI or INT), adjusting for confounders.

e) Making a judgement based on examination of the panel of all these results for each candidate exposure-response relationship as to the presence, character and significance of the relationship.

Sets of analyses were carried out using different exposure variables - CEI, INT and LOS, and MnB. Only analyses using CEI as exposure were reported as these gave rise to the strongest effects, unless indicated otherwise in the text.

4. RESULTS

SOCIO-DEMOGRAPHIC CHARACTERISTICS

From the smelter works 201 high, 201 medium, and 107 low exposed workers were tested, along with 67 unexposed referent workers. Descriptive information is provided in Table 3.

Table 3: Descriptive statistics - Comparison of Smelter Workers and external unexposed referents.

	Smelter	**Unexposed**
Continuous variables	**Mean (SD)**	**Mean (SD)**
Age (years)	45.1 (8.4)	38.6 (10.3)
School standard passed (years)	4.7 (3.2)	8.0 (2.5)
Length of service (years)	18.2 (7.6)	9.4 (7.0)
Resp. Cumulative exposure index mg-yrs/m^3	2.013(2.622)	0.003(0.002)
Resp. Average intensity of exposure mg/ m^3	0.105(0.125)	0.0003(0.00005)
Blood manganese µg/L	12.5(5.6)	6.4 (1.7)
Urine manganese µg/L	10.5(20.3)	0.96 (0.81)
Serum Prolactin µg/L	6.1(3.0)	6.2 (2.5)
Categorical variables	**Percent (95%CI)**	**Percent (95%CI)**
Previous job involving neurotoxins	14% (11-17)	6% (2-15)
Previous head injury	28% (24-32)	22% (13-34)
Current alcohol drinker	43% (39-48)	58% (46-70)
Past alcohol drinker	17% (14-21)	9% (3-19)
Current smoker	38% (34-42)	60% (47-72)
Past smoker	32% (28-36)	7% (2-16)

This also shows the distribution of other factors that might have affected performance on the neurobehavioural testing.

Variables from the pretest questionnaire (Appendix 2) including previous night hours of sleep, past 24 hours alcohol, smoking and coffee consumption and visual acuity were included in regression models but did not influence any of the results.

WORKPLACE EXPOSURE

Personal respirable dust samples were measured in various homogeneous exposure-zones for jobs in different production locations. Eight production locations weresampled with the number of samples ranging from three to 25 per location. Seventy-five samples were taken in total. These enabled the construction of exposure indices for each subject. Table 3 shows the arithmetic mean of the respirable manganese dust cumulative exposure index (CEI) in mg/m^3-years, and average lifetime exposure intensity (INT) in mg/m^3 across all Mn exposed jobs at the works. Figures 1 and 2 illustrate the skewness of both CEI and INT.

Figure 1. Distribution of average lifetime exposure intensity (INT)

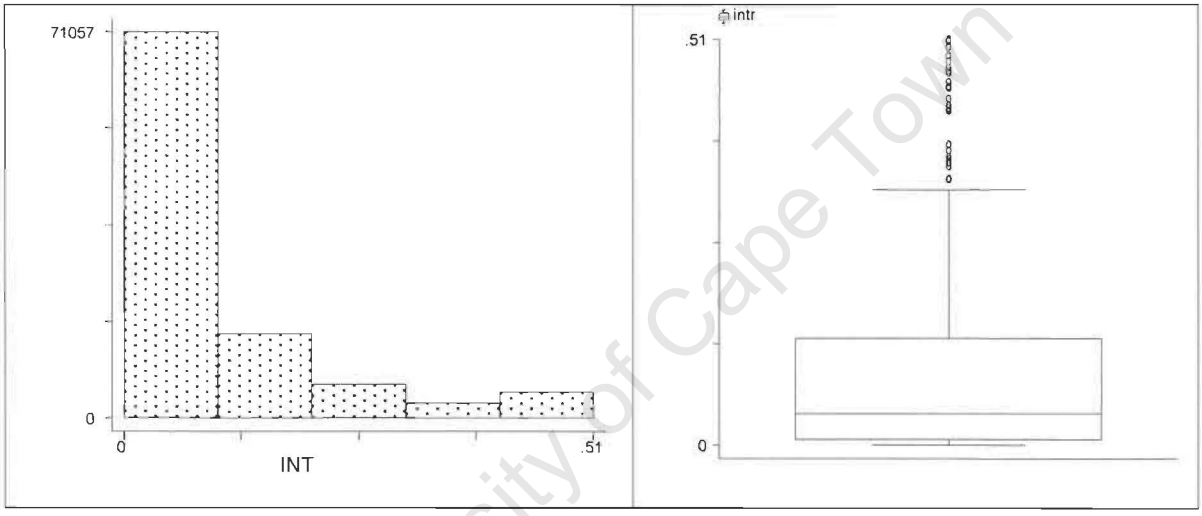
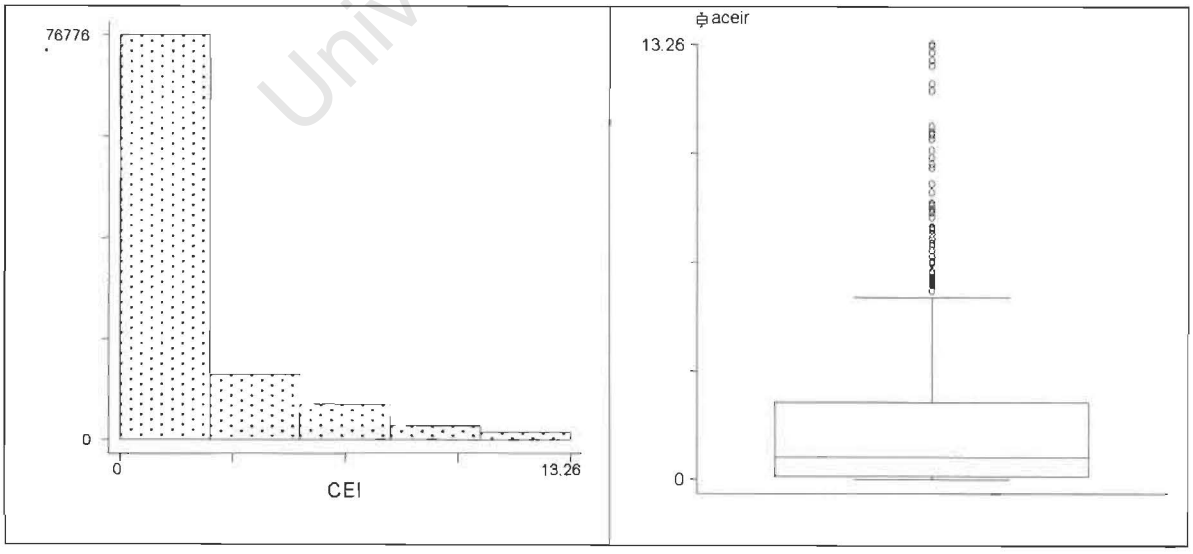


Figure 2. Distribution of cumulative exposure index (CEI)



The median CEI was 0.92mg/m^3-years (range 0.015;13.26) and median INT 0.058mg/m^3 (range 0.003;0.51) with the geometric means being 0.69mg/m^3 and 0.042mg/m^3 respectively. The cumulative exposure index and average intensity were categorized using the cut-points in Table 4. The former are based on equal numbers in each category of those exposed at the works, while the latter are based on cutoff values that relate to the hypothesis viz. the new proposed OEL of 0.1mg/m3 respirable dust. Correlations between CEI and INT, and biological monitoring, are summarized in Table 5.

Table 4: Categorisation of exposure variables – Respirable dust

Category names	Exposure ranges in mg/m^3	Significance	n
Average exposure intensity across all jobs (INT) in mg/m^3			
0	0	Unexposed external referents (below IEH recom.)	67
1	0<=x<0.01	Bottom quintile of exposed (below IEH recom.)	115
2	0.01<=x<0.04	Second last quintile (below IEH recom.)	108
3	0.04<=x<0.1	Middle quintile (below IEH recom.)	117
4	0.1<=x<0.2	Second to topmost quintile (above IEH recom.)	85
5	>=0.2	Topmost quintile of exposed	85
Cumulative exposure index (CEI) in mg-years/m^3			
0	0	External unexposed referents	67
1	0<=x<0.15	Bottom quintile of exposed	102
2	0.15<=x<0.59	Second last quintile	103
3	0.59<=x<1.38	Middle quintile	102
4	1.38<=x<3.52	Second to topmost quintile	103
5	>=3.52	Topmost quintile of exposed	102

Table 5: Spearman's correlation between CEI and INT, and biological monitoring.

	CEI	INT
Blood Mn (umols/litre)	r= 0.5989; p 0.000	r= 0.6062; p 0.000
Urine Mn (ug/g creatinine)	r= 0.4164; p 0.000	r= 0.4296; p 0.000
Prolactin (ug/l)	r= -0.0439; p 0.349	r= -0.0172; p 0.715
Inhalable Mn (CEI vs CEI and INT vs INT)	r= 0.9360; p 0.0000	r= 0.9276; p 0.0000

CONTINUOUS VARIABLE TEST OUTCOMES

WHO-NCTB tests

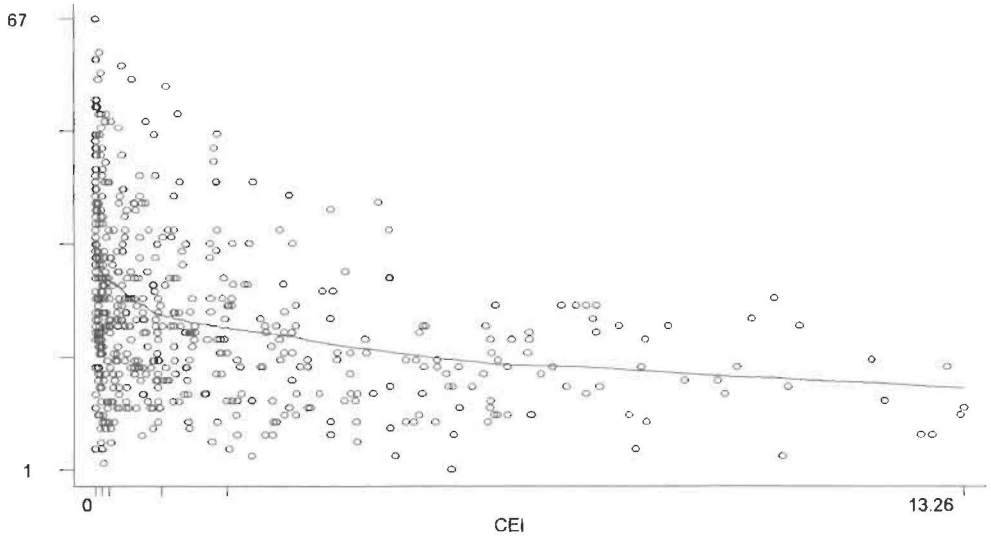
Table 6 shows that of four independent tests from the WHO-NCTB battery, the differences are mainly between the external referents and all the exposed. In the table, row one shows the mean values for the baseline external referents, and in row two the value in the first column (betas) show the change (+ or -) in the mean for the group in that row compared with the baseline, and the level of significance of this change from baseline in the second column. For the digit symbol test there was a significant difference between all the exposed and external referents, and between internal referents and the rest of the exposed. There was also a significant overall trend, and an increase in the effect as one moved to higher exposure categories (dose-response relationship). For the Santa Ana test, there was only a difference between the external referents and the exposed as a whole. Although there appeared to be a significant trend, this was not borne out by the effect across the exposure categories, which did not show an exposure-response relationship. The digit span test (forwards and backwards scoring) was similar to digit symbol but less pronounced. The Benton test showed no differences. Figure 3 shows the clearest (although unadjusted) exposure-response relationship found i.e. digit symbol score plotted against the CEI.

Table 6: Selected WHO NCTB Test result panels

Analysis		**Digit-span (forward and backwards)**		**Digit symbol**		**Santa Ana**	
Unexposed referents	Mean score	15.64		33.81		49.4	
		β	p	β	p	β	p
Dichotomous comparisons	All exposed vs external referents CEI	-2.31	0.000	-2.76	0.008	-4.51	0.000
	Rest of exposed vs internal referents CEI	-1.29	0.001	-2.13	0.009	-0.10	0.909
Overall trend	CEI	-0.20	0.001	-0.51	0.000	-0.27	0.045
* Exposure response by CEI categories	Category 1	-1.36	0.017	-1.17	0.337	-4.44	0.001
	Category 2	-2.33	0.000	-2.72	0.021	-4.72	0.000
	Category 3	-2.35	0.000	-2.42	0.045	-4.32	0.001
	Category 4	-3.00	0.000	-3.92	0.002	-4.49	0.001
	Category 5	-3.00	0.000	-4.83	0.000	-4.54	0.001

*comparison for each category of cumulative exposure is relative to external referents as baseline

Figure 3. Digit symbol score vs cumulative exposure index



SPES tests

Table 7 shows a panel of results for four SPES tests of which the three tapping tests are not wholly independent. Two of three tap tests (endurance and tapping with the dominant hand) showed differences between external referents and all of the exposed. The overall trend was significant however there was no evidence of an exposure-response relationship for all three tapping tests.

Table 7: Selected SPES test result panels

Analysis		**Mean reaction time**		**Tapping dominant hand**		**Tapping non-dominant hand**		**Endurance**	
Unexposed referents	Mean score	266.4		59.4		54.6		337.1	
		β	p	β	p	β	p	β	p
Dichotomous comparisons	All exposed vs external referents CEI	11.69	0.055	-3.64	0.001	-1.99	0.060	-13.81	0.016
	Rest of exposed vs internal referents CEI	9.80	0.061	-1.31	0.155	-1.37	0.126	-6.41	0.169
Overall trend	CEI	1.48	0.10	-0.53	0.001	-0.41	0.008	-2.03	0.016
*Exposure response by CEI categories	Category 1	4.48	0.532	-2.62	0.044	-0.93	0.457	-8.60	0.200
	Category 2	13.08	0.059	-4.17	0.001	-2.34	0.051	-15.10	0.019
	Category 3	10.17	0.157	-2.62	0.045	-1.57	0.208	-10.54	0.118
	Category 4	17.57	0.019	-4.27	0.002	-2.16	0.096	-18.33	0.009
	Category 5	20.00	0.015	-5.99	0.000	-4.35	0.002	-23.57	0.002

* comparison for each category of cumulative exposure is relative to external referents as baseline

DPD :Catsys

An examination of the 18 test parameters revealed that there was neither significant difference between external referents versus all exposed nor between internal controls versus the rest of the exposed. The overall trend CEI was significant for fast hand pronation/supination on the right hand side and for reaction time on the left hand side. However, no exposure-response relationship was observed for any test across the categories of exposure. Adjusting for dominant handedness did not make any difference to these results.

DPD: Tremor

An examination of the eight test parameters (Table 8) showed no differences between external referents and the rest of the exposed. Left and right sided median frequency was significantly decreased while left and right sided dispersion around the median frequency were significantly increased for the rest of the exposed versus internal referents. The overall trend with CEI was significant for the mean of four replicative tests for tremor intensity on right side, left and right-sided median frequency, and right-sided dispersion around the median frequency. No exposure-response relationship was observed for any test across the categories of exposure. .

DPD: Sway

Mean sway across the four test conditions showed neither significant difference between external referents and all exposed, nor between rest of exposed and internal referents. The overall trend CEI was significant for the condition eyes open and feet insulated with a suggestive dose-response relationship (Table 8), however only the effect in the highest category of exposure was significantly different from baseline. No exposure-response relationships were found for the other three conditions, and specifically not for the most stressed condition (eyes closed and feet insulated).

CATEGORICAL VARIABLE TEST OUTCOMES

Questionnaire

An examination of the 42 questionnaire items revealed the following associations (Table 9). Differences between external referents and all the exposed were evident for irritation (OR=2.54; 95%CI 1.26-5.15), depression (OR=2.25; 95%CI 1.12-4.52) and having sex less than contemporaries (OR=36.8; 95%CI 4.89-277.75). Differences

between internal referents and the rest of the exposed were shown for irritation (OR=1.72; 95%CI 1.00-2.94), depression (OR=2.18; 95%CI 1.25-3.78) and tiredness (OR=2.01; 95%CI 1.24-3.28) but not for having sex less than contemporaries. The overall trend was significant for having sex less than contemporaries, sense that smell has changed, being uninterested in social activities, having spells of terror / panic, feeling that something bad may happen any moment and for irritation. Having sex less than contemporaries showed a significant stepwise increase between exposure categories 2 and 3.

Clinical examination

Only two subjects had glabellar reflexes that were exaggerated, while four had abnormal gait (three mild, one more marked), none had immobile facies, while 42 had some level of difficulty walking backwards on a line. A combined clinical abnormality variable had 45 subjects with one or more of the above abnormalities. This showed neither a significant difference between external referents and all of the exposed, nor between the internal referents and the rest of the exposed (Table 9). There was a significant overall trend OR=1.21 (p=0.001) but on examination, although change did increase with level of exposure at no point was any change significant with respect to baseline for any of the categories. When Mn blood as a continuous variable was used as exposure measure there was also a small but significant overall trend OR = 1.08 (p=0.008) however there was also a non-significant trend in point estimates across exposure categories.

Luria Nebraska tests

When categorized (0, >=1), items 22R, 22L and 23L showed a significant effect when comparing all exposed to external referents (Table 9). Items 1R, 2L and 2R showed a significant effect when comparing rest of exposed with internal referents. Although the overall trends were all significant, the effect was protective for all except a step up for 1R between categories 3 and 4.

All the analyses were repeated with INT plus length of service (LOS) instead of CEI with no substantial differences in the findings.

Table 8: Selected DPD test results panels

Analysis		Left sided median frequency		Right sided median frequency		Left sided dispersion around median frequency		Right sided dispersion around median frequency		Left reaction time		Mean sway: Eyes open and feet insulated	
Unexposed referents	Mean score	9.31		9.36		3.25		3.19		0.212		5.72	
		β	p	β	p	β	p	β	p	β	p	β	p
Dichotomous comparisons	All exposed vs external referents CEI	0.180	0.262	0.090	0.600	-0.120	0.298	-0.060	0.592	-0.002	0.622	0.50	0.150
	Rest of exposed vs internal referents CEI	-0.42	0.001	-0.44	0.002	0.21	0.022	0.21	0.022	0.005	0.176	0.37	0.186
Overall trend	CEI	-0.05	0.014	-0.045	0.032	0.025	0.072	0.03	0.029	0.001	0.015	0.09	0.040
* Exposure response by CEI categories	Category 1	0.50	0.008	0.42	0.040	-0.27	0.039	-0.22	0.099	-0.01	0.299	0.23	0.566
	Category 2	0.25	0.174	0.05	0.790	-0.19	0.128	-0.09	0.485	-0.003	0.590	0.36	0.359
	Category 3	0.06	0.753	0.07	0.710	-0.03	0.813	-0.03	0.844	-0.01	0.195	0.61	0.129
	Category 4	-0.03	0.881	-0.14	0.476	-0.05	0.722	0.02	0.861	0.004	0.495	0.58	0.162
	Category 5	-0.05	0.794	-0.08	0.716	0.09	0.524	0.11	0.405	0.006	0.282	0.93	0.028

*comparison for each category of cumulative exposure is relative to external referents as baseline

Table 9: Selected categorical test results panels

Analysis		Less sex than peers		Irritation		Depression		Clinical test		Ln01r		Ln022r		Ln022l		Ln023l	
Unexposed referents	Proportion abnormal	1.49		20.9		22.39		1.49		29.85		23.88		44.78		35.82	
		OR	p	OR	p	OR	p	OR	p	OR	p	OR	p	OR	p	OR	p
Dichotomous comparisons	All exposed vs external referents CEI	36.84	0.000	2.54	0.009	2.25	0.023	4.17	0.191	1.05	0.891	0.35	0.006	0.43	0.009	0.50	0.039
	Rest of exposed vs internal referents CEI	1.62	0.088	1.72	0.049	2.18	0.006	3.80	0.079	2.61	0.001	1.20	0.589	1.47	0.159	1.43	0.211
Overall trend	CEI	1.13	0.002	1.10	0.016	1.05	0.251	1.21	0.001	1.23	0.000	1.1	0.014	1.09	0.040	1.16	0.000
*Exposure response by CEI categories	Category 1	26.15	0.002	1.70	0.208	1.21	0.659	1.23	0.874	0.51	0.093	0.3	0.013	0.32	0.004	0.39	0.023
	Category 2	25.89	0.002	2.86	0.008	2.83	0.008	2.42	0.450	0.79	0.526	0.38	0.028	0.41	0.016	0.39	0.015
	Category 3	51.85	0.000	2.39	0.034	2.16	0.057	3.97	0.227	0.98	0.966	0.15	0.000	0.40	0.016	0.36	0.010
	Category 4	46.80	0.000	3.24	0.005	2.92	0.010	4.01	0.226	1.78	0.137	0.39	0.034	0.41	0.021	0.59	0.173
	Category 5	55.26	0.000	3.32	0.005	2.68	0.020	8.64	0.054	2.38	0.031	0.65	0.316	0.79	0.561	1.30	0.520

* comparison for each category of cumulative exposure is relative to external referents as baseline

5. DISCUSSION

In this large study, with a wide exposure range, it was possible to look beyond bivariate comparisons between exposed and unexposed subjects, and to explore the nature of exposure-response relationships in detail across the exposure range. Using respirable dust as the exposure metric the arithmetic mean of the intensity of dust exposure was 0.105 mg/m^3 amongst the exposed with 30% having levels above the recommended $0.1mg/m^3$. As also found by Ellingsen et al (2003), there was a high correlation between respirable and inhalable Mn (Spearman's r= 0.9276; p 0.000). The correlations with blood and urine Mn were also significant with the correlation coefficients being higher than the correlations by Myers et al (2003) based on inhalable dust.

This study tested a comprehensive set of endpoints. Using the analysis plan set out in Myers et al (2003) where inhalable dust was the exposure metric, the results were categorized into three groups. Group 1 showed differences between external referents and all the exposed and/or differences between internal referents and the rest of the exposed, but no further exposure-response relationship. Group 2 showed the presence of more substantive exposure-response relationships. Table 10 summarizes the tests, which fell into either group 1 or 2, and compares these to the results from Myers et al (2003).

The digit symbol test from the WHO NCTB showed the clearest exposure response relationship which was however strongest at very low exposures making it difficult to interpret clinically and toxicologically. In comparison to Myers et al (2003) (Table 10), the Benton test for memory did not form part of group 1 whereas the Digit span cognitive ability test demonstrated an exposure-response relationship. The SPES tests were essentially the same as found by Myers et al (2003).

The DPD tests which were assumed to be likely more sensitive to subtle Mn effects contributed disappointingly little. Catsys kinesometry and sway was non-contributory with sway findings being inconsistent with the findings of Chia et al. (1995) who showed that manganese exposed workers had significantly poorer postural stability compared to a referent group. Effects shown for tremor parameters median frequency

and its dispersion were in the opposite direction to those expected, and inconsistent with findings reported by other investigators [Despres et al., 2000; Lucchini et al., 1999]. Luria Nebraska test results were not consistent with those of Lucchini et al. (1999). Lucchini found linear exposure-response relationships with items 1, 2, 3, 4 but not 21, while this study as found by Myers et al (2003) found an exposure-response relationship with item 1R.

Table 10: Comparison of endpoints with results from Myers et al (2003)

Group	Test	This study	Myers et al (2003)
1	WHO NCTB	Santa Ana	Santa Ana Benton Digit Span
	SPES	Endurance Finger tapping with dominant hand	Endurance Finger tapping both hands
	DPD	Left and right sided median frequency Left and right sided dispersion around the median frequency	Increased sway under conditions eyes open without foot insulation, and eyes open with foot insulation Right sided fast hand pronation and supination.
	Questionnaire	Depression Irritation Tiredness	Depression Irritation Tiredness Having to take notes in order to remember things Feeling that something bad is going to happen Subjects' perception that they had sex less often than normal
	Clinical examination	-	Clinical abnormality
	Luria Nebraska	Items 22R, 22L, 23L	Item 2L
2	WHO NCTB	Digit symbol Digit span tests	Digit symbol
	Questionnaire	Subjects' perception that they had sex less often than normal	-
	Luria Nebraska	Item 1R	Item 1R

Group 3 contained the overwhelming majority of test results (almost all the questionnaire items, almost all the DPD tests including sway and diadochokinesis, and the clinical test) for which exposure effects were either null or in a counterintuitive direction. By comparison with Myers et al, the clinical test showed a significant overall trend for exposure, but there was no evidence of an increasing effect when these were examined by increasing category of exposure. When Mn blood, as a continuous variable was used as exposure metric, there was also a small but significant overall trend OR = 1.08 (p=0.008) with no significant exposure response across categories.

One explanation for the very few tests showing meaningful effects, and particularly only for one motor function test, is that this study lacks validity. Only seventy-five direct respiratory dust measurements were taken and the job exposure matrix had to be completed by making many guesses, interpolations and extrapolations. Estimates were based on workplace assessment impressions that certain job categories have similar exposures, or by using conversion factors based on likely relationships between respirable and inhalable fractions based on the production location, or by making interpolations based on an understanding of the production process (subjective occupational hygiene judgements). This could have resulted in exposure misclassification, which is likely to have been non-differential as such misclassification did not depend upon any knowledge of neuro-behavioural outcome or endpoint.

In favour of valid study findings, however, are the following: a) There was good correlation between respirable dust, blood and urine measures of Mn; b) Standardized tools were used for testing the endpoints limiting information bias. Compared with previous results found in SA workers similar to those at the smelter, WHO NCTB test results were very similar [London et al (1997); Myers et al (1999)]. The DPD test results compared well with reference values reported in the literature by Despres et al (2000) and the SPES battery test values compared well with those in other studies. The proportion of test score variance explained by years of education and age similarly compares well with previous South African and other international studies [Myers et al, 1999]; c) There were no obvious sources of selection bias as all production workers in the three categories of broad exposure (high, medium and low) were enrolled in the study (with no refusals to participate); and d) Known

confounders were taken into account by adjusting exposure effects throughout for age, years of schooling, smoking status, alcohol consumption, past job exposures to neurotoxins, previous head injury and home language.

The small number of convincing effects, especially motor function effects, and the character of the exposure-response relationships where effects were observed (exposure-response being larger at low exposures and much less at higher exposures), in this study raise the question of whether such findings are not due to chance. Furthermore, these findings are consistent with recent studies conducted by Myers et al (2003) on a large number of manganese miners (exposed to average exposure intensity for inhalable dust around the ACGIH TLV) and smelter workers, where no convincing Mn effects were found.

Neuro-behavioural effects based on respirable dust as the exposure metric and below the new occupational exposure limit (0.1mg/m^3 respirable Mn or less than category 4 when exposure is categorised) proposed by the IEH are few and unconvincing when appropriately adjusted and when the character of exposure-response relationships is closely examined.

6. CONCLUSION

In this large study among ferroalloy workers, neuro-behavioural effects based on respirable dust as the exposure metric and below the new occupational exposure limit ($0.1 mg/m^3$ respirable Mn or less than category 4 when exposure is categorised) proposed by the IEH are few and unconvincing when appropriately adjusted, and when the character of exposure-response relationships is closely examined. There is no evidence, given potential dilution of exposure-response relationships, as a result of non-differential misclassification of exposure, that respirable dust is a more sensitive metric in the identification of significant exposure-response relationships.

7. RECOMMENDATIONS

There is a need for further studies using respirable dust as the exposure metric where more representative exposure measurements should be taken in order to decrease the likely dilution of any existing exposure-response relationships.

8. ACKNOWLEDGEMENTS

- Prof Myers, Department of Public Health and Family Medicine, University of Cape Town, for guidance and advice through all the stages of this research.
- All workers and management personnel involved as subjects.
- The interviewers for the data collection.
- The study coordinator
- Funding by the company, the South African Medical Research Council, National Centre for Occupational Health and the Research Committee of the Health Sciences Faculty at the University of Cape Town.

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10. APPENDICES

APPENDIX 1 Questionnaire

QUESTIONNAIRE FOR PARTICIPANTS IN THE STUDY OF NERVOUS SYSTEM EFFECTS OF OCCUPATIONAL ENVIRONMENTAL MANGANESE EXPOSURE

Card 1

Survey no. : _____ 1☐☐☐

Date of interview : ____/____/_____ (dd/mm/yy) 4☐☐☐☐☐☐

Time interview begins (24 hour clock): _____ 10☐☐☐☐

Interviewer initials :_____ 14☐

Language of interview: circle the appropriate one 15☐

i) Sesotho
ii) Xhosa
iii) Afrikaans
iv) English

FIRST OF ALL I NEED TO WRITE DOWN YOUR FULL NAME, THE SHIFT YOU ARE WORKING AND THEN ASK YOU A FEW QUESTIONS

a) What shift are you working at the moment? ***ring the answer*** 16☐

i) 6am to 2 pm
ii) 2pm to 10 pm
iii) 10 pm to 6 am
iv) 7 am to 3 pm

b) When did this shift start? _____/__ . . (dd/mm) 17☐☐☐☐

c) What was your previous shift? ***ring the answer*** 21☐

i) 6am to 2 pm
ii) 2pm to 10 pm
iii) 10 pm to 6 am
iv) 7 am to 3 pm

A : PERSONAL DETAILS

1. Surname :_____ 22☐☐☐☐☐☐☐☐☐☐☐

First name :_____ 33☐☐☐☐☐☐☐☐☐☐☐

Pension number :_____ 44☐☐☐☐☐☐

Date of birth : _____/_____/_____(dd/mm/yy) 50☐☐☐☐☐☐

2. School

2.1 What was your last **standard** passed at school? _____ 56

2.2.1 Do you read newspapers ? ***ring the answer*** 58

1) always
2) sometimes
3) rarely
4) never

2.2.2 If never , can you read ? 1.YES 2. NO 59

3. Handedness : show me :

3.1) how you would hammer in a nail 1. right 2. left 3. both 60

3.2) how you would throw a stone 1. right 2. left 3. both 61

3.3) how you would sign your name 1. right 2. left 3. Both 4. N/A 62

4. Video games : ***ring the correct answer***

4.1 Do you know what a video game is ? 1.YES 2. NO 63

4.2 Have you seen such a machine in the past ? 1.YES 2. NO 64

4.3.1 Have you ever played on one of these machines ? 1.YES 2. NO 65

4.3.2 ***If yes*** , how many times have you played in your life ? 66
(ring one answer only)

1) 1
2) 2 - 4
3) 5 – 10
4) 11 – 20
5) more than 20

4.4 Have you ever used a computer? 1.YES 2. NO 67

4.5 Have you ever used an autobank machine to get money ? 1.YES 2. NO 68

5. Head injury & trauma : *ring the correct answer*

5.1 Have you ever been dazed or unconscious as a result of:

5.1.1 A car accident in which you were in the car	1.YES	2.NO	69 ☐
5.1.2 A car accident in which you were a pedestrian struck by a vehicle	1.YES	2.NO	70 ☐
5.1.3 A blow to the head by a blunt object (brick , stick , iron bar)	1.YES	2.NO	71 ☐
5.1.4 A penetrating wound on the head (bullet , knife , axe)	1.YES	2.NO	72 ☐
5.1.5 Accident while playing sport / falling	1.YES	2.NO	73 ☐
5.1.6 Near drowning in water	1.YES	2.NO	74 ☐
5.1.7 Suffocating as a result of a gas stove /fire inside a room	1.YES	2.NO	75 ☐
5.1.8 Suffocating from car exhaust fumes, a veld fire or fumes in general	1.YES	2.NO	76 ☐
5.1.9 Poison / poisonous gases	1.YES	2.NO	77 ☐
5.1.10 Something happening at work	1.YES	2.NO	78 ☐

if yes , please explain what happened? _____

_____

_____

5.2 ***If yes to any of the above , proceed to 5.2.1***
if no to all, then go to 5.3

Card 2

5.2.1 Question number : _____ 1 ☐☐☐

For how long were you dazed / unconscious ? _____(days) 4 ☐☐☐

_____(hours) 7 ☐☐☐

_____(min) 10 ☐☐

Were you taken to hospital? 1. YES 2. NO 12 ☐

If yes ,for how long were you in hospital ?_____ (days) 13 ☐☐

5.2.2 Question number :_____ 15☐☐☐

For how long were you dazed / unconscious ? _____(days) 18☐☐☐

_____(hours) 21☐☐☐

_____(min) 24☐☐

Were you taken to hospital? 1. YES 2. NO 26☐

If yes ,for how long were you in hospital ?_____(days) 27☐☐

5.2.3 Question number :_____ 29☐☐☐

For how long were you dazed / unconscious ? _____(days) 32☐☐☐

_____(hours) 35☐☐☐

_____(min) 38☐☐

Were you taken to hospital? 1. YES 2. NO 40☐

If yes ,for how long were you in hospital ?_____(days) 41☐☐

5.3 Have you ever been diagnosed by a doctor for any of the following medical conditions ?

if yes please give details

5.3.1 **Epilepsy** (falling sickness, seizures / convulsions) 1. YES 2. NO 43☐

If yes , For how long ? _____ (years) 44☐☐

_____ (months) 46☐☐

Are you on treatment ? 1. YES 2. NO 48☐

If yes, what treatment ? _____

_____

_____

5.3.2 **Mental problem** 1. YES 2. NO 49☐

If yes, For how long ? _____ (years) 50☐☐

_____ (months) 52☐☐

Are you on treatment ? 1. YES 2. NO 54☐

If yes, what treatment ? _____

_____

_____

5.3.3 **Diabetes** 1. YES 2. NO 55☐

If yes, For how long ? _____ (years) 56☐☐

_____ (months) 58☐☐

Are you on treatment ? 1. YES 2. NO 60☐

If yes, what treatment ? _____

_____

_____

5.3.4 **Any disease affecting your nervous system** 1. YES 2. NO 61☐

If yes, What disease ? _____

For how long ? _____ (years) 62☐☐

_____ (months) 64☐☐

Are you on treatment ? 1. YES 2. NO 66☐

If yes, what treatment ? _____

_____

_____

5.3.5 **Injury to your arm including your elbow (specify right / left) by breaking or crushing**

1. YES 2. NO 67☐

If yes please explain

_____
_____
_____
_____

5.3.6 **Injury to your hand including your wrist (specify right / left) by breaking or crushing**

1. YES 2. NO 68☐

If yes please explain

_____
_____
_____
_____

5.3.7 **Injury to your fingers, more specifically your index and middle finger (specify right / left) by breaking or crushing**

1. YES 2. NO 69☐

If yes please explain

_____
_____
_____
_____

5.3.8 **Injury to your legs or feet (specify right / left) by breaking or crushing**

1. YES 2. NO 70☐

If yes please explain

_____
_____
_____
_____

5.3.9 Have you ever been admitted to hospital at any time in the past?

1. YES 2. NO 71☐

If yes , 5.4.1 Why ? _____
_____

5.4.2 For how long ? _____(days) 72☐☐

B : WORK EXPERIENCE

PRESENT JOB

Card 3

1.1 How long have you been you working for this company ? _____(years) 1☐☐

_____(months) 3☐☐

1.2 How long have you been working in your current job ? _____(years) 5☐☐

_____(months) 7☐☐

1.3 What job do you do ?

1.3.1 Job title _____ 9☐☐

1.3.2 Job location :_____ 11☐☐

1.3.3 Job description :_____

_____

_____

1.3.4 Does your job include exposure to dust / fumes ? ***ring the correct answer***

1.never 2. seldom 3. sometimes 4. always 13☐

1.3.5 Do you wear a mask ? 1.never 2. seldom 3. sometimes 4. always 14☐

*If **NOT NEVER**,* for how long have you been wearing a mask ? _____(years) 15☐☐

? _____(months) 17☐☐

1.4 Before your current job, have you ever had any other jobs at Samancor in Meyerton?

1. YES 2. NO 19☐

If no, go to 2
If yes, go to 1.4.1

1.4.1 Job 1 :

1.4 .1.1 Job title _____ 20☐☐

1.4.1.2 Job location :_____ 22☐☐

1.4.1.3 Job description :_____

_____

_____

1.4.1.4 How long did you work in that job ? _____(years) 24☐☐

_____(months) 26☐☐

1.4.1.5 Did that job include exposure to dust / fumes ? ***ring the correct answer***

1.never 2. seldom 3. sometimes 4. always 28☐

1.4.1.6 Did you wear a mask ? 1.never 2. seldom 3. sometimes 4. always 29☐

If NOT NEVER, for how long did you wear a mask ? _____(years) 30☐☐

? _____(months) 32☐☐

1.4.2 Job 2 :

1.4.2..1 Job title _____ 34☐☐

1.4.2.2 Job location : _____ 36☐☐

1.4.2.3 Job description : _____

_____

_____

1.4.2.4 How long did you work in that job ? _____(years) 38☐☐

_____(months) 40☐☐

1.4.2.5 Did that job include exposure to dust / fumes ? ***ring the correct answer***

1.never 2. seldom 3. sometimes 4. always 42☐

1.4.2.6 Did you wear a mask ? 1.never 2. seldom 3. sometimes 4. always 43☐

If NOT NEVER, for how long did you wear a mask ? _____(years) 44☐☐

? _____(months) 46☐☐

1.4.3 Job 3 :

1.4.3.1 Job title _____ 48☐☐

1.4.3.2 Job location : _____ 50☐☐

1.4.3.3 Job description : _____

_____

_____

1.4.3.4 How long did you work in that job ? _____(years) 52☐☐

_____(months) 54☐☐

1.4.3.5 Did that job include exposure to dust / fumes ? ***ring the correct answer***

1.never 2. seldom 3. sometimes 4. always 56☐

1.4.3.6 Did you wear a mask ? 1.never 2. seldom 3. sometimes 4. always 57☐

If NOT NEVER, for how long did you wear a mask ? _____(years) 58☐☐

? _____(months) 60☐☐

1.4.4 Job 4 :

1.4.4.1 Job title _____ 62☐☐

1.4.4.2 Job location :_____ 64☐☐

1.4.4.3 Job description :_____

_____

_____

1.4.4.4 How long did you work in that job ? _____(years) 66☐☐

_____(months) 68☐☐

1.4.4.5 Did that job include exposure to dust / fumes ? ***ring the correct answer***

1 never 2. seldom 3. sometimes 4. always 70☐

1.4.4.6 Did you wear a mask ? 1.never 2. seldom 3. sometimes 4. always 71☐

If NOT NEVER, for how long did you wear a mask ? _____(years) 72☐☐

? _____(months) 74☐☐

PREVIOUS JOB EXPERIENCE (BEFORE WORKING AT THIS SMELTER)

Prompt list for the questions below:

2.1 Did or do you do any of the following at work or at home? ***ring the correct answer*** Card 4

2.1.1 Spray painting cars – at work or at home	1.YES 2.NO	1☐
2.1.2 Other spray painting – at work or at home	1.YES 2.NO	2☐
2.1.3 Working with car batteries – at work or at home	1.YES 2.NO	3☐
2.1.4 Working with chemicals – at work or at home	1.YES 2.NO	4☐
2.1.5 Working at any other smelter	1.YES 2.NO	5☐
2.1.6 Working with chemicals on a farm, dry-cleaning or in a laboratory	1.YES 2.NO	6☐

If yes to any of the above, obtain the details below. If no to all of the above, then go to the next section.

2.2 Previous jobs :

2.2.1 First job: Question number: _____ 7☐☐☐

Name of workplace _____

What did they make there ? _____

What did you do ? _____

How long did you work there ? ___ _ (years) 10☐☐

_____ (months) 12☐☐

2.2.2 Second job: Question number: _____ 14☐☐☐

Name of workplace _____

What did they make there ? _____

What did you do ? _____

How long did you work there ? _____ (years) 17☐☐

_____ (months) 19☐☐

2.2.3 Third job: Question number: _____ 21☐☐☐

Name of workplace _____

What did they make there ? _____

What did you do ? _____

How long did you work there ? _____ (years) 24☐☐

_____ (months) 26☐☐

2.2.4 Fourth: Question number: _____ 28☐☐☐

Name of workplace _____

What did they make there ? _____

What did you do ? _____

How long did you work there ? _____ (years) 31☐☐

_____ (months) 33☐☐

2.2.5 Fifth job: Question number: _____ 35☐☐☐

Name of workplace _____

What did they make there ? _____

What did you do ? _____

How long did you work there ? _____ (years) 38☐☐

_____ (months) 40☐☐

2.3 Home :

2.3.1. Question number: _____ 42☐☐☐

What did you make ? _____

What did you do ? _____

How long did you do this type of work? _____ (years) 45☐☐

_____ (months) 47☐☐

2.3.2. Question number: _____ 49☐☐☐

What did you make ? _____

What did you do ? _____

How long did you do this type of work? _____ (years) 52☐☐

_____ (months) 54☐☐

2.3.3. Question number: _____ 56☐☐☐

What did you make ? _____

What did you do ? _____

How long did you do this type of work? _____ (years) 59☐☐

_____ (months) 61☐☐

2.3.4. Question number: _____ 63☐☐☐

What did you make ? _____

What did you do ? _____

How long did you do this type of work? _____ (years) 66☐☐

_____ (months) 68☐☐

C : SYMPTOMS

Q16 *ring the correct answer*

Show the cards to prompt the appropriate response to the questions below.

Card 5

1. Are you abnormally tired ?	1. YES 2. NO	1
2. Do you have palpitations of the heart when you do not exert yourself ?	1. YES 2. NO	2
3. Do you often have painful tingling in some part of your body ?	1. YES 2. NO	3
4. Do you often feel irritated without any particular reason ?	1. YES 2. NO	4
5. Do you often feel depressed without any particular reason ?	1. YES 2. NO	5
6. Do you often have problems concentrating ?	1. YES 2. NO	6
7. Do you have a short memory ?	1. YES 2. NO	7
8. Do you often perspire without any particular reason ?	1. YES 2. NO	8
9. Do you have any problems with buttoning and unbuttoning ?	1. YES 2. NO	9
10.Do you generally find it hard to get the meaning from reading newspapers and books ?	0. standard 4 or less =CANNOT READ 1. YES 2. NO	10
11.Have your relatives told you that you have a short memory ?	1. YES 2. NO	11
12. Do you sometimes feel a heavy feeling on your chest ?	1. YES 2. NO	12
13. Do you often have to make notes about what you must remember ?	0. standard 4 or less =CANNOT READ 1. YES 2. NO	13
14. Do you often have to go back and check things you have done such as locking the door ?	1. YES 2. NO	14
15. Do you have a headache at least once a week ?	1. YES 2. NO	15
16. How many times do you have sex per week? _____		16
16a. Do you think that this is less than most persons of your age?	1. YES 2. NO	18

17. Do you feel that your sense of smell has changed ? 1.YES 2. NO 19☐

if yes, a) How ? _____

b) Since when is that ? _____

Alert: the format of the answers are different from the above. Bring this to the attention of the subject. Show the cards to prompt the appropriate response to the questions below.

AUTONOMIC: *ring the correct answer*

1. Do you suffer from an earache ? 1.hardly ever 2. sometimes 3. often 4. always 20☐

2. Do you feel that you sweat more than is normal? 1.hardly ever 2. sometimes 3. often 4. always 21☐

3. Do you suffer from diarrhoea ? 1.hardly ever 2. sometimes 3. often 4. always 22☐

4. Do you suffer from constipation ? 1.hardly ever 2. sometimes 3. often 4. always 23☐

5. Do you suffer from dizziness ? 1.hardly ever 2. sometimes 3. often 4. always 24☐

6. Do you suffer from pain / a burning sensation on passing urine ?

1.hardly ever 2. sometimes 3. often 4. always 25☐

NEUROLOGICAL: *ring the correct answer*

Alert: the format of the answers are different from the above. Bring this to the attention of the subject. Show the cards to prompt the appropriate response to the questions below.

1. Do you unintentionally drop things ? 1.never 2. sometimes 3. often 4. always 26☐

2. Do you find it difficult to walk in the dark without falling over ?

1.never 2. sometimes 3.often 4. always 27☐

3. Do you find that your hands tremble a lot ? 1.never 2. sometimes 3.often 4. always 28☐

4. Do you find that your ankles swell ?* 1.never 2. sometimes 3. often 4. always 29☐

Alert: the format of the answers are different from the above. Bring this to the attention of the subject. Show the cards to prompt the appropriate response to the questions below.

MOOD: *ring the correct answer*

1. Do you become upset about trivial things? 1.never 2. sometimes 3. often 4. always 30☐

2. Do you worry a lot about trivial things? 1.never 2. sometimes 3. often 4. always 31☐

3. Do you become restless? 1.never 2 sometimes 3. often 4. always 32☐

4. Do you experience strong mood swings? 1.never 2. sometimes 3. often 4. always 33☐

5. Do feel that you have been uninterested in social activities?

1.never 2. sometimes 3. often 4. always 34☐

6. Do you have difficulty in controlling your anger? 1.never 2. sometimes 3. often 4. always 35☐

7. Do you become suddenly scared for no reason? 1.never 2. sometimes 3. often 4. always 36☐

8. Do you feel that you are watched or talked about by others?

1.never 2. sometimes 3. often 4. always 37☐

9. Do you feel like beating, injuring, or harming someone?

1.never 2. sometimes 3. often 4. always 38☐

10. Do you feel like breaking or smashing things? 1.never 2. sometimes 3. often 4. always 39☐

11. Do you feel uneasy in crowds? 1.never 2. sometimes 3. often 4. always 40☐

12 Do you feel spells of terror or panic? 1.never 2. sometimes 3. often 4. always 41☐

13. Do you get into arguments? 1.never 2. sometimes 3. often 4. always 42☐

14. Do you feel nervous when you are left alone? 1.never 2. sometimes 3. often 4. always 43☐

15. Do you experience feelings of guilt? 1.never 2. sometimes 3. often 4. always 44☐

16. Do you ever worry about dying? 1.never 2. sometimes 3. often 4. always 45☐

17. Do you ever think of committing suicide? 1.never 2. sometimes 3. often 4. always 46☐

18. Do you feel that something bad may happen at any moment?

1.never 2. sometimes 3. often 4. always 47☐

D : SMOKING HISTORY

THERE ARE SEPARATE SECTIONS FOR CURRENT SMOKERS, EX-SMOKERS AND NEVER-SMOKERS. ADDITIONALLY FOR CURRENT SMOKERS THERE ARE SEPARATE SECTIONS ON WHAT THEY SMOKE NOW AND WHAT THEY SMOKED IN THE PAST IF THIS IS LESS OR MORE THAN THEY SMOKE NOW

ring the correct answer

1.Do you smoke ? 1. YES 2. NO 48☐

If no , go to QUESTION 4 AS THIS COULD BE EITHER AN EX-SMOKER OR A NEVER SMOKER
If yes , THIS IS A CURRENT SMOKER – GO TO QUESTION 2 BELOW

2. QUESTIONS FOR CURRENT SMOKERS

If YOU ARE A CURRENT SMOKER :

2.1 What do you smoke ? 1. cigarettes 49☐
2. tobacco
3. other

2.2 How many cigarettes do you usually smoke each day ?
or how much tobacco do you smoke per week?

Show different boxes of cigarettes and packets of tobacco

2.2.1 cigarettes 50☐

1)less than 10
2)10 to 19
3)20 to 29
4)30 and more

2.2.2 'tobacco' 51☐

1)small packet
2)medium packet
3)big packet

2.3 How old were you when you first started to smoke? ___ years old 52☐☐

3. Do you now smoke more or less than you did in the past ? 1.YES 2. NO 54☐

If no , go to QUESTION 5 ABOUT DAGGA SMOKING
If yes , go to QUESTION 3.1 ABOUT CHANGING SMOKING PATTERNS IN CURRENT SMOKERS BELOW

QUESTIONS FOR

CURRENT SMOKERS WHO SMOKE MORE OR LESS NOW COMPARED WITH HOW MUCH THEY SMOKED IN THE PAST

3.1 How many did you usually smoke each day in the past before your current pattern?

Show different boxes of cigarettes and packets of tobacco

3.1.1 cigarettes 55☐

1)less than 10
2)10 to 19
3)20 to 29
4)30 and more

3.1.2 'tobacco' 56☐

1)small packet
2)medium packet
3)big packet

3.2 For how long did you smoke this amount ? _____years 57☐☐

4. Have you ever smoked in the past? 1. YES 2. NO 59☐

If no , THIS IS A NEVER SMOKER -> go to QUESTION 5 ABOUT DAGGA SMOKING
If yes , THIS IS AN EX-SMOKER -> go to the questions below

QUESTIONS FOR EX-SMOKERS

4.1 How old were you when you first started smoking? _____ years old 60☐☐

4.2 How long ago did you stop smoking ? a) less than 1year (00) 62☐☐
b) _____ years (number)

4.3 What did you smoke ? 1. cigarettes 64☐
2. tobacco
3. other

4.4 How many did you smoke each day? (**circle the appropriate response**)

Show different boxes of cigarettes and packets of tobacco

4.4.1cigarettes 65☐

1)less than 10
2)10 to 19
3)20 to 29
4)30 and more

4.4.2 'tobacco' 66☐

1)small packet
2)medium packet
3)big packet

DAGGA SMOKERS

5.1 Have you ever tried dagga ? 1. YES 2. NO 67☐

If NO, go to next section

5.2 If yes , do you still smoke it ? 1 YES 2. NO 68☐

5.2.1 If yes to 5.2. how often ? 69☐

1) every day
2) not every day but more than once a week
3) less than once a week
4) some times but less than once a month
5) never

5.2.2 For how long have you been smoking this amount ?

_____ (years) 70☐☐

_____ (months) 72☐☐

5.2.3 Did you ever smoke more or less compared to now ? 1.YES 2. NO 74☐

5.2.4 If yes to 5.2.3 , how often ? 75☐

1) every day
2) not every day but more than once a week
3) less than once a week
4) some times but less than once a month
5) never

5.2.5 For how long did you smoke this amount ?

_____ (years) 76☐☐

_____ (months) 78☐☐

E : ALCOHOL USAGE

THERE ARE SEPARATE SECTIONS FOR CURRENT DRINKERS, EX-DRINKERS AND NEVER-DRINKERS.

ADDITIONALLY FOR CURRENT DRINKERS THERE ARE SEPARATE SECTIONS ON WHAT THEY DRINK NOW AND WHAT THEY DRANK IN THE PAST IF THIS IS LESS OR MORE THAN THEY DRINK NOW

ring the correct answer

Card 6

1.Do you take alcohol ? 1. YES 2. NO 1☐

If yes , THIS IS A CURRENT DRINKER, GO TO QUESTION 2 BELOW
If no, go to QUESTION 6 AS THIS COULD BE AN EX-DRINKER OR A NEVER DRINKER

2. QUESTIONS FOR CURRENT DRINKERS ONLY

2.1 How much do you drink during the week ?

Indicate number & specify size according to key below

	Beer	Wine	Spirits	Home made	
Mon to Thurs	_____	_____	_____	_____	2☐☐☐
Friday	_____	_____	_____	_____	5☐☐☐
Saturday	_____	_____	_____	_____	8☐☐☐
Sunday	_____	_____	_____	_____	11☐☐☐

Key : Beer – dumpy :A
Beer – Quart : B
Beer – Pint : C
Beer – can : D
Beer – supercan : E
Spirits – half jack : F
Spirits – 750ml : G
Spirits - quarter jack : H
Spirits 1 litre : I
Wine bottle (750ml) : J
Glass : K
Jug : L
Juba : M

SHOW VARIOUS ITEMS

2.2 How old were you when you started drinking ? _____years 14☐☐

3. If you are drinking alcohol now. has the amount you are drinking changed from the past ?

1. YES 2. NO 16☐

If NO, go to QUESTION 4 ABOUT YOUR DRINKING PATTERN IN THE PAST WEEK
If yes, go to QUESTION 3.1 BELOW ABOUT CHANGING DRINKING PATTERNS IN CURRENT DRINKERS BELOW

QUESTIONS FOR CURRENT DRINKERS WHO DRINK MORE OR LESS NOW COMPARED WITH HOW THEY DRANK IN THE PAST

3.1 How much did you usually drink during this period before changing to your current pattern of drinking?

Indicate number & specify size according to key above.

	Beer	Wine	Spirits	Home made	
Mon to Thurs	_____	_____	_____	_____	17☐☐☐
Friday	_____	_____	_____	_____	20☐☐☐
Saturday	_____	_____	_____	_____	23☐☐☐
Sunday	_____	_____	_____	_____	26☐☐☐

Use the same key as above. Show various items.

3.2 For how long (years) did you drink this amount ? _____years 29☐☐

QUESTIONS FOR CURRENT DRINKERS ABOUT WHETHER THEIR DRINKING PATTERN IN THE PAST WEEK WAS DIFFERENT FROM WHAT THEY USUALLY DRINK

4. During the **PAST WEEK**, did your drinking pattern differ from the usual ? 1. YES 2. NO 31☐

If yes, answer the following questions
If no, go to EXTRA QUESTIONS (5) FOR CURRENT DRINKERS

Indicate number & specify size according to key above.

	Beer	Wine	Spirits	Home made	
Mon to Thurs	_____	_____	_____	_____	32
Friday	_____	_____	_____	_____	35
Saturday	_____	_____	_____	_____	38
Sunday	_____	_____	_____	_____	41

Use the same key as above. Show various items.

EXTRA QUESTIONS FOR CURRENT DRINKERS

5. When visiting a friend for a drink or going to a bar with friends ***circle the correct answer***

5.1 How many drinks do you usually have at one sitting?

_____ cans 44

_____ dumpies 46

_____ glasses 48

5.2 Have you ever felt that you should drink less? 1. YES 2. NO 50

5.3 Have other people ever made you angry by criticising your drinking habits? 1. YES 2. NO 51

5.4 Have you ever felt guilty or bad because you drink? 1. YES 2. NO 52

5.5 Have you ever had a drink early in the morning in order to make you feel better / to cure your hangover ? 1. YES 2. NO 53

5.6 Do you think your drinking habits are normal ? 1. YES 2. NO 54

5.7 Have you ever got so drunk that you cannot remember what happened? 1. YES 2. NO 55

5.8 Can you stop easily after 1 or 2 drinks ? 1. YES 2. NO 56

5.9 Do your friends and family think that you have normal drinking habits ? 1. YES 2. NO 57☐

5.10 Have you ever been in hospital because of alcohol ? 1. YES 2. NO 58☐

5.11 Have you ever lost friends or girlfriends because of alcohol ? 1. YES 2. NO 59☐

5.12 Have you ever neglected your family because of alcohol ? 1. YES 2. NO 60☐

5.13 Have you ever hallucinated (heard voices / saw visions) that were not there after all ? 1. YES 2. NO 61☐

5.14 Have you ever sought help for your drinking habits ? 1. YES 2. NO 62☐

5.15 Have you ever got into trouble at work because of drinking alcohol? 1. YES 2. NO 63☐

NOW GO TO THE END OF THE QUESTIONNAIRE AND FILL IN THE TIME

QUESTION FOR EX-DRINKERS OR NON-DRINKERS

6. Did you drink alcohol in the past ? 1. YES 2. NO 64☐

If yes , THIS IS AN EXDRINKER, GO TO QUESTION 6.1 BELOW
If no, this is a NEVER DRINKER, GO TO THE END OF THE QUESTIONNAIRE AND FILL IN THE TIME

QUESTIONS FOR EX-DRINKERS

6.1 If you only drank alcohol in the past;

Card 7

How old were you when you started drinking ? _____years 1☐☐

How old were you when you stopped drinking ? _____years 3☐☐

Why did you stop ? _____

_____

_____

6.2 How much did you drink during a week ?

indicate number & specify size according to key below

	Beer	Wine	Spirits	Home made	
Mon to Thurs	_____	_____	_____	_____	5☐☐☐
Friday	_____	_____	_____	_____	8☐☐☐
Saturday	_____	_____	_____	_____	11☐☐☐
Sunday	_____	_____	_____	_____	14☐☐☐

Key : Beer – dumpy :A
Beer – Quart : B
Beer – Pint : C
Beer – can : D
Beer – supercan : E
Spirits – half jack : F
Spirits – 750ml : G

Spirits - quarter jack : H
Spirits 1 litre : I
Wine bottle (750ml) : J
Glass : K
Jug : L
Juba : M

SHOW VARIOUS ITEMS

EXTRA QUESTIONS FOR EX DRINKERS

7. In the past, when visiting a friend for a drink or going to a bar with friends ***circle the correct answer***

7.1 How many drinks did you usually have at one sitting?

_____ cans 17☐☐

_____ dumpies 19☐☐

_____ glasses 21☐☐

7.2 Did you ever feel that you should drink less? 1. YES 2. NO 23☐

7.3 Did other people ever make you angry by criticising your drinking habits? 1. YES 2. NO 24☐

7.4 Did you ever feel guilty or bad because you drank? 1. YES 2. NO 25☐

7.5 Did you ever have a drink early in the morning in order to make you feel better / to cure your hangover ? 1. YES 2. NO 26☐

7.6 Did you think your drinking habits were normal ?	1. YES 2. NO	27☐
7.7 Did you ever get so drunk that you could not remember what happened?	1. YES 2. NO	28☐
7.8 Could you stop easily after 1 or 2 drinks ?	1. YES 2. NO	29☐
7.9 Did your friends and family think that you had normal drinking habits ?	1. YES 2. NO	30☐
7.10 Were you ever in hospital because of alcohol ?	1. YES 2. NO	31☐
7.11 Did you ever lose friends or girlfriends because of alcohol ?	1. YES 2. NO	32☐
7.12 Did you ever neglect your family because of alcohol ?	1. YES 2. NO	33☐
7.13 Did you ever hallucinate (hear voices / see visions) that were not there after all ?	1. YES 2. NO	34☐
7.14 Did you ever seek help for your drinking habits ?	1. YES 2. NO	35☐
7.15 Did you ever get into trouble at work because of drinking alcohol?	1. YES 2. NO	36☐

Time interview ends (24 hour clock): _____ 37☐☐☐☐

APPENDIX 2 Pre-test Questionnaire

PRE TEST QUESTIONNAIRE FOR PARTICIPANTS IN THE STUDY OF NERVOUS SYSTEM EFFECTS OF OCCUPATIONAL ENVIRONMENTAL MANGANESE EXPOSURE

Survey number : _____ 1☐☐☐

Work number of participant : _____ 4☐☐☐☐☐

Date : ___/___/_____ (dd/mm/yy) 9☐☐☐☐☐☐

Time begin (24 hour clock): _____ 15☐☐☐☐

Ring the correct answer

1. Were you told about the following (adequate sleep, no tea/coffee/coca-cola, no smoking and no alcohol for 24 hours prior to testing)?

1. YES 2.NO 19☐

2. How long did you sleep last night ? 2.1 8 - 10 hrs 20☐

2.2 6 - 8 hrs

2.3 4 - 6 hrs

2.4 less than 4 hrs

3. Right now you are feeling : 3.1 energetic 21☐

3.2 fresh

3.3 average

3.4 tired

3.5 exhausted

4. Did you drink coffee tea / coca-cola in the last 24 hours ? 1. YES 2.NO 22☐

If yes , how much did you drink

4.1 coffee : _____ cups 23☐

4.2 tea : _____ cups 24☐

4.3 coca-cola :_____ cans 25☐

5.1 Do you smoke ? 1. YES 2.NO 26☐

if yes , did you smoke in the last 24 hours ? 1. YES 2.NO 27☐

If yes , how much did you smoke

5.2.1 about the usual amount 28☐

5.2.2 more than usual 29☐

5.2.3 less than usual 30☐

6.1 Do you drink alcohol ? 1. YES 2.NO 31☐

if yes , did you drink in the last 24 hours ? 1. YES 2.NO 32☐

if yes , how much did you drink ?

6.2.1 about the usual amount 33☐

6.2.2 less than usual 34☐

6.2.3 more than usual 35☐

7. Are you taking any medicine currently ? 1.YES 2. NO 36☐

if yes , what are they ?

_____

_____

_____

_____

_____

8.Vision :8.1 Have you ever used glasses / contact lenses ? 1. YES 2.NO 37☐

8.2 Did the glasses / contact lenses help you to see better ? 1. YES 2.NO 38☐

8.3 Did you receive instructions to bring your glasses or contact lenses with you? 1. YES 2.NO 39☐

8.4 Do you have your glasses /contact lenses with you? 1. YES 2.NO 40☐

Time end (24 hour clock): _____ 41☐☐☐☐