

2. Research on health and environment determinants and their management in human settlements

2.1 Lead exposure and poisoning from paint in South Africa

Even at low concentrations in blood (less than 10 $\mu\text{g}/\text{dl}$), lead is associated with reductions in IQ, mild intellectual impairment, hyperactivity, shortened concentration span and poor school performance. Higher blood lead levels are associated with hearing loss, the emergence of aggressive or violent behaviour, a delay in the onset of puberty and detrimental effects on virtually all organ systems, including the brain, heart, liver, kidneys and circulatory system. Children in Africa are thought to be at particularly high risk of exposure to lead in the environment.

Epidemiological studies undertaken in 2002 and 2003 (as well as earlier), showed that an unacceptably high proportion of first grade South African school children, especially in Johannesburg and other urban settings, have elevated blood lead concentrations. One of the major risk factors for high blood lead concentrations was living in a house or attending a school in close proximity to a heavily trafficked road. These findings contributed to a parliamentary decision to phase out the use of leaded petrol in South Africa as from 1 January 2006.

Exposure to lead-based paint was an additional risk factor for elevated blood lead concentrations. For example, children who lived in homes with peeling paint or who had pica for paint, had significantly elevated blood lead levels, compared to other children. A series of supplementary investigations showed that lead continues to be added to paint in South Africa, despite the existence of a voluntary agreement amongst members of the South African Paint Manufacturers' Association to limit the use of lead in paint. The lead concentrations in pigmented enamel paints being sold to the general public were, in some instances alarmingly high - up to 189 000 $\mu\text{g}/\text{g}$, compared to the United States of America standard of 5 000 $\mu\text{g}/\text{g}$.

It is likely that lead-based enamel paints are being applied to children's rooms and furniture, as well as toys and playground or educational equipment. In respect of toys (purchased from large toys stores, supermarkets, stationery stores and craft/flea markets in Johannesburg), a preliminary scan showed that paint with lead concentrations up to 145 000 $\mu\text{g}/\text{g}$ was being used to coat children's toys, relative to the international standard of 90 $\mu\text{g}/\text{g}$.

On presentation of a technical report on the study findings to the Minister of Health by the Medical Research Council President, Anthony MBewu, an

instruction was given to the Department of Health's Legal Services Division to draft regulations to ban the use of lead in paint intended for sale to the general public in South Africa.

Little is known of the extent of use of lead in paint in countries elsewhere in Africa, or of the export practices (as well as importation from other countries) of South African paints and painted children's toys and furniture to other African countries.

Cost of Lead Study:

R350 000 (received from the United States Environmental Protection Agency).

2.2 Lead hazard awareness in pregnant women in Johannesburg

A 2002/3 study showed that Johannesburg children were at particular risk of elevated blood lead concentrations. Given the challenges and prohibitive cost of primary prevention (the removal of lead-based paints from homes, schools and other infrastructure) in a developing country setting, it has been decided to conduct a study to measure the impact of a personal and environmental hygiene intervention on children's blood lead levels and neurobehavioural development. In this regard a formative study is currently underway, with the objectives of:

- determining the levels of knowledge among pregnant women of lead hazards;
- determining current personal and environmental hygiene practices; and
- identifying potential sources of lead exposure in the homes of the study population.

The study is being undertaken at the Coronationville Hospital in Johannesburg, which is the only hospital in Gauteng dedicated to the health concerns of women and children. The formative/pilot phase of the research is being undertaken by Ms Tanya Haman as part of a Masters in Public Health course at the School of Public Health (University of the Witwatersrand). Tanya is currently employed as a lecturer at the University of Johannesburg, and her research work is being supervised by Angela Mathee (MRC), Brendon Barnes (MRC) and Andre Swart.

Cost of Study:

Approximately R12 000.00 (MRC).

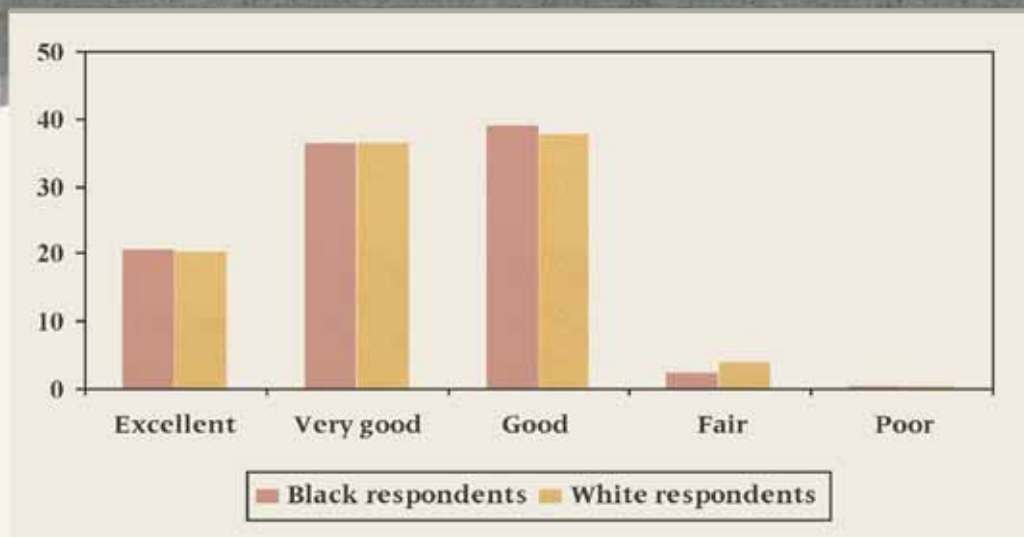


Figure 2: Health and well-being for black and white respondents

2.3 Evaluation of the impact of personal/ environmental hygiene intervention on the blood lead levels and neurobehavioural performance of young children

In this study, a test group (pregnant women or mothers of young children) will be informed about the sources, hazards, pathways of exposure and mechanisms for exposure prevention in relation to lead. Blood sampling for lead content analysis will take place prenatally (maternal), at birth (cord blood lead levels) and at 1 and 2 years of age. Development assessments will be conducted at various ages, and home assessments will be undertaken to measure the concentrations of lead in paint, water and dust.

2.4 The effects of integrated service delivery on health, well-being and quality of life in Orange Grove and surrounding suburbs: Phase 2 (2005)

In February/March 2004, prior to the implementation of integrated service delivery projects (Social Services, Sport, Recreation and Aquatics, Library and Information Services, Housing, Clinics and Priority Health Programmes, Environmental Health Services, and Local Economic Development), a baseline study was conducted with a stratified random sample of 791 residents. In 2005, 20 fieldworkers administered the questionnaires to 338 respondents (43% of the original sample). One hundred and seven

Domain	Reasons	%
SAPS (police)	Do not respond	49
Metro (police)	Ineffective, invisible & corrupt	80
Safety and security	Too much crime in the area	83
Street lighting	Not enough and old system	57
Public clinics	Not enough of them	64
Private clinics	Too expensive	67
Parks	Not well kept and unsafe	86
Air quality	Too much pollution from traffic	68
Noise level	Too much noise from traffic	84
Local government	Invisible and not responsive	75

Table 1: Major reasons for dissatisfaction with ten environmental quality of life domains

Moinca Feit has agreed to work from the MRC as a volunteer and undertake the study towards a doctoral degree.

Costing:

The budget is yet to be determined.

respondents were not found, unknown or had moved, 43 refused to participate and 3 were deceased. With the exception of age, demographics were virtually identical to 2004.

Health, well-being and disability

The study results showed that 97% of black respondents rated their health and well-being as good or better, in comparison with 90% in 2004.

Ninety five per cent of white respondents rated their health and well-being as good or better, in comparison with 91% in 2004 (Figure 2). Unemployed respondents tended to rate their health and well-being as poorer than employed respondents. Only 8% of black and 15% of white respondents reported a disability. Respondents with disabilities were less likely to be employed and rated their health and well-being as poorer than respondents without disabilities ($p < 0.05$). These findings were very similar to 2004 and suggested that health and well-being are relatively stable concepts.

Environmental quality of life

Respondents were most satisfied with their housing and least satisfied with jobs in 2004 and 2005. The major reason for dissatisfaction with jobs in 2004 and 2005 was the lack of local employment opportunities for black and white respondents. There were fluctuations in satisfaction levels between 2004 and 2005. The

by street lighting (Table 2). In 2005, housing accounted for 10% more of the variance in neighbourhood satisfaction than was found in 2004. It is noteworthy that street lighting (a proxy for safety and security) was considered to be an essential aspect of neighbourhood satisfaction in 2005.

In conclusion, unemployed respondents had poorer health and well-being than employed respondents. Both black and white respondents were equally likely to rate their health and well-being as good or better. Health and well-being were the core components of personal quality of life. However, being happy and having a good social life were more important for life satisfaction than being healthy. High crime rates, low Metro police service and local government presence, the expense of private health facilities, the lack of public health facilities and pollution from traffic appear to be the major reasons for dissatisfaction

2004				2005			
Predictors	Adjusted R^2	Beta	T	Predictors	Adjusted R^2	Beta	t
Housing	0.22	0.3	5.56	Housing	0.32	0.49	6.95
Safety and security	0.08	0.18	3.12				
Parks	0.04	0.2	3.63				
Employment opportunities	0.03	0.17	3.35				
Street lighting	0.02	0.16	2.94	Street lighting	0.12	0.36	5.02
$F(5,246) = 32.62, p < 0.001$	0.39			$F(2,117) = 46.97, p < 0.001$	0.44		

Table 2: Predictors of neighbourhood satisfaction in 2004 and 2005

major reasons for dissatisfaction are shown in Table 1. Dissatisfaction appears to stem from high crime rates, low Metro police service and local government presence, the expense of private health facilities, the lack of public health facilities and pollution from traffic.

Neighbourhood satisfaction and environmental quality of life

All environmental satisfaction domains were regressed on neighbourhood satisfaction and two variables explained 44% of the variance. Housing explained 32% of the variance in neighbourhood satisfaction and an additional 12% was explained

with the environmental quality of life domains. The findings suggest that these integrated service delivery projects have had some influence in improving health and well-being, but have had a minor impact on personal and environmental quality of life. It is possible that a one-year time-frame is too short to see an impact on quality of life.

Cost of Study:

The City of Johannesburg (Region 3) paid for the interviewers and photocopying of the questionnaires (R16 000.00). The costs of data capture and cleaning, as well as data analysis was covered by the MRC.

2.5 Examining the association between manganese and blood lead levels in school children in selected regions of South Africa

In South Africa, anthropogenic sources of manganese and lead derive primarily from industrial activities and vehicular emissions of petrol additives. At elevated levels, both metals are neurotoxic with manganese being also an essential nutritional element.

At present in South Africa, petrol producing oil companies are developing alternative petrol formulations as part of ongoing automobile technology development, as well as in preparation for phasing out of lead as an additive in the country's fuels by 2006. Among available octane enhancing alternative additives, the methyl tertiary butyl ether (MTBE), ethyl tetra butyl ether (ETBE), ethanol and manganese containing methylcyclopentadienyl manganese tricarbonyl (MMT) are under consideration, with MMT already introduced to petrol in Gauteng in late 2000.

Recently, a number of studies have investigated not only the mechanism of manganese uptake and excretion, but also the possibility of synergetic toxic effects of lead and manganese. A study that concurrently measured lead and manganese blood levels in schoolchildren residing in four different geographical regions of South Africa found that the manganese levels of 12% of the children in Johannesburg, 4% of the children in Cape Town and 8% in Kimberley equalled or exceeded $14 \mu\text{g/l}$, the upper normal values as specified by Agency for Toxic Substances Disease registry (ATSDR).

The relationship between blood lead and manganese levels (treating each in turn as a response) was investigated by fitting linear mixed models (multilevel models). An examination of residuals suggested log transformation for manganese, but that of lead did not need to be transformed. The results for the blood manganese and lead levels are summarised in Table 3. In addition, a questionnaire was completed by the caregiver of each child, in order to obtain information on socio-demographic variables and other potential risk factors.

Statistics	Cape Town	Johannesburg	Kimberley	Aggeneys	Pella	Onseepkans
N	427	381	355	21	55	43
Mn mean	6.75	9.76	9.72	9.86	8.30	7.75
std deviation	3.47	3.53	3.12	2.63	2.74	2.02
Median	6.2	9.2	9.5	9.2	8	7.4
Iqr	4.7-7.8	7.4-11.4	7.5-11.2	7.6-11.9	6.5-10.2	6.0-9.5
Range	1.6-32.8	3.6-26.5	1.5-23.7	6.5-16.1	3.3-17.4	3.8-12.2
Pb mean	6.44	9.06	7.07	7.76	5.73	5.71
Std devn	2.90	3.11	2.72	2.88	2.58	1.99
Median	6.1	8.9	6.7	7.9	5.1	5.7
Iqr	4.5-8.1	6.7-11.3	5.1-8.4	6.0-9.3	4.0-6.6	4.2-7.4
Range	1.0-24.5	1.1-18.1	2.1-22.6	2.8-13.4	2.5-17.1	2.4-12.1

Table 3: Concentration of manganese ($\mu\text{G/L}$) and lead ($\mu\text{G/DL}$) in blood by study area

MMT, like tetraethyl lead, is a neurotoxin that can cause agitation and convulsions, as well as pulmonary damage at elevated concentrations. Consequences of widespread long-term exposure in the public at all ages, including those with impaired health status, pregnant woman and children, to manganese emission products of MMT are virtually unknown. The potential for injury to the nervous system has never been independently assessed, nor has the possible long-term consequences of widespread early exposure to manganese been examined.

When mixed models were fitted with the natural log of manganese blood concentration as a response variable and the blood lead levels as the principal explanatory variable, the important confounders were found to be the following:

- ♦ gender (with blood manganese levels being higher for females); race (with manganese levels being lower for black Africans than for the other races);



Photo: Graa Maruanda

- ♦ paint peeling outdoors (which led to lower manganese levels);
- ♦ whether the child ate paint (which led to lower manganese levels); and
- ♦ whether anyone engaged in spray painting at home (which led to lower manganese levels).

When adjusting for these confounders, strong evidence of a linear trend of log (Mn) with increasing blood lead ($P < 0.001$) was found, including significant linear trends for Cape Town, Johannesburg and Kimberley.

When fitting mixed models, with blood lead concentration being the response variable and the log of manganese as the principal explanatory, the important confounders were found to be the following:

- ♦ gender (with blood lead level being lower in females);
- ♦ race (with blood lead level being lowest for Indians and whites and highest for Coloureds);
- ♦ whether the house had paint peeling indoors (which led to higher lead levels);
- ♦ whether the child ate paint (which leads to higher levels); and
- ♦ whether the child attended crèche (which leads to lower levels).

Adjusting for these there was strong evidence of a linear effect of blood manganese level on lead level.

In conclusion, although some evidence of association between lead and manganese levels in blood in four centres was found, this was not homogeneous due to the large variability in manganese and lead blood levels between selected centres. A follow-up study is suggested in anticipation of increased use of MMT in petrol in the near future. This is of significance as current lead and manganese blood levels in South African school children and residual environmental lead levels are high when compared with international levels.

Study Cost:

Engen contributed an amount of R50 000 towards the study.

2.6 Levels of persistent toxic substances in blood and urine from pregnant women from selected areas of South Africa: A pilot study

Levels of persistent toxic substances (PTS) in maternal blood during pregnancy give an indication of the potential risk to the developing foetus. Of particular concern are long-term, subtle effects that might influence reproductive health, pregnancy outcomes, reduce defence against diseases, affect children's mental development, or increase the risk of cancer. Several of these substances move from mother to foetus via the umbilical cord and to the child via its mother's breast milk.

Several multidisciplinary international projects are in progress, that focus on levels of PTS in people of different geographical regions to establish the relationship between levels of these chemicals and health. South Africa, having dimensions of both developed and developing countries, has the potential to contribute to global research in the science of environmental pollutants and human health outcomes. Currently a pilot study is being carried out by the South African Medical Research Council in collaboration with the University of Tromsø (Norway), the Norwegian Institute of Air Research, the Norwegian National Institute of Occupational Health, Centre du Toxicologie de Quebec, Canada and the South African Council for Geoscience to assess possible health risks related to exposure to persistent toxic substances (PTS) in selected areas of South Africa.

Data and sample collection were completed in the rural village of Morokweng, situated in the North West Province. This site was purposely selected because of its isolation from industrial, agricultural and traffic activities to serve as a baseline for other sites that include urban, industrial, mining and fishing areas. To date preliminary data on maternal and newborns as well as some analytical results are completed for polychlorinated biphenyl (PCB) congeners and pesticides. The latter were compared with Russian and Norwegian study populations and showed, as expected, very low levels of contamination for pesticides and PCBs. Analytical work is in progress to assess metal content (both toxic and essential).

Study Cost:

An amount of R90 000.00 (received from the University of Tromsø) was secured for the pilot study.



2.7 Exposure to mercury in informal, small-scale gold mining

There is an increasing population of artisanal gold miners in South Africa, including local as well as foreign workers. There is ongoing interest in assessing the level of exposure amongst artisanal gold miners to mercury.

With support from the Department of Science and Technology, Vathiswa Papu has been appointed to design and undertake a study in this regard. In terms of the contract with the Department of Science and Technology, Ms Papu is required to work towards a doctoral degree.

Cost of Study:

The budgeting process is currently underway.



2.8 Can behavioural change reduce child indoor air pollution exposure in developing countries?

Indoor air pollution is causally associated with acute lower respiratory infections (ALRI) in children, and is the fourth largest killer of young children in developing countries. The sustainability of expensive technological interventions (such as cleaner fuels and stoves)

has been questioned in poor rural areas. Behavioural change may offer a cheaper alternative but has yet to be scientifically evaluated. The aim of this study was to determine the impact of a behavioural intervention on child exposure to indoor air pollution and child respiratory health in a poor rural village in South Africa. A cohort of children = 4 years old (N=502) was recruited and allocated to either an intervention (n=244) or control group (n=258).

Results showed that the two groups were well balanced at baseline in terms of socio-economic status, exposure indicators (exposed versus non-exposed, PM10 [kitchen], CO [kitchen] and CO [child]) and child ALRI (including known confounders). The intervention promoted three simple behaviours:

- ♦ burn outdoors for longer;
- ♦ when fires are brought indoors, to improve ventilation; and
- ♦ to reduce the amount of time that children spend in the burning room.

The intervention was implemented amongst primary caregivers in the intervention group after the baseline assessment. Follow-up visits (12 months later) showed significant reductions in adjusted child indoor air pollution exposure indicators amongst the intervention group. While the control group showed evidence of exposure reductions, children in the intervention group were over three times (adjusted OR=3.1) more likely to remain non-exposed during colder winter spells. More importantly, when fires were brought indoors, the intervention group significantly reduced mean PM10 [kitchen] concentrations from 607 to 231 $\mu\text{g}/\text{m}^3$, mean CO[kitchen] from 205 to 128ppm and mean CO[child] from 111 to 78ppm while the control group only reduced PM10 [kitchen]. This is the first study of its kind worldwide to highlight the potential of behavioural change to reduce indoor air pollution exposure developing countries. Although the study was implemented in a rural setting without access to modern energy sources (i.e. worst case scenario), plans are underway to implement similar studies in urban contexts.

Costing:

USAID grant implemented through the Academy for Educational Development (AED) (R250 000); and WHO-AFRO (R50 000).