ABSTRACT
For the past three decades it has been known that considerable numbers of South African children have blood lead levels that exceed international guidelines. The health effects associated with even very low blood lead levels are beyond doubt, and include reductions in IQ scores, an inability to concentrate and learning difficulties. There is also an emerging body of evidence that links lead exposure in childhood with the emergence of aggressive and violent behaviour. Poor school performance and violence are two major socio-political concerns in South Africa, and comprehensive approaches to resolving these should include a focus on lead poisoning prevention. Two important milestones have been reached in recent years that will undoubtedly bring about a beneficial lowering of childhood blood lead distributions in South Africa: the phase-out of leaded petrol and the promulgation of legislation to control the use of lead in paint. On the whole, however, the approach to lead poisoning prevention in South African children has been piecemeal, and action has been tardy. Lead poisoning is preventable, and the prompt implementation of a comprehensive and integrated lead poisoning prevention strategy has been demonstrated to yield health, social and economic benefits that greatly outweigh the economic cost of implementation.

Keywords: lead poisoning, violence, children, South Africa

INTRODUCTION
Lead is a heavy metal that is found naturally in the earth’s crust. It has a low melting point, is malleable and also resistant to corrosion. Since it was discovered thousands of years ago, these properties have resulted in lead being used in a myriad of processes and products. However, there is now an overwhelming body of evidence associating lead exposure with a wide range of detrimental health effects. The use of lead increased dramatically around the time of the industrial revolution, making a major contribution to its current status as a global environmental contaminant and major public health concern. Before the industrial revolution, body lead burdens were more than 500 times lower than what they are today. Because lead is a persistent metal, and does not readily get converted to less toxic forms in nature, it is likely to remain of public health concern for generations to come, especially in low-income countries (Nriagu, 1983; Tong, von Schirnding & Prapamontol, 2000). The Chapter objectives are as follows:

a. To outline what is known about the impacts of lead exposure on children’s health and development.

b. Using the limited available information, to describe the lead exposure situation in South Africa in relation to children.

c. To describe the interventions undertaken in South Africa in recent years to limit childhood lead exposure.

d. To reflect on the essential outstanding actions
needed to further reduce blood lead distributions in South African children.

**SOURCES OF EXPOSURE TO LEAD**

Natural sources of lead include volcanic activity, geochemical weathering and sea spray emissions. However, human extraction and use of lead has been the main cause of elevated public exposure to environmental lead. For example, lead was used in petrol for decades to improve engine efficiency (and still is in some countries), as well as lead-acid batteries, paint, solder, jewellery, plumbing, pottery, electronic equipment, cabling, ammunition, fishing and wheel balancing weights and leaded glass (Tong *et al.*, 2000).

With the proliferation, and rapid rate of replacement of computers, cellular telephones and other electronic equipment (often lead-containing), the disposal of electronic equipment is emerging as an important lead exposure concern. The concern is greatest in low-income countries because of transfer of electronic waste from high-income countries for disposal (Zheng *et al.*, 2008).

**PATHWAYS OF EXPOSURE**

Human exposure to lead may occur through direct dermal absorption, respiration or ingestion. Ingestion of lead-rich dust or soil, through the hand-to-mouth pathway, is by far the predominant route of lead exposure in children. Lead inhalation can also occur during unusual circumstances, such as heat gun stripping of painted surfaces, welding and burning of lead-contaminated items such as batteries, in or near children’s homes. In these situations, very fine particles of airborne lead are generated and can be inhaled by children, which may lead to severe cases of paediatric lead poisoning.

Young children absorb more lead from the environment than adults (Ahamed & Siddiqui, 2007). Children’s behaviour, including their natural tendency to touch and taste objects in their surroundings, may increase their risk of exposure to lead. Children with pica (a habit of eating non-food items such as soil or paint) or excessive mouthing behaviour are at particular risk of exposure to environmental lead. The risk of lead exposure is particularly high under the age of four years, when exploratory behaviour is at a peak. Children also retain more lead in their bodies than adults. In the body lead is distributed to several organs, including the brain, liver and kidneys, and is stored in the teeth and bones, where it accumulates over time. Children’s nervous systems are rapidly developing, and therefore more susceptible to lead-induced disruption (Finkelstein, Markowitz & Rosen, 1998).

Lead absorbed during childhood, and stored in the skeletal system, may subsequently be released from the bones during pregnancy, especially in cases of calcium deficiency. The placenta constitutes a weak barrier to the transfer of lead from mother to foetus during pregnancy, with the potential for lead exposure prior to birth. Maternal and foetal blood lead concentrations are usually highly correlated (Raghunath, Tripathi, Sastry & Krishnamoorthy, 2000). Thus, even in the absence of an obvious source of contemporary exposure to lead in pregnant women, the risk of foetal lead exposure remains, with the potential for lead-related health and developmental effects to occur before birth (Gulson, Mizon, Korsch, Palmer & Donnelly, 2003).

**HEALTH EFFECTS**

Worldwide, lead poisoning is an important public health problem, and accounts for nearly 1% of the global burden of disease (Fewtrell, Prüss-Üstün, Landrigan & Ayuso-Mateos, 2004). The toxic nature of lead was realised more than four thousand years ago. However, over the past century in particular, increasingly sophisticated epidemiological studies have more adequately revealed the wide range of health effects that can result from exposure to lead,
and that lead can cause health effects at blood lead levels previously thought to be safe.

Acute, high-dose exposure to lead can cause a variety of symptoms, including nausea, vomiting, abdominal pain, malaise, drowsiness, anaemia, headaches, irritability, lethargy, convulsions, muscle weakness, ataxia, tremors, paralysis, coma and death. However, lead has also been shown to affect health in children at very low levels in blood. For example, chronic, low-level exposure to lead is associated with lowered intelligence quotients (IQ), attention deficit disorder and aggression. In recent years, studies have linked lead exposure to neurobehavioral damage at blood levels of 5 µg/dl and lower (well below the current, internationally accepted action level of 10 µg/dl) (Needleman & Bellinger, 1981; Needleman, 2009). There appears to be no threshold level at which lead does not cause injury to the developing human brain (Gilbert & Weiss, 2006).

There is a small but growing body of evidence pointing to an association between environmental factors in general (Carpenter & Nevin, 2009), and more specifically, lead exposure, and violent or delinquent behaviour. A 2002 publication outlined the findings of a case control study conducted in the United States of America of elevated lead exposure in pre-school years and subsequent involvement in crime. The average bone lead level in those who had been involved in violent crime was 11.0 (± 32.7) ppm, while in control subjects the level was significantly lower (1.5 ± 32.1 ppm). The difference remained after taking account of confounding factors, and held true in both white and African American subjects (Needleman, McFarlans, Ness, Fienberg & Tobin, 2002). A prospective longitudinal study of lead and child development by Dietrich, Douglas, Succop, Berger and Bornschein (2001) confirmed earlier research pointing to a relationship between lead and anti-social behaviour. The Dietrich study showed that both prenatal and post-natal exposure to lead was associated with reported antisocial acts (Dietrich et al., 2001). A 2002 study, using data from the USA, Britain, Canada, France, Australia, Italy, West Germany and New Zealand (Nevin, 2007) showed a strong association between high blood lead levels during pre-school years and subsequent involvement in violent crime, with a lag period of around 20 years. The author postulated that the dramatic decline in juvenile crime observed during the 1990s in the USA may be attributable to the phase-out of leaded petrol, the ban on using lead solder in food cans and action to reduce childhood exposure to lead-based paint in the 1970s.

In pregnant women lead can cause miscarriage, stillbirth, premature birth and low birth weight. In men the effects of lead include decreased sperm count and increased number of abnormal sperm. In the adult population in general, lead has been associated with hypertension, renal damage and cardiovascular disease.

**LEAD EXPOSURE IN SOUTH AFRICA**

Children in low-income countries are usually at elevated risk of exposure to lead, involving multiple sources and higher levels of exposure than observed in high-income countries (Nriagu Blankson & Ocran, 1996). African children, in particular, may be at high risk of lead exposure and poisoning as a consequence of a paucity of information available to the public on the sources and mechanisms of exposure to lead in children, ongoing use of lead in many products, inadequate regulatory frameworks, weak enforcement of existing legislation, high levels of poverty and inequity, poor housing conditions and extensive malnutrition (Nriagu et al., 1996; Tong et al., 2000).

Lead was first discovered in South Africa in 1782 and the country continues to be a major producer of lead in the world (Dzioubinski & Chipman, 1999; Snodgrass, 1986). The Black Mountain mine near
Aggeneys in the Northern Cape is the main mining site (Joseph & Verwey, 2001). Studies conducted at mines around the world have shown that children living in close proximity to a mine may be at increased risk of lead exposure (Lyle et al., 2006; von Schirnding et al., 2003). Batteries account for around 80% of lead use in South Africa, but are not the main cause of widespread lead exposure in children. Exceptions include the children of parents who work in battery manufacturing or recycling plants, who may transfer lead particles from work to home on their clothing. Para-occupational exposure to lead (through transfer of lead particles from workplaces into home settings) is also a concern in industries such as mining, spray painting workshops and construction sites. In the informal sector, homes may be used as a site for the dismantling of batteries to extract and sell the lead plates; in such homes residents, especially children, are at risk of severe lead poisoning (refer to Box).

Until the mid-1980s the maximum permissible petrol lead concentration in South Africa was 0.836 g/litre; amongst the highest concentrations ever used anywhere in the world. Commencing in 1986 the maximum petrol lead concentration was reduced in phases until 2006, when exclusive use of unleaded petrol was instituted (Mathee, Röllin, Levin & Naik, 2007).

Lead compounds have been added to paint all over the world to protect against corrosion, for pigmentation and to increase the speed at which paint dries. However, the peeling or weathering of old lead-based paint from walls, doors and windowsills of homes, schools and other buildings may emit lead particles into the local environment. Lead-based paint was first recognised as a source of childhood lead poisoning in Australia in 1904 (Gibson, 1904). With growing awareness of the neurological damage suffered by children after ingesting lead-based paint, the International Labour Organisation (ILO) acted to prohibit the use of white lead in paint (ILO, 1921). Around the 1970s many countries drafted legislation to also control the use of other forms of lead in paints intended for household and general use. The use of white lead in paint in South Africa was abolished late in the 1940s. Other forms of lead remained unregulated, and were freely used in paints manufactured in South Africa. A 1970s voluntary agreement among some paint manufacturers in the country to limit the addition of lead to paint was not adhered to by all signatories. Regulations to control the use of lead in paint were published for comment in South Africa in 2008, and following subsequent promulgation, came into full effect only in 2010. However, past application of lead-based paint to homes, schools, toys, educational materials and playground equipment will result in ongoing exposure to lead-based paint, especially in areas of poverty.

In 2007-2008 an investigation into the deaths of eighteen children living on the periphery of the City of Dakar, Senegal, showed severe lead poisoning as the cause. Prior illness in the children had been misdiagnosed, variably as malaria, cholera, meningitis and other conditions. The source of the lead was later identified as the dismantling and recycling of lead batteries by many households in the suburb for income generating purposes. Laboratory analyses showed that the blood lead levels of siblings were also high, and ranged from 39.8 to 613.9 µg/dl. Blood lead levels in adults tested ranged from 32.5 to 98.8 µg/dl. Those with elevated blood lead levels had a higher prevalence of gastrointestinal and neuropsychiatric (irritability, anxiety, sleep disturbance) disorders. In situ, measurements of the lead content of soil revealed that the lead content ranged up to 14 000 mg/kg inside households and up to 302 000 mg/kg outdoors.

Source: Haefliger et al. (2009).
In a Johannesburg study to determine lead concentrations in paint on the walls of homes constructed over a period between 1901 and 2004, around 20% of homes were found to be coated with lead-based paint. Paint with a lead content that exceeded international guideline levels was found in old as well as recently constructed dwellings (Montgomery & Mathee, 2005). In 2008 the Medical Research Council conducted a survey of the lead content of paint applied to playground equipment in 49 public children’s play parks in the Gauteng municipalities of Johannesburg, Tshwane and Ekurhuleni. The results showed that paint lead concentrations measured up to 10.4 mg/cm² (compared to the international reference level of 1 mg/cm²) and that lead-based paint could be found on equipment in 96% of play parks. In the majority of parks studied, paint was found to be peeling and detaching from the park equipment (Mathee et al., 2009b). In 2004 and 2005 researchers at the Medical Research Council purchased paint samples from stores in Johannesburg and Cape Town for lead content analysis. While elevated lead concentrations were not found in water-based paints, concentrations of lead as high as 189 000 µg/g (compared to the reference value of 5 000 µg/g) were found in pigmented enamel paints. A further study of the lead content in paint on children’s toys purchased from popular stores showed lead concentrations up to 145 000 µg/g (Mathee et al., 2007).

During the first decades of the 20th century lead plumbing and lead-lined water tanks were widely used in the Cape, leading to high levels of lead in domestic water and widespread lead poisoning (Grobler, Theunissen & Maresky, 1996). By the 1930s, lead poisoning was regarded as a serious enough concern in Cape Town to warrant the formation of a special commission to investigate the problem. On the recommendation of the commission lead water storage tanks and plumbing were replaced on a city-wide basis with water treatment plants and copper pipes (Retief-Steyn, 1976). More recent data indicate that lead levels in water are generally low in South Africa.

Some communities may be at serious risk of lead poisoning because of traditional or cultural practices. For example, anecdotal reports have been received of the contents of lead batteries being ground and added to a mud mixture to impart a desired hue on the walls and floors of adobe dwellings. High levels of lead have also been found in some Chinese and Indian traditional and herbal medicines. Topical agents applied around the eyes, such as surma or kohl, may also have highly elevated lead concentrations (Al-Ashban, Aslam & Shah, 2004). In some cultures women traditionally eat soil or other non-food items during pregnancy (geophagia or pica). Soils extracted from some locations can contain high levels of lead, leading to high blood lead levels in both mother and foetus (Shannon, 2003).

**POVERTY AND LEAD POISONING**

In contrast to Roman times, when elevated lead exposure was a particular concern amongst the wealthy classes, in the present time elevated lead levels are principally a problem among socially and economically deprived children. Poor people are more likely to live in substandard housing or near industrial centres and heavily trafficked areas. In lead-related industries, low-income workers are more likely to be exposed to lead, and to transport lead particles from the work environment into their homes on their hair, skin, clothing and motor vehicles. A greater likelihood of nutritional deprivation in poor communities also increases their susceptibility to lead exposure (since lead competes with calcium for absorption) and lead-related ill health effects (Tong et al., 2000).

**EPIDEMIOLOGY OF CHILDHOOD LEAD EXPOSURE IN SOUTH AFRICA**

There is no national blood lead surveillance programme in place in South Africa, nor has a
comprehensive, nationwide survey been conducted in the country. Lead poisoning is a notifiable disease in South Africa; however it is likely that considerable under-reporting occurs. The information available to paint a picture of childhood lead exposure in the country has been obtained from sporadic site-based studies conducted by various groups. From such sources we know that in 1974 for example, six children were admitted to the Frere Hospital in East London with severe lead encephalopathy. The blood lead levels of four of the children ranged from 106 to 290 µg/dl (the blood lead levels of the remaining two children were unknown). Initial misdiagnoses occurred in four of the six cases. At least two of the six children are known to have subsequently died (Harris, 1976). In 1993 Rees and Schneider reported on the case of a 3-year old Soweto child who had been admitted to hospital with signs of severe lead poisoning and a blood lead level above 100 µg/dl. Further investigation determined blood lead concentrations of 78 µg/dl and 96 µg/dl in two other children living in the same house. Damaged car batteries were found in the yard, and it was determined that household members had been removing lead plates from old car batteries for sale. Researchers at the Medical Research Council continue to receive enquiries from the public about backyard and informal sector dismantling of car batteries, though there is usually reluctance to provide details to support investigations for fear of loss of jobs or income.

Currently the internationally accepted action level for lead in blood is 10 µg/dl. However, with increasing evidence of health effects below this level, there have been calls for a lowering of the action level to 5, or even 2 µdl (Gilbert & Weiss, 2006). In 1990 a study of the cord blood lead levels of 881 newborns in the Birth to Twenty cohort showed that by the time they were born, many Soweto babies had already been exposed to lead (Mathee, von Schirnding, Ismail & Huntley, 1996). Their blood lead levels ranged from 2 to 20 µg/dl, with the mean level equalling 5.9 µg/dl. Similarly, in a sample of 21 newborns at a Durban hospital the mean cord blood lead was 15.53 ± 4.80 µg/dl. The cord blood lead levels of 95% of the newborns exceeded the internationally accepted action level of 10 µg/dl and in one case the cord blood lead level exceeded 25 µg/dl (Chetty, Jinabhai & Green-Thompson, 1993).

In 1986 a paper was published on the blood lead distribution in 293 Cape Town pre-school children aged four to six years. The mean blood lead level was 16 µg/dl (individual levels ranged from 2 to 49 µg/dl). The blood lead levels of 85% of the children were 10 µg/dl or higher, and 4% had blood lead levels of 30 µg/dl or above. Children with elevated blood lead levels tended to live in inner city suburbs, and in homes close to a busy road. High lead concentrations were found in paint, soil and dust samples taken from the homes of children with the highest blood lead levels. Mouthing behaviour was most pronounced amongst children with the highest blood lead concentrations (Deveaux, Kibel, Dempster, Pocock & Formenti, 1986).

The first indications of high blood lead levels among Cape Town school children emerged from a screening study undertaken by von Schirnding and colleagues in 1982, at a time when the maximum permissible petrol lead concentration in South Africa was 0.836 g/litre. Among 1 234 coloured grade one and two children attending schools in the Cape Peninsula, the average blood lead level of children from an urban industrial area was twice as high as among children from a suburban area (von Schirnding & Fuggle, 1986). At a school situated in Woodstock (close to the central business district of Cape Town), the average blood lead level was 22 µg/dl, while at a control school in Hout Bay, the level was 11 µg/dl. Seventeen percent of children from the Woodstock school had blood lead levels ≥ 30 µg/dl, while no children from Hout Bay had blood lead levels in this
range. Pilot investigations suggested no obvious lead source, such as lead plumbing or water with a high lead content, in the homes of children with the highest blood lead levels. There was, however, evidence of behavioural abnormalities in children with high blood lead levels (von Schirnding & Fuggle, 1984).

Following the screening survey, a cross-sectional, analytical study of Woodstock grade one school children was carried out, together with a nested case-control study to determine sources of lead exposure in the home environment among children with high blood lead levels, as compared to children with low concentration levels (von Schirnding, Bradshaw & Fuggle, 1991a; von Schirnding, Fuggle & Bradshaw, 1991b). The median blood lead level for all children living in the inner city study area of Woodstock was 16 μg/dl. A statistically significant difference in blood lead concentrations existed between white and coloured children, with the former having a mean level of 12 μg/dl and the latter a mean of 18 μg/dl. Thirteen percent of coloured pupils, and no white pupils, had blood lead levels of 25 μg/dl or higher. Mean blood lead levels also varied significantly across schools (8 to 21 μg/dl). There was a strong association between mean blood lead levels and the proximity of schools to busy roads, even after taking account of socio-economic factors. In coloured schools located in high traffic density areas median blood lead levels ranged from 18 to 21 μg/dl; in schools away from heavy traffic median blood lead levels averaged around 13 μg/dl. Other factors found to be associated with children’s blood lead levels included the state of their housing, certain cultural factors, and home language (von Schirnding et al., 1991b).

From the nested case control study it emerged that certain physical and social characteristics of the child’s home environment were important, as well as factors relating to behaviour. Sources of lead were found in the homes of both cases and controls, but were more accessible in the homes of cases than of controls. The homes of cases were in a more dilapidated state than those of the controls, with more flaking lead paint and more lead-rich dust, and were also in considerable need of attention as far as overall domestic hygiene was concerned. Lead levels in water, air and street dust were not found to vary significantly between cases and controls, nor were there significant differences with respect to the overall nutritional status or reported dietary habits of children. However, the homes of cases were found to be more crowded than those of the controls, and the mother’s level of schooling, as well as the total family income was lower among cases than controls. Previous history of pica also differed between cases and controls. Although most children were not reported to have routinely ingested non-food items, and pica for paint was not a significant factor, more cases than controls had been observed to eat items such as plaster, cement, soil, sticks and matchsticks. Generalised mouthing activity was also more pronounced in cases than controls.

A repeat blood lead survey was carried out in 1991 (by which time the maximum permissible petrol lead concentration had been reduced from 0.836 to 0.4 g/litre) at the same schools (as in the 1984 study) as well as in comparison suburbs (von Schirnding, Mathee, Robertson, Strauss & Kibel, 2001). The results showed that insufficient time had elapsed for the reduction in petrol lead levels to translate into lower blood lead levels in children. In both 1984 (when the first cross-sectional analytical study was carried out) and 1991, the median blood lead levels were 16 μg/dl in the inner city Woodstock area, and more than 90% of children had blood lead levels above 10 μg/dl. However, by 2002, by which time unleaded petrol has been introduced in the country, blood lead levels in Cape Town children were shown to have declined significantly (Mathee, Röllin, von Schirnding, Levin & Naik, 2006).
A 1995 cross-sectional survey of blood lead levels in first grade Johannesburg school children showed that blood lead concentrations in that city were similarly high. Seven schools in three Johannesburg areas of relatively low socio-economic status were studied; three schools in downtown Johannesburg, two schools in the Alexandra Township and two schools in the townships of Westbury and Newclare. Blood lead levels for the total sample of 433 children ranged from 6 to 26 mg/dl, with the mean level equalling 12 mg/dl. No statistically significant differences in mean blood lead levels by area, or amongst the seven schools, were determined. The blood lead levels of 78% of children were 10 µg/dl or above. A number of risk factors and potential outcomes were associated with elevated blood lead levels. These included the mother having only a primary school education, the presence of smokers in the home, and regular consumption of canned foods. In addition, elevated blood lead levels were associated with the respondent’s perception that the child’s schoolwork was poor, and that the child was overactive (Mathee et al., 2002). A repeat survey in 2002 (by which time unleaded petrol had been introduced) in a similar group of Johannesburg schools showed that blood lead levels appeared to have reduced. In 2002 the mean blood lead level was 9.1 µg/dl and 35% of children had blood lead levels ≥10 µg/dl. Blood lead levels ranged from 1.1 to (SD 3.59). Further investigation of the subject with the highest blood lead level (44.4 µg/dl) indicated a severe case of pica for paint; the paint on walls of both her home and school were highly elevated (Mathee et al., 2007).

In a study of the blood lead distribution among more than 1 200 children from KwaZulu-Natal, the mean blood lead level in children from an informal settlement in Durban was 10 µg/dl. Five percent of children had blood lead levels >25 µg/dl. Risk factors for elevated blood lead levels included distance from tarred roads, overcrowding, household hygiene habits, and the use of solid fuels as a domestic energy source (Nriagu, Jinabhai, Naidoo & Coutsodis, 1997).

A rapid screening study undertaken in a 2007-2008 indicated a mixed picture of encouraging and worrying results. In some of the schools studied the proportion of children with elevated blood lead concentrations was relatively low; 9% in Mitchell’s Plain schools in Cape Town and 12% in two schools in Soweto. On the other hand however, in some locations, unacceptably high proportions of children had excessive concentrations of lead in their blood. For example in the Cape Town inner city suburb of Woodstock, 24% of children had blood lead levels that exceeded 10 µg/dl. In Johannesburg’s inner city suburbs even more children (54%) had high blood lead levels (Mathee et al., 2009a).

A blood lead survey was undertaken at a primary school in the lead mining town of Aggeneys, and in the comparison, non-mining town of Pella, located around 40 kilometres away. Eighty six children from Aggeneys aged between 6 and 10 years and 68 children from Pella were studied. Statistically significant differences in blood lead distributions between the two communities were found. Blood lead levels in Aggeneys averaged around 16 mg/dl, with 66% of children having blood lead levels > 15 mg/dl. In Pella, the mean blood lead level was 13 mg/dl, with 35% > 15 mg/dl. Blood lead levels in Aggeneys ranged from 9 to 27 mg/dl, and at Pella from 6 to 22 mg/dl. Aggeneys children were slightly taller and heavier than children from Pella. In general, the impoverished community in Pella lived in small houses (many of them make-shift), which were more dilapidated and densely populated than those of people living in the more affluent Aggeneys. More parents of children living in Aggeneys had a high school education (64% versus 43% in Pella) and more Aggeneys fathers had post-Matric qualifications (25% versus 0 in Pella). Further analyses of blood lead levels among children in
the mining town of Aggeneys were conducted, comparing those with blood lead levels less than 18 mg/dl, to those greater than or equal to 18 mg/dl (18 µg/dl formed a mid-point within the distribution of blood lead levels in the sample). This revealed that within Aggeneys, more “low” than “high” blood lead children had a father with a post-school qualification, and that children who had failed a grade at school, had higher blood lead levels than other children. It was also found that children of fathers/male guardians who showered or bathed at home immediately upon returning from work tended to have lower blood lead levels than those who did not. Two-thirds of fathers of high blood lead children showered at work, compared to 41% of fathers of low blood lead children. A higher percentage of the former group had their clothes washed at work rather than at home, and none of the former group showered immediately upon coming home, whereas 19% of the latter group did so. The mean blood lead levels of children in both Aggeneys and Pella were higher than expected in a rural setting. Blood lead levels at Aggeneys in particular, which averaged around 16 mg/dl, were comparable to blood lead levels of Cape urban (inner-city) coloured children of a similar age (18 mg/dl) (von Schirnding et al., 2003).

DISCUSSION

Investigations have shown that multiple sources of environmental lead exist in South Africa. The studies outlined here show that exposure to lead in South African children is widespread, includes apparent “hotspots”, and may be commencing even prior to birth. Children living in deteriorating housing conditions, those with parents who work in lead-related occupations (in either the formal or informal sectors), as well as those with pica or excessive mouthing behaviour, are amongst the groups at highest risk.

There is now irrefutable evidence of the intellectual deficits and detrimental behavioural outcomes (shortened concentration spans and hyperactivity for example) associated with exposure to lead in children, even at very low levels of exposure. In recent years increasing attention has been devoted to the role of environmental factors in violent behaviour (Carpenter & Nevin, 2009). In respect of lead, in particular, a growing number of studies point to an association between lead exposure during childhood with later involvement in violent crime and delinquent behaviour (Needleman et al., 2002; Nevin, 2007). Violence and poor school performance are both major socio-political concerns in South Africa, with serious implications for the ability of the country and its people to reach their full potential.

Two important and commendable milestones have been reached in South Africa in recent years to bring down the level of lead exposure in children: the phase-out of leaded petrol and the promulgation of legislation to control the use of lead in paint. These actions are likely to contribute to reductions in the blood lead distributions in South African children as occurred elsewhere (Iqbal, Muntner, Batuman & Rabito, 2008). Overall, however, lead poisoning prevention efforts in the country have been tardy and patchy, and have lacked the holistic and inter-sectoral approaches that resulted in dramatic improvements in children’s blood lead levels in other countries. For example, while several countries acted to remove lead from petrol and paint in the 1970s, these achievements were only realised in South Africa in 2006 and 2009 respectively; a lag of more than three decades. As a result, the blood lead levels of large numbers of South African children continue to be unnecessarily high, with serious consequences for their ability to reach their full achievement potential and earning capacity in life.

While the mechanisms required to prevent undue lead exposure and poisoning are undeniably complex in nature, and need to involve multiple sectors and disciplines, the body of conclusive or growing
evidence of detrimental health and socio-behavioural effects associated with lead exposure, together with evidence of undue lead exposure in South African children, warrant a concerted effort to reduce blood lead levels in the South African population. Yet, lead poisoning prevention has seldom featured strongly, if at all, on health, education or violence prevention agendas in the country. In this regard, there is much that South Africa can learn from countries such as the United States of America, where a high level of success has been achieved in lead poison preventative efforts through a multi-sectoral and comprehensive approach, and where cost-benefit analyses have demonstrated that the social and economic benefits that accrue from national action to prevent lead poisoning greatly outweigh the cost of such action.

In relation to the USA and other countries where average child blood lead levels are now around 2 µg/dl and below, a major obstacle to mounting an effective lead poisoning prevention programme in South Africa is the absence of a national blood lead surveillance system and of blood lead screening programmes, even in high-risk areas and groups. A comprehensive research programme is also needed to identify sources and risk factors of local relevance. The availability of essential information for the identification of high risk groups, sites, items and practices for lead exposure will facilitate the necessary development of source control legislation, the promulgation of standards for lead in blood and key items and the development of screening and response protocols. Campaigns to educate the public, including parents, children, and officials from health, education and social development sectors about lead hazards have been implemented, but not in a comprehensive and sustained manner, and have also not been evaluated. In South Africa there is also a need to tackle the problem of lead exposure in the information sector or in home-based cottage industries. In taking lead poisoning prevention efforts in South Africa forward, a dedicated, cross-sectoral lead poisoning prevention unit is needed at national level to coordinate the effort, with strong links to equivalent structures at local level.

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