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# A preliminary study of residential paint lead concentrations in Johannesburg ☆

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**Abstract**

While efforts are underway to phase out the use of leaded petrol in South Africa, relatively little attention has been devoted to the potential for childhood exposure to lead used in paint. This is one of the first studies undertaken on the African continent to report on the presence of lead-based paint. In South Africa, there is a dearth of information available on the extent of past and current use of lead-based paint. Recent studies demonstrate that large numbers of young South African children continue to be at risk of elevated blood lead concentrations. To investigate the prevalence of lead-based paint in Johannesburg dwellings, the South African Medical Research Council recently undertook a preliminary study in which samples of residential paint were collected from homes in 60 randomly selected suburbs across the city. The results indicate that 17% of all of the samples collected were lead-based paint (paint that contains lead levels equal to or greater than 0.5% by weight). The percentage of lead by weight in the samples ranged from 0.01% to 29.00%. Lead-based residential paint was found in 20% of the sampled homes, located in both new and old suburbs, and in suburbs from a variety of different socioeconomic backgrounds. These results, in conjunction with those emanating from other studies of childhood lead exposure currently being conducted by the Medical Research Council, indicate that weathering, peeling, or chipping lead-based paint may play an important role in childhood lead exposure in South Africa. Children who have a pica tendency may be at particular risk.


*Keywords:* Paint; Lead; Children; Exposure; South Africa

## 1. Introduction

Lead is a heavy metal, the social and health effects of which, including reductions in IQ scores, hyperactivity, shortened concentration spans, poor school performance, and hearing loss, are now well established (Needleman, 1993). Lead can affect individuals of any age, but it has a disproportionate affect on children because their behavioral patterns place them at higher risk for exposure to lead, their bodies absorb a larger percentage of the lead that they ingest, and they exhibit lead toxicity at lower levels of exposure than adults (ATSDR, 1999). In addition, neonates can experience decreased motor control skills and attention span from low-level prenatal lead exposure (Emory et al., 1999). If a child consumes large amounts of lead he or she can experience to blood anemia, kidney damage, colic (severe "stomachache"), muscle weakness, and brain damage (ATSDR, 1999). The sources of environmental lead are wide-ranging, but in terms of public health petrol lead additives and lead-based paint have been of particular importance. While phasing out the use of

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leaded petrol in many countries has been followed by significant reductions in children's blood lead levels (Thomas et al., 1999), addressing the contribution to elevated blood lead concentrations of lead-based paint has been more challenging. Lead-based paint was first recognized as a source of childhood lead poisoning in Australia in 1904 (Gibson, 1904). Over the following century, numerous studies demonstrated that children suffer neurological damage after ingesting even small amounts of lead-based paint (Hamilton, 1911; Needleman and Gatsonis, 1990; Needleman and Bellinger, 1991). Following the promulgation of International Labor Organization Convention 13 on the prohibition of the use of lead-based paint, numerous countries adopted international and national laws that limit or ban the use of lead-based paint (ILO, 1921).

In many African countries the extent and nature of childhood lead exposure is only now being recognized (Tong et al., 2000; Nriagu et al., 1996), and relatively little is known about the contribution of lead-based paint to the elevated blood lead levels being observed in African children. Epidemiological studies conducted in South Africa, for example, have indicated that large numbers of young children are at risk of elevated blood lead concentrations. In the late 1980s (when maximum petrol lead levels equaled 0.836 g/L) as well as in the early 1990s (by which time the maximum petrol lead concentration had been reduced to 0.4 g/L) studies undertaken in and around Cape Town demonstrated that well over 90% of first-grade school children had blood lead concentrations that equaled or exceeded the internationally accepted action level of 10 μg/dL (von Schirnding et al., 1991a, 2001; CDC, 1991). A number of risk factors were associated with elevated blood lead concentrations, including the proximity of children's schools to heavily trafficked roads and the presence of dust and flaking paint in their homes (von Schirnding et al., 1991b). Similarly, a study conducted in Johannesburg in 1995 showed that blood lead levels in 433 first-grade study children ranged from 6 to 26 μg/dL, with a mean of 12 μg/dL (Mathee et al., 2002).

Since the introduction of unleaded petrol in South Africa in 1996, childhood blood lead concentrations have been significantly reduced. In Johannesburg, for example, a study undertaken in 2002, 6 years after unleaded petrol first became available (around 30% of the petrol purchased was unleaded), tested the blood lead levels of 383 children from 5 to 12 years of age with a median age of 7. The results showed that the proportion of children with elevated blood lead concentrations had declined to 35% (Mathee et al., unpublished data). Preliminary analyses showed that blood lead levels were higher among children who had been observed to ingest paint chips ($P = 0.0016$) and who lived in homes with peeling paint ($P = 0.00619$) (Mathee, unpublished data). The highest blood lead concentration was measured in a 7-year-old girl with pica for paint, putty, and soil. Follow-up investigations showed that paint lead concentrations in the girl's home were particularly elevated, equaling up to 4.6% (46,000 μg/g) (Montgomery and Mathee, unpublished data).

There are currently few data available on the extent of the use of lead-based paint in South African homes. While the use of "white lead" in paint was abolished in the 1940s, and a voluntary agreement has been in place among some industry stakeholders since the 1970s to limit the use of lead in paint, no formal legislation has been promulgated in this regard.

The objective of this project was to conduct a preliminary investigation into the extent of the use of lead-based paint in suburbs across the city of Johannesburg. This study is one of the first formal attempts to estimate the extent of the use of lead-based paint in Johannesburg.

## 2. Materials and methods

Using a database of the Planning Department of the Johannesburg Metropolitan Municipality, 60 Johannesburg suburbs, stratified by date of proclamation, were randomly selected from a total of 3890 suburbs for inclusion in the study. The date of proclamation represents the oldest possible age of the homes confined to the suburb. Residential houses are not to be built in a particular area until the Johannesburg Planning Committee has given the official date of proclamation to the suburb.

Thus, we selected 20 suburbs dating from each of three different periods: from the periods 1901–1947 (when the use of white lead is estimated to have been discontinued), 1948–1978 (around the time when the voluntary industry agreement to limit the addition of lead to paint was reached), and 1979 to the present day (during which time it was expected that the use of lead-based paint would be limited). The selected sample and sampling frame both contained suburbs that incorporated all of the major population groups found in Johannesburg and a broad range of income categories from impoverished to extremely wealthy. Around four dwellings from each of the selected suburbs were included in the study. Through drive-by exercises, dwellings that appeared to be in a state of degeneration, or where peeling/flaking paint was observed, were selected for inclusion in the study. Informed verbal consent was sought from a senior member of the household present at the time of the visit, and when approval was given, paint chip samples were collected from the interior and exterior surfaces of the dwellings for lead-content analysis.

The paint chip collection methodologies adopted in this study were consistent with the United States Environmental Protection Agency guidelines (US EPA, 2001) and the United States Department of Housing and Urban Development 1995 "Guidelines for the Evaluation and Control of Lead-Based Paint Hazards in Housing" (US HUD, 1995). A stainless steel paint scraper was used to remove all layers of paint from the surface and the removal of layers of substrate was avoided. Single-surface rather than composite samples were collected. The paint chip samples were 5–8 $cm^2$ in size (2–3 $in^2$). At least one deteriorated paint sample from an interior or exterior wall or an impact/friction surface was obtained from each dwelling. An impact/friction surface was defined as a windowsill underneath a frequently used window. Wherever possible, both interior and exterior samples were collected.

All of the samples were analyzed by a laboratory certified by the National Lead Laboratory Accreditation Program using atomic-absorption spectroscopy. The paint chips were analyzed according to US EPA Method SW846-7420, 3050B. Levels of lead in paint are reported in percentage weight. Paint lead concentrations were assessed against standards of the US EPA, which stipulates that "lead-based paint is paint that contains lead levels equal to or greater than 5000 μg/g or 0.5% by weight" (US EPA, 2001).

## 3. Results

The results of the laboratory analyses of the lead content of the paint samples collected are given in Table 1. As can be seen, of the 316 paint samples collected, 17% contained levels of lead equal to or greater than 0.5% by weight. The mean percentage weight of lead found in all of the samples was 0.474%, with individual-sample lead concentrations ranging from 0.01% to 29.00%. The frequency distribution of all of the residential paint samples is given in Fig. 1. Of the total 316 samples collected, 261 of the samples were collected from exterior surfaces and 55 from interior surfaces. Fifteen percent of the exterior paint samples contained lead-based paint with results ranging from 0.01% to 5.70%, and 25% of the interior samples contained lead-based paint with results ranging from 0.01% to 29.00%. Paint samples were collected from a total of 239 homes, of which 48 (20%) contained at least 1 lead-based paint sample. In 34 (55%) of the 60 suburbs included in the study, a lead-based paint sample was collected from at least 1 home. There was little difference in the proportion of homes with lead-based paint across the three suburb age groups, with suburbs proclaimed in 1901–1947, 1948–1978, and 1979–present having, respectively, 50%, 60%, and 60% of dwellings with lead-based paint.

## 4. Discussion

The results of this preliminary investigation into the extent of the use of lead-based paint in the City of

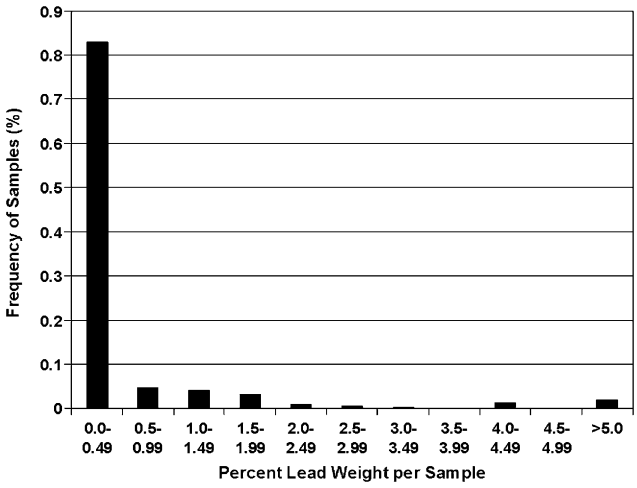


Fig. 1. Distribution of all residential paint samples by lead concentration.

Table 1
Paint lead concentrations (% by weight)

| | % Lead-based paint | Mean | Standard deviation | Range |
|---|---|---|---|---|
| All samples ($n = 316$) | 17 | 0.474 | 1.886 | 0.01–29.00 |
| All homes ($n = 239$) | 20[a] | 0.419 | 1.262 | 0.01–15.25[b] |
| All suburbs ($n = 60$) | 55[c] | 0.459 | 0.951 | 0.01–6.60[d] |
| Suburbs proclaimed 1901–1947 ($n = 20$) | 50[c] | 0.305 | 0.887 | 0.01–5.70 |
| Suburbs proclaimed 1948–1978 ($n = 20$) | 60[c] | 0.545 | 1.268 | 0.01–7.40 |
| Suburbs Proclaimed 1979–present ($n = 20$) | 60[c] | 0.594 | 2.981 | 0.01–29.00 |

[a]% Of homes containing at least one lead-based paint sample.
[b]Range of the mean % lead weight for each individual home.
[c]% Of suburbs containing at least one home with lead-based paint.
[d]Range of the mean % lead weight for each of the suburbs.

Johannesburg, South Africa, point to a potential risk of childhood environmental lead exposure emanating from the use of lead-based paint in residential buildings. Around 20% of homes included in the study had been coated with lead-based paint, and dwellings with lead-based paint were found in more than half of the study suburbs, which included a wide spectrum of socio-economic situations. Sample-paint lead concentrations equaled up to 58 times the US EPA standard. Contrary to expectation, there was little difference in the proportion of suburbs with lead-based paint across the three suburb-age categories. Instead, the paint sample with the highest concentration of lead (29.00%) was found in one of the newest suburbs. These findings imply that the addition of lead to paint and the use of lead-based paint in new residential housing may be continuing in Johannesburg and possibly in the country at large.

Our study was a preliminary screening study on the use of lead-based paint in Johannesburg and we acknowledge the limitations of our results. Our study results might have been biased toward the use of lead-based paint in older dwellings in the prospective age categories because we chose to include homes that exhibited peeling or flaking paint on their exterior surfaces. However, a preliminary screening study of paint that is currently for sale in paint and hardware stores has found that certain colors of enamel paint have been found to contain levels of lead greater than 5000 μg/g (Mathee and Rollins, unpublished data).

In addition, the methods that we used to sample paint in the selected homes might have resulted in an underestimate of the true proportion of homes that contained lead-based paint. On average we collected less than two samples per home, and there is a reasonable expectation that if we had sampled a larger number of surfaces per home, using a portable XRF analyzer, we would have found a higher percentage of homes with lead-based paint.

It is important that further research be conducted to confirm these preliminary findings and to provide additional information to characterize the risk of paint-related childhood lead exposure in South Africa. In the event of confirmation, it is critical that efforts to reduce childhood exposure to environmental lead, currently focused on phasing out the use of leaded petrol, be extended to a more holistic and integrated approach to childhood lead-poisoning prevention. There is clear evidence that large numbers of urban South African children have unacceptably high blood lead levels. In the past, the role of lead-based paint in elevated childhood blood lead levels may have been masked by the vast contribution from lead particle emissions from motor vehicle exhausts. With the planned phase-out of the use of leaded petrol in the country by 2006, lead-based paint is likely to gain increasing prominence as a key contributor to the public health problem of lead exposure in South Africa. As shown by the experience of the USA (Needleman, 1998), addressing the problem of lead-based paint will prove to be particularly challenging and costly, especially in the context of a country such as South Africa (as well as African countries in general), where levels of poverty and inequity are high, where a process of rapid urbanization continues, and where housing backlogs are significant. However, the financial costs of dealing with the short- and long-term medical and social problems caused by childhood lead poisoning may well exceed the costs of lead-based paint hazard prevention, remediation, and containment.

Important within a future program of action to reduce childhood lead exposure in South Africa and other African countries are increased public, health, and education sector awareness of the sources and mechanisms of exposure to lead, the implementation of research and screening programs to identify high-risk areas and groups, the development of blood lead standards for children, the provision of secondary prevention measures (both medical and environmental), and the strengthening of the role of civil action to prevent childhood lead poisoning. In terms of lead-based paint in particular, banning or the development of standards for the use of lead in paint is critical Testing needs to be undertaken to identify high-risk dwellings and school buildings, prospective home owners need to be alerted of the presence and health impacts of lead-based paint in properties of interest, and provisions should be made for the safe management of lead-based paint in the worst affected dwellings and school buildings using a combination of in-place containment and more permanent removal methods.

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