



Lead exposure in young school children in South African subsistence fishing communities



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ABSTRACT

Background: Lead is an established toxic substance, with wide-ranging health effects, including neurodevelopmental decrements and behavioural problems, even at low levels in blood. Anecdotal reports of lead melting to make fishing sinkers in South African subsistence fishing communities prompted the conduct of an epidemiological study in two South African fishing villages to investigate the extent of lead melting and the associated risks in children.

Objectives: The objectives of the study were to determine the extent of lead melting, and the blood lead distributions and associated risk factors in children.

Methods: Cross-sectional, analytical studies were undertaken among 160 young school children in the fishing villages of Struis Bay and Elands Bay located along the south-eastern and western South African coastline, respectively. Blood samples were collected for lead content analysis, and anthropometric and hemoglobin measurements were taken. Questionnaires were administered to obtain information about socio-economic status and risk factors for lead exposure.

Results: Blood lead levels ranged from 2.2 to 22.4 µg/dl, with the mean blood lead level equalling 7.4. Around 74% of the children had blood lead levels ≥5 µg/dl and 16% had blood lead levels ≥10 µg/dl. Socio-economic factors, and lead melting practices were strongly associated with elevated blood lead levels.

Conclusions: Blood lead levels in these remote subsistence fishing communities were unexpectedly elevated, given the absence of local lead industries or other obvious sources of lead exposure. Lead exposure and poisoning is an important, yet neglected, public health concern in South African subsistence fishing communities, and potentially on the entire African continent.

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1. Introduction

The human toxicity of lead is well established. Studies over several decades, and in a variety of settings, have shown associations between elevated blood lead concentrations and reductions in intelligence scores, hearing loss, hyperactivity, shortened concentration spans and poor school performance in children, as well as lowered lifetime earnings (Tong et al., 2000). Relatively recent studies have also pointed to links between lead exposure and aggression or violent behaviour (Needleman et al., 2002, 1996; Nevin, 2007). The growing global body of research illustrating the detrimental health and social effects of lead, as well as the lack of a

threshold of safety, have prompted the consideration of lower blood lead action or guideline levels by international health bodies and governments (Betts, 2012; Gilbert and Weiss, 2006). Recently for example, it was recommended to the Centers for Disease Control (CDC) in the United States of America, that the current level of concern of 10 µg/dl be replaced with a reference range established as the 97.5th percentile of the blood lead distribution in that country. Currently that level equals 5 µg/dl, but may be changed following reviews expected to take place at four-yearly intervals (Betts, 2012).

African children have been identified as a group at particular risk of poisoning from exposure, often simultaneously, to multiple sources of lead (Nriagu et al., 1996). Two recent incidents of large scale lead poisoning in Zamfara, Nigeria (Lo et al., 2012) and Dakar, Senegal (Haeffliger et al., 2009) have brought the vulnerability of African children to lead poisoning into sharp focus. Despite this, few, if any, African countries have comprehensive lead poisoning

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prevention or research/surveillance programmes in place, and the paucity of data or information in this regard has been highlighted (Tong et al., 2000). Instead, what is known about the sources and pathways of lead exposure in African children is derived mainly from ad hoc studies undertaken in a relatively small number of sites. For example, papers published on lead exposure from gasoline, paint (Mathee et al., 2007; Montgomery and Mathee, 2005), landfill sites (Graber et al., 2010), lead mining in the informal (Dooyema et al., 2012) and formal (von Schirnding et al., 2003) sectors, and the dismantling of batteries (Haefliger et al., 2009) have all highlighted the high degree of risk of lead poisoning in African children.

There is a particular dearth of published studies regarding lead exposure in subsistence fishing communities in Africa, as well as elsewhere in the world. One of only a handful of studies reported was undertaken in the Chuuk islands of Micronesia. In 256 children blood lead levels ranged from 1 to 37 $\mu\text{g}/\text{dl}$, with the mean level equalling 4 $\mu\text{g}/\text{dl}$. Amongst other risk factors, elevated blood lead levels were significantly associated with having a family member who made fishing weights; children with elevated blood lead levels were more than three times more likely to have a family member who made fishing weights. Elevated blood lead levels in the adults studied were also associated with making fishing weights. The authors concluded that making lead fishing weights was a significant source of lead exposure in adults and children in Chuuk islands (Brown et al., 2005). A blood lead survey undertaken among children aged 5 to 9 years in the coastal town of Cartagena, Colombia, showed that in 189 subjects blood lead levels ranged from 1 to 21 $\mu\text{g}/\text{dl}$, with the mean level equalling 5.5 ± 0.23 $\mu\text{g}/\text{dl}$. Just over 7% of children had blood lead levels ≥ 10 $\mu\text{g}/\text{dl}$. Amongst other risk factors, elevated blood lead levels were associated with the production of fishing sinkers (Olivero-Verbel et al., 2007). Although reports of ingestion of fishing sinkers are rare, one such case of an 8-year old boy has been published in the literature. The boy was discovered to have pica, and had ingested around 25 lead fishing sinkers (Mowad et al., 1998).

Given its position at the southern tip of the African continent, South Africa is bordered by both the Atlantic and Indian Oceans, and has more than 2500 km of coastline. Relative to the rest of the African continent, South Africa has a high coastal population density, with subsistence and recreational fishing being important sources of income and recreation, respectively. Subsistence fishing communities along the South African coastline are widely characterized by high levels of poverty and economic hardship. Prompted by several anecdotal reports, a study was undertaken in two fishing villages along the South African coast in March 2012 to assess the prevalence of lead melting practices, the extent of childhood lead exposure and the associated risk factors. This paper describes the study findings.

2. Methods

Cross-sectional, analytical studies were undertaken at primary schools in March 2012 in the fishing villages of Struis Bay and Elands Bay—located along the southern (Indian Ocean) and western (Atlantic Ocean) coasts of South Africa, respectively. The villages were selected because of their known, substantial subsistence fishing communities. Children in grades 0, 1 and 2 in the local primary school were included in the study, after obtaining prior, written, informed consent from their parents or guardians, and assent from children themselves on the day of the study. Structured questionnaires were designed to obtain information about the health of study children, household socio-economic status, housing type, involvement of family members in fishing and lead smelting as well as other potential risk factors for elevated blood lead levels. Questionnaires were translated into Afrikaans, which was the predominant language spoken, by professional translators, and back-translated to ensure accuracy. Questionnaires were distributed to the homes of study children in advance, and self-administered by parents or guardians. Parents were requested to return completed questionnaires to the school on the following day. Respondents were provided with contact details for the research

team, and were encouraged to call in the event of any uncertainty about the questionnaire, or the study in general.

On the day of data collection, height and weight measurements were taken for each child. Samples of approximately 7 ml of venous blood were collected from participating children into sterile test tubes (BD Vacutainer system) containing EDTA. A drop of blood was also collected to measure haemoglobin levels using a Hemocue instrument. All blood samples were collected by medical practitioners currently registered with the Health Professions Council of South Africa (HPCSA). Disposable, sterile blood sampling equipment and aseptic sampling techniques were used throughout. Collected blood samples were stored under refrigeration and despatched to the analytical laboratory in Johannesburg as soon as possible, using a specialised biological tissue transportation service.

Blood lead analyses were carried out in the laboratories of the National Institute for Occupational Health in Johannesburg, which participates in national and international quality control programs. Lead concentrations were measured using a flameless atomic absorption method of addition (Model Perkin-Elmer Analyst 300 with HGA 850). With each batch of samples a reagent blank and set of working standards were run simultaneously. The coefficient of variation in blood lead samples was 5.8%. The limit of detection for lead in blood was 0.1 $\mu\text{g}/\text{dl}$.

Blood lead levels were skewed positively and thus log transformed, and geometric means calculated. Blood lead levels were analysed as a continuous variable in the bivariate analysis and then stratified into low (< 5 $\mu\text{g}/\text{dl}$) and high (≥ 5 $\mu\text{g}/\text{dl}$) blood lead levels to determine odds ratios in the bivariate and multivariate analysis. The level of 5 $\mu\text{g}/\text{dl}$ was based on the current CDC (USA) reference level (Betts, 2012). Determinants of high exposures included sex of the child, socio-economic factors, housing type and conditions, behaviour of child or adult in household that could increase exposure to lead. Analysis of the association between blood lead levels and determinants of exposure were conducted using the survey command in the Stata statistical software package (version 11). Families were the primary unit of analysis (five children in Grade 0 had a sibling either in grade 1 or 2 in the sample) and the data were stratified according by town. A p -value of < 0.05 was considered significant. All factors that were significantly associated with high blood lead levels were included in the multivariate analysis.

The study protocol was approved by the Committee for Ethical Research on Human Subjects of the University of the Witwatersrand. Written, informed consent was secured from the parents of all children who participated in the study.

3. Results

3.1. Sample profile

A total of 160 children from impoverished communities in the Western Cape fishing villages of Struis Bay ($n=81$) and Elands Bay ($n=79$) were studied. The ages of the children, who were in grades 0 (27%), 1 (41%) and 2 (32%), ranged from 6 to 14 years, with the mean age equalling 7.5 years. Fifty two percent of the sample was male, and the predominant home language was Afrikaans (85%). The remainder of the sample spoke mainly Xhosa (11%), English (3%) and 1% lacked information on language. Households in the sample comprised a median of 5 people (the mean was 5.2), and household size ranged up to 18 people.

Poverty was widespread, with 52% of households reporting that they earned less than R1000.00 (~USD 125) monthly, or had no income at all. Only 4% of the sample earned more than R5000.00 (~USD 625) per month. Both paternal and maternal education levels were low; 59% of the mothers had never been to school or had only a primary school education (or part thereof), while 46% of fathers had only primary school education or no schooling at all. Only 1% each of mothers and fathers had a tertiary educational qualification.

The majority of the sample (88%) lived in free-standing dwellings or fishermen's cottages, while 7% and 3%, respectively, lived in backyard and informal dwellings. On average, dwellings were 14 years old. Electricity was the main fuel used for daily cooking in 93% of dwellings, with small proportions using gas (2%), paraffin (kerosene) (2%) and wood (1%). Most dwellings had an indoor water supply, but in 16% of children's homes water was sourced from outside the house, and 2% of households made use of communal water supplies. The majority of dwellings had indoor toilets, but 14% were fitted with an outside toilet. Peeling paint indoors and outdoors was reported by 31% and 35% of respondents, respectively, and 44%

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