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Exposure to lead in South African shooting ranges

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ABSTRACT

Introduction: Lead exposure in shooting ranges has been under scrutiny for decades, but no information in this regard is available in respect of African settings, and in South Africa specifically. The aim of this study was to determine the blood lead levels in the users of randomly selected private shooting ranges in South Africa's Gauteng province.

Methods: An analytical cross sectional study was conducted, with participants recruited from four randomly selected shooting ranges and three archery ranges as a comparator group.

Results: A total of 118 (87 shooters and 31 archers) were included in the analysis. Shooters had significantly higher blood lead levels (BLL) compared to archers with 36/85 (42.4%) of shooters versus 2/34 (5.9%) of archers found to have a BLL ≥10 µg/dl ($p < 0.001$).

Conclusion: Shooting ranges may constitute an import site of elevated exposure to lead. Improved ventilation, low levels of awareness of lead hazards, poor housekeeping, and inadequate personal hygiene facilities and practices at South African shooting ranges need urgent attention.

1. Introduction

Lead is associated with an array of contemporary products and activities (such as batteries, paint, the use of arms and ammunition, pottery and the crafting of fishing sinkers) and a broad range of detrimental health and social outcomes in children as well as adults (Bellinger and Needleman, 2003; Tong et al., 2000). Reductions in intelligence, shortened concentration spans, hearing loss, poor school performance, aggression and violence (Bellinger, 2008; Nevin, 2007; Schwartz and Otto, 1991) are amongst the detrimental health and social effects associated with lead exposure (Bellinger et al., 1991). In adults, lead exposure has been associated with kidney damage, hypertension, cardiac disease and lowered levels of fertility (Hu et al., 2007; Martin et al., 2006). Lead-related health effects have been demonstrated even at very low levels of exposure (around 3 µg/dl), and there is widespread consensus regarding the absence of a blood lead threshold of safety (Betts, 2012; Gilbert and Weiss, 2006).

Growing recognition of the devastating personal and community consequences of lead exposure and poisoning prompted many countries to commence multi-faceted lead exposure reduction programmes in the 1970 s. Amongst the measures implemented were phasing out the use of leaded gasoline, and controlling the use of lead in products such as paint, fishing sinkers, food cans and toys. In the United States of America (USA), where a concerted programme of action to reduce lead exposure has been underway since the 1970 s, children's blood lead levels have since declined considerably (Pirkle et al., 1994; Tong et al., 2000).

In contrast to the experience in well-resourced countries, lead exposure reduction efforts have been relatively weak and piecemeal in many poorly resourced countries. In various African countries for example, studies conducted have indicated ongoing lead exposure from mining (Lo et al., 2012), paint (Mathee et al., 2007), fishing sinkers (Mathee et al., 2013), playground equipment (Mathee et al., 2009), traditional medicines (Mathee et al., 2015), traditional drinking brews (Mosha et al., 1996), e-waste (Olafisoye et al., 2013), cosmetics (Orisakwe and Otaraku, 2013), cultural practices such as geophagia (Mathee et al., 2014; Nyaruhucha, 2009), food (Makokha et al., 2008) and the formal and informal occupational sectors (Haefliger et al., 2009). It is probable that in many African countries further, as yet unstudied, sources of lead exposure exist alongside those mentioned above.

By the 1970 s, the use of firearms and shooting ranges had been

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Table 1
Profile of archers and gun shooters.

Risk Factor	Archers	Shooters	Significance
N	31	87	
Age	Mean: 34.7 (SD12.55); median: 32; range 19–64 years	Mean: 38.9 (SD13.77); median: 38; range=18–74 years	0.144
Sex	25.8% female	10.3% female	0.069
Educational Attainment			
% tertiary education	87.1%	54.9%	0.002
Employment status			
% unemployed	9.7%	7.1%	0.669
Monthly household income			
% with household income > R10 000.00	80%	74%	0.620
% users of tobacco	12.9%	27.6%	0.180

recognized as a key source of lead exposure in the USA (Anderson et al., 1977), but to our knowledge, few if any studies on this group have been undertaken in African settings. In this paper we describe a study, the first to our knowledge, of blood lead distributions and associated risk factors, in a sample of users of shooting ranges in South Africa.

2. Methods

A cross-sectional, analytical study of blood lead concentrations, and associated risk factors, was undertaken at archery and shooting ranges in the cities of Johannesburg, Ekurhuleni and Pretoria in South Africa's Gauteng Province. Written invitations to participate in the study were sent to 9 archery and 26 shooting ranges that had been randomly selected from databases provided by the South African National Archery Association (list of 17) and the South African Police Service (list of 64) respectively. Timeous, written, informed consent to participate in the study was received from four archery and 4 shooting ranges; however one of the archery ranges was eliminated when a mutually agreeable date for fieldwork could not be found in the time available.

On fieldwork days, study participants, who were defined as adults aged 18 years or older, were regular shooters, not pregnant, and who had provided written, informed consent, were included in the study. The study protocol, consent form and participant information sheet had been approved by the Research Ethics Committee of the South African Medical Research Council. In three cases hand wipes were taken before and after shooting, as were surface wipes (tables and walls) in the shooting range. Dust samples were collected in accordance with the guidelines of the USA Department of Housing and Urban Development (http://portal.hud.gov/hudportal/documents/huddoc?id=lbph-40.pdf – accessed 25/05/2016). Analyses were undertaken by ICP/MS at a laboratory accredited through the *South African National Accreditation System* (*SANAS*). Blood lead levels were measured using a LeadCare®II blood lead testing instrument. An 50 µl aliquot of whole blood was obtained from a finger prick after participants had washed their hands with soap and water. The test was conducted immediately in the field or within 24 h of blood collection. All blood samples were collected and tested by a registered medical practitioner. Two participants for whom the LeadCare II instrument indicated highly elevated blood lead levels, had venous blood samples drawn for laboratory analyses, which confirmed highly elevated blood lead concentrations. All participants with a blood lead level $\geq$25 µg/dl were counselled and referred to a medical practitioner for further investigation. A self-administered questionnaire was completed by each participant to collect information on socio-economic factors, shooting practices and health status.

Data were captured in Excel, and cleaned and inspected for errors before being exported to Stata version 12, which was used to conduct the analyses. Sex, education and other categorical data are described in terms of frequencies, proportions and percentages. Continuous data are presented in terms of measures of spread and central tendency. Univariate analysis for individual characteristics and blood lead level were compared using χ^2 or Fishers' Exact test for categorical data and a two-tailed student's *t*-test for normally distributed continuous data. The Mann-Whitney *U* test was utilized in univariate analysis of nonparametric continuous variables. The level of significance was taken at a two-tailed α=0.05.

3. Results

The study sample, recruited from four gun shooting (three of which were indoor ranges) and three archery ranges (all outdoors) in and around Johannesburg and Pretoria, initially comprised 121 individuals: 67 gun shooters and 46 archers. Three of those recruited at the shooting ranges turned out to be shooting range workers, but not regular shooters, and were therefore excluded from further analyses. Fifteen of 46 (33%) archers reported that they were also regular gun shooters, and were thus re-classified as shooters, leaving a final study sample of 118 individuals, of whom 87 (74%) were gun shooters and 31 were exclusively archers. A profile of the study population, broken down by archers and shooters, is given in Table 1.

3.1. Blood lead distributions

Blood lead levels in the total sample (archers as well as gun shooters; n =118) ranged from 2.0 to 60.0 µg/dl, with the mean and median levels respectively equalling 9.3 (SD 9.5) and 7.0 µg/dl. The blood lead levels of 62.7% of the sample equalled or exceeded 5 µg/dl, while 28.8% had blood lead levels $\geq$10 µg/dl. In 5.9% of cases, blood lead levels were $\geq$25 µg/dl.

3.2. Blood lead levels by place of recruitment (archery vs gun shooting ranges)

Table 2 gives the blood lead distributions by shooting/archery range. As shown, blood lead levels amongst participants recruited at archery ranges ranged from 2.0 to 10.4 µg/dl, with the mean and median levels equalling 3.5 (SD 2.1) and 2.0 µg/dl respectively. Around 26.7% of this group had blood lead levels $\geq$5 µg/dl, while the blood lead levels of 2.2% equalled or exceeded 10 µg/dl. Amongst those recruited at gun shooting ranges on the other hand, the respective values for the mean and median blood lead levels were 12.8 (SD 10.5) (a 3.7-fold increase) and 9.3 µg/dl, with individual blood lead levels ranging from 2.0 to 60.0 µg/dl. Amongst gun shooters 84.9% had blood