



HEAVY METAL EXPOSURE IN SOUTH AFRICA AND RELATED HEALTH RISKS

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Lead, mercury, cadmium and arsenic are on the WHO's List of Top Ten Chemicals of Public Health Concern

SOURCES OF METALS

- *Natural sources*
 - Volcanoes, weathering of parent materials
 - Volatile metals and metals that become attached to fine particles can be widely transported on very large scales
- *Anthropogenic sources*
 - various industrial processes
 - mining
 - foundries, smelters
 - combustion of fossil fuel and gasoline

TOXICITY OF METALS

Depends on several factors including:

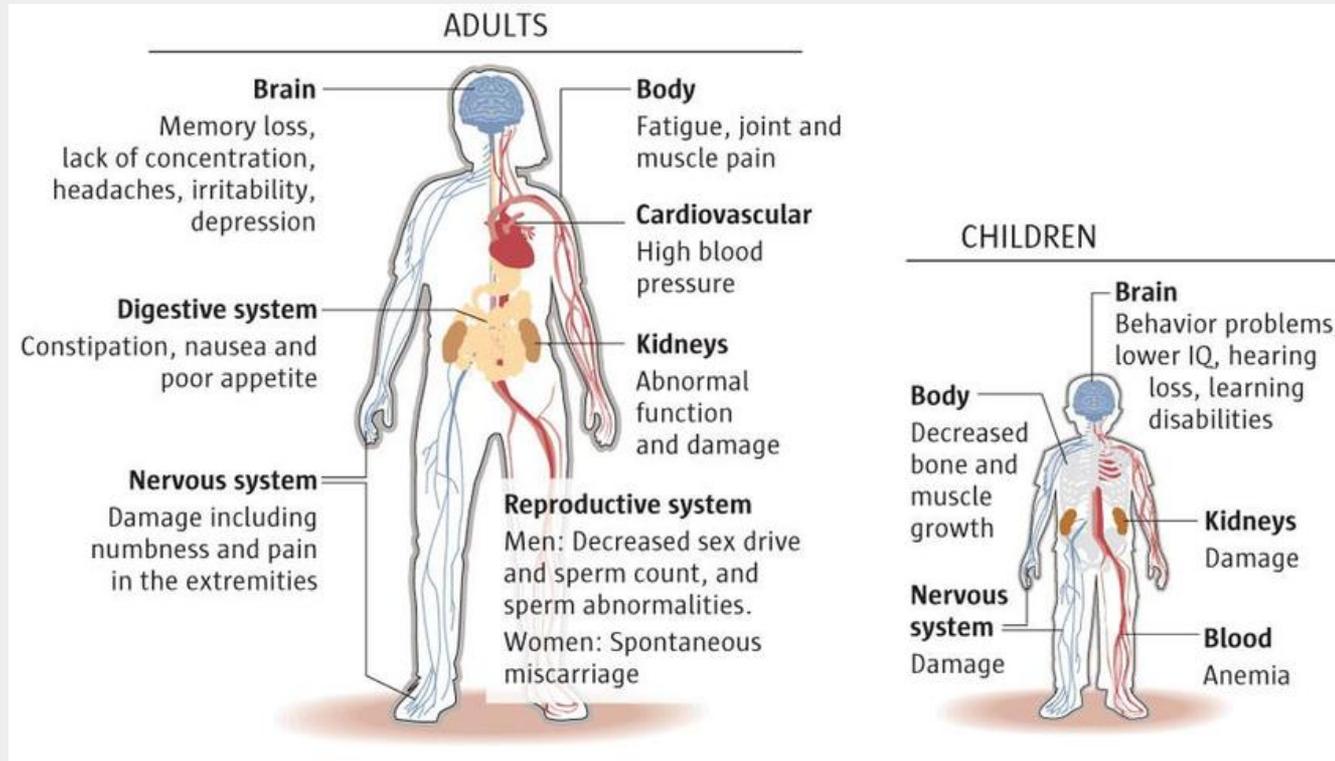
- the dose
- route of exposure
- chemical species
- as well as the age, gender, genetics, and nutritional status of exposed individuals.

LEAD (Pb)

- Lead sources (batteries, petrol, paint [*homes, toys, playground equipment*], fishing sinkers, firearms, ammunition, toys, solder, electronic equipment, wheel balancing weights, cabling, protective gear, traditional medicines, low cost beverages, mobile phones, laptops, radio & TV sets, foodstuffs, cookware....)
- Very useful, highly toxic
- Toxic to virtually all organ systems



HEALTH EFFECTS OF LEAD



Aggression, violent & criminal behaviour

PATHWAYS OF EXPOSURE TO LEAD

- Ingestion
 - *Hand-to-mouth pathway*
- Respiratory
- Dermal

- *The younger you are, the greater the risk*





LEAD IN PETROL

- Pre-1980s - SA amongst the highest levels of lead in petrol used anywhere in the world;
- >90% of urban children had elevated blood lead levels
- Highest blood lead levels in children whose schools or homes were alongside busy roads
- Reductions in petrol lead levels from mid-1980s & introduction of unleaded petrol in 1996;
- SAMRC research presented to cabinet as part of motivation for complete phaseout of leaded petrol in 2006
- SAMRC research shows decline in children's blood lead levels since introduction of unleaded petrol.

LEAD IN PAINT

- Elevated blood levels in children living in homes with peeling paint;
- 20% of Johannesburg dwellings have elevated lead in paint;
- Highly elevated levels of lead in paint on children's toys;
- Lead paint used on playground furniture in public play parks;
- High levels of lead in new paint purchased from stores.



GOVERNMENT NOTICE

DEPARTMENT OF HEALTH

No. 801

31 July 2009

HAZARDOUS SUBSTANCES ACT, 1973 (ACT 15 OF 1973)

DECLARATION OF LEADED PAINT AS GROUP 1 HAZARDOUS
SUBSTANCE

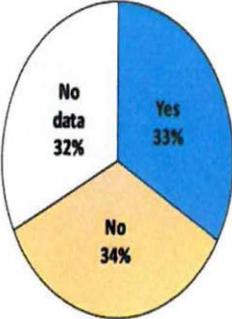
The Star
**CLAMP
ON
POISON
PAINT**

Sunday Times
**POISON
TOYS
BANNED**
www.sundaytimes.co.za

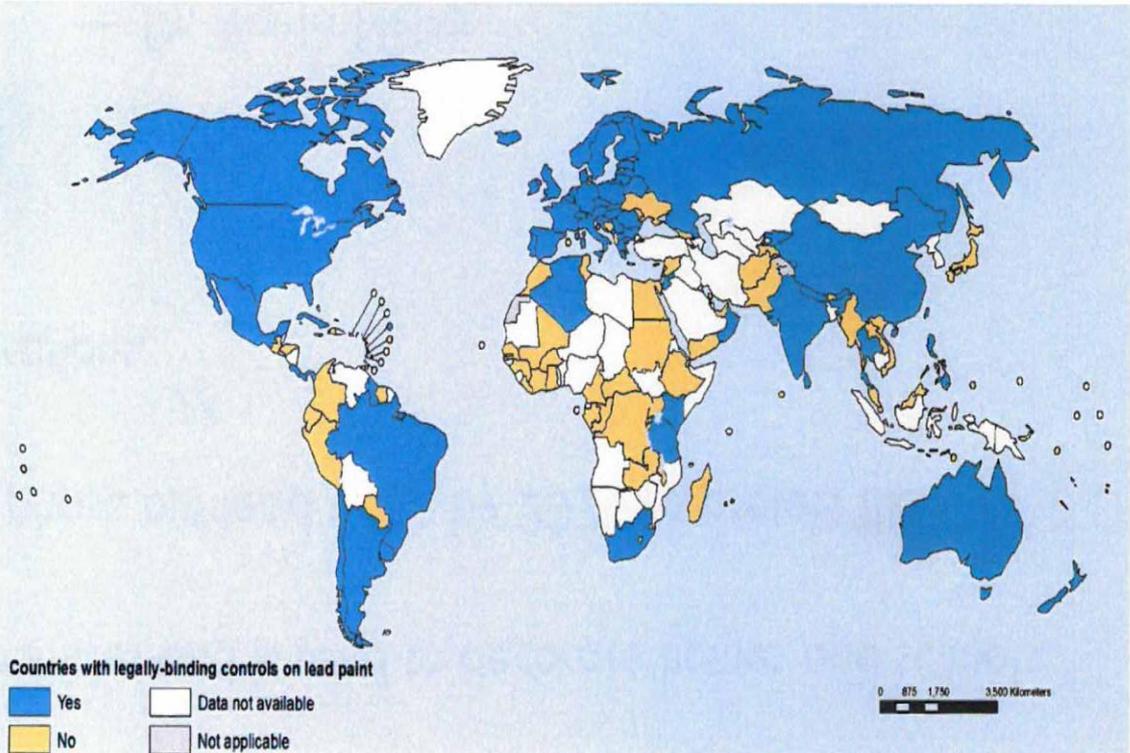
The Star
POISON-PAINT THREAT
State aims to protect children against unsafe levels of lead

While many countries have long-established bans on lead paint, **it is still legal to sell lead paint for use in homes, schools and other buildings in more than one third of the world's countries.**

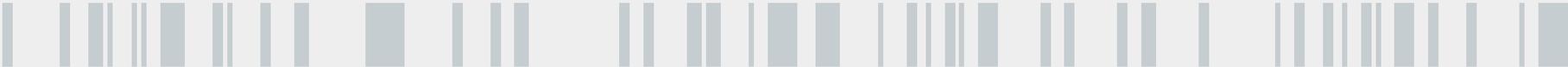
Children living in low- and middle-income countries, where there are few governmental controls on lead, are disproportionately affected.



Last year, over one hundred ILPPW events took place in 42 countries. This year the fifth annual ILPPW will take place in **the week of 22-28 October 2017.**



Countries with Legally Binding Controls on Lead Paint
as of February 2017



LEAD AND ARSENIC IN GARDEN SOILS

- The 2017 Lancet Commission on Pollution and Health identified soil as an important, daily route of public exposure to a variety of pollutants.

STUDY ON SOILS

- 538 samples from 4 study sites in Johannesburg (Bertrams , Riverlea, Bramfischerville, Hospital Hill)
- Composite soil samples collected from residential gardens (EPA methods);
- Dried and analysis of metal content using a Niton analyser.

THE STUDY SITES

Braam Fischerville

Bertrams
Bertrams

Riverlea

Hospital Hill

Image © 2016 DigitalGlobe

Image © 2016 DigitalGlobe

Google Earth

Imagery Date: 9/24/2016 26°13'02.73" S 27°59'01.88" E elev 5569 ft / eye alt 22.08 mi

ARSENIC IN GARDEN SOILS (MG/KG)

	N	RANGE	MEAN (SD)	MEDIAN	% ≥ South African reference level (48 mg/kg)	% ≥ Canadian reference level (18 mg/kg)	% ≥ total sample mean
Bertrams	95	0.1-60.5	5.3 (11.7)	0.1	1.1%	16.8%	18 (18.9%)
Riverlea	131	0.1-65.3	18.3 (11.7)	19.1	1.5%	56.5%	105 (80.2%)
Bramfischerville	162	0.1-22.4	4.6 (7.1)	0.1	0%	6.2%	48 (29.6%)
Hospital Hill	150	0.1-45.5	3.7 (7.8)	0.1	0%	5.3%	31 (20.7%)
Total Sample	538	0.1-65.3	7.8 (11.2)	0.1	0.6%	20.1%	202 (37.5%)

LEAD IN GARDEN SOILS (MG/KG)

	N	RANGE	MEAN (SD)	MEDIAN	% ≥ SA reference level (230 mg/kg) (DEA, 2010)	% ≥ Canadian reference level (120 mg/kg) (CMoE, 2011)	% ≥ TOTAL SAMPLE MEAN
Bertrams	95	0.1-2141.0	241.7(282.8)	158.1	32.6%	65.3%	84 (90.5%)
Riverlea	131	0.1-884.3	42.6(82.6)	29.9	1.5%	3.8%	24 (18.3%)
Bramfischerville	162	0.1-292.0	8.1 (28.5)	0.1	0.6%	1,2%	5 (3.1%)
Hospital Hill	150	0.1-243.1	4.0 (24.3)	0.1	0.7%	1.3%	4 (2.0%)
Total Sample	538	0.1-2141	56.6 (153.8)	0.1	6.5%	13.2%	114 (21.6%)

- **Possible Short Term Interventions**

- Hand-to-mouth pathway

- Wash hands:

- before eating

- After playing or gardening outside

- Keep nails clean and short

- Avoid mouthing behavior

- Discourage pica

- Wash fruit & vegetables thoroughly before eating

- House cleaning – wet, soapy methods

LEAD EXPOSURE CHALLENGES IN SUBSISTENCE FISHING COMMUNITIES

- Prompted by anecdotal reports of lead melting to craft fishing sinkers, cross-sectional surveys of the blood lead levels of young school children were undertaken in two remote coastal South African fishing villages in 2012.
- The results showed that blood lead levels ranged from 2.2 to 22.4 mg/dl, with the mean blood lead level equalling 7.4 mg/dl.
- The study showed that local fisher folk were collecting waste lead (for example from wheel balancing and alignment centres) and lost fishing sinkers, which were melted down (usually in the home environment) to craft new sinkers





Do NOT Melt Lead!

- Lead is a poisonous substance
- Lead is especially harmful to the health of children
- Melting lead to make fishing sinkers is very dangerous



Metals in traditional medicines

WHO recognizes
plant; animal
and/or **mineral**
based products
in TM



AYURVEDIC MEDICINE

- Practised in India for millennia
- Gained increasing popularity beyond the Indian sub-continent in recent decades
- Rasa shastra – deliberate inclusion of minerals, metals

THE USE OF METALS IN AYURVEDIC MEDICINES (rasa shastra)

- Gold - Swarna bhasma
- Silver - Roupya bhasma
- Copper - Taamra bhasma
- Iron - Ioha bhasma
- Lead - Naaga bhasma
- Tin - Vanga bhasma
- Zinc - Yasad bhasma

*“There is no better medicine than **mercury**, no greater god than Mahadeva, no better friend than the physician, and no better deed than a gift.”*

B. Mukherji

LEAD CONTENT OF AYURVEDIC MEDICINES

- Around 20% of Ayurvedic preparations contain lead;
- Health alerts issued in many countries (USA, UK, NZ, Australia, Spain);
- Growing public health concern, especially in the light of direct internet sales.

Gunturu et al. *Journal of Hematology & Oncology* 2011, 4:51
<http://www.jhoonline.org/content/4/1/51>



CASE REPORT

Open Access

Ayurvedic herbal medicine and lead poisoning

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Abstract

Although the majority of published cases of lead poisoning come from occupational exposures, some traditional remedies may also contain toxic amounts of lead. Ayurveda is a system of traditional medicine that is native to India and is used in many parts of world as an alternative to standard treatment regimens. Here, we report the case of a 58-year-old woman who presented with abdominal pain, anemia, liver function abnormalities, and an elevated blood lead level. The patient was found to have been taking the Ayurvedic medicine Jamburūn prior to presentation. Chemical analysis of the medication showed high levels of lead. Following treatment with an oral chelating agent, the patient's symptoms resolved and laboratory abnormalities normalized. This case highlights the need for increased awareness that some Ayurvedic medicines may contain potentially harmful levels of heavy metals and people who use them are at risk of developing associated toxicities.

Keywords: Lead poisoning, basophilic stippling, anemia, Ayurveda

Background

Ayurvedic medicine is a traditional system native to India [1]. This system stresses the use of natural plant-based medicines, and minerals including sulfur, arsenic, lead, copper and gold are often added to formulations with the belief that these metals are essential components of vital molecules within the human body. In India, over 100 colleges offer degrees in traditional Ayurvedic medicine and in western countries, Ayurvedic medicine is gaining popularity as complementary treatment to modern medicine. Ayurvedic medicines are used to treat a wide spectrum of diseases from headaches to cancer. Currently, the United States does not specify a certification requirement for Ayurvedic practitioners, although many training programs are being offered through state-approved institutions. These practitioners are able to prescribe the medications and sometimes manufacture it themselves.

From 2000 to 2003, the Centers for Disease Control reported 12 cases of lead poisoning in adults associated with Ayurvedic medication intake occurring in five different states [2]. Some Ayurvedic preparations have been found to contain contained lead and/or mercury at

100 to 10,000 times greater than acceptable limits [3]. Although not common in western societies, lead exposure through dietary sources is a well-recognized phenomenon and in past years, calcium supplements have been a source of lead poisoning [4]. In addition to Ayurvedic medicine, other traditional medicines originating from Asian, Middle Eastern and Hispanic cultures have been found to contain lead and other heavy metals [5]. Although many health supplements are now subject to limited government regulation in the U.S. through the Dietary Supplement and Health Education Act of 1994, these medicines are readily obtainable as herbal remedies in health food stores and through the internet and their safety and efficacy are not regulated by government agencies such as the U.S. Food and Drug Administration (FDA) [6]. Thus, without sufficient public awareness, the risk of heavy metal exposure in individuals taking these supplements is quite high. Here, we present a case of lead poisoning secondary to ingestion of Indian Ayurvedic medicine, Jamburūn.

Case presentation

A 58-year-old woman from India residing in the U.S. presented to the emergency department with a 10-day history of progressively worsening post-prandial lower abdominal pain and nausea accompanied by non-bilious and non-bloody vomiting. She was in her usual state of

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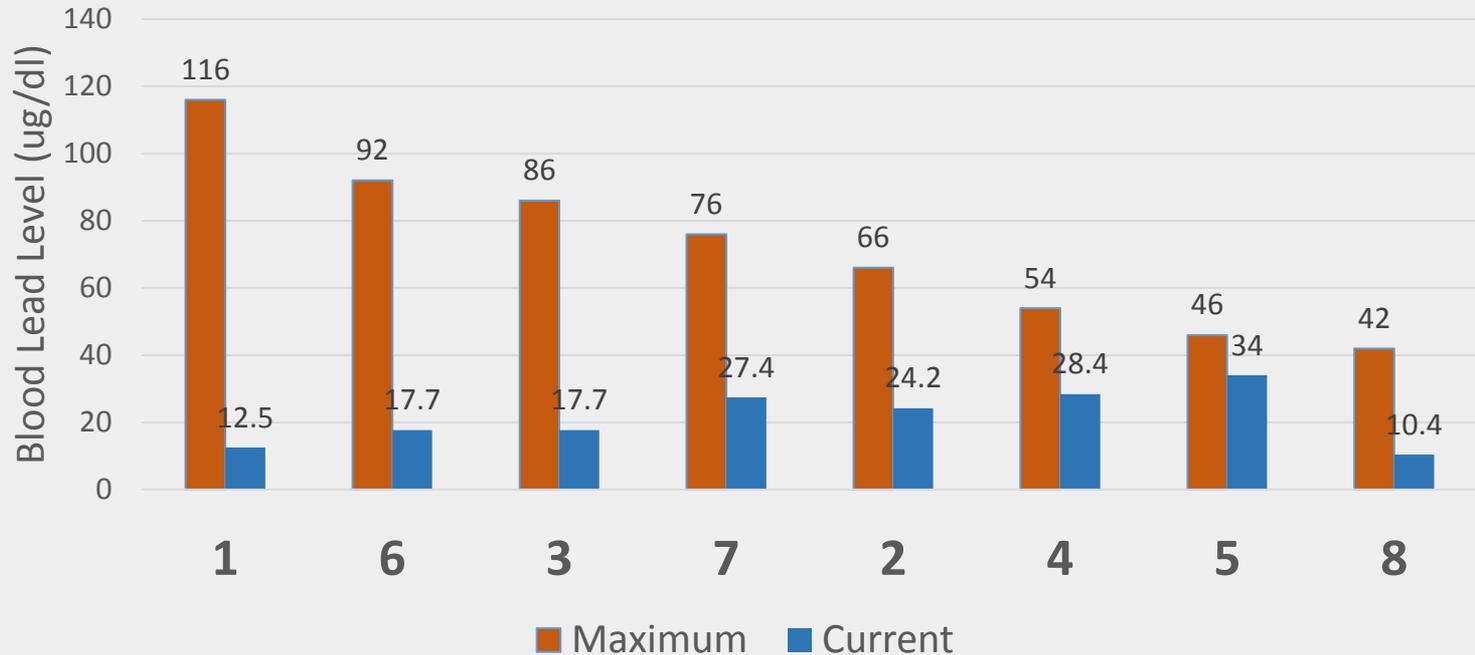
BACKGROUND TO OUTBREAK IN SA

- In 2012 in Durban, a lead poisoning outbreak among adolescents was associated with the consumption of an Ayurvedic medicine for the treatment of skin conditions
- Consumption of Ayurvedic medication for up to 18 months;
- A range of symptoms within 4 to 6 weeks of commencing new batch;
- 5 females; 3 males (4 others emigrated).

RANGE OF SIGNS & SYMPTOMS DURING ACUTE PHASE

- Difficulty concentrating
- Irritability
- Weakness & pain in joints and muscles
- Clumsiness
- Exhaustion
- Lethargy
- Vomiting
- Impaired memory
- backache
- Soreness over entire body
- Headaches
- Nose bleeds
- none
- Tiredness
- Nausea
- Anaemia
- Abdominal cramps
- Shortness of breath
- Severe itching
- Emotional instability
- None
- Headaches
- Soreness over entire body
- Leg pains
- Loss of appetite

BLOOD LEAD LEVELS: MAXIMUM & CURRENT ($\mu\text{g}/\text{dl}$)





LEAD CONTENT OF IMPLICATED CAPSULES

- Maximum recommended daily intake (Canadian guidelines): 20 µg
- Laboratory analyses: 71 208 µg
- Maximum dose: 4 capsules
- Maximum lead intake: 284 834 µg
- Guideline exceeded by factor of 14 241

Metals in African traditional medicine

- An occupational cohort in Durban had unexplained high levels of Cr(VI) in their blood during pre-employment screening.
- Various hypotheses were put forward including medicinal use of class 1 carcinogen, Cr(VI) known as *ndonya*.



Cr(VI) in African traditional medicine

Methods

- Interviews with 395 THPs
- 318 ndonya-containing medicines were purchased

Results

- 72% of THP prescribed ndonya for healing purposes
- Primary route was by enema
- Cr(VI) content in mutis was between 4 ug/L – 53g/L (note: WHO limit for Cr(VI) in drinking water is 50ug/L)
- Human intake varied from 7.5mg – 4.5g per single dose



Metals in African traditional medicine



Analytical determination of metal salts using SEM-EDX

(Scanning electron microscopy-energy dispersive X-ray)



Identified salts:

1. Ammonium
chloride (NH_4Cl)



Itshe lemsipha

2. Calcium sulphate
($\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$)
(Gypsum, plaster of Paris)



Umkhandu yemhlophe

3. Sulfur
(S)



Isibabule

Results

4. Copper sulfate
($\text{CuSO}_4 \cdot 5\text{H}_2$)



5. Potassium permanganate
(KMnO_4)



6. Iron chromite ore
(Mg 6%, Al 9%, Cr 49%, Fe 30%)



★ Not widely available/used

Results

7. Potassium dichromate ($K_2Cr_2O_7$)



7. Sodium chloride (NaCl)



Interview with 201 THPs on use of 7 *imikhando*

1. Mercury
2. Copper sulfate
3. Potassium permanganate
4. Potassium dichromate/table salt
5. Ammonium chloride
6. Calcium sulphate
7. Sulfur

5.

7.

2.

4.



Mercury use in South African traditional medicine



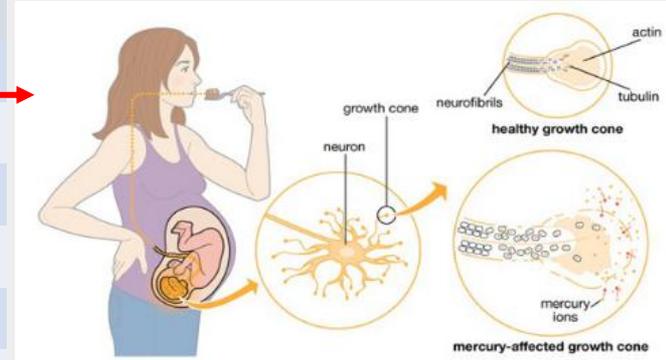
- Mercury for therapeutic purposes was prevalent until the 20th century when the detrimental effects of its exposure became notorious
- In efforts to **eliminate mercury-related diseases**, WHO has emphasized the need to identify traditional practices involving mercury
- Nonetheless, mercury in traditional healthcare systems is still widespread today
 - Chinese medicine - colloquial names of '*cinnabaris*' (mercuric sulfide) and '*calomel*' (mercurous chloride)
 - Caribbean and Latin American traditions, mercury ('*azogue*') is used for a range of cultural and religious practices linked to healthcare including the use of mercury to treat intestinal disorders
 - In SA trad med, mercury is an example of an *imikhando*, and is colloquially referred to as ***isigidi*** ('millions').



*Reasons for mercury administration (N)

Childbirth	70 (90%)
Protection from guns	39 (50%)
Sterility	4
During pregnancy	3
Protection ritual on house	2
Gynaecological complaints	1
Aphrodisiac	1
STIs	1
Gastrointestinal: aches and cramps	1
Liver	1
Kidney/bladder	1
Nervousness	1
Aches, pains and swelling	1
Love medicine	1

*multiple responses allowed



*Modes of mercury administration (N)

Orally	66 (85%)
Sub-cutaneous implantation	46 (59%)
Enema	2
Use in bath	2
Inhalation/facial sauna	1
Licking off hand	1

*multiple responses allowed



Copper sulphate use in South African traditional medicine



- 145 THPs use CuSO₄ for healing purposes (72%)
- The use of CuSO₄ was strongly associated with gender ($p = 0.009$) where the proportion of CuSO₄ users was higher for female than male THPs
- CuSO₄ was reportedly administered to individuals of all ages, including infants and children
- The main routes of administration were enema ($n = 110$; 76%), oral ($n = 40$; 28%) and use in bath ($n = 40$; 28%)
- The reasons cited for use were diverse and included skin rashes ($n = 43$; 30%), aches, pains and swelling ($n = 38$; 28%) as well as sexually transmitted diseases ($n = 28$; 19%)

In the case of Cu poisoning incidence data, exposure types may be misclassified to that of **agrochemical exposures** instead of being related specifically to CuSO₄ in traditional medicine

- ❖ Possible underestimation of CuSO₄ related complications from traditional medicines?

Investigation of multi-metal exposure from artisanal cookware as a potential public health threat in South Africa



Introduction

- In developing countries, informal recycling of metal-containing products and e-waste is widespread
- It is an important socio-economy safety net for many individuals but can pose a risk for human health and the environment
- An example of recycling of scrap metal is the casting of liquid aluminum from a collection of scrap metal into cooking pots



Introduction

- In Cameroon, a study on locally manufactured artisanal aluminum cookware revealed that raw materials used included engine parts (from both cars and motorbikes), waste aluminum and e-waste (computer parts).
 - The study revealed that this cookware was a source of metals including cadmium (Cd) and lead (Pb)
- A second study investigated cookware from ten developing countries (Bangladesh, Guatemala, India, Indonesia, Ivory Coast, Kenya, Nepal, the Philippines, Tanzania and Vietnam)
 - Al, As, Cd and Pb were present in some leachates at potentially harmful levels

(Weidenhamer et al, 2014; Weidenhamer et al, 2017)

Introduction

- In South Africa, artisanal aluminum pots have been in circulation for over two decades.
- Nonetheless, the locally available artisanal aluminum pots have not been investigated as a possible source of metal exposure.

South Africa: Pensioners cook with 'time bomb' pots

Mozambique • South Africa • Southern Africa



By Mzilikazi wa Afrika

Nelspruit — Thousands of pensioners in South Africa run the risk of lead poisoning or having toxic cooking pots explode in their faces as a Mozambican syndicate smuggles thousands of defective "potjie" pots into the country.

The syndicate smuggles the three-legged, silver-coloured aluminium pots into at least three South African provinces, and sells them cheaply at pension payout points, said police investigators on Monday. The South Africa department of health declared the pots "unhealthy" three years ago and warned that they were "very dangerous" for domestic use, as each pot contains 1,8 milligrams of lead which pose a health threat if used for food storage or preparation.



Artisanal pot making process



Scrap metal



Burning site



Artisanal pot making process

Typical work station



Artisanal pot making process

Making of molds
from soil before
casting the
aluminium



Artisanal pot making process

Home made furnace from metal drums

Melting scrap metal



Research aims and objectives

Study aim:

To determine the risk of metal exposure posed by artisanal cookware available in South Africa

Research objectives include:

- To screen artisanal cookware for metals including aluminum (Al), arsenic (As), cadmium (Cd) and lead (Pb)
- To quantify the level of metals in various leachate scenarios
- To determine the deterioration of artisanal cookware over time

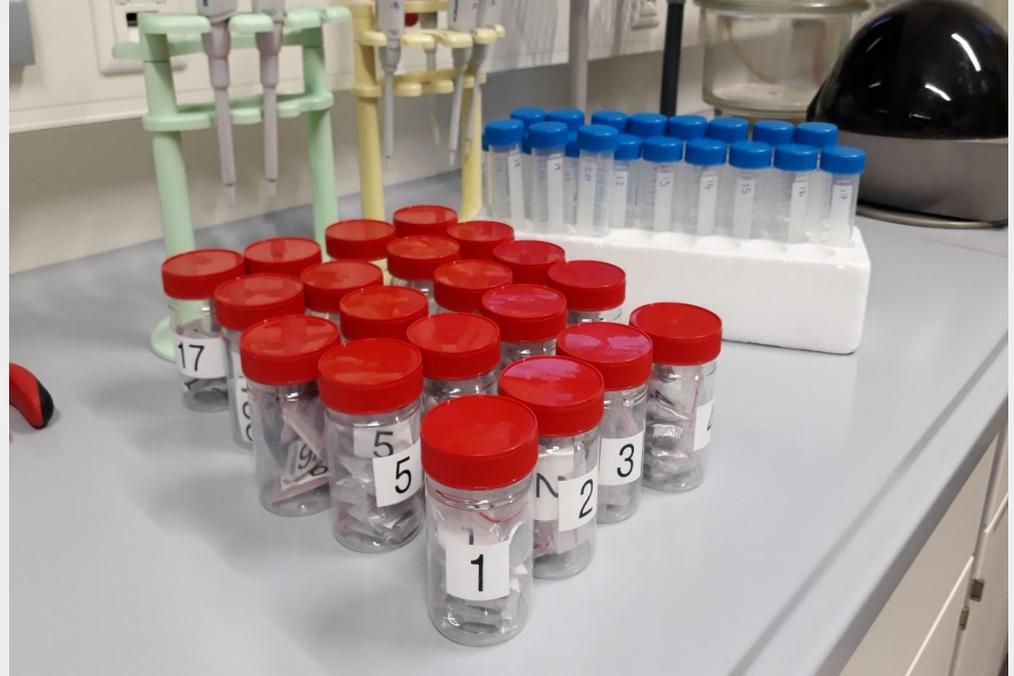
Methodology

- Work package 1: Artisanal cookware sampling and sample preparation
- Work package 2: Determination of metal elements in aluminum cookware
- Work package 3: Determination of leachable elements with ICPMS (3% acetic acid at 95 degrees for 2h)

WP1: sampling and sample preparation



WP1: sampling and sample preparation



WP2: Total metals in artisanal cookware



Digestion attempt 1



Digestion attempt 2



In conclusion

- **Successes:**

- Lead phased out of petrol
- Regulation of lead content of paint
- Strengthening of lead paint regulations

- **Awareness:**

- Lead poisoning is a disease of poverty (paint, occupation levels, housing location)

- **Next challenges:**

- Unfinished agenda (informal sector) is the greatest challenge



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