Concentrations of lead in ceramic tableware in South Africa

AUTHORS:
Angela Mathee[1,2]
Louise Renton[1]
Renée Street[1,2]

AFFILIATIONS:
[1]Environment and Health Research Unit, South African Medical Research Council, Johannesburg, South Africa
[2]Department of Environmental Health, Faculty of Health Sciences, University of Johannesburg, Johannesburg, South Africa

CORRESPONDENCE TO:
Angela Mathee

EMAIL:
angie.mathee@mrc.ac.za

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Ceramic ware is used around the world, usually daily. In the past, lead was used in the glazes and decorative paints applied to ceramic ware, mainly to increase durability, impart a smooth, glasslike finish to glazes and intensify decorative pigments. However, this use of lead at times contributed to lead exposure and poisoning. While measures have been put in place to limit the use of lead in ceramic ware in well-resourced countries, there is relatively little information on the situation in poorly resourced settings. In the current preliminary South African study, we assessed the lead content and leaching rates from newly purchased ceramic ware. The majority of the 44 ceramic ware items had lead levels $\geq$ 90 ppm. Elevated lead concentrations were found in the leachate from only one item. The findings indicate a need for further research on the potential for lead exposure from ceramic wares, and support calls for increased attention to the many potential sources of lead exposure in poorly resourced settings.

Significance:

- The study reveals the potential for lead contamination of certain types of ceramic ware available in South Africa.
- Daily use of lead-contaminated ceramic ware may increase the risk of lead exposure, especially among the poorest.
- The study findings are indicative of a need for further research to fully characterise the extent of lead in ceramic ware.

Introduction

Around the world, ceramic ware is often used daily. Lead has been used for decades in the glazes and decorative paints applied to ceramic ware, mainly to increase durability, impart a smooth, glasslike finish to glazes and intensify decorative pigments. Because of the associated health implications, there has been long-standing concern about the potential for lead to leach from ceramic ware and contaminate foodstuffs.[1] Some ceramic wares, especially artisanal products, have been found to leach significant quantities of lead into the foods they contain[2-4]; for example, when the glaze has been incorrectly fired, it becomes degraded over time, or when chips or cracks form as a consequence of daily wear and tear. Lead leaching rates have also been shown to be affected by the temperature and acidity of foodstuffs (for example foods containing vinegar or fruit juice), as well as the duration of cooking or food storage, amongst other factors.[5-7] At high concentration levels, lead leached from artisanal ceramic ware has been associated with cases of serious or fatal lead poisoning, as well as lead poisoning outbreaks.[8-11] Even low lead levels in blood have been linked to a range of detrimental effects, especially in children, including reductions in intelligence scores, changes in behaviour and increased aggression and violence.[12] In adults, lead poisoning has been associated with kidney damage, hypertension and cardiac disease, amongst other effects.[13,14]

There is a paucity of published research on lead exposure from ceramic ware in South Africa, of both artisanal and commercial origin. However, an instance is known of the US Food and Drug Administration (FDA) issuing an import alert in relation to certain types of commercially produced ceramic ware from South Africa.[15] To obtain information in this regard, a small-scale, preliminary study was undertaken to determine the lead content of commercially available ceramic ware available in Johannesburg, South Africa.

Methods

Randomly selected ceramic ware was purchased from six large retail chains, with a minimum of four samples per retail chain. A total of 44 items, including side plates and shallow bowls with a capacity of less than 1.1 L, comprised the sample. The items were subjected to X-ray fluorescence (XRF) analysis using a portable, hand-held XRF device, set for elemental ceramic analysis. In addition, a 4% acetic solution was left standing in the ceramic ware items for 24 h at room temperature. The lead content of the leachate was determined by inductively coupled plasma-atomic emission spectroscopy (ICP-AES) according to the protocols of the FDA.[16] A reference level of 2 μg/mL was used as a cut-off point for unacceptable concentrations of ceramic ware leaching lead.

Results and discussion

Lead levels in the ceramic ware ranged from undetectable (0.0 parts per million; ppm) to a maximum of 64 668.4 ppm, with mean and median concentrations of 4 248.2 ppm and 107.5 ppm, respectively (Table 1). More than 59% of measurements exceeded 90 ppm, which is the level that countries around the world, including South Africa, have agreed to as legally binding with respect to lead in paint, glazes and other coatings.[17] The majority of items included in the sample had been manufactured in China (64%), with smaller proportions originating from Thailand (7%), Portugal (5%), Indonesia (2%) and South Africa (2%). A further 20% of items did not have the country of origin specified. At least a proportion of the products from all countries, apart from Thailand, had lead levels exceeding 90 ppm. Variation in ceramic ware lead levels may include glaze type or firing conditions.

Table 1: Lead content and leachate concentrations in commercially available ceramic wares in South Africa

	n	Lead content analysis using XRF				Lead content of leachate (ICP-AES)			
		Range	Mean (SD)	Median	Above 90 ppm	Range	Mean (SD)	Median	Above FDA reference level
Supplier									
1	13	0 – 64 668	8768 (19 489)	101	54%	0.0 – 38.8	3.1 (10.7)	0.0	7.7%
2	7	24 – 52 038	7525 (19 629)	108	57%	0.0 – 0.0	0.0 (0.0)	0.0	0.0%
3	6	297 – 4802	1526 (1905)	393	100%	0.0 – 0.2	0.0 (0.1)	0.0	0.0%
4	6	332 – 1577	565 (497)	368	100%	0.0 – 0.2	0.0 (0.1)	0.0	0.0%
5	4	0 – 107	53 (45)	52	25%	0.0 – 0.0	0.0 (0.0)	0.0	0.0%
6	8	0 – 7300	940 (2570)	28	25%	0.0 – 0.0	0.0 (0.0)	0.0	0.0%
Country of origin									
Not specified	9	67 – 52 038	6142 (17 217)	332	89%	0.0 – 0.2	0.0 (0.1)	0.0	0.0%
South Africa	1	64 668 – 64 668	64 668 (0)	64 668	100%	38.0 – 38.0	38.8 (0.0)	38.8	100.0%
Thailand	3	0 – 59	31 (30)	33	0%	0.0 – 0.1	0.0 (0.1)	0.0	0.0%
Portugal	2	0 – 35 811	19 635 (22 877)	19 635	100%	0.0 – 0.0	0.0 (0.0)	0.0	0.0%
Indonesia	1	653 – 653	653 (0)	653	100%	0.0 – 0.0	0.0 (0.0)	0.0	0.0%
China	28	0 – 8949	963 (2276)	82	50%	0.0 – 1.8	0.1 (0.3)	0.0	0.0%
Background colour									
White	11	0 – 8949	2278 (3289)	360	73%	0.0 – 1.8	0.2 (0.5)	0.0	0.0%
Cream/beige/yellow	11	23 – 653	168 (202)	101	55%	0.0 – 0.0	0.0 (0.0)	0.0	0.0%
Orange/red	4	28 – 392	195 (194)	180	50%	0.0 – 0.0	0.0 (0.0)	0.0	0.0%
Shades of blue	4	0 – 35 811	9046 (17 844)	186	50%	0.0 – 0.0	0.0 (0.0)	0.0	0.0%
Shades of green	5	40 – 64 668	24 096 (31 619)	3459	80%	0.0 – 38.8	7.8 (17.4)	0.0	20.0%
Brown/black	7	33 – 1577	352 (558)	67	43%	0.0 – 0.2	0.0 (0.1)	0.0	0.0%
Multiple colours	2	0 – 108	54 (76)	54	50%	0.0 – 0.0	0.0 (0.0)	0.0	0.0%
Pattern colour									
White	7	0 – 2920	570 (1048)	133	71%	0.0 – 0.0	0.0 (0.0)	0.0	0.0%
Cream/beige/yellow	3	23 – 24	23 (0.7)	23	0%	0.0 – 0.0	0.0 (0.0)	0.0	0.0%
Orange/red	5	28 – 7300	1622 (3178)	332	60%	0.0 – 0.0	0.0 (0.0)	0.0	0.0%
Shades of blue	8	0 – 35 811	5274 (13 468)	52	43%	0.0 – 0.0	0.0 (0.0)	0.0	0.0%
Shades of green	6	40 – 64 668	20 148 (29 889)	1933	83%	0.0 – 38.8	6.6 (15.8)	0.0	16.7%
Brown/black	9	33 – 4804	820 (1572)	108	56%	0.0 – 0.2	0.1 (0.1)	0.0	0.0%
Multiple colours	6	0 – 8949	1593 (3605)	107	83%	0.0 – 1.8	0.3 (0.7)	0.0	0.0%
Total sample	44	0 – 64 668	4248 (13 259)	108	59%	0.0 – 38.8	0.9 (5.8)	0.0	2.3%

The product with the highest lead measurement was manufactured in South Africa; South Africa was also the country of origin of the only item from which lead leached at a concentration exceeding the reference level of 2 μg/mL. While it is reassuring that lead did not leach from the majority of surveyed products at the time of purchase, from a public health perspective, concern remains over what might occur over time, with erosion of the glazes and pigments through general wear and tear, and with chipping and cracking of ceramic ware surfaces. While we focused on new ceramic ware in this study, the use of old, antique dinner ware has also been found to be of concern.[18] Microwave ovens have also been associated with increased leaching of lead from ceramic ware[19]. as has the use of acidic ingredients, longer contact times between ceramic ware and foodstuffs, and higher temperatures[20].

Lead exposure, as well as the associated detrimental health and social outcomes, are well established to be elevated in settings of poverty.[21] With regard to ceramic ware, poor people are unlikely to be able to afford frequent replacement of cracked or chipped ceramic ware, and in this regard too, may be at elevated risk of exposure and the concomitant health effects. Reductions in IQ points associated with lead exposure in South Africa has been calculated to cost the national economy around USD17.7 billion annually[22]; in this light, uncompromising action to reduce lead exposure, especially in the most vulnerable communities in South Africa, is warranted.

When lead paint was first identified as a public health concern in South Africa[23-25], the government response was to draft regulations to limit the use of lead in paint intended for household use in the country. Initially promulgated in 2009, those regulations are on the verge of being strengthened by reducing the maximum permissible concentration of lead in paint from 600 ppm to 90 ppm, and by making the regulations applicable to all paints and coatings, including those used in the commercial and industrial sectors. These developments ought to provide a higher level of public health protection against lead exposure from ceramic ware, but, importantly, need to be accompanied by a programme of monitoring and surveillance of the lead content of paint and other coatings manufactured, imported, sold and used in South Africa. This should include both the formal and informal sectors, with concomitant punitive action, where warranted. Given that levels of awareness of lead hazards in South Africa are very low[26], a public education campaign is also key.

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Competing interests

We have no competing interests to declare.

Authors' contributions

A.M.: Conceptualisation, methodology, formal analysis, writing – original draft preparation, writing – review and editing, supervision. L.R.: Methodology, formal analysis, investigation, writing – original draft preparation, writing – review and editing, supervision, project administration. R.S.: Formal analysis, writing – review and editing.

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