

Evaluating metal cookware as a global source of lead exposure

Background

- Through in-home investigations of children with elevated blood lead levels, aluminum cookware was found to contain high levels of lead.
- The extent to which metal cookware represents a source of lead exposure to all US residents is unclear.
- The objective of this study was to test cookware for lead content and its propensity to leach lead and other toxic metals.



Results

- Many aluminum and brass cookware contained >100 ppm lead
- Many also leached enough lead to exceed recommended dietary limits
- Stainless-steel and cast-iron cookware leached much lower levels of lead

Material	Country	Type	XRF, ppm		15 mins:		24 hours:			
			Median	(Range)	Conc, µg/mL	Dose, µg/250 mL	Conc, µg/mL	Dose, µg/250 mL		
Aluminum	Unknown	Cookpot	10 ¹	(0, 192)	0.00026	0.065	0.0031	0.775		
		Cookpot	11 ¹	(0, 203)	0.00053	0.1325	0.00278	0.695		
		Cookpot	0 ¹	(0, 134)	0.0002	0.05	0.0002	0.05		
		Caldero	10 ¹	(0, 19)	0.00065	0.1625	0.00657	1.6425		
		Caldero	11 ¹	(0, 124)	0.0007	0.175	0.00395	0.9875		
		Steamer	10 ¹	(0, 85)	0.0009	0.225	0.0113	2.825*		
		Pr. Cooker	42	(0, 78)	0.00276	0.69	0.0287	7.175*		
		Stock Pot	9	(0, 38)	0.00005	0.0125	0.00023	0.0575		
		Skillet	387	(8, 489)	0.0149	3.725*	0.424	106**		
		Cookpot	476	(12, 554)	0.0155	3.875*	0.138	34.5**		
		Pr. Cooker	595	(103, 53,668)	0.0141	3.525*	2.12	530**		
		Pr. Cooker	12 ¹	(0, 5,323)	0.00099	0.2475	0.00328	0.82		
		Afghanistan	Afghanistan	Cookpot	14,318	(7,148, 17,094)	1.59	397.5**	4.06	1,015**
				Cookpot	2,807	(803, 4,182)	0.0808	20.2**	0.14	35**
				Cookpot	8,807	(2,751, 18,599)	0.359	89.75**	1.26	315**
				Cookpot	634	(217, 742)	0.0152	3.8*	0.0276	6.9*
				Cookpot	360	(157, 714)	0.154	38.5**	0.274	68.5**
				Cookpot	4,660	(0, 33,062)	0.154	38.5**	0.417	104.25**
				Cookpot	2,016	(1,469, 56,950)	0.117	29.25**	0.37	92.5**
				Cookpot	3,553	(2,582, 29,429)	0.191	47.75**	0.56	140**
Cookpot	1,533			(0, 43,643)	0.0248	6.2*	0.0342	8.55*		
Cookpot	301			(0, 440)	0.118	29.5**	0.221	55.25**		
Cookpot	3,117			(662, 28,287)	0.0499	12.475**	0.189	47.25**		
Cookpot	4,546			(3,162, 32,612)	0.0877	21.925**	0.132	33**		
Pr. Cooker	222			(0, 68,926)	0.0422	10.55**	0.0957	23.925**		
Pr. Cooker	5,063			(0, 40,158)	0.258	64.5**	0.584	146**		
Pr. Cooker	393			(0, 43,900)	0.067	16.75**	0.104	26**		
Pr. Cooker	556			(8, 37,040)	0.195	48.75**	6.3	1,575**		
Pr. Cooker	693			(0, 66,374)	0.284	71**	7.77	1,942.5**		
Pr. Cooker	497			(0, 53,425)	0.279	69.75**	7.11	1,777.5**		
Pr. Cooker	538			(0, 48,193)	0.183	45.8**	3.96	990**		
Pr. Cooker	605			(0, 64,852)	0.194	48.5**	4.63	1,158**		
Pr. Cooker	548	(0, 51,021)	0.131	32.8**	3.12	780**				
China	China	Caldero	10 ¹	(0, 367)	0.00041	0.1025	0.00599	1.4975		
		Caldero	12	(0, 26)	0.00074	0.185	0.00983	2.4575*		
		Steamer	28	(0, 44)	0.0008	0.2	0.0138	3.45*		
		Stock Pot	0 ¹	(0, 19)	0.0004	0.1	0.0013	0.325		
		Stock Pot	50	(0, 94)	0.00105	0.263	0.010	2.55*		
		Cookpot	9 ³	(0, 26)	0.00045	0.113	0.001	0.243		
		Cookpot	0 ¹	(0, 20)	0.00013	0.0325	0.00024	0.06		
		Cookpot	13	(0, 26)	0.013	3.25*	0.0207	5.18*		
		Cookpot	8 ¹	(0, 18)	0.00006	0.015	0.00029	0.0725		
		Cookpot	28	(10, 260)	0.00127	0.3175	0.00651	1.6275		
		Pr. Cooker	8 ¹	(0, 147)	0.00053	0.133	0.004	0.898		
		Caldero	96 ¹	(0, 225)	0.0272	6.8*	0.21	52.5**		
		Caldero	138	(0, 183)	0.00952	2.38*	0.249	62.25**		
		Caldero	13	(0, 71)	0.00092	0.23	0.0185	4.63**		
		Caldero	8 ¹	(0, 15)	0.00075	0.188	0.0157	3.93*		
Caldero	9 ¹	(0, 15)	0.0006	0.15	0.0167	4.18*				
Caldero	7 ¹	(0, 17)	0.0006	0.15	0.0149	3.73*				
El Salvador	El Salvador	Stock Pot	15	(0, 27)	0.00118	0.295	0.0105	2.63*		
		Pr. Cooker	8 ¹	(0, 3,828)	0.00007	0.0175	0.00191	0.4775		
India	India	Cookpot	95	(0, 374)	0.0072	1.8	0.0632	15.8**		
		Idli Maker	715	(308, 1,327)	0.028	7*	0.27	67.5**		
		Steamer	24	(10, 47)	0.214	53.5**	0.226	56.5**		
Thailand	Thailand	Cookpot	14	(0, 27)	0.00183	0.458	0.0154	3.85*		
USA	USA	Stock Pot	11 ¹	(0, 19)	0.0001	0.025	0.00187	0.468		
		Stock Pot	51	(0, 83)	0.00014	0.035	0.0007	0.175		
		Stock Pot	11 ¹	(0, 15)	0.00014	0.035	0.003	0.793		
		Dutch Oven	0 ¹	(0, 17)	0.00083	0.208	0.00255	0.638		
Vietnam	Vietnam	Cookpot	0 ¹	(0, 34)	0.00012	0.03	0.0003	0.0825		
Hindalium	India	Idli Maker	626	(81, 1,463)	0.0182	4.55*	0.132	33**		
		Uruli/Kadai	256	(103, 290)	0.00434	1.09	0.0268	6.7*		
		Tadka Pan	290	(0, 306)	0.00389	0.973	0.135	33.8**		
		Appam Pan	716	(603, 794)	0.0144	3.6*	12.3	3,080**		
		Kadai	756	(15, 813)	0.0245	6.13*	0.926	232**		
		Kadai	528	(0, 624)	0.0457	11.4**	1.36	340**		
		Unknown	517	(362, 636)	0.0157	3.93*	1.05	263**		
		Pital Pot	3,611	(2,859, 4,585)	5.72	1,430**	10.8	2,700**		
Brass	India	Wok	0 ¹	(0, 0)	0.00455	1.13	0.00549	1.38		
		Kadai	5,049	(128, 47,191)	0.766	192**	1.34	335**		
		Saucepan	0 ¹	(0, 1,182)	0.079	19.8**	0.129	32.3**		
		Tope	1,343	(1,012, 1,544)	0.418	105**	0.728	182**		
Pital Pot	3,611	(2,859, 4,585)	5.72	1,430**	10.8	2,700**				

¹ More than 50% of XRF measurements < LOD *Estimated dose ≥ child IRL (2.2 µg/day) and < adult IRL (8.8 µg/day) ** Estimated dose ≥ adult IRL (8.8 µg/day)

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Methods

Acquisition of Cookpots

- 115 pieces of aluminum, brass, stainless-steel, and cast-iron cookware acquired/purchased 11/2019 - 01/2025, from local and online marketplaces
- Cookware details (type, material, country of origin) were determined through the manufacturer/seller supplied information

XRF Analysis

- Bruker S1 Titan handheld XRF
- Multiple scans (walls, base, lid, handles, rivets)

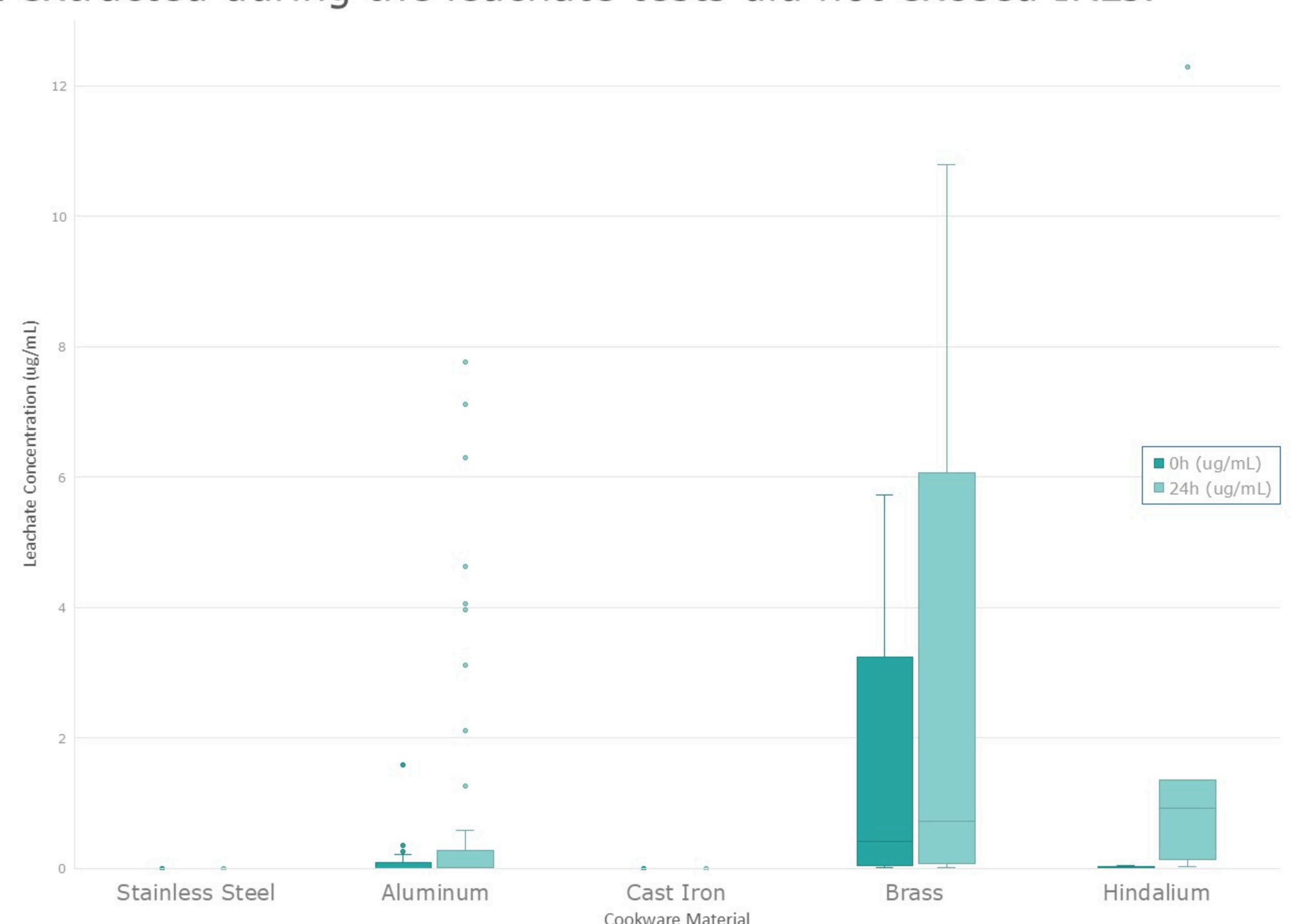


Leachate Analysis

- Modified U.S. FDA Elemental Analysis Manual Method 4.1
- Results compared to FDA Lead Interim Reference Level (IRL) / 250mL 'serving':
2.2 µg/day for children and 8.8 µg/day for people of childbearing age
- Cookware filled with 4% v/v acetic acid, simmered for 15 minutes, and 100 mL aliquot taken for testing
- Cookware sat for 24 hours (68-75°F); another 100 mL aliquot taken for testing
- Analyzed via ICP-MS based on EPA 200.8 / EPA 6020A Rev.1 2007

Conclusions

- Some Aluminum cookware readily available in the United States contains high lead levels and leaches sufficient lead to represent an important source of lead exposure.
- Hindalium (an aluminum alloy) in particular, contains high lead levels.
- Most brass cookware contained very high lead levels and/or the amount extracted during the leachate tests exceeded IRLs.
- Lead-containing cookware appears to be manufactured overseas, where it is imported/distributed for sale online and in local stores.
- Stainless-steel and cast-iron cookware contained very low lead levels, and the amount extracted during the leachate tests did not exceed IRLs.



- To our knowledge, this study is the first to identify metal cookware purchased in the United States as a potentially important source of lead exposure.
- This study confirms our hypothesis that stainless steel is a safer alternative to aluminum and brass for cookware.
- The ready availability of cookware originating from multiple countries via the global marketplace and elsewhere indicates that
 - both newcomer populations and longer-term residents of the US (and other high-income countries) are exposed to lead via metal cookware, and
 - this cookware likely represents a significant contributor to lead poisoning in low- and middle-income countries.