Assessment of food contamination and dietary intake of lead and thallium in a Northern Italy population

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Introduction

Lead (Pb) and thallium (Tl) are heavy metals released in the environment after natural and anthropogenic activities. Since the ban of lead as fuel addictive in gasoline, lead exposure decreased in the last decades, especially from air, leaving food and water as major sources of human exposure. On the converse, human activities have increased thallium contamination in the environment, especially in the vicinity of industrial (e.g. smelting) facilities. In this study, we aimed at characterizing lead and thallium content in food consumed in our population in order to estimate dietary intake of these metals.

Methods

We assessed dietary habits of a Norther Italian community though the validated EPIC questionnaire, a semi-quantitative food frequency questionnaire (FFQ) specifically developed for the Central-Northern Italy population.

We collected food samples during the period from October 2016 to February 2017, and we measured lead and thallium content using inductively coupled plasma-mass spectrometry.

We then reported the concentrations of investigated trace elements according to the food consumption patterns and food categories typical of this Italian population, as assessed though the EPIC FFQ.

We combined data on the estimated trace elements in foods and the EPIC FFQ to compute total daily trace element intake using the equation in Box 1.

Accordingly, we estimated daily dietary lead and thallium intake for the total diet and for each food category by reporting median and interquartile ranges of intake.

$$Daily\ dietary\ exposure\ \left(\frac{\mu g}{day}\right) = \sum \frac{element\ food\ content\ \left(\frac{\mu g}{kg}\right) \times food\ intake\ \left(\frac{g}{day}\right)}{1000}$$

Box 1. Equation for element daily intake estimation

	Lead (μg/kg)			Thallium (μg/kg)		
Food (N)	**50th**	**(IQR)**	**<LOD N (%)**	**50th**	**(IQR)**	**<LOD N (%)**
Cereals (126)	6.87	(3.73 - 12.07)	7 (5.6)	0.038	(0.001 - 0.469)	55 (43.7)
Meat (86)	5.26	(2.40 - 9.56)	2 (2.3)	0.052	(0.001 - 0.374)	36 (41.9)
Milk & dairy products (72)	4.25	(1.92 - 8.35)	1 (1.4)	0.044	(0.001 - 0.210)	31 (43.1)
Eggs (9)	0.31	(0.01 - 0.86)	4 (44.4)	0.442	(0.001 - 0.516)	3 (33.3)
Fish & seafood (62)	6.20	(1.88 - 13.83)	2 (3.2)	0.006	(0.001 - 0.217)	29 (46.8)
Vegetables (193)	4.73	(1.89 - 13.28)	6 (3.1)	0.256	(0.001 - 1.583)	64 (33.2)
Legumes (42)	6.55	(1.49 - 10.90)	1 (2.4)	0.001	(0.001 - 0.343)	25 (59.5)
Potatoes (14)	3.63	(2.93 - 4.66)	5 (35.7)	0.046	(0.001 - 0.509)	5 (35.7)
Fresh fruits (65)	1.75	(0.67 - 3.09)	10 (15.3)	0.001	(0.001 - 0.207)	34 (52.3)
Dry fruits (39)	2.30	(0.01 - 4.11)	1 (2.6)	0.648	(0.125 - 2.250)	8 (20.5)
Sweets (64)	7.06	(3.58 - 15.70)	0 (0.0)	0.386	(0.056 - 2.211)	11 (17.2)
Oils and fats (22)	0.83	(0.25 - 2.64)	1 (4.5)	0.001	(0.001 - 0.134)	13 (59.1)
Beverages (96)	3.47	(0.98 - 10.44)	1 (1.0)	0.079	(0.020 - 0.230)	7 (7.3)

Table 1. Levels of lead and thallium in analyzed samples divided according to food categories. N: number of samples, IQR: interquartile range, LOD: limit of detection of 0.003 μg/kg and 0.001 μg/kg for lead and thallium, respectively.

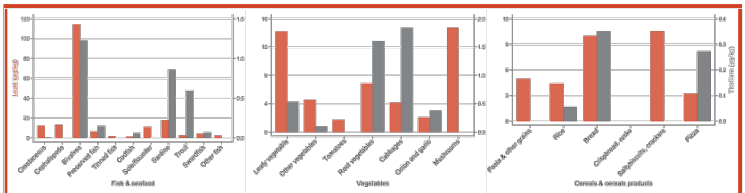

Figure. Levels of lead (red columns) and thallium (gray columns) in food composing main contributor food categories (fish & seafood, vegetables and cereals)

Results

In the 890 analyzed food samples, the highest lead contamination levels were found in fish & seafood, vegetables, sweets and beverages. The estimated dietary intake of lead was 5.758 (interquartile range - IQR: 4.547-7.427) μg/day, corresponding to 0.089 (IQR: 0.069-0.113) μg/kg of body weight (bw) per day, with cereals, beverages and vegetables as major contributors.

About thallium, one third of specimens showed very low levels below the limit of detection, with the highest contamination levels in vegetables, dry fruits and sweets. The estimated dietary intake of thallium was 0.236 (IQR: 0.183-0.312) μg/day, mainly due to vegetables, beverages, cereals and sweets.

	Lead (μg/day)		Thallium (μg/day)	
Food	**50th**	**(IQR)**	**50th**	**(IQR)**
Cereals	1.275	(0.758 - 1.901)	0.036	(0.020 - 0.051)
Meat	0.448	(0.290 - 0.631)	0.020	(0.012 - 0.032)
Milk & dairy products	0.296	(0.206 - 0.422)	0.023	(0.012 - 0.039)
Eggs	0.004	(0.002 - 0.007)	0.006	(0.003 - 0.009)
Fish & seafood	0.197	(0.094 - 0.410)	0.002	(0.001 - 0.007)
Vegetables	1.034	(0.624 - 1.566)	0.049	(0.031 - 0.083)
Legumes	0.088	(0.042 - 0.157)	-	
Potatoes	0.065	(0.037 - 0.117)	0.001	(0.000 - 0.001)
Fresh fruits	0.448	(0.280 - 0.631)	-	
Dry fruits	0.001	(0.000 - 0.004)	-	
Sweets	0.347	(0.198 - 0.589)	0.037	(0.018 - 0.063)
Oils and fats	0.018	(0.013 - 0.024)	-	
Beverages	0.854	(0.444 - 1.599)	0.028	(0.013 - 0.055)
Total	**5.738**	**(4.547 - 7.427)**	**0.241**	**(0.183 - 0.316)**

Conclusions

In conclusion, our study provides an estimation of lead and thallium intake in a Northern Italian community and shows a generally low exposure levels from dietary sources. However about lead, despite its environmental exposure decreased in the last decades, a threshold for critical lead-induced effects could not be established. Our results particularly show that intake levels of a portion of the study population are still at risk for the development of adverse health effects, including impairment of systolic blood pressure (>0.50 μg/kg of bw/day) and chronic kidney disease (>0.63 μg/kg bw/day).

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