Cumulative dietary exposure to four heavy metals in Finland

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INTRODUCTION

Heavy metals such as cadmium, lead, arsenic and mercury are ubiquitous in nature and enter the food chain through raw agricultural products and water. The toxicological reference values for lead and methyl mercury are based on their neurotoxic effects such as decreasing the cognitive abilities of children after pre-birth or early-life exposure. Literature also suggests that cadmium and inorganic arsenic can damage the nervous system, although to our knowledge, no dose-response data for humans has been reported. As people are exposed to the four heavy metals simultaneously through their daily diet, and as the compounds affect the same organ, we assessed, in a pilot study, the effect of exposure to the mixture, which Finnish people are exposed to through their usual diet, as well as the main sources of exposure to the heavy metal mixture.

METHODOLOGY

This work is based on further processing of exposure data from DOI 10.5281/zenodo.851785 and DOI 10.5281/zenodo.3772612. The exposure assessments on single heavy metals reported in the links were based on occurrence data from national monitoring, supplemented by analysis data from research projects and some own control results from industry, as well as food consumption data collected in the DIPP and FinDiet 2012 surveys. For adults, the whole diet was included in the assessment, while for children, some food groups with minimal exposure, e.g. eggs or fats, were not included due to limitations on the original exposure assessment. The online program MCRA was used to assess the exposure from these data.

Cumulative exposure was estimated by using relative potency factors (RPF) derived from the literature for the neurotoxic effects of cadmium, lead, inorganic arsenic and methyl mercury. The most neurotoxic compound had RPF 1 and the others RPF <1. The exposure of Finnish children (3 to 6 years) and adults (25 to 64 years) to the mixture was assessed, combining the RPFs and the results of exposure to the individual compounds.

RESULTS

With the RPFs we used and explained in Suomi et al. (2017), lead contributed ca. 75 % and 66 % to the heavy metal mixture exposure of children and adults, respectively; cadmium contributed 17 %, inorganic arsenic 6-7 % for children and 13 % for adults, and methyl mercury contributed only 3 to 4 % as its only source was fish and seafood. The margin of exposure between the benchmark dose of neurotoxicity of lead and the median exposure of 3-year-old and 6-year-old children was only 1.2 and 1.4, respectively, while for adults it was 2.4. The main source of heavy metal exposure, particularly for children, was cereals and cereal products; they contributed 37-40 % of the total exposure. The concentrations measured in these foodstuffs were clearly below the maximum levels of (EC) 1881/2006, but due to their high and frequent consumption, they are an important source for three (Cd, Pb, As) of the four studied heavy metals.

The toxicological data from the literature are not directly comparable, since some were from human epidemiological studies and some were from animal tests with a different neurotoxic effect measured as the endpoint. Therefore, the results presented here are to be considered indicative.

DISCUSSION

Lead was the most potent neurotoxicant of the studied heavy metals, and was therefore used as the reference compound in the mixture assessment. The margin of exposure between the toxicological endpoint for lead and the median exposure to the heavy metal mixture was low, considering that EFSA estimates MOE of 10 or higher (for lead exposure alone) to be of negligible risk. The lead exposure alone in the studied age groups already exceeded the dose for negligible risk, which means that the risk of neurological damage visible as cognitive defects cannot be ruled out, neither for lead alone nor especially for the mixture of lead, cadmium, arsenic and mercury that Finnish people are exposed to through their diet.

The authors thank Liisa Valsta, Suvi Virtanen and Sari Niinistö (THL) for their expertise on the food consumption data, and the Finnish Food Authority, Customs Laboratory, Finnish Food and Drink Industries' Federation, Finnish Environment Institute, Natural Resources Institute Finland and the University of Helsinki for the occurrence data of heavy metals in foodstuffs. The results concerning 6 year olds have been published in Suomi et al., 2017 (DOI: 10.1080/10807039.2017.1314760).