Dietary exposure of Finnish children and adults to inorganic arsenic

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Introduction

Inorganic arsenic is an environmental carcinogen, and it enters the food chain through plants taking up the heavy metal from the soil as well as through water. International expert organizations have determined that there is no safe threshold value for inorganic arsenic exposure (EFSA 2009), and therefore, the margin of exposure to a benchmark dose is used to estimate the risk to consumers. Benchmark doses have been determined by e.g. the FAO/WHO expert group (JECFA 2011) based on cancer risk increase, particularly that of lung cancer, with dietary exposure via food and drinking water.

Materials & Methods

The occurrence data for arsenic comprised national monitoring data or research project results from Finnish Food Authority, Customs Laboratory, Finnish Environment Institute and National Resources Institute Finland, as well as industry data. The national data were supplemented by literature data, mainly from EFSA (2014), for foodstuffs with no national analysis results. Most of the data were of total arsenic, and the relative portion of inorganic arsenic was estimated using fixed percentages: 100% in water, 2% in fish, 3.5% in seafood, and 70% in all other foodstuffs. The data used for calculation of children's exposure is described in (Suomi et al. 2015; Suomi et al. 2018).

The food consumption data for children aged 1 to 6 years were collected in Type 1 Diabetes Prediction and Prevention (DIPP) Study (Kyttälä et al. 2008) as 3-day food diaries. The food consumption data for Finnish adults of 25 to 74 years were collected in the FINDIET 2012 Survey (Helldán et al. 2013) as 48-h food recall interviews. The food consumption was calculated to ingredient level and used in the calculations at individual level for each foodstuff. The consumption data of children in the study did not span the entire diet: some of the less used foodstuffs with low concentrations, e.g. eggs and fats, were not included. The consumption data of adults were comprehensive.

The online program MCRA v.8.0 (MCRA 2013) was used for dietary exposure assessment. The dataset on concentrations in different foodstuffs and the datasets on individual food consumption data were combined probabilistically.

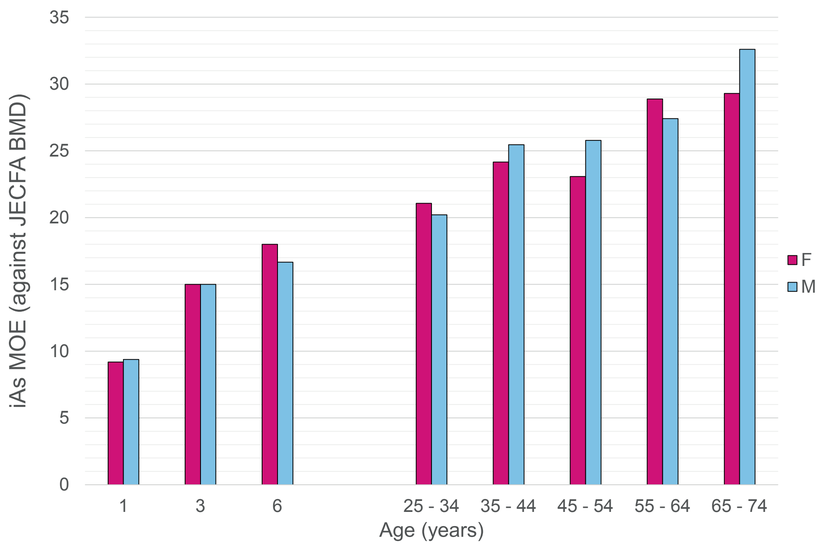

Figure 1. Margin of exposure (benchmark dose divided by mean exposure to inorganic arsenic) for the different age groups. Women (F) and men (M) are shown separately. The BMD_{05} determined by JECFA (2011), 4.5 µg/kg body weight / day, is based on increased risk for cancers, particularly lung cancer, with dietary exposure.

Results and Discussion

Exposure to inorganic arsenic is highest for the youngest children and decreases with increasing body weight and change in consumption habits. The margin of exposure is inversely correlated with exposure. (Figure 1). The margin of exposure was lowest for 1-year-old girls, for whom it was slightly above 9, and highest for 65–74-year-old men, for whom it was nearly 33. These values mean that the risk for cancer from dietary exposure in Finland is low to moderate.

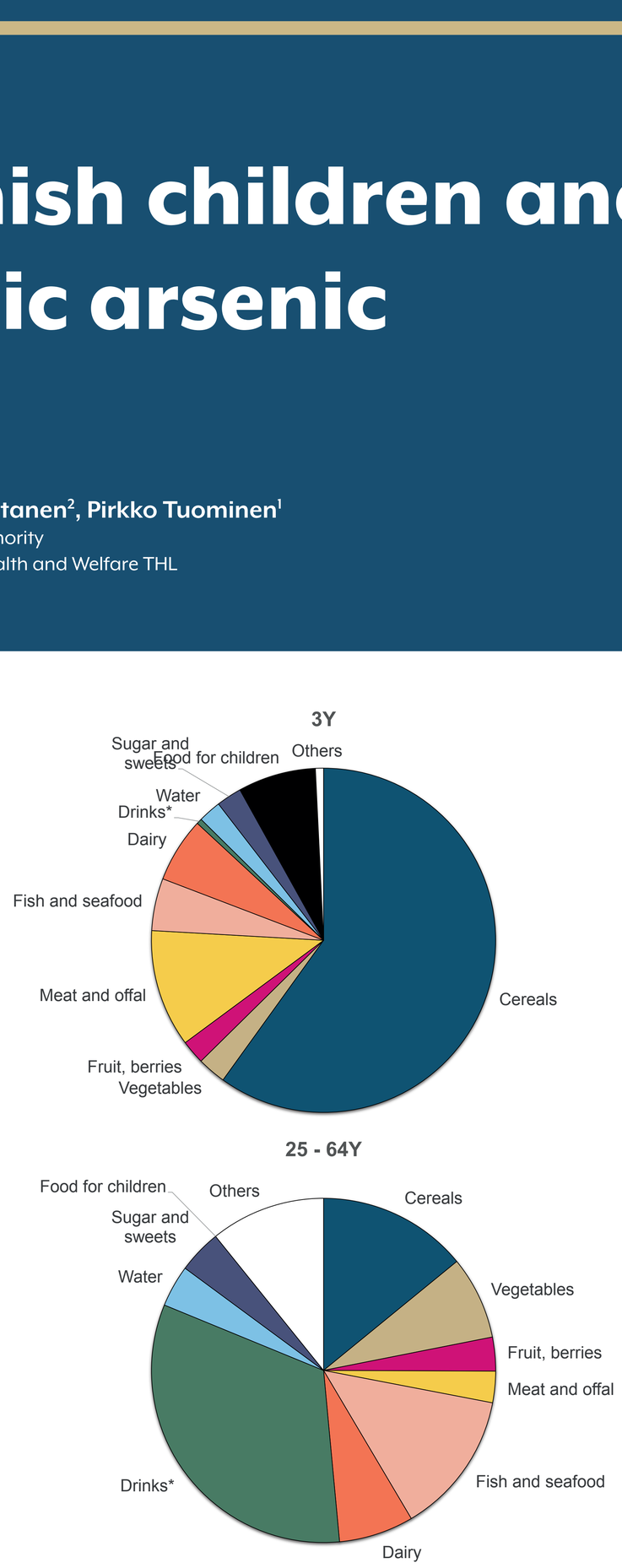

Figure 2. The sources of inorganic arsenic exposure for Finnish children of 3 years and adults of 25 to 64 years. The group "cereals" includes rice. The group "drinks" includes both nonalcoholic and alcoholic drinks, juices and follow-on formulae.

Cereal products were the main source of inorganic arsenic for children and an important source also for adults (Figure 2). Rice contributed more than half of the exposure from cereals, despite its fairly low consumption. The mean total arsenic concentration in rice was 218 µg/kg, while the concentration in other cereal grains was 18 to 73 µg/kg. The concentrations in other foodstuffs were mostly low.

The main source of inorganic arsenic in the adult population was drinks, particularly nonalcoholic ones, which include e.g. rice drinks.

The inorganic arsenic exposure from foods and tap water in this study is low compared to the exposure that can occur from habitual consumption of contaminated well water. Thus, individuals drinking well water in arsenic-rich areas have a higher risk than the population average presented here.

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