Intake of Polybrominated Diphenyl Ethers from Food in Finnish Children Aged One to Six Years: Risk Management Implications

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Introduction

Polybrominated diphenyl ethers (PBDEs) used as flame retardants are detected worldwide at present. Human exposure is commonly evidenced (McDonald 2005, Sjödin 2003, Toms et al. 2009) with potential adverse effects (Main et al. 2007, Wenning 2002). It is presumed that food and fish are the main sources for the general exposure to PBDEs in Finland (Isosaari et al. 2006; Kiviranta et al. 2004, 2006). Due to concerns of higher intakes in children compared to adults, we estimated for the first time both the sum and individual congener intakes of PBDEs from food in Finnish children. Children-specific intake estimates are also needed for risk management purposes.

Materials and Methods

We investigated the gender-specific food consumption of 1, 3, and 6 years old Finnish children by 3-d food records using participants of a Finnish Type 1 diabetes prediction and prevention study (a population-based cohort study) as study subjects (Kupila et al. 2001, Virtanen et al. 2006). We measured the concentrations of PBDEs in all the main food items used, and used these two existing databases, food consumption data and food contamination data, to derive the PBDE lower and upper bound intakes as probability distributions to account for the variation both in the intakes and the contaminant analyses. Our data corresponds to years 2002-2005.

Results and Discussion

The daily upper bound PBDE intakes from food were on average 0.98 (±0.87), 1.51 (±1.16), 1.49 (±0.93) and 1.03 (±0.92), 1.41 (±0.83), 1.11 (±0.60) ng/kg bw by the boys and girls of 1, 3 and 6-years

of age, respectively (Fig 1). The food-mediated intakes in Finnish children appeared to be at the same level as with the children in the U.S., but contrary to Finland, additionally other important sources of exposure seem to account for the total population exposure in the U.S. (Schecter et al. 2006). The lower bound intakes of PBDEs were on average 78 (±6) % of those measured upper bound (Fig 1).

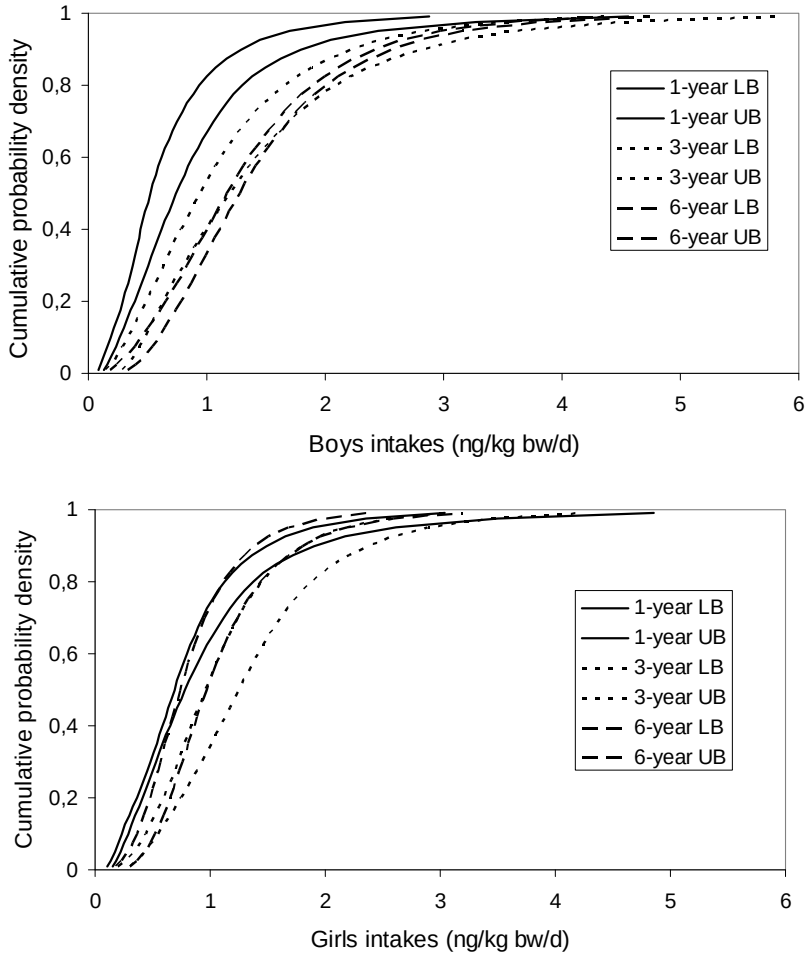

Figure 1. The cumulative probability density of lower bound and upper bound sum of PBDE intakes (ng/kg bw/d) in Finnish 1, 3 and 6 year-old boys and girls based on a 3-d food record study. Year-class-specific upper bound intakes are always higher.

Among the PBDE congeners, intake of BDE-47 was the highest. Other congeners detected were in descending order of their mean daily ingestion levels: 99>100>154≈153>183>66>119>85 (Fig 2). This is a typical exposure pattern to PBDEs by humans and other top predator species worldwide (Boon et al. 2002, Hites 2004, Law et al. 2006). BDEs 28, 71, 75, 77, 138 and 209 were not detected in the foodstuffs analyzed.

Based on a preliminary LOAEL (lowest-observed-adverse-effect-level) of 1 mg/kg bw/d (Darnerud et al. 2001) and on the maximum intake observed in our data, 5.8 ng/kg bw/d for 3-year-old boys, a

safety margin in the intakes of Finnish children – if we base our estimation to a benchmark dose approach and roughly assume a NOAEL (no-observed-adverse-effect-level) to be one order of magnitude lower – is in the order of 10^4. For PBDEs, no provisional tolerable intake or corresponding resting on a solid threshold has been established so far (FAO/WHO JECFA, 2005).

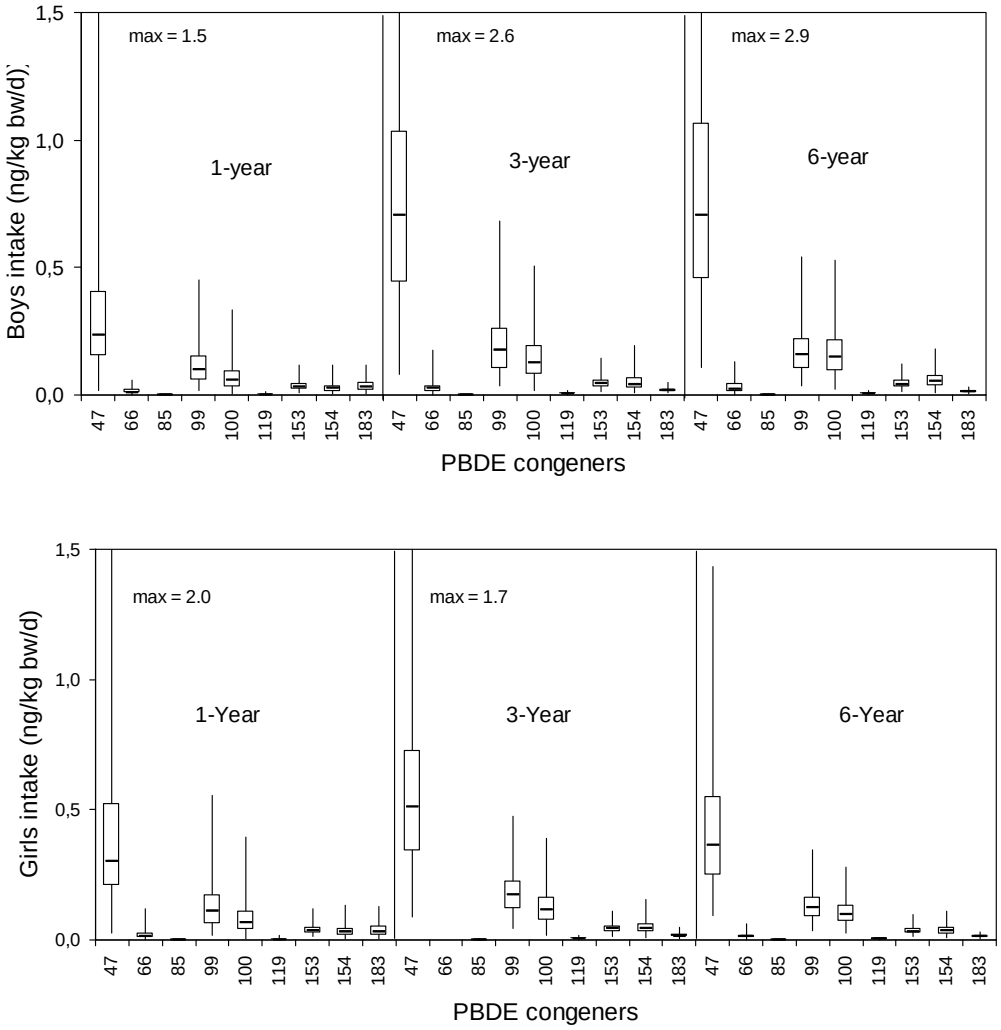

Figure 2. PBDE congener-specific lower bound intakes (min, 1st quartile, median, 3rd quartile, max) in Finnish 1, 3 and 6 year-old boys and girls.

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