Cadmium exposures in infants aged 0 to 12 months and young children aged 1 to 5 years

In this guide

Sources of cadmium exposure

Human breast milk

24. In general, low levels of cadmium are found in breast milk (EFSA, 2009).

25. As part of the 2004 SUREmilk study, levels of cadmium were measured in breast milk from women in the UK. In 104 samples, only one had a concentration at the limit of detection (LOD) of 0.3 µg/kg, the remainder being below this value (Woolridge *et al*., 2004). The COT[1] previously noted that the SUREmilk samples were collected primarily to explore the viability of breast milk collection methods and did not constitute a rigorous survey. Nevertheless, in the case of metals, the Committee was able to conclude that estimated intakes associated with the highest detected concentrations in the breast milk samples did not raise toxicological concerns, based on comparison with available health-based guidance values. Literature searches for papers on cadmium in breast milk found a number of publications more recent than the EFSA opinion of 2009 but the most recent data for the UK other than SUREmilk was from 1984. Since only one of these papers considered data from the UK, the evaluation was widened to include non-UK data. These data are summarised in Table 1 below.

Table 1. Concentrations of cadmium breast milk available from the published literature.

Country	**Number of samples**	**Average concentration (µg/L)[a]**	**Maximum concentration (µg/L)**	**Reference**
UK	28	0.40+0.28	1.20	Kolvar *et al,* 1984
UK	104	-	0.3(LOD)	Woolridge *et al*, 2004
Poland		0.11+ 0.07**	-	Olszowsk *et al*, 2016
Turkey	107	1.62*	-	Dursun *et al,* 2016
Poland	323	2.11±6.33	7.36	Winiarska-Mieczan, 2014

China	-	-	0.23	Sun *et al,* 2013
Turkey	64	4.62 (single sample)	6.35	Gürbay *et al,* 2012
Taiwan	34	0.35+0.18	-	Chao *et al,* 2014
Spain	30	1.31	-	García-Esquinas *et al,* 2011

** Mean and standard deviation excluding samples below the detection limit of 0.15 µg/**L.**

Average concentration is the mean or median, where it is the median this has been indicated with *. Where it was available, the standard deviation has also been provided (as ±…).

26. In 1984, Kolvar *et al* collected breast milk from 28 nursing mothers at 5 days postpartum and analysed it for cadmium using atomic absorption spectrometry after electrothermal excitation in a graphite furnace. Although demographic and lifestyle data were collected (place of residence relative to sources of pollution such as major roads and industrial chimneys and smoking habits) these were not taken into account when the results were presented.

27. In the absence of other UK data on cadmium in breast milk and the fact that the data from the Kolvar study are of a similar order of magnitude as some of the later studies from around the world, the values from this study have been used in the present paper. This study had several shortcomings that may have compromised its accuracy (small sample size, no accounting for demographic data, lower analytical sensitivity in 1984 than is now available) and for these reasons it is possible that these values may be overestimates.

28. In 2006, a report by AEA Technology for Defra, the Welsh Assembly. Scottish executive and Department of the Environment for Northern Ireland showed that UK environmental emissions of Cd had fallen by 83% (26.3 to 4.5 tonnes/ year) between 1970 and 2002. The major contributor to emissions,

municipal solid waste incineration, fell from about 9.5 tonnes/ year to about 0.5 tonnes between 1993 and 1997 and was about 0.3 tonnes/ year in 2002. Emissions from coal and oil industries fell from around 4 tonnes/ year to under 1 tonne/ year and metals industry from 9 to about 2.4 tonnes/ year between1970 to 2002. The European Environment Agency (2016) reported that Cd emissions had fallen across most European countries between 1990 and 2014, with the UK having the third greatest fall at 86% (after Malta and Slovakia). In the same period, emissions from Spain had fallen by 68%, while those from Poland had fallen by 38%. No absolute values were reported. Changes in cadmium, mercury and lead emissions for each sector (EEA-33) — European Environment Agency (europa.eu).

29. While there appears to be a linear relationship between soil concentration and uptake of cadmium into plants in any particular soil type, the soil mobility of cadmium and hence its percentage uptake varies with soil pH and organic and mineral matter content (Smolders, 2001; McBride *et al.*, 2014). Low pH and lack of sequestering agents in the soil lead to increased uptake of Cd into plants.

30. Defra's report on the development of Category 4 Screening Levels for assessment of land affected by contamination - SP1010 (Development of Category 4 Screening Levels for assessment of land affected by contamination - SP1010 (defra.gov.uk) suggests that the range of soil pH may lead to the uptake of cadmium into crops to be under or over estimated by a factor of 10. However, since most soil on allotments, which may be more contaminated than soil used in commercial enterprises, is in the pH range of 6 – 8, there is less of an effect of pH range on uptake in this scenario.

31. Deposition of Cd from atmospheric emissions appears to make a minor contribution to total Cd levels in crops in areas where deposition is low but can be a major source of Cd in plants where deposition is elevated, for example in the vicinity of smelting sites. The aerial parts of plants are initially affected but Cd also accumulates in roots and other tissues (Smolders, 2001).

32. Thus industrial emissions may lead to contamination of crops by cadmium to an extent unrelated to the content of the soil. Reducing emissions from metallurgical sites may therefore reduce the level of cadmium in the food chain and hence levels in breast milk.

Infant formulae and food

33. Concentrations of cadmium have recently been measured in an FSA survey of metals and other elements in infant formulae and foods (e.g. commercial infant foods) (referred to as the Infant Metals Survey, FSA 2016a), and in the composite food samples of the 2014 Total Diet Study (TDS, FSA 2016b).

Food contact materials

34. The migration of cadmium from food contact materials could represent an additional source for the presence of cadmium in food and drinking water. The EU, in Council Directive (84/500/EEC) – migration of lead (Pb) and cadmium (Cd) into food contact ceramic articles, has set a migration limit for cadmium from ceramic glazes into liquids contained in fillable articles as follows:

Table 2. Permissible limits of release of Cd from food contact articles.

Category of ceramic wares	**Permissible limit of Cd release**
(1) Articles which cannot be filled and articles which can be filled, the internal depth of which, measured from the lowest point to the horizontal plane passing through the upper rim, does not exceed 25 cm.	0.07 mg/dm^2
(2) All other articles which can be filled	0.3 mg/l
(3) Packaging and storage vessels having a capacity of more than three litres	0.1 mg/l

35. Rebeniak *et al.* (2014) analysed cadmium migration into 4% aqueous acetic acid from the decoration on 1273 samples of ceramic and glass ware from the EU and Asia. Only 7% of the category (1) products (shallow articles) showed Cd migration. None exceeded the permissible limit. In category (2) (deeper articles), 8.6% of the samples had detectable Cd migration, within the permissible limit. For glassware with highly decorated rims, 19% of beverage glasses and 7% of wine/vodka glasses exceeded the permissible limit and a further 11% of the samples had detectable levels. No exceedances were detected for migration from

the inner surfaces. The authors pointed out that in use, migration would probably be lower than into the food simulant, food contact time would be shorter than that used (24 hours), and migration would decline with each use of the vessel.

Drinking water

36. The primary sources of cadmium in drinking water are leaching into groundwater, as a consequence of dissolution from cadmium ore-bearing rocks, and anthropogenic sources (WHO, 2011).

37. In water, cadmium is present as Cd(II). In their assessment, EFSA found the contribution of drinking water to the total exposure to cadmium to be very small across all age groups (EFSA, 2009).

38. EU legislation has set a value of 5.0 μg/L for cadmium in water intended for human consumption (Directive 98/83/EC), and a maximum level of 3 μg/L in natural mineral waters (Directive 2003/40/EC). The WHO has established a guidance level of 3 μg/L for cadmium in drinking water (WHO, 2011).

39. Levels of cadmium in drinking water in 2014/2015 from England and Wales, Northern Ireland and Scotland were provided by the Drinking Water Inspectorate (DWI), Northern Ireland Water and the Drinking Water Quality Regulator (DWQR) for Scotland, respectively. Median and 97.5th percentile values calculated from this data are shown in Table 3. These values have been used to calculate exposures to cadmium from drinking water in combination with exposures from food.

Table 3. Median and 97.5th percentile concentrations (μg/L) of cadmium in water across the UK for 2014/2015.

Country	**Number of samples**	**Limit of Detection (μg/L)**	**Median concentration (μg/L)**	**97.5th Percentile concentration (μg/L)**
England and Wales	13325	0.01-0.10*	0.04	0.25
Northern Ireland	392	0.01	0.01	0.16

Scotland	1500	0.02	0.02	0.40

* The DWI noted that the water companies had reported a range of LODs that varied with the analytical method used, and clarified that the relevant drinking water regulations specify that the LOD must not be more than 10% of the prescribed value (5 µg/L for cadmium).

Environmental

Dust

40. Harrison (1979) determined the levels of cadmium and other metals in outside and domestic dust samples collected in Lancaster. “Available” cadmium levels in domestic dust, i.e. those extractable from the dust by 0.07N HCl to mimic gastric acid, were 7.3 + 6.2 mg/g (Mean + SD, n = 4, range 1.0 – 14.0 m g/g).

41. Turner and Simmonds (2006) determined the concentration of cadmium in 32 household dust samples from 4 regions of the UK (Birmingham, Plymouth and rural areas within 50 km of each of these cities) by ICP-MS. Across all of the samples, the median and maximum values were 1.1 and 4.9 mg/g respectively. These values will be used in the exposure assessment.

Soil

42. Cadmium is present at about 0.1 mg/kg in the Earth’s upper continental crust (Rawlins *et al*., 2012). It occurs naturally at high levels in some types of rock, and is released to soils from anthropogenic activities such as smelting. A total concentration of 10 mg/kg (for sandy loam soil) was adopted as the Soil Guideline value for residential soils (Environment Agency, 2009) and is well above the concentration found in most soils.

43. Concentrations of cadmium were measured in 5,670 topsoil (from a depth of 0 to 15 cm) samples collected between 1978 and 1982 in England and Wales. Samples were analysed 30 years later (Rawlins *et al.*, 2012). The median and 90th percentile concentrations were reported as 0.33 and 0.88 mg/kg, respectively.

44. In 2012 and 2013, Defra published normal background concentrations (NBCs) for cadmium in soil in England and Wales (Defra, 2012 and 2013). An NBC

is the 95th percentile upper confidence interval of the available data; it is defined as a contaminant concentration that is seen as typical and widespread in top-soils (depth 0 - 15 cm). In order to establish meaningful NBCs, the available soil data were grouped in domains (e.g. principal, urban, and ultrabasic) that were defined by the most significant controls on a contaminant's high concentrations and distribution. The NBCs for each domain in England and Wales were published following a Defra-commissioned British Geological Survey (BGS) project to define the typical background concentrations for soil contaminants.

45. As part of the BGS project, summary statistics were derived from topsoil data from 2 or 3 core datasets held for England and Wales (Ander *et al*., 2012 and 2013). Although the NBCs and summary statistics were derived for several domains for England and Wales, the most significant domain for each country was the principal domain. The principal domains are areas which do not contain significantly elevated levels of cadmium. Overall, for England and Wales, the area covered by the principal domains constitutes approximately 99% and 94% of each country respectively. The summary statistics reported for the principal domain in England were a median of 0.31 mg/kg and a 95th percentile of 1.0 mg/kg (n = 4418 samples). The statistics reported for the same domain in Wales were a median of 0.33 mg/kg and a 95th percentile of 1.2 mg/kg (n = 685 samples).

46. Between 2004 and 2006, 6,862 samples of rural surface soil (depth 5 – 20 cm) were collected from sites in Northern Ireland as part of the Tellus survey. The samples were collected on a systematic basis and following the protocols set out in the BGS's Geochemical Baselines Survey of the Environment (G-BASE) programme. The limit of detection (LOD) used was 0.5 mg/kg (Smyth and Johnston, 2013). The median and 95th percentile concentrations derived from the data[x] are 0.50 and 1.0 mg/kg, respectively.

47. The median value of 0.5 mg/kg (the LOD) and the highest 95th percentile concentration value for cadmium in soil from the Defra-commissioned BGS project on NBCs (1.2 mg/kg) have been used to estimate exposures to soil in the present assessment. These data have been used as they are recent, and represent a relevant domain for estimating exposure for the general population.

Air

48. In the atmosphere cadmium occurs mainly as fine respirable particles (1 µm) and is eventually suspended onto particulate matter from sea spray, industrial emissions and the burning of fossil fuels. Metallic cadmium has a very

low vapour pressure and thus would not be expected to make much contribution to atmospheric levels except in the vicinity of smelting works where vaporisation could occur. Anthropogenic sources account for more than 80% of the atmospheric cadmium burden, with the remainder accounted for by natural sources such as soil dust, volcanoes and forest fires (EFSA, 2009).

49. The EU Fourth Daughter Directive (2004/107/EC) defined the 'target value' for cadmium in the PM10 particulate fraction of ambient air as 5 ng/m^3. The DEFRA Technical report on UK supplementary assessment under the Air Quality Directive (2008/50/EC), the Air Quality Framework Directive (96/62/EC) and Fourth Daughter Directive (2004/107/EC) for 2012 found no exceedances of the target value for Cd.

50. Data from 22 air sampling sites across the UK (2 in Northern Ireland, 2 in Scotland and the rest distributed across England and Wales) are collected annually by Defra (Lead, Trace Elements and Industrial Metals data - Defra, UK).The latest data, for 2015 have yielded median values across the sites of 0.0238 to 1.18 ng/m^3 and maximum values of 0.0418 to 16.8 ng/m^3. The latter maximum value and a value of 10.3 ng/m^3 were both from a sampling site near Walsall and the only samples to exceed the 5 ng/m^3 limit set by the 4^{th} Daughter directive.

51. While infants are very unlikely to actively smoke tobacco, the presence of second-hand smoke in the home is a possible route of exposure to cadmium. In a study in Korea, Jung *et al*. (2015) found a significant positive relationship between B-Cd levels and exposure to second-hand smoke in non-smoking women at work (p 0.001) and at home (p 0.04) after > 1 hour of exposure. However, Richter *et al*. (2009) in the USA found no relationship between second-hand smoke exposure and urinary Cd concentrations in 7766 -12 year-old children, although levels increased in non-smokers' urine with age.

[1] suremilk.PDF (food.gov.uk)