Exposure assessment - Statement on potential risks from cadmium in the diet of infants

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52. Consumption data (on a bodyweight basis) from the Diet and Nutrition Survey of Infants and Young Children (DNSIYC) (DH, 2013), and the National Diet and Nutrition Survey Rolling Programme (NDNS) (Bates *et al.*, 2014) have been used for the estimation of dietary exposures for ages 4 to 18 months, and 18 to 60 months respectively. Bodyweight data used in the estimation of other cadmium exposures are shown in Table 4 below.

53. Thorough exposure assessments have been performed for the dietary sources of exposure to cadmium. The assessments for the non-dietary

sources of exposure (i.e. dust, soil and air) have been included to give a more holistic view of exposures, but are not as detailed since the focus of this statement is the diet of infants and young children.

Table 4. Average bodyweights used in the estimation of cadmium exposures where individual body weights are unavailable.

Age group (months)	Bodyweight (kg)
0 to 4	5.9[a]
4 to 6	7.8[b]
6 to 9	8.7[b]
9 to 12	9.6[b]
12 to 15	10.6[b]
15 to 18	11.2[b]
18 to 24	12.0[c]
24 to 60	16.1[c]

a DH, 1994,

b DH, 2013,

Bates *et al*., 2014.

Infants (0 to 12 months)

Breast milk

54. No consumption data were available for exclusive breastfeeding in infants aged 0 to 6 months. Therefore, the default consumption values used by

the COT in other evaluations of the infant diet of 800 and 1200 mL for average and high level consumption have been used to estimate exposures to cadmium from breastmilk. These estimates were based on a mean cadmium concentration of 0.4 µg/L and a maximum of 1.2 µg/L. The ranges of exposure to cadmium in exclusively breastfed 0 to 6-month olds were 0.041 to 0.16 and 0.062 to 0.24 µg/kg bw/day in average and high level consumers respectively (Table 5).

Table 5. Estimated cadmium exposure from exclusive breastfeeding in 0 to 6 month old infants.

Cadmium concentration (µg/L)	**Average consumer: Exposure (µg/kg bw/day)**	**Average consumer: Exposure (µg/kg bw/day)**	**High consumer: Exposure (µg/kg bw/day)**	**High consumer: Exposure (µg/kg bw/day)**
	(800 mL/day)	**(800 mL/day)**	**(1200 mL/day)**	**(1200 mL/day)**
Cadmium concentration (µg/L)	**0 to 4 months**	**4 to 6 months**	**0 to 4 months**	**4 to 6 months**
Mean 0.4	0.054	0.041	0.081	0.062
Max 1.2	0.16	0.12	0.24	0.18

Values rounded to 2 significant figures (SF).

55. Data on breast milk consumption for infants aged 4 to 18 months were available from the DNSIYC and the NDNS, and have been used to estimate exposures at these ages (Table 6), based on a mean cadmium concentration of 0.4µg/L and maximum concentration at 1.2 mg/L. There were too few records of breast milk consumption for children older than 18 months in the NDNS to allow a reliable exposure assessment, and breast milk is expected to contribute minimally in this age group.

56. Mean exposures to cadmium for 4 to 18-month olds were 0.010 to 0.037 µg/kg bw/day at 0.4 mg Cd/L and 0.03 to 0.11 µg/kg bw/day at 1.2 mg Cd/L

The 97.5th percentile exposures were 0.021 to 0.062 µg/kg bw/day at 0.4 mg Cd/L and 0.063 to 0.20 µg/kg bw/day at 1.2 mg Cd/L (Table 6).

Table 6. Estimated cadmium exposure in 4 to 18-month old infants from breast milk.

Exposure (µg/kg bw/day	**Age group (months)**	**Age group (months)**	**Age group (months)**	**Age group (months)**	**Age group (months)**
Mean@0.4 mg Cd/l	0.037	0.027	0.015	0.012	0.010
97.5th percentile @0.4 mg Cd/l	0.062	0.067	0.046	0.030	0.021
Mean@1.2 mg Cd/l	0.11	0.081	0.048	0.036	0.030
97.5th percentile @1.2 mg Cd/l	0.19	0.20	0.14	0.090	0.063

Values rounded to 2 SF.

Infant formulae and complementary foods

57. Cadmium exposure estimates for this category were derived using occurrence data from the Infant Metals Survey (FSA, 2016a), based on both lower bound (LB) and upper bound (UB) concentrations. Exposure estimates for 0 to 6-month olds were calculated for exclusive feeding on infant formulae using the default consumption values of 800 and 1200 mL (Table 7). Consumption data from the DNSIYC were used to estimate exposures for 4 to 12-month olds (DH, 2013).

58. In 0 to 6-month olds, exposures to cadmium from ready-to-feed formula were 0 to 0.03 µg/kg bw/day in average consumers, and 0 to 0.04 µg/kg bw/day in high level consumers. Exposures to cadmium calculated for

reconstituted formula incorporating the water concentration from the TDS, and the highest median and 97.5th percentile concentrations for cadmium in water reported in Table 3 were 0.06 to 0.22 µg/kg bw/day in average consumers, and of 0.08 to 0.33 µg/kg bw/day in high level consumers (Table 7).

Table 7. Estimated average and high-level exposures to cadmium from exclusive feeding on infant formulae for 0 to 6 month olds.

Cadmium Exposure (LB-UB Range) (µg/kg bw/day).

Food	**0 to 4 months**	**0 to 4 months**	**4 to 6 months**	**4 to 6 months**
Infant Formula	**Average consumer (800 mL/day)**	**High level consumer (1200 mL/day)**	**Average consumer (800 mL/day)**	**High level consumer (1200 mL/day)**
Ready-to-Feed [a]	0-0.03	0-0.04	0-0.02	0-0.03
Dry Powder [b, c]	0.06-0.08	0.09-0.12	0.05-0.06	0.07-0.09
Dry Powder [c] + TDS water of 1.2 µg/L [d]	0.19-0.22	0.30-0.33	0.15-0.16	0.23-0.25
Dry Powder [c] + median water of 0.04 µg/L [d]	0.07-0.09	0.10-0.13	0.06-0.07	0.08-0.10
Dry Powder [c] + 97.5 [th] percentile water of 0.4 µg/L [d]	0.11-0.13	0.16-0.19	0.10-0.11	0.12-0.14

Values rounded to 2 SF.

a Exposure based on first milk infant formula using LB to UB cadmium concentrations of 0-0.2 µg/L.

b Exposure does not include the contribution from water.

c Exposure based on first milk infant formula using LB to UB cadmium concentrations of 3-4 µg/kg.

d Calculated assuming reconstituted formula comprises 85% water.

59. Total mean exposures (excluding water) to cadmium from infant formulae, commercial infant foods, and other foods, for 4 to 12 month olds were 0.12 to 0.28 µg/kg bw/day, and 97.5th percentile exposures were 0.45 to 0.62 µg/kg bw/day. Total mean and 97.5th percentile exposures were also calculated using the highest median and 97.5th percentile concentrations for cadmium in water reported in Table 3. The resulting total mean and 97.5th percentile exposures indicated that levels of cadmium in water made a negligible contribution to total exposure (Table 8).

Table 8. Estimated exposures to cadmium from infant formulae, commercial infant foods and other foods for 4 to 12-month olds.

Cadmium Exposure (LB-UB Range) (µg/kg bw/d).

Food	**Age Group**	**Mean**	**97.5th**
Infant formula	4 to 6 Months (n=116)	0-0.01	0.01-0.03
Infant formula	6 to 9 Months (n=606)	0-0.01	0-0.03
Infant formula	9 to 12 Months (n=686)	0-0.01	0.01-0.02
Commercial infant foods	4 to 6 Months (n=116)	0.05-0.06	0.23

Commercial infant foods	6 to 9 Months (n=606)	0.08	0.29-0.30
Commercial infant foods	9 to 12 Months (n=686)	0.08	0.32-0.33
Other foods	4 to 6 Months (n=116)	0.05-0.06	0.23
Other foods	6 to 9 Months (n=606)	0.08	0.29-0.30
Other foods	9 to 12 Months (n=686)	0.08	0.32-0.33
Total (excl. water)	4 to 6 Months (n=116)	0.12-0.13	0.45-0.48
Total (excl. water)	6 to 9 Months (n=606)	0.22-0.23	0.55
Total (excl. water)	9 to 12 Months (n=686)	0.27-0.28	0.60-0.62

Values rounded to 2 SF.

* Determined from a distribution of consumption of any combination of categories rather than by summation of the respective individual 97.5th percentile consumption value for each of the three food categories.

Children aged 12 to 18 months

60. Estimated exposures to cadmium from food for children aged 12 to 18 months were calculated using occurrence data from both the Infant Metals Survey (FSA, 2016a), and the 2014 TDS (FSA, 2016b). The exposure data derived from the Infant Metals Survey allow estimation of cadmium exposure in infant formula, commercial infant foods and the most commonly consumed adult foods ('other foods') as sold, whereas the results from the TDS are based on analysis of food that is prepared as for consumption. In addition, the Infant Metals Survey included analysis of infant formulae and commercial infant foods which are not included in the TDS. Exposure estimates based on both LB and UB concentrations are provided.

61. The consumption data from the DNSIYC were used for the estimation of exposure for children aged 12 to 18 months (DH, 2013).

Exposure estimates based on the Infant Metals Survey

62. The ranges of total mean and 97.5th percentile exposures (excluding water) to cadmium from infant formula, commercial infant foods and other foods were 0.26 to 0.27 and 0.54 to 0.58 µg/kg bw/day, respectively. As for infants the total mean and 97.5th percentile exposures including water (calculated using the highest median and 97.5th percentile values in Table 3) were equal to those estimated for the total mean exposures excluding water (Table 9).

Table 9. Estimated exposures to cadmium from infant formulae, commercial infant foods and other foods in children aged 12 to 18 months.

Cadmium Exposure (LB-UB Range) (µg/kg bw/d).

Food	**12 to 15 Months (n=670), Mean**	**12 to 15 Months (n=670), 97.5th**	**15 to 18 Months (n=605), Mean**	**15 to 18 Months (n=605), 97.5th**
Infant formula	0-0.004	0-0.02	0 – 0.002	0-0.01
Commercial infant foods	0.04	0.21-0.22	0.02	0.14

Other Foods	0.22-0.23	0.54-0.55	0.24-0.25	0.53
Total (excl. water)	0.26-0.27	0.56-0.58	0.26-0.27	0.54

Values rounded to 2 SF.

* Determined from a distribution of consumption of any combination of categories rather than by summation of the respective individual 97.5th percentile consumption value for each of the three food categories.

Exposure estimates based on the TDS

63. Table 10 shows the estimated cadmium exposures calculated using the TDS data for children aged 12 to 18 months. The cadmium concentration for the tap water group in the TDS was reported to be below the limit of detection (LOD) of 1.2 µg/L. This LOD is higher than that reported for cadmium in tap water by the water authorities across the UK (Table 3). The calculation was therefore also performed using the highest median (0.04 µg/L) and 97.5th percentile (0.40 µg/L) cadmium concentration in tap water reported in Table 3.

64. Table 10 refers to dietary intakes of Cd based on the Total Dietary Survey and illustrates that concurrent intake of UK water, whether at the highest recorded median or highest 97.5th percentile Cd concentration (see Table 3) has a negligible impact on the amount taken in with food. Total mean and 97.5th percentile exposures to cadmium from a combination of all food groups are in the region of 0.29 to 0.55 and 0.60 to 0.93 µg/kg bw/day, respectively (Table 10). These are higher than those estimated from the Infant Metals Survey due to the inclusion of a greater number of foods in the exposure estimate for the TDS.

Table 10. Estimated dietary exposure to cadmium based on the TDS data in children aged 12 to 18 months, taking into account the contribution from of UK water containing the highest median and 97.5th percentile concentrations of cadmium.

Dietary Cadmium Exposure (LB-UB Range) (µg/kg bw/day).

Cadmium concentration in the water				
12 to 15 Months (n=670), Mean	**12 to 15 Months (n=670), 97.5th**	**15 to 18 Months (n=605), Mean**	**15 to 18 Months (n=605), 97.5th**	
0.04 µg/L[a]	0.29-0.50	0.61-0.93	0.32-0.55	0.60-0.90
0.4 µg/L[b]	0.29-0.50	0.61-0.93	0.32-0.55	0.60-0.90

Values rounded to 2 SF.

a Highest median concentration in UK drinking water. [b] Highest 97.5th percentile concentration in UK drinking water.

65. In general, the food groups making the highest contribution to cadmium exposure were miscellaneous cereals, bread and potatoes (FSA, 2016b), as shown in Table 11.

Table 11 Contribution to total dietary cadmium exposure by the three food groups containing the highest levels of Cd based on TDS data.

Exposure-LB-UB (mg/kg bw/day).

Food Groups	**12 to 15, Mean**	**12 to 15, 97.5th Percentile**	**1518, Mean**	**1518, 97.5th Percentile**
Bread	0.053	0.15	0.060	0.16
Miscellaneous Cereals	0.090	0.28	0.11	0.32

Potatoes	0.070	0.26	0.065	0.21
Total	0.21	0.69	0.24	0.69

Children aged 18 months to 5 years

66. Exposure estimates for these age groups were derived using occurrence data from the 2014 TDS, and consumption data from the NDNS (Bates *et al*., 2014).

67. Table 12 shows the cadmium exposures that were calculated using the TDS data for children aged 18 months to 5 years as described in paragraph 62, the exposures have been estimated using the TDS water concentration (1.2 µg/L, the LOD), and the highest median (0.04 µg/L) and 97.5th percentile (0.4 µg/L) cadmium concentrations in water reported in Table 3. This results in total mean and 97.5th percentile exposures to cadmium from a combination of all food groups of 0.32 to 0.59 and 0.52 to 0.92 µg/kg bw/day, respectively (Table 12). Once more the figures in Table 12 demonstrate that the cadmium content of water has a negligible impact on total dietary exposure to cadmium of young children in the UK.

Table 12 Estimated dietary exposure to cadmium based on the TDS data in children aged 18 months to 5 years, taking into account the contribution from of UK water containing the highest median and 97.5th percentile concentrations of cadmium.

Dietary Cadmium Exposure (LB-UB Range) (µg/kg bw/day).

Cadmium concentration in water	**18 to 24 Months (n=70), Mean**	**18 to 24 Months (n=70), 97.5th**	**24 to 60 Months (n=429), Mean**	**24 to 60 Months (n=429), 97.5th**
0.04 µg/L[a]	0.34-0.59	0.57-0.92	0.32-0.52	0.52-0.80
0.4 µg/L[b]	0.34-0.59	0.57-0.92	0.32-0.52	0.52-0.80

Values rounded to 2 SF.

a Highest median concentration in UK drinking water. b Highest 97.5th percentile concentration in UK drinking water.

68. As with the younger children, the food groups making the highest contribution to cadmium exposure in the TDS were miscellaneous cereals, bread and potatoes (FSA, 2016b), shown in Table 13.

Table 13 Contribution to total dietary cadmium exposure by the three food groups containing the highest levels of Cd based on TDS data.

Exposure-LB-UB (mg/kg bw/day).

Food Groups	12 to 15, Mean	12 to 15, 97.5th Percentile	1518, Mean	1518, 97.5th Percentile
Bread	0.063	0.14	0.072	0.17
Miscellaneous Cereals	0.12	0.24	0.095	0.24
Potatoes	0.067	0.14	0.061	0.18
Total	0.25	0.52	0.23	0.58

Exposure to cadmium from soya-based infant formulae

69. Cadmium has been reported in powdered soya formula at a level of 11 µg/kg, which is higher than in other types of infant formulae (3 - 4 mg/kg for first milk infant formula, FSA, 2016a). This is because soybean plants concentrate cadmium from the soil by active uptake (Cataldo *et al*, 1983), even when grown in soils with permitted levels of the metal (Zhi *et al*., 2015). Therefore, exposure to cadmium from consumption of soya formula was considered separately. Using the EFSA default values of 800 and 1200 ml for exclusive consumption of infant formula for the 4 to 6-month age group, exposure estimates for cadmium in soya formula would be 0.17 and 0.26 µg/kg bw/day for average and high-level consumers, respectively before taking into account water used in reconstitution,

i.e. approximately 3 times the exposure for non-soya formula shown in Table 7.

Dust

70. Potential exposures of UK infants aged 6 to 12 months and young children aged 1 to 5 years to cadmium in dust were calculated assuming ingestion of 30 or 60 mg/day, respectively (US EPA, 2011a). Younger infants, who are less able to move around and come into contact with dust, are likely to consume less dust than children of these age groups. Median and maximum cadmium concentrations in dust of 1.1 and 4.9 mg/kg, respectively, were used to estimate average and high-level exposures (paragraph 48) (Table 14).

Table 14. Possible cadmium exposures from dust in infants and young children aged 6 months to 5 years.

Exposure (µg/kg bw/day).

Cadmium concentration (mg/kg)	Age (months) 6 to 9	Age (months) 9 to 12	Age (months) 12 to 15	Age (months) 15 to 18	Age (months) 18 to 24	Age (months) to 60
1.1 (Median)	0.0038	0.0034	0.0062	0.0059	0.0055	0.0041
4.9 (Maximum)	0.017	0.015	0.028	0.026	0.025	0.018

Values rounded to 2 SF.

Soil

71. Potential exposures of UK infants aged 6 to 12 months and young children aged 1 to 5 years to cadmium in soil were calculated assuming ingestion of 30 or 50 mg/day, respectively (US EPA, 2011a). Younger infants, who are less able to move around and come into contact with soil, are likely to consume less soil than children of these age groups. Median and 90th percentile soil concentrations of 0.50 and 1.2 mg/kg respectively were used in these exposure estimations (paragraph 54) (Table 15).

Table 15. Possible cadmium exposures from soil in infants and young children aged 6 months to 5 years.

Exposure (µg/kg bw/day)

Cadmium concentration (mg/kg)	Age (months) 6 to 9	Age (months) 9 to 12	Age (months) 12 to 15	Age (months) 15 to 18	Age (months) 18 to 24	Age (months to 60
0.5 (Median)	0.0017	0.0015	0.0023	0.0022	0.0021	0.0016
1.2 (95th percentile)	0.0041	0.0038	0.0057	0.0054	0.0050	0.0037

Values rounded to 2 SF.

Air

72. Potential exposures of UK infants aged 0 to 12 months and young children aged 1 to 5 years to cadmium in air were estimated using the body weights shown in Table 4, and by assuming the mean ventilation rates presented in Table 16; these rates have been derived from the US EPA exposure factors handbook (US EPA, 2011b). The resulting exposures are presented in Table 17.

Table 16 Mean ventilation rates used in the estimation of cadmium exposures from air (derived from US EPA, 2011b).

Age group (months)	Ventilation rate (m^3/day)
0 to 4	3.5
4 to 6	4.1
6 to 9	5.4
9 to 12	5.4
12 to 15	8.0

15 to 18	8.0
18 to 24	8.0
24 to 60	10.1

73. The cadmium concentrations used in the exposure calculations were the lowest and highest median values and lowest and highest maximum values of 0.024, 1.2, 0.042 and 17 ng/m^3, respectively, from monitoring sites in the UK (paragraph 50).

Table 17. Possible exposures to cadmium in infants and young children from air.

Exposure (µg/kg bw/day).

Cadmium concentration (ng/m^3)	**Ages (months)0 to 4**	**Ages (months)4 to 6**	**Ages (months)6 to 9**	**Ages (months)9 to 12**	**Ages (months)12 to 15**	**Ages (months)15 to 18**
(lowest median value)	0.000014	0.000011	0.000015	0.000013	0.000018	0.000017
(highest median value)	0.00070	0.00062	0.00073	0.00066	0.00089	0.00084
(lowest maximum value)	0.000025	0.000022	0.000026	0.000024	0.000032	0.000030
(highest maximum value)	0.010	0.0088	0.010	0.0095	0.013	0.012