Exposure Assessment

In this guide

This is a paper for discussion. This does not represent the views of the Committee and should not be cited.

Exposure from food

59. The FSA Exposure Assessment Team provided dietary exposure data on mercury for women of childbearing age (16-49 yrs of age) as a proxy for the maternal diet (Table 1). Exposure to mercury was determined using data from the National Diet and Nutrition Survey (NDNS) (Bates et al., 2014, 2016, 2020; Roberts et al., 2018), and 2014 total diet survey (TDS) (FERA, 2015).

60. Exposure estimates are presented as lower- and upper-bound mean and 97.5th percentile. Lower bound: concentration values below the limit of quantification (LOQ) are treated as zero. Upper bound: concentration values below the LOQ are treated as at the LOQ. The food commodities that result in the highest exposures to mercury are fish and seafoods, and non-alcoholic beverages with mean exposure values of 0.13 and 0.07 µg/kg bw/week, and 97.5th

percentile values of 0.62 and 0.17 µg/kg bw/week, respectively.

61. Mean total exposure (combined exposure from all food groups) to mercury for women of child-bearing age ranges from 0.13-0.29 µg/kg bw/week, whilst exposure in high consumers (97.5th percentile) ranges from 0.62-0.84 µg/kg bw/week.

Table 1. Estimated exposure (in µg/kg bw/day and µg/kg bw/week) to mercury from foods consumed by women of childbearing age (16-49 years).

Food Groups	**Daily exposure to mercury LB to UB (µg/kg bw/day) ***	**Daily exposure to mercury LB to UB (µg/kg bw/day) ***	**Weekly exposure to mercury LB to UB (µg/kg bw/week) ***	**Weekly exposure to mercury LB to UB (µg/kg bw/week) ***
	Mean	**97.5th Percentile**	**Mean**	**97.5th Percentile**
Bread	0-0.00099	0-0.0026	0-0.0069	0-0.018
Misc Cereals	0-0.0010	0-0.0029	0-0.007	0-0.020
Carcass meat	0-0.00034	0-0.0016	0-0.0024	0-0.011
Offal	0.000045	0.00075	0.00032	0.0053
Meat products	0-0.00027	0-0.0011	0-0.0019	0-0.0077
Poultry	0-0.00039	0-0.0014	0-0.0027	0-0.0098
Fish and seafood	0.018	0.089	0.13	0.62
Fats and oils	0-0.000086	0-0.00027	0-0.00060	0-0.0019

Eggs	0-0.00014	0-0.00067	0-0.00098	0-0.0047
Sugars and confectionary	0.00033	0.0013	0.0023	0.0091
Green vegetables	0-0.00028	0-0.0011	0-0.0020	0-0.0077
Potatoes	0-0.0011	0-0.0032	0-0.0077	0-0.022
Other vegetables	0-0.0013	0-0.0043	0-0.0091	0-0.030
Canned vegetables	0-0.00026	0-0.0012	0-0.0018	0-0.0084
Fresh fruit	0-0.0012	0-0.0045	0-0.0084	0-0.032
Fruit products	0-0.00038	0-0.0021	0-0.0027	0-0.015
Non-alcoholic beverages	0-0.010	0-0.024	0-0.07	0-0.17
Milk	0-0.00090	0-0.0033	0-0.0063	0-0.023
Dairy products	0-0.0004	0-0.0015	0-0.0028	0-0.011
Nuts and seeds	0-0.000043	0-0.00037	0-0.00030	0-0.0026
Alcoholic beverages	0-0.00083	0-0.0055	0-0.0058	0-0.039

Meat alternatives	0-0.000024	0-0.00029	0-0.00017	0-0.0020
Snacks	0.000055	0.00025	0.00039	0.0018
Desserts	0-0.000039	0-0.00025	0-0.00027	0-0.0018
Condiments	0-0.00010	0-0.00038	0-0.0007	0-0.0027
Tap water only	0-0.0014	0-0.0061	0-0.0098	0-0.043
Bottled water still or carbonated	0-0.00034	0-0.0028	0-0.0024	0-0.020
Total	0.019-0.041	0.089-0.12	0.13-0.29	0.62-0.84

LB= Lower-bound; UB = Upper-bound.

Exposure from drinking water

62. The main chemical forms in which mercury occurs in water are elemental mercury, complexes of mercuric mercury with various inorganic and organic ligands, and organic mercury forms, mainly MeHg and dimethylmercury. The chemical form in which mercury occurs depends on the pH, redox potential, and the concentration of inorganic and organic complexing agents. The contribution of MeHg to total mercury is typically less than 5 % in estuarine and marine waters but can be up to 30 % in fresh water (EFSA, 2012).

63. Concentrations of mercury in water were provided by the Drinking Water Inspectorate for England and Wales, the Drinking Water Quality Regulator for Scotland and Northern Ireland (NI) Water. 2023 median and 97.5th percentile concentrations were provided for England and Wales. 2023 data for NI and Scotland was requested however NI had no results greater than the LOQ (0.041 µg/L) and Scotland had no results greater than the limit of detection (LOD) (0.02 µg/L). The LOD and LOQ were therefore used as proxies for 97.5th percentiles for

Scotland and NI. For median concentrations, 2016 data were used for Scotland and NI from a previous COT paper (COT, 2018).

64. The FSA Exposure Assessment Team has provided values for water consumption for women of child-bearing age of 8 (mean) and 32 (97.5^{th} percentile) g (ml) of water per kg bodyweight per day using data from the 2014 TDS (FERA, 2015). Using the median mercury concentration values in drinking water of 0.04, 0.03 and 0.01 µg/L for England/Wales, Scotland and NI respectively, then 97.5^{th} percentile concentration of 0.12 for England/Wales, and LOD and LOQ concentrations of 0.041 and 0.02 µg/L for Scotland and NI respectively, the calculated exposures to mercury from drinking water are shown in Table 2.

Table 2. Calculated mean and 97.5th percentile exposures (in µg/kg bw/day and µg/kg bw/week) for women of childbearing age to Mercury from drinking water.

Region	**N (number of samples)**	**Median (µg/kg bw/day)***	**Median (µg/kg bw/week)***	**97.5th percentile (µg/kg bw/day)***	**97.5th percentile (µg/kg bw/week)***
England and Wales	7944	0.00032	0.00224	0.0038	0.027
Scotland	Median 16424; LOD 585	0.00016	0.00112	0.0013^{L}	0.0091^{L}
Northern Ireland	Median 395; LOQ 1782	0.000080	0.00056	0.00064^{L}	0.0045^{L}

* Average body weight for women of childbearing age = 70.3 kg, value provided by the FSA Exposure Assessment Team from years 1 – 11 of the rolling National Diet and Nutrition Survey, NDNS (Bates et al., 2014, Bates et al., 2016, Roberts et al., 2018). L = calculated using 2023 LOD/LOQ.

Exposure from the air

65. Mercury is naturally emitted from land and ocean surfaces as elemental mercury. Anthropogenic sources result in the emission of elemental mercury, mercuric mercury, and particle-bound mercury. In general, elemental mercury is the predominant form of mercury in the atmosphere (EFSA, 2012).

66. The WHO estimates that the average inhalation rate for a 70 kg adult is 20 m^3/day (WHO, 2000). The Department for Environment, Food and Rural Affairs (DEFRA) UK-Air Data Selector tool was used to retrieve total mercury air concentrations and the most recent data available were from 2018 at two sites. The average air mercury concentration in London Westminster (urban background) was 2.68 ng/m^3 and 15.34 ng/m^3 from Runcorn Weston Point (urban industrial site).

67. As a worst-case scenario, if an adult female were to be constantly exposed to an air mercury concentration of 15.34 ng/m^3 then this would result in a daily exposure to 306.8 ng of mercury from the air. For women with an average body weight of 70.3 kg, (value provided by the FSA Exposure Assessment Team from years 1 – 11 of the rolling National Diet and Nutrition Survey, NDNS (Bates et al., 2014, Bates et al., 2016, Roberts et al., 2018) this gives an exposure of 4.36 ng/kg bw/day equivalent to 0.031 µg/kg bw/week.

68. This assumes that there is full absorption of all mercury in the particles inhaled, but this depends upon particle sizes and some of the inhaled dose may become trapped in other parts of the nasopharynx.

Exposure from the soil

69. Mercury is most commonly found in the environment in elemental form, as inorganic mercuric (Hg^{2+}) compounds, or as monomethylmercury compounds with the general formula, CH3HgX. Monomethylated mercury compounds are most likely to be found in soil as a result of natural microbial transformation of inorganic mercury (Environmental Agency, 2009). In surface soils, about 1–3 % of total mercury is in the methylated form with the rest predominantly as Hg^{2+} compounds (Environment Agency, 2009).

70. Mercury was measured in topsoil from England from a depth of 0-15 cm as part of a DEFRA-commissioned project (Ander et al, 2013).

71. Table 3 shows the mercury exposures from soil for women of child-bearing age. Mean and 75th percentile mercury concentrations from soil in regions classified as principal (non-urban) and urban were used to assess potential exposures of adults through soil ingestion (Ander et al, 2013).

72. An ingestion rate of 50 mg soil/day was assumed based on the rate used by the Environment Agency in their Contaminated Land Exposure Assessment (CLEA) model (Environment Agency, 2009) and was based on a consensus value from studies by the U.S. EPA (1997) and Otte et al. (2001). It is a combined value for soil and dust as most of the evidence used to determine the ingestion rate does not differentiate between soil and household dust. Furthermore, the evidence base for selecting a representative soil ingestion rate for adults is much smaller than that for children and as such the U.S. EPA (1997) cautioned that the value is highly uncertain and based on a low level of confidence.

Table 3. Median and 75th percentile exposure values (in µg/kg bw/day and µg/kg bw/week) for women of childbearing age to mercury from soil.

Median / 75th percentile	Region	Soil concentration of mercury (mg/kg)	Mercury exposure (µg/kg bw/day)*	Mercury exposure (µg/kg bw/week)*
Median	Non-urban	0.12	0.000085	0.00060
Nedian	Urban	0.33	0.00024	0.0017
75th percentile	Non-urban	0.23	0.00016	0.0011
75th percentile	Urban	0.65	0.00046	0.0032

* Average body weight for women of childbearing age = 70.3 kg, value provided by the FSA Exposure Assessment Team from years 1 – 11 of the rolling National

Diet and Nutrition Survey, NDNS (Bates *et al*., 2014, Bates *et al*., 2016, Roberts *et al*., 2018).

73. The data presented are representative of mercury concentrations in the soil in England only.

Pica behaviour

74. A discussion paper on the effects of pica during pregnancy was presented to the COT in 2023 but was unpublished. The key points are summarised below.

75. Pica behaviour is described as the craving for and intentional ingestion of substances that are not described as food. The most frequently reported pica behaviours globally are: geophagia- the consumption of earth, soil or clay, amylophagia- the consumption of starch, and pagophagia- the consumption of ice (Miao et al., 2015). Globally, it is thought to affect up to 28 % of pregnant women, albeit with a high degree of geographic variability (Fawcett et al, 2016). The majority of pica in pregnant women in the UK is geophagia and therefore the risks posed to women of maternal age is likely to be from contaminants present within these substances.

76. Geophagia primarily occurs in migrant populations from Africa and South Asia where the practice is commonplace. As such, the soils, chalks and clays that are consumed are not of UK origin. The soils are frequently imported from regions where the practice is prevalent following rudimentary processing such as being oven baked into blocks (Dean et al., 2004).

77. The most likely health risks from geophagia were reported to be heavy metal contamination by lead, arsenic and cadmium, not mercury.

78. The discussion paper highlighted several uncertainties regarding the toxicological risk of pica to pregnant women. These include: the mineralogical and contaminant profile of the soil and clays consumed is highly variable; the soils and clays are often imported from a variety of countries resulting in variation; and studies rely on self-reporting of pica behaviour through questionnaires which could lead to bias in the data and underreporting of pica potentially due to stigma associated with consuming non-food substances.

79. In summary, pica presents a potential route of exposure to mercury from soils/clays. However, pica has not been considered as part of this statement due to the lack of data available on pica behaviour.

Exposure from food supplements

80. The FSA has no analytical data on the presence of mercury in supplements, but the levels are regulated in the UK under Assimilated Regulation (EC) 629/2008 at a maximum level of 0.1 mg/kg.

81. The EFSA evaluation of mercury and MeHg in food (EFSA, 2012) conducted a consumer only exposure assessment and found that the 95th percentile dietary exposure estimations in dietary supplements consumers varied from a minimum LB of 0.00 µg/kg bw per week to a maximum UB of 0.24 µg/kg bw per week in adults. EFSA did not consider dietary supplements a major source of mercury exposure.

Aggregate exposure

82. Aggregate exposure to mercury from food, drinking water, soil and dust, and air were derived by considering a number of scenarios based on the available data. Table 4 shows scenarios of aggregate exposure from the sources listed above and includes estimate of average and high exposure from these sources as indicated below.

83. Average and high exposure for food and drinking water represents the mean and 97.5th percentile exposure. Data for exposure from drinking water in England and Wales were used as this represented the highest exposure compared to Scotland and Northern Ireland. The contribution from air in all scenarios is based on average inhalation rates and the average concentration from an urban industrial site in England. For exposure from soil, the average and high exposure represents the mean and 75th percentile exposure respectively for the region with the highest exposure (i.e., urban region as shown in Table 3).

Table 4. Aggregate exposure to Mercury (in µg/kg bw/day and µg/kg bw/week) from food, drinking water, soil and air*.

Scenarios	**Aggregate exposure (µg/kg bw/day)**	**Aggregate exposure (µg/kg bw/week)**
Average exposure from all sources[a]	0.045	0.315

High exposure from all sources[b]	0.13	0.91
High exposure from food and mean exposure from all other sources[c]	0.12	0.84
High exposure from drinking water and mean from other sources[d]	0.049	0.34
High exposure from soil and mean from other sources[e]	0.046	0.32

a This scenario represents a summation of average exposure from food, water and soil and a value for air*.

b Exposure is based on summation of 97.5th percentile estimates for food and water, 75th percentile for urban soil and a value for air*.

c Exposure is based on summation of 97.5th percentile estimates for food and the averages for water, urban soil and a value for air*

d Exposure is based on summation of 97.5th percentile estimates for drinking water and the averages for food, urban soil and a value for air*

e Exposure is based on summation of 75th percentile estimate for urban soil and averages for food, water and a value for air*.

*The contribution from air in all scenarios is based on average inhalation rates and the maximum concentration identified for England and Wales.