COMMITTEE ON TOXICITY OF CHEMICALS IN FOOD, CONSUMER PRODUCTS AND THE ENVIRONMENT

Statement on the potential risks from excess iodine in the diets of infants aged 0-12 months and children aged 1 to 5 years.

Introduction

1. The Scientific Advisory Committee on Nutrition (SACN) is undertaking a review of scientific evidence that will inform the Government dietary recommendations for infants and young children. The SACN is examining the nutritional basis for the advice. The COT was asked to review the risk of toxicity of chemicals in the diets of infants and young children. The reviews will identify new evidence that has emerged since the Government recommendations were formulated and will appraise that evidence to determine whether the advice should be revised. The recommendations cover diet from birth to age five years.

2. Iodine is an essential micronutrient in the human diet, required for the production of thyroid hormones including thyroxine. These hormones are necessary for cell metabolism, growth and development at all stages of life. The most visible manifestation of iodine deficiency is goitre – an enlargement of the thyroid gland in the neck but there is concern, that in the fetus, infant, and young child, more modest changes may impair psychomotor development in the absence of overt thyroid enlargement (SACN, 2014).

3. The consequences of an excess of iodine vary considerably between individuals. The adult thyroid gland secretes about 80 µg thyroxine per day which requires a dietary intake of between 100 and 150 µg/day of iodine. Humans have a number of mechanisms by which they can counter an excess of iodine. These include the sodium-iodide symporter which blocks the transport of iodine into the thyroid cells and the Wolff-Chaikoff effect, more details of which can be found in the review by Bürgi (2010). Most people can tolerate a chronic excess of iodine of up to 2 g of iodine per day but there will be some individuals who experience effects at much lower levels, close to the upper recommended limit for intake (Bürgi, 2010).

4. The iodine status of an individual will also affect the consequences of excess iodine. The normal thyroid gland will adapt relatively easily to excess iodine. People who have had a partial thyroidectomy or treatment with radio-iodine or who have autoimmune thyroiditis (post-partum or Hashimoto's variants) can experience hypothyroidism, including goitre, following exposure to excess iodine in the diet, probably related to persistently elevated thyroid stimulating hormone (TSH) or thyroid stimulating antibodies which keep the NIS activated and thyroid iodine concentrations high. Populations who are slightly iodine-deficient can experience hyperthyroidism, with even low level increases in iodine intake. The mechanism is

still uncertain, but evidence from Denmark following the introduction of iodised salt has shown an increase in hyperthyroidism in the 20-39 year age group (Bliddal, 2015).

5. The UK population's exposure to iodine was measured in the 1997 Total Diet Study (TDS). The dietary exposure of adults to iodine for mean and high level consumers was respectively 0.22 and 0.43 mg/day[1]. The COT reviewed the results from the 1997 TDS and concluded that the estimated total dietary intake of iodine is unlikely to pose a risk to health in normal, healthy individuals[2]. In 2000, the COT reviewed data from a survey of iodine in cows' milk. At that time, the Committee concluded that concentrations of iodine in cows' milk are unlikely to pose a risk to health, even in those children who are high level consumers[3]. More recently, the Food Standards Agency completed a survey of 15 elements, including iodine, in infant formula, commercial infant foods and other foods. From the measured levels of iodine, the Committee concluded that the current estimated dietary exposures to iodine were not of toxicological concern[4]. A literature search on iodine has not been completed since the UK Expert Group on Vitamins and Minerals (EVM) looked at iodine in 2003 and therefore the COT considered that a full review of the literature published since this time should be carried out[5].

6. The Reference Nutrient Intake (RNI) for iodine was set by COMA in 1991 to be 0.14mg/day for adults and between 4.8 and 8.8 µg/day for children[6] (DH, 1991). The RNI for iodine for infants aged six months and younger in the UK is between 50-60 µg/day (DH, 1991). Data from the Diet and Nutrition Survey of Infants and Young Children (DNSIYC) indicated that infants and young children aged 4 to 18 months in the UK show a mean iodine dietary intake (including from supplements) of 94 to 174 µg/day (equivalent to approximately 12 to 16 µg/kg bw/day); the corresponding range of 97.5th percentile intakes is 148 to 337 µg/day (equivalent to 19 to 31 µg/kg bw/day) (DH*,* 2013). Intake data excluding the use of supplements were not provided in the DNSIYC report. The mean and 97.5th percentile dietary intake of iodine (including supplements) for 1.5 to 3 years old children estimated from the National Diet and Nutrition Survey (NDNS, Bates *et al* 2014) were 143 and 303 µg/day, respectively (equivalent to approximately 10 and 21 µg/kg bw/day). Mean and high-level intakes reported in NDNS in the absence of supplement intake were similar: 142 and 303 µg/day respectively. The milk and milk products food group made the main contribution (64%) to total intake of iodine from food in children aged 1.5 to 3 years.

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[1] According to the Expert Group on Vitamins and Minerals available at: https://cot.food.gov.uk/sites/default/files/vitmin2003.pdf
[2] Available at: http://cot.food.gov.uk/sites/default/files/cot/cotcomcocrep_cot.pdf
[3] Available at: https://cot.food.gov.uk/sites/default/files/cot/iodin2.pdf
[4] Available at: https://cot.food.gov.uk/cot-meetings/cotmeets/cot-meeting-5-july-2016
[5] Minutes of the COT (October 2015) available at: https://cot.food.gov.uk/sites/default/files/cotfinalminutes-27oct15.pdf
[6] RNIs set by COMA in 1991: 0-3 months (formula fed) 50 µg/day (8.5 µg/kg bw/day assuming 5.9kg); 4-6 months 60 µg/day (7.7 µg/kg bw/day assuming 7.8kg); 7-9 months 60 µg/day (6.7 µg/kg bw/day assuming 9.0kg); 10-12 months 60 µg/day (6.1 µg/kg bw/day assuming 9.8kg); 1-3 years 70 µg/day (4.8 µg/kg bw/day assuming 14.6kg); 4-6 years 100 µg/day (4.8 µg/kg bw/day assuming 20.9kg) .

7. There is a significant amount of literature available that suggests that the British population, including pregnant women, is moderately iodine-deficient which may have an implication for development of the fetus (SACN, 2014). However, due to the high levels of iodine in British cows' milk, young children are generally considered to have an adequate iodine intake from this source (BNF, 2011).

8. SACN recently published a scoping paper on iodine. In their conclusions, SACN state "Intake data from the National Diet and Nutrition Survey (NDNS) suggest that children aged ten years and younger and adults aged 19 years and older in the UK generally have adequate iodine intakes, in relation to the Reference Nutrient Intake (RNI), although 21% of girls aged 11-18 years have intakes below the Lower Reference Nutrient Intake (LRNI). However, insecurities surrounding food composition data for iodine and the phenomena of underreporting in dietary assessments are sources of error and uncertainty in the estimation of iodine intakes." The RNIs can be found in Table 8.

9. SACN conclude by stating that it is appropriate to examine data gathered in the NDNS on the UIC (Urinary Iodine Concentration) of the general UK population, provisionally available in 2015, to enable the UK profile to be assessed, before a full risk assessment on iodine and health is considered. The Committee will keep a watching brief on the arising evidence to inform future research in this area and any updates to the public health guidance on iodine for the UK population (SACN, 2014)

Background

10. In the environment, iodine is usually found in the form of iodate salts or organo-iodide compounds synthesized by algae and bacteria. Iodate is reduced in the GI tract to iodide which is the biologically active form (SACN, 2014).

11. Iodine is an essential micronutrient in the human diet, required for the production of thyroid hormones. These hormones are necessary for cell metabolism, growth and development at all stages of life. The most visible manifestation of iodine deficiency is goitre – an enlargement of the thyroid gland in the neck but other, more subtle effects can be noted, in IQ and physical development, at lower levels of deficiency (SACN, 2014).

12. In some countries, including Denmark, iodine deficiency has been tackled through the mandatory iodization of all salt, including table salt and salt in bread. Monitoring instigated prior to mandatory fortification in Denmark found an increase in thyroid auto-antibodies and higher levels of thyroid autoimmune disease in the 15 years following fortification (Laurberg et al, 2006; Rasmussen et al, 2008; Pedersen et al, 2011; Bliddal et al, 2015). The UK has no such fortification scheme for iodine.

Expert Opinions on Health-Based Guidance Values (HBGVs)

13. The Expert Group on Vitamins and Minerals (EVM) looked in detail at the metabolism of iodine and the effects of excess iodine in 2003[7]. Further information can be found in the background document prepared for the EVM[8]. The EVM concluded that there were insufficient data to set a Safe Upper Level (SUL) for iodine but for guidance they indicated that a level of 0.5 mg/day of supplemental iodine in addition to the background intake of 0.43 mg/day would be unlikely to cause adverse effects in adults based on slight alterations in serum thyroid hormone levels at supplemental doses of 0-2 mg/day in a range of human studies. Information published since the EVM opinion was published in 2003 was obtained through a literature search in PubMed using the search terms noted in appendix 1. This information has been included in this paper.

14. In 2002, the European Scientific Committee on Food (SCF) published an opinion on the tolerable upper intake levels of vitamins and minerals. For iodine, they set a tolerable upper level (TUL) of 600 µg/day for adults, reduced on a body surface area (body weight$^{0.75}$) basis for children to 200 µg/day for ages 1-3 years and 250 µg/day for ages 4-6 years. This would be the equivalent of 13.7 µg/kg bw/day at ages 1-3 years (based on an average bodyweight of 14.6 kg) and 11.96 µg/kg bw/day at ages 4-6 years (based on an average bodyweight of 20.9kg) (SCF, 2002). This TUL was based on dose/response studies of short duration in humans, which showed changes in serum thyroid hormone levels at dose levels of 1800 µg/day and backed up by longer term studies with approximately similar doses that did not show adverse effects, but lacked detailed iodine intake data. An uncertainty factor of 3 was used. These values were endorsed by EFSA in 2006.

15. In 1989 the Joint Expert Committee on Food Additives (JECFA) established a provisional Maximum Tolerable Daily Intake (PMTDI) for iodine of 17 µg/kg bw/day from all sources, based on the same longer term studies in adults used by the SCF in 2002 in support of their TUL (Saxena et al, 1962; Thomas et al, 1978). No safety factors were used as these studies encompassed a relatively large number of subjects (JECFA, 1989).

Iodine exposures in infants aged 0-12 months and young children aged 1-5 years

Sources of iodine exposure

Cows' milk and milk products

16. Iodine-based compounds are used to clean the udders of cows during milk collection and these leach into the milk, adding to the natural levels of iodine present. Cows' milk is therefore considered to be one of the richest sources of iodine in the diet. A survey of cows' milk carried out in 1998-9 found that the overall mean iodine concentration in cows' milk was 311 mg/kg. Mean iodine concentrations were found to be lower in summer (200 µg/kg) compared to winter (430 µg/kg). At these levels, the COT concluded that the concentrations of iodine in cows' milk are unlikely to

[7] Available at: https://cot.food.gov.uk/sites/default/files/cot/vitmin2003.pdf
[8] Available at:
http://tna.europarchive.org/20110911090542/http://www.food.gov.uk/multimedia/pdfs/evm0006p.pdf

pose a risk to health, even in those children who are high level consumers (COT, 2000[9]).

Human breast milk

17. An iodine concentration of 70 µg/kg is reported for mature breast milk in McCance and Widdowson (2015). This value was obtained using the pooled samples of breast milk donated by 96 mothers from different parts of Great Britain. Up to 15% of the mothers in this study took vitamin and/or iron supplements during lactation but the iodine content of the supplements, if any, was not reported. No data specifically focussing on the influence of regular use of iodine supplements on levels of iodine in breast milk of UK mothers were identified.

Infant formulae and food

18. Levels of iodine have recently been measured in an FSA survey of metals and other elements in infant formulae and food (FSA, 2016a) and in the composite food samples of the 2014 Total Diet Study (TDS) (FSA, 2016b). For iodine, the total mean and high level exposures were 11 µg/kg bw/day and 23 µg/kg bw/day, respectively.

Drinking water

19. Iodine was detected at low levels (8 µg/L) in tap water in the 2014 TDS (FSA, 2016b). No further data were identified.

Environmental

Dust and soil

20. Iodine levels in soil are highly variable. A median value of 5.9 mg/kg and a 90th percentile value of 14.2 mg/kg have been reported for UK soil by the British Geological Survey (BGS 2016). No specific value for dust was identified from the literature.

Air

21. According to the expert panel on Air Quality Standards, concentrations of particle bound iodine in UK air between 1996 and 2001 ranged from 0.8 $x10^{-6}$ - 2.0 x 10^{-6} mg/m^3 (DEFRA, 2006).

Medication

22. Iodine is used as a topical antiseptic, which can result in absorption through the skin. Absorption in infants appears to be greater than in adults (Leung and Braverman, 2014). There are other medications that also contain iodine, which may be released metabolically into the systemic circulation.

[9] Available at: https://cot.food.gov.uk/sites/default/files/cot/iodin2.pdf

Exposure assessment

23. Consumption data (on a bodyweight basis) from DNSIYC (DH, 2013), and from years 1-4 of the 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 iodine exposures are shown in Table 1 below.

24. Comprehensive exposure assessments have been performed for the dietary sources of exposure to iodine. Non-dietary sources of exposure (i.e. soil) have been estimated, to provide a more holistic view of total exposure, but are not as detailed, as iodine from the diet is of greater importance in infants and young children.

Table 1. Average bodyweights used in the estimation of iodine exposures when individual body weights were not available

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
[c] Bates *et al*., 2014

Exposure from Breast milk

25. 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 iodine from breast milk. The ranges of mean and high-level exposure to iodine in exclusively breast-fed 0 to 6 month old infants were 7.2 - 9.5 µg/kg bw/day and 11 - 14 µg/kg bw/day respectively (Table 2).

26. Data on breast milk consumption for infants and young children aged 4 to 18 months were available from the DNSIYC and the NDNS, and have been used to estimate exposures at these ages (Table 2), based on a mean iodine concentration of 70 µg/kg (paragraph 17). 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.

27. Mean exposures to iodine from breast milk for 4 to 18 month olds were 1.8 to 6.4 µg/kg bw/day, and 97.5th percentile exposures were 3.6 to 11 µg/kg bw/day (Table 2).

Table 2. Estimated iodine exposure in 0 to 18 month old infants and young children from breast milk, containing iodine at 70 µg/kg.

Exposure (µg/kg bw/day)	Age group (months)					
	0 to <4	**4 to <6**	**6 to <9**	**9 to <12**	**12 to <15**	**15 to <18**
Average	9.5[a]	7.2[a] 6.4[b]	4.7[b]	2.7[b]	2.1[b]	1.8[b]
High-level	14[a]	11[a] 11[b]	11[b]	8.1[b]	5.3[b]	3.6[b]

[a] Based on default consumption values of 800 and 1200 mL for average and high level exclusive consumption of breast milk. .
[b] Based on mean and 97.5th percentile consumption of breast milk from DNSIYC (DH,2013)
Values rounded to 2 SF

Exposure from Infant formulae and complementary foods

28. Iodine exposure estimates for infant formulae and complementary foods were derived using occurrence data from the Infant Metals Survey (FSA, 2016a). The basis for this survey is explained in Annex A, but in brief, the exposure data derived from the Infant Metals Survey allow estimation of iodine exposure from infant formula, commercial infant foods and the most commonly consumed adult foods (‘other foods’) as sold.

29. Exposure estimates for 0 to 6 month olds were calculated for infants exclusively fed on ‘first-milk’ formulae using the default consumption values of 800 and 1200 mL (Table 3). In 0 to 6 month olds, exposures to iodine from exclusive feeding on ready-to-feed formula were 15 to 19 µg/kg bw/day in average consumers, and 22 to 29 µg/kg bw/day in high level consumers. Exposures to iodine calculated for reconstituted formula incorporating an iodine concentration in tap water taken from the 2014 TDS (paragraph 19) were 16 to 20 µg/kg bw/day in average consumers, and of 23 to 30 µg/kg bw/day in high level consumers (Table 3). The iodine concentration in tap water used for reconstitution of dry formula made a minimal contribution to total exposure from this source.

Table 3. Estimated average and high level exposures to iodine from exclusive feeding on infant formulae for 0 to 6 month olds.

Infant Formula (concentration)	Iodine Exposure (µg/kg bw/day)			
	0 to <4		**4 to <6**	
	Average consumer (800	**High level consumer (1200**	**Average consumer (800 mL/day)**	**High level consumer (1200 mL/day)**

	mL/day)	mL/day)		
Ready-to-Feed[a]	19	29	15	22
Dry Powder[b,c]	19	29	15	22
Dry Powder[b]+ water at 8 µg/L [d]	20	30	16	23

[a] Exposure based on first milk infant formula using an iodine concentration of 143 µg/L
[b] Exposure based on first milk infant formula using an iodine concentration of 948 µg/kg
[c] Exposure does not include the contribution from water.
[d] Determined by applying a factor of 0.85 to default formula consumption of 800mL and 1,200mL per day for estimating water consumption. Iodine concentration for tap water was from 2014 TDS. Values rounded to 2 SF.

30. Consumption data from the DNSIYC were used to estimate exposures from infant formula and complementary foods for 4 to 18 month olds (DH, 2013), based on upper-bound (UB) and lower-bound (LB) iodine concentrations in groups of complementary foods and levels detected in infant formula. Total mean exposures (excluding water) to iodine from infant formulae, commercial infant foods, and other foods, for 4 to 18 month olds were 8.6 to 11 µg/kg bw/day, and 97.5th percentile exposures were 18 to 23 µg/kg bw/day (Table 4). These values are within the range of total intake of iodine that was reported in the DNSIYC survey for 4 to 18 month old children (DH 2013). Total mean and 97.5th percentile exposures have also been calculated using an iodine concentration of water of 8 µg/L (paragraph 19). The resulting total mean and high level exposures indicated that iodine levels in tap water made a negligible contribution to total exposure.

Table 4. Estimated exposures to iodine from infant formulae, commercial infant foods and other foods for 4 to 18 month olds

Values rounded to 2 SF

Iodine Exposure (LB-UB Range) (µg/kg bw/day)										
Food	**4 to <6 Months (n=116)**		**6 to <9 Months (n=606)**		**9 to <12 Months (n=686)**		**12 to <15 Months (n=670)**		**15 to <18 Months (n=605)**	
	Mean	**97.5th**	**Mean**	**97.5th**	**Mean**	**97.5th**	**Mean**	**97.5th**	**Mean**	**97.5th**
Infant formula	9.2	20	6.8	15	4.9	10	2.0	9.0	1.1	6.6
Commercial infant foods	0.35-.40	1.6-1.8	0.44-0.51	1.8-1.9	0.37-0.44	2.0-2.1	0.18-0.22	1.1-1.2	0.087-0.11	0.55-0.65
Other foods	0.52-0.53	3.4	1.7	6.0-6.1	3.1	16	8.6-8.7	23	8.8	19
Total (excl. tap water)	11	21[a]	9.4-9.5	18 [a]	8.6-8.8	19 [a]	11	23[a]	9.8-9.9	19[a]
Total (incl. tap water at a concentration of 8 µg/L)[b]	11	21	9.5-9.6	18	8.7-8.9	20	11	23	9.9-10	19

[a] 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

[b]. Iodine concentration for tap water was from 2014 TDS.

Exposure estimates based on foods in the TDS

31. Results from the TDS are based on analysis of food that is prepared as for consumption (FSA, 2016b). The consumption data from the DNSIYC were used for the estimation of exposure for children aged 12 to 18 months (DH, 2013) whereas consumption data from NDNS (Bates et al., 2014) were used for estimating exposure in older children. Exposure estimates based on data from the 2014 TDS are presented only as UB, because the few food groups with concentrations below the LOQ or the LOD (green vegetables, fresh fruit and nuts) had a minimal impact on the total dietary exposure. A more detailed breakdown of individual food groups for the TDS can be found in Annex B. Mean and 97.5th percentile exposures to iodine from a combination of all food groups of up to 12 and 26 µg/kg bw/day, respectively were estimated (Table 5). These estimates of dietary exposure are comparable to the intake values for iodine which were reported in NDNS (Bates *et al* 2014) for 1.5 to 3 year old children. The food groups making the highest contribution to iodine exposure in the TDS were milk and dairy products (Annex B).

Table 5. Estimated dietary exposure to iodine in children aged 18 months to 5 years.

UB iodine exposure (µg/kg bw/day)							
12 to <15 Months (n=670)		**15 to <18 Months (n=605)**		**18 to <24 Months (n=70)**		**24 to <60 Months (n=429)**	
Mean	**97.5th**	**Mean**	**97.5th**	**Mean**	**97.5th**	**Mean**	**97.5th**
11	24	11	22	12	26	8.4	17

Values rounded to 2 SF

Soil/dust

32. Potential exposures to iodine in soil and dust were estimated assuming combined soil and dust ingestion of 60 or 100 mg/day, for 6 to 12 month olds and 1 to 5 year old children, respectively (US EPA, 2011). Children of these age groups are likely to consume more soil and dust than younger infants who are less able to move around and come into contact with soil and dust. The median and 90th percentile values mentioned in paragraph 20 were used for estimating the exposures reported in Table 7. Data specific to dust were not available and therefore for the purposes of this evaluation, it is assumed that levels in dust are the same as in soil, (Table 7). The potential exposures to iodine in soil and dust in infants and young children based on the median and 90th percentile concentration of iodine in soil ranged from 0.036 to 0.056 µg/kg bw/day and 0.088 and 0.13 µg/kg bw/day, respectively. These exposures are at least an order of magnitude lower than overall exposures from dietary sources. Hence, the contribution from non-food sources is very small and not considered further.

Table 6. Potential iodine exposures (µg/kg bw/day) from soil and dust in infants and young children aged 6 to 60 months.

Iodine concentration	Age (months)					
	6 to <9	9 to <12	2 to <15	5 to <18	8 to <24	4 to <60
Median (5.9 mg/kg)	0.041	0.037	0.056	0.053	0.049	0.036
90^{th} percentile (14.2 mg/kg)	0.097	0.088	0.13	0.13	0.12	0.088

Values rounded to 2 SF.

ADME and new data from animal studies

33. Iodine metabolism is complex, especially when present in excess. Iodine is used in the thyroid to produce about 80 µg/day thyroxine, which corresponds to about 52 µg of iodine per day.

34. One of the acute effects of iodine excess is to impair the conversion of iodine to organic iodine (this is called the Wolff-Chaikoff effect). Excess iodine also causes inhibition of hormone secretion, thyroid blood flow, glucose and amino acid transport and protein and RNA biosynthesis. As most of the inhibitory effects of iodine are reversed by thionamides like methimazole and propylthiouracil, which inhibit peroxidase activity, but thyroid hormones per se have no direct effect on the thyroid, it has been proposed that other organic iodine compounds are responsible for these inhibitory effects – most likely iodolipids (Gartner, 2009).

35. Recent studies have shown the presence of the sodium-iodide symporter (NIS) in the gastric mucosa of rats with evidence suggesting that this serves to move iodine from the blood stream into the lumen of the GI tract – suggesting a role in iodine excretion as well as in iodine absorption. However, others have suggested that the main function of this NIS activity is to augment the possible role of iodine as an antimicrobial – helping to reduce chances of infection in the GI tract (Joseffson, 2006). The kidneys have also been shown to be important in iodine excretion (Spitzweg, 2001).

36. In a study in female Sprague-Dawley rats administered methylnitrosourea to induce tumours, thyroid and mammary tissue were found to vary considerably in their uptake of iodine depending on the form in which the iodine was found and the status of the tissue (lactating, tumoral or normal in the case of mammary tissue). The rate of iodine uptake via the NIS was found to be 300 times faster in thyroid tissue and four times faster in lactating mammary tissue than in tumoral and normal mammary tissue. (Anguiano et al, 2007).

Human studies, including case studies with excess iodine

37. One of the most accurate methods of assessing iodine status is to test urinary iodine concentration (UIC) but this can vary considerably depending on short term iodine intake and fluid consumption and therefore whole day urine analysis with

standardised fluid consumption is far more representative of total iodine intake than single sample concentrations (spot urines) (Andersen et al, 2009). Unless otherwise stated the studies below used single urine samples to estimate UIC.

38. In a cross-sectional study of 696 healthy infants aged 6-24 months in Nepal, urine, blood and household salt samples were collected. UIC, serum free thyroxine thyrotropin, thyroglobulin and the iodine content of household salt samples were determined. Median urinary iodine concentration (MUIC) was 407 µg/L and 76% of infants had a UIC of >300 µg/L suggesting iodine excess. MUIC was greater in the 6-12 month age group compared to older infants (p=0.004). No significant differences in median TSH, free thyroxine or thyroglobulin were found between age groups. Forty one cases of sub-clinical hypothyroidism were found, with the highest prevalence in the 6-12 month age group. Groups were then reclassified by iodine intakes, which were estimated using the MUICs, and infants were divided into three groups: deficient (<100 µg/day), sufficient (100-299 µg/day) and excess (≥300 µg/day). Serum TSH and free thyroxine did not differ between the three groups. Among the 380 infants found to have excess intakes of iodine, 37 showed signs of thyroid dysfunction, 28 of which were defined as subclinical hypothyroidism. Elevated, but not statistically significant, thyroglobulin was observed in the deficient and the excess groups compared to the sufficient iodine group, but across the 3 categories of intake, no significant differences were observed in the prevalence of thyroid disorders (Nepal et al, 2015).

39. During routine congenital hypothyroidism screening in Japan, 34 infants who were found to be positive for this condition were selected for further study. Serum TSH, free thyroxine, thyroglobulin and iodine concentrations in serum, urine and breast milk were all assessed. Maternal thyroid function was assessed using serum TSH, free thyroxine, thyroid peroxidase autoantibodies, and thyroglobulin autoantibodies. Age-matched controls who did not have hypothyroidism were selected. Retrospective food diaries were collected from the mothers and foods were purchased subsequently and analysed for iodine content. Of the 34 infants identified, 6 were thought to be cases of congenital hypothyroidism, 1 was diagnosed with transient hypothyroidism caused by TSH-binding inhibitor immunoglobulin, 9 were diagnosed with hyperthyrotropinemia of unknown etiology and 3 were false positives. The 15 remaining infants were found to have hyperthyrotropinemia linked to an excess of iodine consumed by their mothers during pregnancy. Genetic testing was carried out to exclude congenital hyperthyroidism. Infants were classified into two groups by serum iodine concentration: group A >17 µg/dL (5 infants) and group B <17 µg/dL (10 infants); [urinary iodine is normally considered more accurate]. Concentrations of TSH and thyroglobulin were higher in these two groups than in the control group (p<0.01) but concentrations of free thyroxine did not differ amongst the three groups. Concentrations of TSH (p<0.01) and thyroglobulin (p<0.05) were higher in group A than in group B. Iodine concentrations in breast milk were higher in group A than in group B and the controls (p<0.01). Maternal iodine intakes were calculated to be 2280-3180 µg/day during pregnancy in group A and 820-1400 µg/day during pregnancy in group B. Mothers in group A were advised to reduce their iodine consumption, and their breast milk was monitored for iodine levels and the infants were monitored for UIC and serum iodine concentrations. In two of the 5 infants, iodine concentrations in serum, urine and breast milk returned to normal levels and TSH was reduced. In the remaining 3 cases, mothers did not follow the

advice and continued to consume high levels of iodine themselves and subsequently feed high iodine baby-foods at weaning. Twelve of the 15 infants were treated with levothyroxine between 12 and 24 months, with no significant differences between groups A and B in treatment. Infants were otherwise healthy up to the end of the study at 2 years of age (Nishiyama, 2004).

40. Eight case reports were collected following the recall of a prenatal supplement containing excessive iodine levels in Brazil. In all cases the infant was born with goitre. Three of these infants were treated with levothyroxine. Regardless of treatment, all but one returned to normal thyroid function within 4-6 months of withdrawal of the prenatal vitamin. In the remaining case, normal function resumed after levothyroxine treatment for 18 months. (de Vasconcellos Thomas and Collett-Solberg, 2009).

41. An international study identified children aged 6-12 years (n=3319) from 5 continents who were considered to be of medium to low socioeconomic class. Height, weight and thyroid volume were determined. Iodine intake was assessed by urinary iodine concentration. Participants were grouped by MUIC (300-499 µg/L / 500-999 µg/L / >1000 µg/L) and their thyroid volume was compared. Children from a coastal area of Japan known to have high intakes of iodine were found to have an increased thyroid volume across the whole range of MUIC (38-11100 µg/L) but with the exception of this region, there was no significant correlation between urinary iodine concentrations and thyroid volume. In coastal Japan, higher urinary iodine concentrations significantly predicted higher thyroid volumes in both boys (r = 0.19, p = 0.03) and girls (r = 0.28, p = 0.001); the odds ratio for goitre was 1.75 (95% CI: 1.1, 2.9; P = 0.03) for a 10-fold increase in UI concentration (Zimmerman et al, 2005). Prakesh pointed out that this study does not provide an estimate of the incidence of goitre (thyroid volume compared to body surface area) in the test population and therefore it is difficult to draw conclusions from this study (Prakesh, 2005).

42. A cross-sectional study in 111 children in a refugee camp in Algeria exposed to high iodine levels through breast milk with follow-up 3 years later in 289 children (76 from the baseline study) measured iodine concentrations in urine and breast milk at baseline. At follow-up, urinary iodine, and blood levels of thyroid hormones and serum thyroglobulin were measured. Excessive iodine intake (defined as urinary iodine levels of ≥300 µg/L) was identified in 88% of the group at baseline and 72% at follow-up. At follow-up, 24% of the study group had thyroid hormone disturbance and 9% had subclinical hypothyroidism. Children with subclinical hypothyroidism showed poorer growth and were more likely to be underweight than those without (Aakre et al, 2016).

43. A study in four provinces of China looking at the iodine status of children aged 6-12 and pregnant women residing in areas receiving high iodine-drinking water found that with water containing iodine levels of less than 100 µg/L, children were receiving adequate iodine. MUIC’s were between 200 and 299 µg/L. When water levels exceeded 100 µg/L, MUIC’s were high (above 300 µg/L) in children. Given their higher iodine requirements, the MUIC’s in pregnant women were predictably lower than the children given the same water levels. Although the surveyed groups were receiving relatively high iodine intakes, the rate of goitre was found to be low,

with 5% of individuals consuming water containing more than 300 μg/L iodine demonstrating some degree of thyroid enlargement (Liu et al, 2014).

44. A cross sectional study assessed the iodine status and thyroid function of 1259 children aged 8-10 years from 31 townships across China. Urinary iodine was measured and thyroid volume was assessed by ultrasound in all participants. Goitre was identified in 11% of the group. Subgroup analyses looking at iodine concentrations in water and salt did not show any differences between age groups (Lv et al, 2012).

45. Also by the same group, a study was carried out to look at the impact of removing iodised salt from the diets of children in areas with high iodine-drinking water. Children aged 8-10 years in three towns in a high-iodine area of China were selected either before withdrawal of iodised salt (n=452) or ~18 months after withdrawal (n=459). Children gave urine samples and their thyroid volume was measured by ultrasound. Drinking water and salt samples were also taken from a small number of households in the area. Concentrations of iodine in drinking water were not significantly different between baseline and follow-up sampling. Salt iodine concentration decreased from between 10.4 and 34.1 mg/kg to <5 mg/kg. At baseline, goitre was present in 24.6% of children but in the follow-up study this was reduced to 5.8%. MUIC's decreased from 518 μg/L (interquartile range 347-735 μg/L) in the baseline study to 416 μg/L (interquartile range 274-609 μg/L) at follow-up. Overall, the reduction in MUIC was statistically significant (Lv et al, 2015).

46. A cross-sectional study in China looked at the UICs and thyroid function of 521 children aged 7-13 years. Participants were selected from a high iodine area (n=371) or an adequate iodine area (n=150). Thyroid size was assessed by ultrasound and blood and urine samples were collected from each participant. Concentrations of serum free triiodothyronine, free thyroxine and sensitive thyroid stimulating hormone (sTSH – analysed using a more sensitive test) were measured from each serum sample. The height and weight of the children in the high iodine region were significantly higher than those from the adequate iodine region, but BMI, age and sex allocation did not differ between groups. MUIC was significantly higher between groups (1030 μg/L, interquartile range 721-1370 μg/L for the high iodine region; 123 μg/L, interquartile range 101-201 μg/L for the adequate iodine region; $p<0.001$). Levels of sensitive thyroid stimulating hormone ($p=0.001$), thyroglobulin antibody ($p=0.024$) and thyroid peroxidase antibody ($p=0.002$) were elevated in the children from the high iodine region but levels of free triiodothyronine ($p=0.68$) and free thyroxine ($p=0.79$) did not differ between groups. In the high iodine region, 11.9% of children exhibited thyroid disease whereas in the adequate iodine region this figure was 1.3%. In both groups, thyroid disease primarily manifested as subclinical hypothyroidism (Sang et al, 2013).

47. A total of 6038 schoolchildren aged 6-12 years living in Sudan took part in a cross-sectional study on thyroid status. Children living in Port Sudan (n=654) (a high iodine area) were tested for the prevalence of goitre, and a randomly selected group were tested for UIC and thiocyanate secretion. Drinking water samples were also obtained for this group (n=31). Goitre was assessed by observation using WHO recommended criteria. These values were compared with those from children in other areas of Sudan. The mean urinary iodine concentrations in those from Port Sudan were approximately five times those in other areas of Sudan ($p=0.001$).

Children from Port Sudan had significantly lower serum thyroxine and triiodothyronine levels (both p=0.001) and significantly higher serum thyroid stimulating hormone (p=0.008). Water samples did not appear to have been analysed for iodine content in this study (Medani et al, 2012).

48. An earlier study in 141 children of the same age and also in Port Sudan found that UIC exceeded 300 µg/L and 1000 µg/L in 65% and 9.9% of the study group, respectively. Visible goitre was identified in 17% of children. Salt samples were found to contain >150mg potassium iodate per kg (Izzeldin et al, 2007).

49. In a study of 421 Saharan refugee children aged 6-14 years living in an area of Algeria with high iodine-drinking water, thyroid volume was assessed by ultrasound and urinary iodine concentration and growth parameters were measured. In total, 21% of children were underweight, 24% were stunted and 9% had low BMI for age. Based on thyroid volume for body surface area ratio, 85% of children had goitre. It should be noted that high levels of malnutrition were recorded in the camps, which will confound the results (Henjum et al, 2010).

50. In the studies above, high intakes of iodine in children were found to disturb thyroid function, but these disturbances did not necessarily result in clinical hypothyroidism. Some of these studies were carried out under difficult conditions (such as refugee camps), the iodine intakes are not known and some of the studies are of poor or unclear quality. It is therefore difficult to draw firm conclusions from these studies.

Risk characterisation

51. In 2003, the EVM set a guidance level for iodine of 15 µg/kg bw/day that would not be expected to cause adverse effects in the majority of the population. It should be noted that this is a guidance level only and is based primarily on data from adults; therefore its applicability to infants and young children is uncertain.

52. The EVM concluded that it is often difficult to distinguish toxic effects from effects that are the result of iodine feedback mechanisms designed to accommodate fluctuation in iodine intake. This makes it difficult to set a Safe Upper Level for iodine.

53. The European SCF tolerable upper level (TUL) for iodine was 600 µg/day for adults, reduced on a body surface area basis for children to 200 µg/day for ages 1-3 years and 250 µg/day for ages 4-6 years. This would be the equivalent of 8.6 µg/kg bw/day for adults and between 15.5 - 18.9 µg/kg bw/day when adjusted on a bodyweight basis for children (EFSA, 2006).

54. JECFA established a provisional Maximum Tolerable Daily Intake (PMTDI) of 17 µg/kg bw/day for iodine from all sources, based on the same longer term studies in adults used by SCF in 2002 to support the TUL.

Table 8: Dietary exposures for iodine in children up to 5 years old.

Age		0-<4 months	4-<6 months	6-<9 months	9-<12 months	12-<15 months	15-<18 months	18-<24 months	24-<60 months
Health-based guidance values	EVM	15 µg/kg bw/day total intake not expected to result in adverse effects							
	SCF	No TUL specified for this age group				18.9 µg/kg bw/day Tolerable Upper Level	17.9 µg/kg bw/day Tolerable Upper Level	16.7 µg/kg bw/day Tolerable Upper Level	15.5 µg/kg bw/day Tolerable Upper Level
	JECFA	17 µg/kg bw/day Maximum Tolerable Daily Intake from all sources							
Mean bodyweight for age group		5.9	7.8	8.7	9.6	10.6	11.2	12.0	16.1
Mean exposures (µg/kg bw/day)	Breastfed	9.5(a)	7.2(a)	9.5-9.6(c)	8.7-8.9(c)	11(d)	9.9-11(d)	12(e)	8.4(e)
	Exclusively formula fed	20(b)	16(b)						
	Weaning diet and formula	-	11(c)						
97.5th percentile exposures (µg/kg bw/day)	Breastfed	14(a)	11(a)	18(c)	20(c)	23-24(d)	19-22(d)	26(e)	17(e)
	Exclusively formula fed	30(b)	23(b)						
	Weaning diet and formula	-	21(c)						

Exposure to soil and dust has not been included in this table as their contribution to total exposure is minimal.
Ranges are based on upper bound and lower bound figures for iodine concentration in foods.

a) Taken from Table 2 in this document.
b) Taken from Table 3 in this document.
c) Taken from Table 4 in this document.
d) Taken from Tables 4 & 5 in this document.
e) Taken from Table 5 in this document.

55. As outlined in Table 8, the range of mean iodine intakes was estimated to be 7.2- 20 µg/kg bw/day and range of high level intakes was estimated to be 11-30 µg/kg bw/day. The group with the highest intake is the exclusively formula-fed infants, with a 97.5th percentile intake of 30 µg/kg bw/day – an intake that is twice the total intake expected to be without adverse effects established by the EVM. Apart from breast-fed infants, high level consumers (97.5th percentile) at all age groups were found to exceed the PMTDI level established by JECFA and the TUL set by the SCF in 2006. Infants below 6 months of age and exclusively formula-fed also exceeded the total intake expected to be without adverse effects established by the EVM.

56. These HBGVs are based on limited data. In all cases the relevant studies on which the HBGV was established did not allow an accurate estimation of dietary intakes. The response to high iodine intakes can be highly variable between individuals and will depend on iodine status. Individuals with a low iodine status who are suddenly exposed to high iodine levels are more likely to experience adverse effects than those with an adequate iodine status.

57. For many of the parameters of thyroid function normally assessed, it is difficult to distinguish between adverse effects and normal homeostatic changes due to iodine. Further, the RNI and the guidance levels/tolerable daily intakes are of a similar order of magnitude. These two factors, together with the fact that the relevant available studies are all in adult populations, make it difficult to identify a safe upper level which is applicable for all infants and children.

Conclusions of the Committee:

58. The different health-based guidance values available were discussed. The different assumptions used in their establishment and the effects on which they were based, were noted. They were compared to the RNI value set by COMA. The Safe Upper Levels were around 3-fold of the respective RNI value.

59. The Committee noted the proximity of current intakes of high consumers, and in some groups, of mean consumers, to the health-based guidance values. In most groups mean intake was intermediate between the RNI and the HBGV.

60. It is difficult to distinguish between adverse effects and natural homeostatic changes in response to elevated iodine intakes, based on normal clinical measurements.

61. The Committee concluded that it is important to ensure that any advice reflects the need for adequate iodine intakes in all sectors of the population as well as protection from possible adverse health effects from excess intake. The Committee therefore agreed that it would be important to work with SACN to ensure that advice on iodine to government suitably addresses the closeness of the health-based guidance values and the dietary reference values and the respective uncertainties involved.

62. No data specifically focussing on the influence of regular use of iodine supplements on levels of iodine in breast milk of UK mothers were identified. A more accurate estimate of iodine exposure in breast-fed infants, which takes account of more recent data on levels in breast milk and the influence of iodine supplement use in lactating UK mothers would be of value.

63. The COT concluded that at current intakes, excess iodine is unlikely to pose a toxicological risk to health.

COT Statement 2017/2

October 2017

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Appendix 1

Literature search terms

In order to update our knowledge on iodine, we carried out a literature search using PubMed for data published since the EVM reviewed iodine toxicity in 2003 with emphasis on data in children aged 1-5 years.

Time period covered by search: 2003 – present.

Search terms (No. papers retrieved):

Iodine toxicity (2847)
Iodine safety (1443)
Iodine in drinking water, UK (10)
Iodine in soil, UK (32)
Iodine in breastmilk/breast milk (10)
Iodine excess children (194)

Papers were not included if they related to radioactive iodine, did not look at children, looked only at iodine deficiency, were reviews or were not available in English. A small number of studies in animals were included if they provided useful ADME data.

Papers are described in narrative form in text above.

COMMITTEE ON TOXICITY OF CHEMICALS IN FOOD, CONSUMER PRODUCTS AND THE ENVIRONMENT

Review of potential risks from iodine in the diet of infants aged 0 to 12 months and children aged 1 to 5 years

Possible iodine exposure from dietary sources in children aged 4 to 18 months

Two surveys were conducted during 2014 which measured the concentrations of elements in food consumed by infants (4 to 18 months) and young children (18 months to 5 years). The first survey was a survey on types of foods eaten by infants (referred to as the Infant Metals Survey), the other was a total diet study (TDS) which focused on sampling foods eaten by young children. Both studies measured the concentrations of iodine.

The Infant Metals Survey measured the concentrations of metals and other elements in food ‘as sold’, in the following categories: infant formula (Table A1) commercial infant foods (Table A2), and groups of food comprising the top 50 most commonly consumed varieties of foods not specifically marketed for infants (Table A3). The results from this survey were used together with food consumption data from the Diet and Nutrition Survey for Infants and Young Children (DNSIYC) (DH, 2013) to estimate dietary exposures for children aged 4 to 18 months.

The TDS consisted of: (i) selecting foods based on food consumption data, to represent as best as possible a typical diet; (ii) their preparation to food as consumed and (iii) the subsequent pooling of related foods before analysing the composite samples for elements. The concentrations of 26 elements, including iodine, were measured in the 2014 TDS. The composite samples for 27 food groups (Table A4) were collected from 24 UK towns and analysed for their levels of iodine and other elements. Where appropriate, tap water was used in the preparation and cooking of food samples. The results from this survey were also used together with food consumption data from the DNSIYC (DH, 2013) to estimate dietary exposures for children aged 4 to 18 months.

Table A1. Infant formula

Infant Formula	
Dry Powder	**Made Up Formula**
First and Hungrier Milk	First Milk and Hungrier Milk
Follow On Milk	Follow On milk
Growing Up Milk	Growing up Milk
Soy Milk	
Goat Milk	
Organic Milk	

Comfort Milk	

Table A2. Commercial infant foods

Commercial Infant Foods
Cereal Based Foods and Dishes
Dairy Based Foods and Dishes
Fruit Based Foods and Dishes
Meat and Fish Based Foods and Dishes
Snacks (Sweet and Savoury)
Other Savoury Based Foods and Dishes (excluding Meat)
Drinks

Table A3. Other foods commonly eaten by infants.

Other Foods	
Beverages	Fruit Products
Bread	Green Vegetables
Canned Vegetables	Meat Products
Cereals	Milk
Dairy Products	Other Vegetables
Eggs	Potatoes
Fish	Poultry/Chicken
Fresh Fruit	

Table A4. The 27 food groups used for analysis of 26 elements in the 2014 TDS

TDS Food Groups*	
Bread	Fresh Fruit
Miscellaneous Cereals	Fruit Products
Carcase Meat	Non Alcoholic Beverages
Offal	Milk
Meat Products	Dairy Products
Poultry	Nuts
Fish	Alcoholic Drinks
Fats and Oils	Meat Substitutes
Eggs	Snacks
Sugars	Desserts
Green Vegetables	Condiments
Potatoes	Tap Water

Other Vegetables	Bottled Water
Canned Vegetables	

*Food samples representative of the UK diet are purchased throughout the year in 24 towns covering the UK and 137 categories of foods are combined into 27 groups of similar foods for analysis

Exposure Assessments

Infant Metals Survey

Tables A5, A6 and A7 summarise lower- (LB) and upper-bound (UB) total dietary exposures to iodine calculated using results from the infants Metal Survey for ages 4 to 18 months.

Table A5: Estimated iodine exposure from infant formula in children aged 4 to 18 months using data from the Infant Metals Survey

Food Groups	Infant Formula - Iodine LB to UB (ug/kg bw/day)									
	4 to <6		6 to <9		9 to <12		12 to <15		15 to <18	
	Mean	97.5th Percentile	Mean	97.5th Percentile	Mean	97.5th Percentile	Mean	97.5th Percentile	Mean	97.5th Percentile
Comfort	0	0	0.016	0	0.055	0	0	0	0	0
First Milk: From Birth (Powder)	0.053	1.1	0.077	0	0.021	0	0	0	0	0
Follow On Milk: 6 Months (Powder)	0	0	0.043	0	0.076	0.52	0.0039	0	0.010	0
Growing Up Milk: 12 Months (Powder)	0	0	0	0	0	0	0.033	0	0.012	0
Goat Milk Formula	0	0	0.029	0	0	0	0	0	0	0
Hipp Organic	0	0	0.0054	0	0.0030	0	0.0010	0	0	0
Soy	0.096	0	0.048	0	0.049	0	0.014	0	0.0085	0
First Milk: From Birth (Ready to Feed)	8.2	20	3.4	15	1.5	9.4	0.21	4.0	0.049	0
Follow on: 6 Months (Ready to Feed)	0.89	9.2	3.2	11	3.1	10	0.77	6.5	0.39	4.2
Growing up Milk: 12 Months (Ready to Feed)	0	0	0.0069	0	0.11	0	0.97	7.7	0.63	6.0
Total	9.2	20	6.8	15	4.9	10	2.0	9.0	1.1	6.6

Table A6: Estimated iodine exposure from commercial infant foods in children aged 4 to 18 months using data from the Infant Metals Survey

Food Groups	Commercial Infant Foods - Iodine LB to UB (ug/kg bw/day)									
	4 to <6		6 to <9		9 to <12		12 to <15		15 to <18	
	Mean	97.5th Percentile	Mean	97.5th Percentile	Mean	97.5th Percentile	Mean	97.5th Percentile	Mean	97.5th Percentile
Cereal Based Dishes	0.10	0.48-0.49	0.11-0.12	0.58-0.60	0.082-0.084	0.52-0.54	0.034-0.035	0.34-0.35	0.014	0.15-0.16
Dairy Based Dishes	0.10	1.0	0.10	0.92-0.94	0.063-0.065	0.66-0.68	0.033-0.034	0.45-0.47	0.012	0.18-0.19
Fruit Based Dishes	0.039-0.048	0.30-0.37	0.057-0.070	0.32-0.40	0.054-0.066	0.29-0.36	0.034-0.042	0.25-0.30	0.021-0.026	0.18-0.22
Meat Based Dishes	0.038-0.059	0.24-0.38	0.061-0.096	0.31-0.49	0.058-0.091	0.29-0.46	0.034-0.053	0.23-0.37	0.017-0.027	0.14-0.22
Drinks	0-0.0069	0-0.068	0-0.0090	0-0.091	0-0.0078	0-0.070	0-0.0039	0-0.058	0-0.0035	0-0.042
Other savoury based dishes	0.075-0.077	0.49-0.51	0.11	0.62-0.64	0.12-0.12	0.80-0.83	0.046-0.047	0.45-0.46	0.023	0.34-0.35
Snacks - sweet and savoury	0.0011	0.0068	0.0016	0.0085	0.0016	0.0085	0.0012	0.0077	0.00070	0.0045
Total	0.35-0.40	1.6-1.8	0.44-0.51	1.8-1.9	0.37-0.44	2.0-2.1	0.18-0.22	1.1-1.2	0.087-0.11	0.55-0.65

Table A7: Estimated iodine exposure from other foods commonly eaten by children aged 4 to 18 months using data from the Infant Metals Survey

Food Groups	Other Food - Iodine LB to UB (ug/kg bw/day)									
	4 to <6		6 to <9		9 to <12		12 to <15		15 to <18	
	Mean	97.5th Percentile	Mean	97.5th Percentile	Mean	97.5th Percentile	Mean	97.5th Percentile	Mean	97.5th Percentile
Beverages	0-0.0016	0-0.024	0-0.0045	0-0.035	0-0.0034	0-0.044	0-0.0029	0-0.034	0-0.0042	0-0.070
Bread	0.0011-0.0014	0.016-0.020	0.010-0.013	0.067-0.086	0.029-0.037	0.11-0.15	0.043-0.056	0.14-0.19	0.048-0.062	0.16-0.20
Canned Vegetables	0-0.00050	0-0.0061	0-0.0022	0-0.023	0-0.0051	0-0.037	0-0.0077	0-0.043	0-0.0068	0-0.032
Cereal	0.0014-0.0016	0.016-0.019	0.023-0.027	0.13-0.15	0.034-0.041	0.15-0.18	0.042-0.051	0.17-0.21	0.052-0.063	0.18-0.22
Dairy Products	0.36	2.1	0.77	3.2	0.94	3.5	0.95	3.4	0.87	3.0
Egg	0.0075	0.0081	0.076	0.78	0.16	1.2	0.25	1.5	0.26	1.6
Fish	0.012	0.072	0.094	0.88	0.20	1.3	0.26	1.2	0.23	1.2
Fresh fruit	0-0.0040	0-0.028	0-0.0078	0-0.037	0-0.012	0-0.048	0-0.016	0-0.057	0-0.020	0-0.057
Fruit products	0.0014-0.0020	0.022-0.033	0.0021-0.0031	0.022-0.033	0.0021-0.0031	0.021-0.032	0.0034-0.0051	0.032-0.048	0.0049-0.0074	0.037-0.056
Green vegetables	0.0031-0.0034	0.026-0.030	0.0066-0.0074	0.031-0.035	0.0074-0.0082	0.049-0.055	0.0071-0.008	0.035-0.039	0.0074-0.0082	0.036-0.040
Meat products	0	0	0-0.00090	0-0.016	0-0.0023	0-0.022	0-0.0045	0-0.031	0-0.0061	0-0.050
Milk	0.12	1.4	0.67	3.7	1.7	14	7.1	20	7.1	17
Other vegetables	0-0.0061	0-0.045	0-0.0081	0-0.038	0-0.0074	0-0.032	0-0.0050	0-0.022	0-0.0049	0-0.019
Potato	0-0.0020	0-0.014	0-0.0044	0-0.021	0-0.0060	0-0.024	0-0.0065	0-0.029	0-0.0059	0-0.024
Poultry	0.0025	0.017	0.0075	0.061	0.0099	0.070	0.010	0.059	0.0095	0.064
Total	0.52-0.53	3.4	1.7	6.0-6.1	3.1	16	8.6-8.7	23	8.6	19

Total Diet Study

Table A8 summarise lower- and upper-bound total dietary exposures to iodine calculated using the 2014 TDS for ages 12 to 18 months. The data for each food category is reported separately so that the contribution to exposure from each class could be assessed more transparently for the most relevant infant age group. In addition the total exposure from the diet has also been provided.

Table A8 Estimated iodine exposure from food eaten by young children aged 12 months to 18 months using data from the TDS Groups.

Food Groups	Total Diet Study - Iodine LB to UB (ug/kg bw/day)			
	12 to <15		15 to <18	
	Mean	97.5th Percentile	Mean	97.5th Percentile
Bread	0.068	0.19	0.077	0.21
Miscellaneous Cereals	0.37	1.1	0.44	1.3
Carcase meat	0.022	0.11	0.028	0.14
Offal	0.00020	0	0.0018	0
Meat products	0.064	0.34	0.079	0.36
Poultry	0.016	0.068	0.017	0.075
Fish	0.75	3.5	0.71	3.6
Fats and oils	0.0061	0.025	0.0072	0.027
Eggs	0.26	1.3	0.26	1.4
Sugars	0.059	0.36	0.089	0.44
Green vegetables	0-0.0051	0-0.023	0-0.0056	0-0.021
Potatoes	0.021	0.077	0.020	0.064
Other vegetables	0.023	0.084	0.023	0.077
Canned vegetables	0.014	0.070	0.013	0.062
Fresh fruit	0-0.028	0-0.097	0-0.035	0-0.10
Fruit products	0.17	1.2	0.19	1.3
Non-alcoholic beverages	0.097	0.46	0.12	0.55
Milk	6.9	20	6.9	17
Dairy products	2.4	13	2.0	8.9
Nuts	0-0.00080	0-0.0033	0-0.00030	0-0.0032
Alcoholic drinks	0.00010	0.00030	0	0
Meat substitutes	0.0010	0	0.0027	0.033
Snacks	0.0094	0.065	0.015	0.10
Desserts	0.060	0.52	0.082	0.60
Condiments	0.014	0.085	0.016	0.083
Tap water	0.079	0.30	0.090	0.36
Bottled water	0.0010	0.0090	0.0014	0.021
Total	11	24	11	21-22

References

DH (Department of Health) (2013). Diet and Nutrition Survey of Infants and Young Children (DNSIYC), 2011. Available at: http://transparency.dh.gov.uk/2013/03/13/dnsiyc-2011/

COMMITTEE ON TOXICITY OF CHEMICALS IN FOOD, CONSUMER PRODUCTS AND THE ENVIRONMENT

Review of potential risks from iodine in the diet of infants aged 0 to 12 months and children aged 1 to 5 years

Possible iodine exposure from dietary sources in young children aged 18 to 60 months

A Total Diet Study (TDS) was conducted during 2014 which measured the concentrations of iodine by young children (18 months and older).

The TDS consisted of: (i) selecting foods based on food consumption data, to represent as best as possible a typical diet; (ii) their preparation to food as consumed and (iii) the subsequent pooling of related foods before analysing the composite samples for elements. The concentrations of 26 elements, including iodine, were measured in the 2014 TDS. The composite samples for 27 food groups (Table B1) were collected from 24 UK towns and analysed for their levels of iodine and other elements. Where appropriate, tap water was used in the preparation and cooking of food samples. The results from this survey were also used together with food consumption data from years 1 to 4 of the National Diet and Nutrition Survey Rolling Programme (NDNS) (Bates *et al.,* 2014) to estimate dietary exposures for young children aged 18 months to 5 years.

Table B1. Food groups used for analysis of 26 elements in the 2014 TDS

TDS Food Groups*	
Bread	Fresh Fruit
Miscellaneous Cereals	Fruit Products
Carcase Meat	Non Alcoholic Beverages
Offal	Milk
Meat Products	Dairy Products
Poultry	Nuts
Fish	Alcoholic Drinks
Fats and Oils	Meat Substitutes
Eggs	Snacks
Sugars	Desserts
Green Vegetables	Condiments
Potatoes	Tap Water
Other Vegetables	Bottled Water
Canned Vegetables	

*Food samples representative of the UK diet are purchased throughout the year in 24 towns covering the UK and 137 categories of foods are combined into 27 groups of similar foods for analysis

Exposure Assessment

Table B2 summarises lower- and upper-bound total dietary exposures to iodine calculated using the 2014 TDS for young children aged 18 months to 5 years. The data for each food category is reported separately so that the contribution to exposure from each class could be assessed more transparently for the most relevant infant age group. In addition the total exposure from the diet has also been provided.

Table B2. Estimated iodine exposure from food eaten by young children aged 18 months to 5 years using data from the TDS Groups.

	Total Diet Study - Iodine LB to UB (ug/kg bw/day)			
	18 to <24		**24 to <60**	
FOOD GROUP	**Mean**	**97.5th Percentile**	**Mean**	**97.5th Percentile**
Bread	0.081	0.18	0.092	0.21
Miscellaneous Cereals	0.47	0.99	0.39	0.98
Carcase meat	0.030	0.16	0.018	0.098
Offal	0.00040	0	0.00060	0
Meat products	0.094	0.43	0.11	0.38
Poultry	0.020	0.057	0.017	0.074
Fish	0.93	3.7	0.71	2.7
Fats and oils	0.0098	0.031	0.0088	0.029
Eggs	0.20	1.1	0.20	1.2
Sugars	0.10	0.49	0.15	0.63
Green vegetables	0-0.0048	0-0.029	0-0.0049	0-0.020
Potatoes	0.020	0.042	0.018	0.053
Other vegetables	0.014	0.047	0.015	0.053
Canned vegetables	0.023	0.088	0.014	0.054
Fresh fruit	0-0.043	0-0.11	0-0.031	0-0.081
Fruit products	0.43	1.7	0.39	1.9
Non-alcoholic beverages	0.16	0.66	0.15	0.44
Milk	6.5	20	4.6	13
Dairy products	2.2	10	1.2	4.9
Nuts	0-0.00020	0-0.00030	0-0.00060	0-0.0080
Alcoholic drinks	0.00010	0	0	0
Meat substitutes	0.00070	0.012	0.0031	0.047
Snacks	0.017	0.10	0.020	0.11
Desserts	0.13	0.69	0.14	0.67
Condiments	0.011	0.056	0.018	0.092
Tap water	0.089	0.47	0.081	0.30
Bottled water	0.00070	0.0070	0.0018	0.0191
Total	12	26	8.4	17

References

Bates, B.; Lennox, A.; Prentice, A.; Bates, C.; Page, P.; Nicholson, S.; Swan, G. (2014) National Diet and Nutrition Survey Results from Years 1, 2, 3 and 4 (combined) of the Rolling Programme (2008/2009 – 2011/2012) Available at: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/310995/NDNS_Y1_to_4_UK_report.pdf