FOOD STANDARDS Australia New Zealand
Te Mana Kounga Kai – Ahitereiria me Aotearoa

Attachment 1 to Supporting Document 2

Occurrence of and dietary exposure to perfluorooctane sulfonate (PFOS), perfluorooctanoic acid (PFOA) and perfluorohexane sulfonate (PFHxS) reported in the literature

Contents

1 Executive Summary

A literature review examining the occurrence of and reported estimates of dietary exposure to perfluroalylated substances (PFAS) in various populations was conducted. The number of PFAS chemicals analysed in each study and inconsistent methods of determining dietary exposure to PFAS made direct comparison between studies difficult.

EFSA published a comprehensive review of occurrence and dietary exposure to perfluoroalkylated substances in Europe in 2012 (EFSA 2012) that was an update of a previous 2008 report (EFSA 2008) on PFOS and PFOA, so the literature search focused on more recent publications for Europe and more generally from other regions.

Occurrence data were reported in both the EFSA report and the literature for a number of European counties, with limited data from Canada, Korea, China and Japan, noting different methods of analysis and limits of reporting were applied across different studies. Generally PFOS, PFOA and PFHxS were present in a similar range of foods and at levels of the same order of magnitude. The meat and meat products and fish and other seafood food groups had the highest reported levels of the three chemicals. However, for these two major food groups, reported PFOS levels were of a higher order of magnitude than those for PFOA, which were higher than those for PFHxS. Another exception was for cereals and grain-based products where PFOA tended to be reported at higher levels than PFOS.

Overall, the 24th ATDS indicates levels of PFOS and PFOA in the general food supply are low. The concentration of PFOS reported in the two foods with a positive result, fish fillets and beef sausages, were in the same range as those reported elsewhere.

The mean and high consumer (95th percentile) dietary exposure estimates for PFOS, PFOA and PFHxS reported for Europe and other regions of the world were surprisingly similar across countries for each chemical. An exception were those reported for PFOS and PFOA by Cornelis *et al.* (2012) for the Belgium population, which are likely to be overestimated due to high LODs applied in the derivation of mean concentration levels (Cornelis *et al.* 2012).

Discounting the values reported by Cornelis *et al.* (2012) and noting that estimates were derived in a number of different ways across the studies, reported mean dietary exposure estimates across all studies for PFOS ranged from 0-14 ng/kg bw/day, high dietary exposure (95th percentile) estimates from 0-29 ng/kg bw/day. Reported mean dietary exposure estimates for PFOA ranged from 0-17 ng/kg bw/day, 95th percentile exposure estimates from 0-32 ng/kg bw/day. Reported mean dietary exposure estimates for PFHxS were available for Europe only and ranged from 0-1.22 ng/kg bw/day, 95th percentile exposure estimates from 0-2.25 ng/kg bw/day.

Where information was available, dietary exposure estimates for a range of PFAS for infants and young children were higher than for other age groups in the same population, when expressed per kilogram of bodyweight (EFSA 2012, Domingo *et al.* 2012, Klenow *et al.* 2013, Cornelis *et al.* 2012). This is likely a result of higher food consumption per kilogram bodyweight due to growth and maintenance requirements Estimates of dietary exposure for a range of PFAS were higher for coastal communities in France, including pregnant women, than for the general population, as consumption of fish and other seafood, a major source of PFAS, was reported to be higher in these coastal areas (Yamanda *et al.* 2014).

This review highlighted that estimated dietary exposure to PFAS based on levels found in foods have generally not been considered to be of concern for the general public, noting that all studies summarised referenced the European Food Safety Authority (EFSA) health based guidance values in the dietary exposure assessment. Reported dietary exposure estimates were all lower than the relevant EFSA TDIs for PFOS (150 ng/kg bw/day) and PFOA (1500 ng/kg bw/day), the health-based guidance values referred to in most of these studies. When evaluated against the TDIs derived by FSANZ for PFOS/PFHxS (20 ng/kg bw/day) and PFOA (160 ng/kg bw/day), virtually all dietary exposure estimates would be lower than these health-based guidance values. This is important because it shows that the FSANZ TDI is reasonable and readily achievable for the general population i.e. suitable for risk management purposes. The exceptions were the conservative upper bound estimate of high dietary exposure to PFOS for toddlers in Europe (EFSA 2012) and the PFOS estimates reported by Cornelius *et al.* for the Belgium population (Cornelius *et al.* 2012).

2 Introduction

This literature review was conducted to assess the reported occurrence levels and estimated dietary exposures to the three most widely researched PFAS: Perfluorooctane sulfanoate (PFOS), Perfluorooctanoate (PFOA) and Perfluorohexane sulfonic acid (PFHxS).

EFSA published a comprehensive review of occurrence and dietary exposure to perfluoroalkylated substances in Europe in 2012 that was an update of a previous 2008 report on PFOS and PFOA (EFSA 2008, EFSA 2012), so the literature search focused on more recent publications for Europe and more generally from other regions.

International studies have shown that most people are exposed to low levels of PFOS and PFOA from the air, indoor dust, food, water, and various consumer products, with diet a major contributor (ATSDR 2015, Cornelis *et al.* 2012, Vestergren 2012, Tittlemier *et al.* 2007).

3 Methods

Relevant research concerning dietary exposure to PFAS was identified by searching both EbscoDiscovery and Google Scholar databases for primary research material. Material deemed appropriate for this review was any peer-reviewed journal article published since 2012.

In order to ensure that relevant studies were not missed, the search terms remained broad. These were "perfluoroalkyl" or "perfluorinated" or "PFAS" or "perfluoroalkyl substances" "perfluorinated substances" (within the title), plus "human" or "diet" or "dietary exposure" anywhere in the title or abstract. No language restrictions were employed. Studies were eligible for consideration in this review if there was recorded data related to PFAS and dietary exposure and/or estimated levels of PFAS in foods.

Once these articles were identified, the reference lists for each article were reviewed to assess whether any other relevant articles were missed from the search terms but were still within the four year publication period, particularly for European countries.

Due to the variable nature of the literature describing methods of dietary intake/exposure of PFAS, articles that investigated either intake or exposure were included in the literature search, noting comparison between studies was difficult due to varying approaches used and different statistical methods.

In addition to the EFSA 2012 report, 20 additional recent studies were identified that presented PFOS, PFOA and/or PFHxS occurrence data separately for some or all of the major food groups referred to in the EFSA report; of these, 15 studies covered 10 European countries (Belgium, Czech Republic, Finland, France, Greece, Italy, Norway, Spain, Sweden, The Netherlands,) and 5 studies covered 4 other countries (Canada, China, Japan, Korea). Five studies were identified that included additional estimates of dietary exposure to PFOS, PFOA and/or PFHxS for the populations of 7 European countries (Belgium, Czech Republic, France, Italy, Norway, Spain, Sweden) and 3 studies provided limited information on estimates of dietary exposure to PFOS, PFOA and/or PFHxS for the populations of Canada, China and Korea.

4 Results

4.1 Occurrence of PFOS, PFOA and PFHxS in foods

4.1.1 Europe

4.1.1.1 EFSA reports (EFSA 2012)

Results taken from submissions for 13 countries from surveys undertaken from 2006-2012 were included in the EFSA 2012 report. A total of 54,195 analytical results were included in the validated occurrence database for 27 PFAS chemical components, with the majority of data submitted by Germany, France and Norway. The compilers noted that it was not always possible to distinguish random from targeted samples, resulting in a tendency for overestimation of summary concentration levels for some foods and food groups.

For all PFAS a high proportion of non-detects was reported with 16 of the 27 chemicals having some quantified data. Mean occurrence data were reported, with lower bound (LB) and upper bound (UB) values derived. LB mean values were derived by assigning a zero to results less than the LOD or LOQ and the UB by assigning a numerical value equal to the LOD or LOQ to non detect results. Depending on the study approach the numerical values for the LOD or LOQ may have varied with each study and food matrix. Where data was based on composite samples (more than one purchase unit combined and one analysis performed), the means were weighted according to the number of samples per composite.

The results for the three chemicals of interest for this assessment (PFOS, PFOA and PFHxS) are summarised below in Table 1. In the EFSA data set PFOS was the most frequently detected (29%) with PFOS at 9% and PFHxS at 2%. In the EFSA report, major food groups with 100% non-detects are indicated in the occurrence data tables but the assigned mean concentration values are not reported, as these are assigned at the food sub group when used in dietary exposure estimates (see Table 2 for an example for the Meat and meat products and Fish and fish products groups). Overall, approximately 80% of the LOD/LOQ values were <1 µg/kg.

Generally PFOS, PFOA and PFHxS were present in a similar range of foods and at levels of the same order of magnitude. The meat and meat products and fish and other seafood groups had the highest reported levels of the three PFAS chemicals. For these two food groups, reported PFOS levels were higher than those for PFOA, which were higher than PFHxS. As these were the two foods groups where detected results for PFOS were reported in the 24th ATDS (fish fillets <LOR-1.0 µg/kg, sausages < LOR- 0.2 µg/kg), a description of European occurrence data for the sub food groups within these two major food groups is given below in Table 2, with high levels for relevant food sub groups bolded. Where 100% samples were non-detects the UB mean was assigned the LOD for that food.

Table 1. Occurrence data for Europe by major food group (EFSA 2012)

Foods	Chemical	Number of samples*	% non-detects#	Mean LB concentration (µg/kg)#	Mean UB concentration (µg/kg)#
Grain and grain-based products	PFOS	79	100	-	-
	PFOA	79 (778)	96	0.0002	0.10
	PFHxS	75	100	-	-
Vegetables and vegetable products	PFOS	286 (1163)	90	0.02	0.12
	PFOA	285 (1162)	88	0.0039	0.13
	PFHxS	186 (1063)	98	0.0001	0.09
Starchy roots and tubers	PFOS	303 (339)	99.7	0.0035	0.63
	PFOA	303 (339)	99.7	0.0009	0.64
	PFHxS	88	100	-	-
Legumes, nuts and oilseeds	PFOS	20 (157)	95	0.0001	0.11
	PFOA	20 (157)	90	0.0031	0.15
	PFHxS	20	100	-	-
Fruit and fruit products	PFOS	34 (136)	68	0.032	0.085
	PFOA	35 (139)	54	0.0111	0.062
	PFHxS	29 (133)	79	0.013	0.046
Meat and meat products	PFOS	3215 (6460)	64	29.5	30.0
	PFOA	3221 (6494)	86	0.78	1.6
	PFHxS	683 (3928)	99	0.001	0.21
Fish and other seafood	PFOS	2534 (4395)	63	1.99	2.4
	PFOA	2542 (4403)	95	0.082	0.69
	PFHxS	1331 (3192)	99	0.0096	0.49
Milk and dairy products	PFOS	318 (2449)	97	0.0007	0.11
	PFOA	319 (2450)	99	0.0018	0.12
	PFHxS	239 (2370)	99.6	0.000002	0.077
Eggs and egg products	PFOS	134 (816)	88	0.034	0.54
	PFOA	138 (820)	89	0.066	0.58
	PFHxS	99 (781)	99	0.0001	0.52
Sugar and confectionary	PFOS	45 (156)	98	0.0035	0.053
	PFOA	45 (156)	91	0.0058	0.049
	PFHxS	10	100	-	-
Animal and vegetable fats & oils	PFOS	56 (161)	98	0.28	0.56
	PFOA	55 (160)	96	0.0021	0.31
	PFHxS	53 (158)	98	0.0003	0.21
Fruit and vegetable juices	PFOS	1	100	-	-
	PFOA	1	100	-	-
	PFHxS	1	100	-	-
Alcoholic beverages	PFOS	6	100	-	-
	PFOA	6 (63)	83	0.0087	0.013
	PFHxS	6 (63)	83	0.0048	0.0065
Herbs, spices and condiments	PFOS	8	100	-	-
	PFOA	8	100	-	-
	PFHxS	8	100	-	-
Food for infants & small children	PFOS	21	100	-	-
	PFOA	21	100	-	-
	PFHxS	10	100	-	-

Foods	Chemical	Number of samples*	% non-detects#	Mean LB concentration (µg/kg)#	Mean UB concentration (µg/kg)#
Composite food	PFOS	45	100	-	-
	PFOA	45 (381)	98	0.0004	0.071
	PFHxS	38	100	-	-
Snacks, desserts & other foods	PFOS	46	100	-	-
	PFOA	46	100	-	-
	PFHxS	46	100	-	-
Drinking water	PFOS	372 (456)	89	0.0005	0.0025
	PFOA	367 (451)	84	0.001	0.0027
	PFHxS	300 (384)	88	0.0007	0.0021

** Number of reported analyses, total number of samples in brackets when adjusted for number of samples in composites*

 # Means were calculated by weighting the results for pooled samples; where 100% samples were non-detects the LB, UB means were not presented in the EFSA report at the major food group level, but were assigned at the sub food group level.

Table 2. Occurrence data for Europe for meat and fish by sub food group (EFSA 2012)

Foods	Chemical	Number of samples*	% non-detects#	Mean LB concentration (µg/kg)#	Mean UB concentration (µg/kg)#
Meat and meat products	PFOS	3215 (6460)	64	**29.5**	**30.0**
	PFOA	3221 (6494)	86	0.78	1.6
	PFHxS	683 (3928)	99	0.001	0.21
Meat & meat products (unspec)	PFOS	15 (15)	100	0	1.0
	PFOA	15 (15)	100	0	1.0
	PFHxS	15 (15)	100	0	1.0
Livestock meat	PFOS	232 (1418)	91	0.0086	0.12
	PFOA	232 (1418)	95	0.0061	0.13
	PFHxS	183 (1369)	99	0.0002	0.081
Poultry	PFOS	150 (735)	97	0.0097	0.14
	PFOA	150 (735)	99	0.0024	0.14
	PFHxS	136 (721)	100	0	0.12
Game mammals	PFOS	569 (569)	71	0.87	1.5
	PFOA	572 (572)	91	0.4	1.2
	PFHxS	26 (26)	96	0.016	0.72
Game birds	PFOS	9 (9)	100	0	0.38
	PFOA	9 (9)	100	0	0.37
	PFHxS	1 (1)	100	0	0.053
Edible offal, farmed animals	PFOS	1261 (1623)	91	0.42	1.9
	PFOA	1265 (1655)	98	0.034	1.4
	PFHxS	145 (507)	99	0.0041	0.62
Edible offal, game animals	PFOS	882 (882)	4	**215**	**215**
	PFOA	881 (881)	59	**5.4**	**8.1**
	PFHxS	90 (90)	99	0.012	2.5
Preserved meat	PFOS	39 (518)	95	0.0003	0.057
	PFOA	39 (518)	97	0.0002	0.067
	PFHxS	36 (515)	100	0	0.055
Sausages	PFOS	43 (480)	88	**0.066**	0.14
	PFOA	43 (480)	100	0	0.1
	PFHxS	36 (473)	100	0	0.061
Pastes, pates & terrines	PFOS	15 (211)	100	0	0.05
	PFOA	15 (211)	93	0.0085	0.069
	PFHxS	15 (211)	100	0	0.041
Fish and other seafood	PFOS	2534 (4395)	63	**1.99**	**2.4**
	PFOA	2542 (4403)	95	0.082	0.69
	PFHxS	1331 (3192)	99	0.0096	0.49
Fish and other seafood (unspec)	PFOS	6 (21)	33	0.52	0.66
	PFOA	6 (21)	50	0.029	0.18
	PFHxS	5 (20)	80	0.013	0.16
Fish meat (fillets)	PFOS	1982 (2978)	67	**2.1**	**2.5**
	PFOA	1993 (2989)	96	0.10	0.64
	PFHxS	927 (1923)	99.9	0.00052	0.46
Fish offal	PFOS	410 (410)	46	**4.9**	**5.5**
	PFOA	410 (410)	99	0.021	1.6
	PFHxS	308 (308)	98	0.07	0.92

Foods	Chemical	Number of samples*	% non-detects#	Mean LB concentration (µg/kg)#	Mean UB concentration (µg/kg)#
Crustaceans	PFOS	78 (302)	32	**1.5**	**1.5**
	PFOA	73 (297)	70	0.15	0.30
	PFHxS	43 (267)	91	0.03	0.19
Water molluscs	PFOS	58 (684)	72	0.031	0.55
	PFOA	60 (686)	95	0.0032	0.54
	PFHxS	48 (674)	100	0	0.54

* *Number of reported analyses, total number of samples in brackets when adjusted for number of samples in composites*

Means were calculated by weighting the results for pooled samples; where 100% samples were non-detects, the lower bound (LB) mean was assigned zero and the upper bound (UB) mean the limit of detection for that food matrix.

For meat and meat products, there was a high level of non-detects, with some exceptions, for example edible offal of game animals and fish. The high LB and UB values for PFOS for the whole meat and meat products food group were driven by reported levels for game mammals and edible offal, in particular edible offal for game animals, the concentration level of which was two orders of magnitude higher than for any other food sub-group. A separate study of PFOS in animal livers indicated a marked accumulation in animal organs in an order of liver > kidney > muscle (Zafeiraki *et al.* 2016a). For fish and other seafood, PFOS levels for fish offal were the highest of the five fish and seafood sub groups but of the same order of magnitude as levels for fish fillets and crustacea.

4.1.1.2 Other occurrence data from studies for Europe 2012-2016

A number of studies have been published since the EFSA 2012 report for specific countries in Europe. These are summarised in Table 3, Table 4 and Table 5 below for PFOS, PFOA and PFHxS respectively, noting different studies may have used different methods of analysis and assigned different LOD/LOQs to non-detect samples of the same food. It is unclear if some of these data had also been submitted to EFSA and included in the 2012 review, as data may have been collected several years prior to publication. Publications that reported total PFAS concentrations were not included in the tables below because different numbers of PFAS chemicals were included in total concentrations (Yamanda *et al.* 2014, D'Hollander *et al.* 2015), so the data were not comparable.

Generally the additional occurrence data reported for 10 individual European countries from 2012-16 for PFOS, PFOA and PFHxS were with the ranges reported in the EFSA 2012 review. Exceptions were for PFOS concentration levels for foods from Belgium reported by Cornelis *et al.* (2012), noting that the reported LODs for this study were higher than most other studies (0.17 - 15 µg/kg). In particular, the PFOS level of 174 µg/kg for freshwater fish was higher than that for sea caught (marine) fish level of 12.9 µg/kg and much higher than the mean levels reported by EFSA (mean PFOS concentrations of 2.1- 2.5 µg/kg for fish meat /fillets and 4.9 – 5.5 µg/kg for fish offal, noting these data did not distinguish between marine and freshwater caught fish). The PFOS values reported for Finland for freshwater fish of 1.5 – 39 µg/kg were also higher than those for marine fish of 0.31-7.5 µg/kg (Koponen *et al.* 2014), but not as high as those reported by Cornelis *et al.* High PFOS concentration levels were reported for marine fish caught in Greek coastal waters of 0.82 – 20.37 µg/kg across 7 species; the same items had higher levels of PFOS once fried in oil (<0.49 – 44.69 µg/kg), but similar values when grilled (Vassiliadou *et al.* 2015).

Table 3. Additional occurrence data for PFOS for Europe by major food group (2012-16)

Foods*	Country	Year	Number and type samples**	Mean PFOS concentration (µg/kg)#	Reference
Grain and grain-based products	Belgium	2012	3 whole group	0.052	Cornelis *et al.* 2012
	Sweden	2010	NS pastries	0.021	Vestergren *et al.* 2012
			NS other	0.022	
	Spain	2011	NS bakery	0.0007	Domingo *et al.* 2012a
			NS other	< 0.0017	
Vegetables and vegetable products	Belgium	2012	36 whole group	0.60	Cornelis *et al.* 2012
	Sweden	2010	NS incl root veg	0.0041	Vestergren *et al.* 2012
	Belgium	2011	NS whole group	0.0032	Herzke *et al.* 2013
	Czech Reb	2011	NS whole group	0.0007	Herzke *et al.* 2013
	Italy	2011	NS whole group	0.0057	Herzke *et al.* 2013
	Spain	2011	NS whole group	0.1	Domingo *et al.* 2012a
Starchy roots and tubers	Belgium	2012	6 whole group	6.18	Cornelis *et al.* 2012
	Sweden	2010	NS potatoes	0.0069	Vestergren *et al.* 2012
	Spain	2011	NS whole group	<0.005	Domingo *et al.* 2012a
Legumes, nuts and oilseeds	Spain	2011	NS whole group	0.0061	Domingo *et al.* 2012a
Fruit and fruit products	Belgium	2012	11 whole group	0.35	Cornelis *et al.* 2012
	Sweden	2010	NS whole group	0.0022	Vestergren *et al.* 2012
	Spain	2011	NS whole group	<0.005	Domingo *et al.* 2012a
Meat and meat products	Belgium	2012	7 pork	0.17	Cornelis *et al.* 2012
			5 poultry	0.63	
			7 other	0.055	
	Sweden	2010	NS whole group	0.025	Vestergren *et al.* 2012
	Spain	2011	NS whole group 99 liver (horse, pig, cow, sheep chicken)	0.034	Domingo *et al.* 2012a
	Netherlands	2014	8 whole group	<0.5 - 4.5	Zafeiraki *et al.* 2016a
	Italy	2013	NS whole group	1.43	Guerannti *et al.* 2013
Fish and other seafood	Belgium	2012	28 marine	12.0	Cornelis et al. 2012
			26 freshwater	**174**	
			745 crust & mollusc	9.86	
	Sweden	2010	NS whole group	1.29	Vestergren et al. 2012
	Spain	2011	NS whole group	2.7	Domingo et al. 2012a
	Greece	2011	28 marine	**0.82 - 20.37**	Vassiliadou et al. 2015
			4 crustacea	**5.15**	
			8 molluscs	<0.49	
	France	2010	NS molluscs	0.04 - 0.2	Munschy et al. 2013
	Finland	2009	253 marine	0.31 - 7.5	Koponen et al. 2014
			23 freshwater	**1.5 - 39**	
			20 farmed	<0.37	
	Italy	2013	16	<LOD - 30.2	Guerannti et al. 2013

Foods*	Country	Year	Number and type samples**	Mean PFOS concentration (µg/kg)#	Reference
Milk and dairy products	Belgium	2012	9 whole group	0.25	Cornelis *et al.* 2012
	Sweden	2010	NS whole group	0.0056	Vestergren *et al.* 2012
	Spain	2011	NS milk	<0.0069	Domingo *et al.* 2012a
			NS other	<0.003	
	Italy^	2011	67 cows milk	0 - 0.097	Barbarossa *et al.* 2014
	Italy	2013	4 milk	0.36	Guerannti *et al.* 2013
			8 cheese	<LOD - 2.88	
Eggs and egg products	Belgium	2012	8	6.86	Cornelis *et al.* 2012
	Sweden	2010	-	0.039	Vestergren *et al.* 2012
	Spain	2011	-	<0.0053	Domingo *et al.* 2012a
	Netherlands	2013	73	3.5##	Zafeiraki *et al.* 2016b
	Greece	2013	45	1.1##	Zafeiraki *et al.* 2016b
Sugar and confectionary	Sweden	2010	-	0.0036	Vestergren *et al.* 2012
Animal and veg fats & oils	Belgium	2012	2	0.033	Cornelis *et al.* 2012
	Sweden	2010	-	0.013	Vestergren *et al.* 2012
	Spain	2011	-	0.0011	Domingo *et al.* 2012a
Alcoholic beverages	Belgium	2012	5 beer	0.013	Cornelis *et al.* 2012
Food for infants & small children	Spain^	2012	10 breast milk	0.05	Lorenzo *et al.* 2016
			16 infant formula	0.061	
			13 dry cereals	1.321	
			12 baby food	0.019	
	Italy^	2013	49 breast milk	0.85	Guerannti *et al.* 2013
	France^	2013	48 breast milk	0.079	Antignac *et al.* 2013
	France^	2010/2013	61 breast milk	0.04	Cariou *et al.* 2015
Drinking water	Belgium	2012	4	0.005	Cornelis *et al.* 2012
	Spain	2011	30	0.0018	Domingo *et al.* 2012b

** No additional data for Fruit and vegetable juices, Herbs, spices and condiments, Food for infants & small children, Composite food or Snacks, desserts & other foods.*

 # Numerical value given for LOD/LOQ if quoted in the study (eg <0.1 µg/kg), otherwise given as <LOD/LOQ if value not reported

^ Cow milk, breast milk and infant formula data in µg/L.

*** NS Number of samples not specified*

Median concentration

Table 4. Additional occurrence data for PFOA for Europe by major food group (2012-16)

Foods	Country	Year	Number and type samples**	Mean PFOA concentration (µg/kg)#	Reference
Grain and grain-based products	Belgium	2012	3 whole group	0.055	Cornelis *et al.* 2012
	Sweden	2010	NS pastries	0.018	Vestergren *et al.* 2012
			NS other	0.062	
	Spain	2011	NS bakery	<0.11	Domingo *et al.* 2012a
			NS other	<0.12	
Vegetables and vegetable products	Belgium	2012	36 whole group	0.65	Cornelis *et al.* 2012
	Sweden	2010	NS whole group	0.022	Vestergren *et al.* 2012
	Belgium	2011	NS whole group	0.0103	Herzke *et al.* 2013
	Czech Reb	2011	NS whole group	0.0019	Herzke *et al.* 2013
	Italy	2011	NS whole group	0.0025	Herzke *et al.* 2013
	Spain	2011	NS whole group	0.37	Domingo *et al.* 2012a
Starchy roots and tubers	Belgium	2012	6 whole group	0.67	Cornelis *et al.* 2012
	Sweden	2010	NS potatoes	0.057	Vestergren *et al.* 2012
	Spain	2011	NS whole group	<0.36	Domingo *et al.* 2012a
Legumes, nuts and oilseeds	Spain	2011	NS whole group	<0.26	Domingo *et al.* 2012a
Fruit and fruit products	Belgium	2012	11 whole group	0.43	Cornelis *et al.* 2012
	Sweden	2010	NS whole group	0.015	Vestergren *et al.* 2012
	Spain	2011	NS whole group	<0.360	Domingo *et al.* 2012a
Meat and meat products	Belgium	2012	7 pork	0.055	Cornelis *et al.* 2012
			5 poultry	0.055	
			7 other	0.52	
	Sweden	2010	NS whole group	0.012	Vestergren *et al.* 2012
	Spain	2011	NS whole group	<0.3	Domingo *et al.* 2012a
Fish and other seafood	Belgium	2012	27 marine	0.59	Cornelis *et al.* 2012
			26 freshwater	0.78	
			652 crust & molluscs	3.34	
	Sweden	2010	NS whole group	0.05	Vestergren *et al.* 2012
	Spain	2011	NS whole group	2.6	Domingo *et al.* 2012a
	Greece	2011	28 marine	<0.6	Vassiliadou *et al.* 2015
			4 crustacea	<0.6	
			8 molluscs	<0.6	
	Finland	2009	253 marine	<0.39-1.8	Koponen *et al.* 2014
			23 freshwater	<0.23	
			20 farmed	<0.37	
Milk and dairy products	Belgium	2012	9	0.12	Cornelis *et al.* 2012
	Sweden	2010	NS whole group	0.029	Vestergren *et al.* 2012
	Spain	2011	NS milk	0.39	Domingo *et al.* 2012a
			NS other	0.19	
	Italy^	2011	67 cows milk	0 - 0.032	Barbarossa *et al.* 2014
Eggs and egg products	Belgium	2012	8 whole group	0.86	Cornelis *et al.* 2012
	Sweden	2010	NS whole group	0.039	Vestergren *et al.* 2012
	Spain	2011	NS whole group	<0.39	Domingo *et al.* 2012a
	Netherlands	2013	73 median	1.1	Zafeiraki *et al.* 2016b
	Greece	2013	45 median	0.5	Zafeiraki *et al.* 2016b
Sugar and confectionary	Sweden	2010	NS whole group	0.013	Vestergren *et al.* 2012

Foods	Country	Year	Number and type samples**	Mean PFOA concentration (µg/kg)#	Reference
Animal and veg fats & oils	Belgium	2012	2 whole group	0.091	Cornelis *et al.* 2012
	Sweden	2010	NS whole group	<LOQ	Vestergren *et al.* 2012
	Spain	2011	NS whole group	<0.140	Domingo *et al.* 2012a
Alcoholic beverages	Belgium	2012	5 beer	0.006	Cornelis *et al.* 2012
Food for infants & small children	Spain^	2012	10 breast milk	0.177	Lorenzo *et al.* 2016
			16 infant formula	0.415	
			13 dry cereals	0.179	
			12 baby food	0.216	
	Italy	2013	49 breast milk	0.16	Guerannti *et al.* 2013
	Spain^	2013	40 breast milk	0.054	Guzmàn *et al.* 2016
	France^	2013	48 breast milk	0.075	Antignac *et al.* 2013
	France ^	2010/2013	61 breast milk	0.041	Cariou *et al.* 2015
Drinking water	Belgium	2012	4	0.002	Cornelis *et al.* 2012
	Spain	2011	30	0.0024	Domingo *et al.* 2012b

**No additional data for Fruit and vegetable juices, Herbs, spices and condiments, Food for infants & small children, Composite food or Snacks, desserts & other foods.*

 # Numerical value given for LOD/LOQ if quoted in the study (eg <0.1 µg/kg), otherwise given as <LOD/LOQ if value not reported

^ Cow milk, breast milk data in µg/L

*** NS Number of samples not specified*

Median concentration

Table 5. Additional occurrence data for PFHxS for Europe by major food group (2012-16)

Foods*	Country	Year	Number and type samples**	Mean PFHxS concentration (µg/kg)#	Reference
Grain and grain-based products	Sweden	2010	NS pastries	<LOQ	Vestergren *et al.* 2012
			NS other	<LOQ	
	Spain	2011	NS bakery	<0.0006	Domingo *et al.* 2012
			NS other	<0.0006	
Vegetables and vegetable products	Sweden	2010	NS incl root veg	0.0012	Vestergren *et al.* 2012
	Belgium	2011	NS whole group	0.0003	Herzke *et al.* 2013
	Czech Reb	2011	NS whole group	<LOQ	Herzke *et al.* 2013
	Italy	2011	NS whole group	<LOQ	Herzke *et al.* 2013
	Spain	2011	NS whole group	0.0045	Domingo *et al.* 2012a
Starchy roots and tubers	Sweden	2010	NS potatoes	<LOQ	Vestergren *et al.* 2012
	Spain	2011	NS whole group	<0.0019	Domingo *et al.* 2012a
Legumes, nuts and oilseeds	Spain	2011	NS whole group	0.0013	Domingo *et al.* 2012a
Fruit and fruit products	Sweden	2010	NS whole group	<LOQ	Vestergren *et al.* 2012
	Spain	2011	NS whole group	<0.0019	Domingo *et al.* 2012a
Meat and meat products	Sweden	2010	NS whole group	0.0045	Vestergren *et al.* 2012
	Spain	2011	NS whole group	0.0032	Domingo *et al.* 2012a
Fish and other seafood	Sweden	2010	NS whole group	0.0092	Vestergren *et al.* 2012
	Spain	2011	NS whole group	0.045	Domingo *et al.* 2012a
	Greece	2011	28 marine	<0.18	Vassiliadou *et al.* 2015
			4 crustacea	<0.18	
			8 molluscs	<0.18	
Milk and dairy products	Sweden	2010	NS whole group	0.001	Vestergren *et al.* 2012
	Spain	2011	NS milk	<0.0026	Domingo *et al.* 2012a
			NS other	<0.0011	
Eggs and egg products	Sweden	2010	NS whole group	0.0025	Vestergren *et al.* 2012
	Spain	2011	NS whole group	<0.002	Domingo *et al.* 2012a
	Netherlands	2013	73 whole group	1.1##	Zafeiraki *et al.* 2016
	Greece	2013	45 whole group	< 0.5##	Zafeiraki *et al.* 2016
Sugar and confectionary	Sweden	2010	NS whole group	0.0015	Vestergren *et al.* 2012
Animal and veg fats & oils	Sweden	2010	NS whole group	<LOQ	Vestergren *et al.* 2012
	Spain	2011	NS whole group	<0.0007	Domingo *et al.* 2012a
Food for infants & small children	Spain^	2012	10 breast milk	<LOD	Lorenzo *et al.* 2016
			16 infant formula	0.034	
			13 dry cereals	0.265	
			12 baby food	<LOD	
	France^	2013	48 breast milk	0.05	Antignac *et al.* 2013
	France^	2010/2013	61 breast milk	0.026	Cariou *et al.* 2015
Drinking water	Spain	2011	30	0.0004	Domingo *et al.* 2012b

** No additional data for Fruit and vegetable juices, Herbs, spices and condiments, Food for infants & small children, Composite food or Snacks, desserts & other foods, Alcoholic beverages, Drinking water.*

 # Numerical value given for LOD/LOQ if quoted in the study (eg <0.1 µg/kg), otherwise given as <LOD/LOQ if value not reported

^ Breast milk data in µg/L

*** NS Number of samples not specified*

Median concentration

4.1.2 Regions other than Europe

In one of the first studies to report on PFAS, limited occurrence data were reported from the Canadian Total Diet Study (TDS), where 49 composite samples were analysed for PFAS chemicals (Tittlemier 2007). Just over half of the samples were taken from the 2004 TDS and the rest from archived samples taken from 1992-2001. PFAS chemicals were detected only in four meat samples (beef steak, roast beef, ground beef, luncheon meat), three fish samples (one marine and two freshwater fish), pizza and popcorn out of the 49 foods included in the review.

Four more recent studies were identified giving occurrence data for PFAS in a range of foods for the Asian region; for Korea (Heo *et al.* 2014) and for China (Wu *et al.* 2012); on foods for infants, including breast milk (Yukiko *et al.* 2012) and on breast milk only (Kang *et al.* 2016). Available data for PFOS, PFPOA and PFHXs are summarised in Table 6 , Table 7 and Table 8 below.

Table 6. Occurrence data for PFOS for regions other than Europe by major food group

Foods*	Country	Year	Number and type samples**	Mean PFOS concentration (µg/kg)#	Reference
Grain and grain-based products	Canada	1998 1999	NS Pizza NS Popcorn	<1.0 0.98	Tittlemier *et al.* 2007
Fruit, vegetables and products	Korea	2011	78 fruit and veg	<LOD	Heo *et al.* 2014
Meat and meat products	Canada Korea	2004 2011	NS Beef NS Luncheon meat 39 whole group	<0.6 to 2.7 <0.6 0.353 LB	Tittlemier *et al.* 2007 Heo *et al.* 2014
Fish and other seafood	Canada China Korea	2004 2004 2009 2011	NS Marine NS Freshwater NS Fatty fish NS Shellfish 99 whole group	2.6 2.0 0.063-0.476 0.008-0.226 0.668 LB	Tittlemier *et al.* 2007 Wu *et al.* 2012 Heo *et al.* 2014
Milk and dairy products	Korea	2011	37 whole group	<LOD	Heo *et al.* 2014
Composite foods	Korea	2011	90 whole group	0.409 LB	Heo *et al.* 2014
Food for infants & small children	Korea^	2013	274 breast milk	0.05##	Kang *et al.* 2016
Drinking water	Korea^	2011	34 tap water 8 bottled water	0.0026 0.0001	Heo *et al.* 2014
Beverages	Korea^	2011	21 whole group	0.024 LB	Heo *et al.* 2014
Other foods	Korea	2011	33 not defined	0.01 LB	Heo *et al.* 2014

** No additional data for Starchy roots and tubers, Legume, nuts and oilseeds, Eggs and egg products, Sugar and confectionary, Animal fats and oils, Fruit and vegetable juices, Alcoholic beverages, Herbs, spices and condiments, Snacks, desserts & other foods.*

 # Numerical value given for LOD/LOQ if quoted in the study (eg <0.1 µg/kg), otherwise given as <LOD/LOQ if value not reported, LB lower bound, LOD limit of detection, LOQ limit of quantification

^ Drinking water, beverages and breast milk data in µg/L

*** NS Number of samples not specified*

Median concentration

Table 7. Occurrence data for PFOA for regions other than Europe by major food group

Foods*	Country	Year	Number and type samples**	Mean PFOA concentration (µg/kg)#	Reference
Grain and grain-based products	Canada	1998	NS Pizza	<1.0	Tittlemier *et al.* 2007
		1999	NS Popcorn	3.6	
Fruit, vegetables and products	Korea	2011	78 fruit and veg	0.001 LB	Heo *et al.* 2014
Meat and meat products	Canada	2004	NS Beef	<0.4 to 2.6	Tittlemier *et al.* 2007
			NS Luncheon meat	<0.4	
	Korea	2011	39 whole group	<LOD	Heo *et al.* 2014
Fish and other seafood	Canada	2004	NS Marine	<0.5	Tittlemier *et al.* 2007
		2004	NS Freshwater	<0.5	
	China	2009	NS Fatty fish	0.016-0.07	Wu *et al.* 2012
			NS Shellfish	0.094-1.459	
	Korea	2011	99 whole group	0.07 LB	Heo *et al.* 2014
Milk and dairy products	Korea	2011	37 whole group	0.261 LB	Heo *et al.* 2014
Composite foods	Korea	2011	90 whole group	0.003 LB	Heo *et al.* 2014
Food for infants & small children	Korea^	2013	274 breast milk	0.072##	Kang *et al.* 2016
	Japan^	2010	30 breast milk	0.0935	Yukiko *et al.* 2012
		2010	5 infant formula	0.0218	
	Korea^	2010	30 breast milk	0.0645	
	China^	2008	30 breast milk	0.0516	
		2010	5 infant formula	0.0281	
Drinking water	Korea^	2011	34 tap water	0.0129	Heo *et al.* 2014
			8 bottled water	0.0002	
Beverages	Korea^	2011	21 whole group	0.153 LB	Heo *et al.* 2014
Other foods	Korea	2011	33 not defined	<LOD	Heo *et al.* 2014

** No additional data for Starchy roots and tubers, Legume, nuts and oilseeds, Eggs and egg products, Sugar and confectionary, Animal fats and oils, Fruit and vegetable juices, Alcoholic beverages, Herbs, spices and condiments, Snacks, desserts & other foods.*

 # Numerical value given for LOD/LOQ if quoted in the study (eg <0.1 µg/kg), otherwise given as <LOD/LOQ if value not reported, LB lower bound, LOD limit of detection, LOQ limit of quantification

^ Drinking water, beverages and breast milk data in µg/L

*** NS Number of samples not specified*

Median concentration

Table 8. Occurrence data for PFHxS for regions other than Europe by major food group

Foods*	Country	Year	Number and type samples**	Mean PFHxS concentration (µg/kg)#	Reference
Fruit, vegetables and products	Korea	2011	78 fruit and veg	<LOD	Heo *et al.* 2014
Meat and meat products	Korea	2011	39 whole group	<LOD	Heo *et al.* 2014
Fish and other seafood	Korea	2011	99 whole group	0.012 LB	Heo *et al.* 2014
Milk and dairy products	Korea	2011	37 whole group	0.029 LB	Heo *et al.* 2014
Composite foods	Korea	2011	90 whole group	0.007 LB	Heo *et al.* 2014
Drinking water	Korea^	2011	34 tap water 8 bottled water	0.0008 <LOD	Heo *et al.* 2014
Beverages	Korea^	2011	21 whole group	<LOD	Heo *et al.* 2014
Other foods	Korea	2011	33 not defined	0.028 LB	Heo *et al.* 2014

** No additional data for Starchy roots and tubers, Legume, nuts and oilseeds, Eggs and egg products, Sugar and confectionary, Animal fats and oils, Fruit and vegetable juices, Alcoholic beverages, Herbs, spices and condiments, Snacks, desserts & other foods.*

 # Numerical value given for LOD/LOQ if quoted in the study (eg <0.1 µg/kg), otherwise given as <LOD/LOQ if value not reported, LB lower bound, LOD limit of detection, LOQ limit of quantification

^ Drinking water, beverages and breast milk data in µg/L

*** NS Number of samples not specified*

Median concentration

4.1.3 Comparison of occurrence data from other regions with the 24th ATDS

The concentration of PFOS reported in fish fillets in the 24th ATDS (<LOD - 1.0 µg/kg) was generally much lower than levels reported in international studies (<LOD - 174 µg/kg), noting freshwater fish concentration levels were generally higher than marine caught fish where reported separately. Although there were no direct comparisons found for beef sausages, PFOS levels reported in sausages in the 24th ATDS (<LOD – 0.2 µg/kg) were higher than those reported for all sausages in Europe (0.066 µg/kg) (EFSA 2012) but lower than the level for ground beef reported in the Canadian study (2.1 µg/kg) (Tittlemier 2007).

4.1.4 Drinking water

A limited number of occurrence data were available for drinking water; for Europe for PFOS from 0.0005 - 0.005 µg/g (EFSA 2012, Cornelis *et al.* 2012, Domingo *et al.* 2012b) and for Korea from 0.0001 (bottled water) to 0.0003 (tap water) µg/L (Heo *et al.* 2014); for Europe for PFOA from 0.001 - 0.0027 µg/g (EFSA 2012, Cornelis *et al.* 2012, Domingo *et al.* 2012b) and for Korea from 0.0002 (bottled water) to 0.0012 (tap water) µg/L (Heo *et al.* 2014); for Europe for PFHxS from 0.0007 - 0.0021 (EFSA 2012, Domingo *et al.* 2012b) and for Korea from <LOD (bottled water) to 0.0008 (tap water) µg/L (Heo *et al.* 2014).

Few countries have set PFAS in guideline levels for drinking water; in the USA the guideline levels are 0.2 µg/L for PFOS and 0.4 µg/L for PFOA (ATSDR 2015). All PFOS, PFOA and PFHxS levels in drinking water reported in the studies assessed were much lower than these guideline levels. In April 2016 enHealth[1] proposed interim guideline levels for drinking water for Australia of 0.5 µg/L for PFOS + PFHxS and 5 µg/L for PFOA, using the EFSA TDIs for PFOS and PFOA as a basis for the calculations (enHealth 2016).

4.1.5 Breast milk

A limited number of occurrence data were available for breast milk for European women in the additional studies ranging from mean concentrations of 0.04 – 0.85 µg/L for PFOS, 0.04 – 0.17 µg/L for PFOA and 0.026 - 0.05 µg/L for PFHxS (Guzmàn *et al.* 2016, Lorenzo *et al.* 2016, Guerannti *et al.* 2013, Antignac *et al.* 2013, Cariou *et al.* 2015). In the Asian region breast milk data were available for Korean women with mean values of 0.005 µg/L reported for

1 The Environmental Health Standing Committee (enHealth) is a standing committee of the Australian Health Protection Principal Committee (AHPPC).

PFOS (Kang *et al.* 2016) and 0.06 - 0.07 µg/L for PFOA (Kang *et al.* 2016, Yukiko *et al.* 2012); mean values for PFOA in breast milk of Japanese and Chinese women were 0.094 µg/L and 0.052 µg/L respectively (Yukiko *et al.* 2012).

Unlike other foods, the proportion of detects in breast milk samples was generally high for PFOS ranging from 27-98%, for PFOA ranging from 2-100% and for PFHxS at 15%. More specifically: 60% PFOS and 100% PFOA, reported in Lorenz *et al.* 2016; 60% for PFOA, Guzman *et al.* 2016; 27% PFOS and 2% PFOA, Guerrenti *et al.* 2013; 82% PFOS, 77% PFOA and 15% PFHxS, Cariou *et al.* 2015; 98% for PFOS and PFOA, Kang *et al.* 2016; >60% for PFOA Yukiko *et al.* 2012. This is to be expected as PFAS chemicals accumulate in the human body over time from all food and non-food sources. However, contributing factors to PFAS levels in breast milk will be different for each population, and may depend to some extent on the amount of meat and meat products, fish and seafood, and other foods consumed as well as genetic, economic and environmental factors. This is also the case for blood serum levels, for example, the Jain 2014 study on factors influencing blood serum levels of PFAS chemicals in the US population, the De Felip *et al.* 2015 study of blood serum levels of PFAS chemicals in Italian women, the Ji *et al.* 2012 study of blood serum levels in Korean population and the Yukoki *et al.* 2012 study of blood serum levels in Japanese, Korean and Chinese women. Possible contributing factors to blood serum levels for Australian populations are subject to a separate study and not reported here.

4.2 Estimated dietary exposure to PFOS, PFOA, PFHxS

Many of the publications reporting occurrence data also reported estimated dietary exposures to PFAS for the populations consuming those foods containing PFAS, including PFOS, PFOA and PFHxS. These are summarised for Europe and other regions below in Table 9, Table 10, and Table 11 respectively. Where estimated dietary exposures were reported for total PFAS, these were not included in this report because different numbers of PFAS chemicals were included in the calculations in each study, so the data were not comparable. Where an estimate was not given for the total diet but for dietary exposure from a major food group only this is noted (Wu *et al.* 2012). Generally, national nutrition survey (NNS) data were used to derive food consumption data and individual body weights for dietary exposure estimates, with the exception of those for Canada (Tittlemeir *et al.* 2007) and Sweden (Vestergren 2012) where per capita consumption data and a standard bodyweight was used.

The EFSA 2008 dietary exposure estimates were known to be overestimates compared to those reported in 2012 due to higher LODs for most foods, lack of information for many countries and conservative assumptions made (EFSA 2008, 2012). In the 2012 report EFSA included only those countries with 2 or more days of food consumption records for each age group, as it was a chronic dietary exposure assessment (EFSA 2012). It is noted in this report that the estimates of dietary exposure to PFHxS were tentative, as there were less data for PFHxs and more uncertainties in the occurrence data set.

The results reported for Belgium by Cornelis *et al.* in 2012 stand out as being much higher than any other estimated dietary exposures reported for Europe, estimates appear to be mainly driven by higher LODs and the high analytical values for fish and seafood, in particular freshwater fish, reported in their study (Cornelis *et al.* 2012).

In a 2007 report from the Canadian Total Diet Study, approximately 60% total exposure to perfluorinated carboxylates and PFOS was attributed to food, <1% to water, with the remaining from household items such as treated carpet and upholstery (29%), dust (7%) and air (3%) (Tittlemier *et al.* 2007).

The mean and high consumer (95^{th} percentile) dietary exposure estimates for PFOS, PFOA and PFHxS reported for Europe and other regions of the world were surprisingly similar across countries for each chemical, with the exception of those reported for PFOS and PFOA by Cornelis *et al.* (2012) for the Belgium population, which are likely to be overestimated due to high LODs applied in the derivation of mean concentration levels (Cornelis *et al.* 2012). Discounting the values reported by Cornelis *et al.* (2012) and noting that estimates were derived in a number of different ways across the studies, reported mean dietary exposure estimates across all studies for PFOS ranged from 0-14 ng/kg bw/day, high dietary exposure (95^{th} percentile) estimates from 0-29 ng/kg bw/day. Reported mean dietary exposure estimates for PFOA ranged from 0-17 ng/kg bw/day, 95^{th} percentile exposure estimates from 0-32 ng/kg bw/day. Reported mean dietary exposure estimates for PFHxS were available for Europe only and ranged from 0-1.22 ng/kg bw/day, 95^{th} percentile exposure estimates from 0-2.25 ng/kg bw/day.

Where information was available, dietary exposure estimates for PFAS for infants and young children were higher than for other age groups in the same population, when expressed per kilogram of bodyweight (EFSA 2012, Domingo *et al.* 2012, Klenow *et al.* 2013, Cornelis *et al.* 2012). This is likely a result of higher food consumption per kilogram bodyweight due to growth and maintenance requirements. Estimates of dietary exposure for PFAS were higher for coastal communities in France, including pregnant women, than for the general population, as consumption of fish and other seafood, a major source of PFAS, was reported to be higher in these coastal areas (Yamanda *et al.* 2014).

This review highlighted that estimated dietary exposure to PFAS based on levels found in foods have generally not been considered to be of concern for the general public, noting that all studies summarised referenced the EFSA health based guidance values in the dietary exposure assessment. Reported dietary exposure estimates were all lower than the relevant EFSA TDIs for PFOS (150 ng/kg bw/day) and PFOA (1500 ng/kg bw/day), the health-based guidance values referred to in most of these studies. When evaluated against the TDIs derived by FSANZ for PFOS/PFHxS (20 ng/kg bw/day) and PFOA (160 ng/kg bw/day), virtually all dietary exposure estimates would be lower than these health-based guidance values. The exceptions were the conservative upper bound estimate of high dietary exposure to PFOS for toddlers in Europe (EFSA 2012) and the PFOS estimates reported by Cornelius *et al.* for the Belgium population (Cornelius *et al.* 2012).

Table 9. Estimated dietary exposure to PFOS

Country	Date	Population	Mean/median PFOS dietary exposure# ng/kg bw/day	High (P95) PFOS dietary exposure# ng/kg bw/day	Reference	Comment
EUROPE						
Europe (data UK, Germany)	2008	All	60 (indicative)		EFSA 2008	
			1 - 4		German Total Diet Study	
			10 - 100	30 - 200	UK Total Diet Study	
Europe (13 countries, ≥2 day records)*	2012	Infants	0.29 - 11	7.0 - 12	EFSA 2012	Major contributors were fish and other seafood, fruit and fruit products, meat and meat products across all age groups (LB model)
		Toddlers	0.58 - 14	2.1 - 29		
		Other children	0.59 - 10	2.3 - 19		
		Adolescents	0.32 - 5.3	1.7 - 12		
		Adults	0.27 - 5.2	1.4 - 10		
		Elderly	0.41 - 3.7	1.7 - 8.2		
		Very elderly	0.40 - 4.1	1.5 - 6.7		
France	2011	Adult general population	0.00 - 0.66	0.00 - 1.15	Yamanda *et al.* 2014	Major contributor was fish and other seafood, esp freshwater fish
		High seafood consumers	1.53 - 2.45	4.42 - 6.5		
		Pregnant women (coastal)	4.05 - 5.25	4.88 - 6.37		
		Pregnant women (other)	0.03 - 0.77	0.08 -1.42		
Belgium	2012	Children 3- 5 years	57.1	96.6	Cornelis *et al.* 2012	Major contributors were potatoes, fish and other seafood, dairy products, eggs and fruit
		Adults ≥ 21 years	24.2	40.9		
Belgium	2013	Adults 18-64 years	0.34 - 0.41	1.46 - 1.53	Klenow *et al.* 2013	Major contributors vary with country but include fish and other seafood, fruit and products, meat and products, eggs, vegetables and products
		Children 3-9 years	0.96 - 1.11	1.91 - 2.07	(PERFOOD project)	
Czech Rep	2013	Adults 18-64 years	0.37 - 0.45	1.59 - 1.68		
		Children 3-9 years	0.96 - 1.09	3.53 - 3.70		
Italy	2013	Adults 18-64 years	0.18 - 0.26	0.99 - 1.06		
		Children 3-9 years	0.40 - 0.54	1.92 - 2.06		
Norway	2013	Adults 18-64 years	0.09 - 0.15	0.34 - 0.40		
		Children 3-9 years	0.08 - 0.21	0.32 - 0.45		

Country	Date	Population	Mean/median PFOS dietary exposure[#] ng/kg bw/day	High (P95) PFOS dietary exposure[#] ng/kg bw/day	Reference	Comment
Sweden	2010	All (per capita food consumption data)	0.86 - 1.44		Vestergren *et al.* 2012	Major contributor was fish and other seafood
Spain	2012	Children 6-9 years	4.24 - 4.48		Domingo *et al.* 2012	
		Adolescents 10-19 years	1.57 - 1.65			
		Adults 20-65 years	1.80 - 2.26			
		Elderly > 65 years	1.92 - 2.29			
Regions other than Europe						
Canada	2007	12-65 years, per capita data	4^ PFOS plus perfluorinated carboxylates		Tittlemier *et al.* 2007	Approximately 44% estimated dietary exposure from PFOS, 28% PFOA, 28% other
China	2012	All (range across 6 provinces), NNS data	0.04 - 0.69		Wu at al 2012	Dietary exposure reported only from consumption of seafood
Korea	2014	Adults, NNS data	0.47 - 3.03		Heo *et al.* 2014	

[*] Estimated dietary exposure derived for countries with food consumption data for each age group and may not be all 13 countries (eg data for two countries only for infants)

[#] Where range is given, it is from minimum lower bound (LB) to maximum upper bound (UB) estimated dietary exposure across all countries in EU with food consumption data for that age group.

^ Applied average bodyweight of 62 kg to total estimated dietary exposure for PFOS and perfluorinated carboxylates (PFOA, PFNA).

Table 10. Estimated dietary exposure to PFOA

Country	Date	Population	Mean/median PFOA dietary exposure# ng/kg bw/day	High (P95) PFOA dietary exposure# ng/kg bw/day	Reference	Comment
EUROPE						
Europe (data UK, Germany)	2008	All	2 (indicative)	6 (indicative)	EFSA 2008	
			1 - 11.6		German Total diet study	
			1 - 70		UK Total Diet Study	
Europe (13 countries, ≥2 day records)*	2012	Infants	0.16 - 11	0.46 - 15	EFSA 2012	Major contributors were fish and other seafood, fruit and fruit products, eggs and egg products and drinking water across all age groups (LB model)
		Toddlers	0.20 - 17	0.44 - 32		
		Other children	0.10 - 13	0.28 - 20		
		Adolescents	0.07 - 5.4	0.20 - 10		
		Adults	0.08 - 4.3	0.22 - 7.7		
		Elderly	0.11 - 4.3	0.21 - 7.2		
		Very elderly	0.10 - 4.1	0.19 - 5.9		
France	2011	Adult general population	0.00 - 0.74	0.00 - 1.5	Yamanda *et al.* 2014	Major contributor was fish and other seafood, esp freshwater fish
		High seafood consumers	1.16 - 2.06	3.83 - 5.86		
		Pregnant women (coastal)	0.10 - 1.52	0.19 - 2.41		
		Pregnant women (other)	0.01 - 0.82	0.01 - 1.53		
Belgium	2012	Children 3- 5 years	20.1	31.5	Cornelis *et al.* 2012	Major contributors were fruit, vegetables, potatoes, fish and other seafood
		Adults ≥ 21 years	6.1	9.6		
Belgium	2013	Adults 18-64 years	0.18 - 0.23	0.84 - 0.89	Klenow *et al.* 2013	Major contributors vary with country but include alcoholic beverages (adults), fruit and products, vegetables and products, meat and products
		Children 3-9 years	0.28 - 0.39	0.85 - 0.97	(PERFOOD project)	
Czech Rep	2013	Adults 18-64 years	0.02 - 0.19	0.05 - 0.23		
		Children 3-9 years	0.04 - 0.33	0.12 - 0.42		
Italy	2013	Adults 18-64 years	0.13 - 0.20	0.32 - 0.39		
		Children 3-9 years	0.25 - 0.38	0.55 - 0.69		
Norway	2013	Adults 18-64 years	0.08 - 0.11	0.18 - 0.21		
		Children 3-9 years	0.15 - 0.20	0.34 - 0.39		

Country	Date	Population	Mean/median PFOA dietary exposure# ng/kg bw/day	High (P95) PFOA dietary exposure# ng/kg bw/day	Reference	Comment
Sweden	2010	All (per capita food consumption data)	0.35 - 0.69		Vestergren *et al.* 2012	Major contributors were cereals and products, vegetables and products, dairy products
Spain	2012	Children 6-9 years	4.73 - 19.0		Domingo *et al.* 2012	
		Adolescents 10-19 years	0.83 - 5.77			
		Adults 20-65 years	1.55 - 6.37			
		Elderly > 65 years	1.10 - 5.50			
Regions other than Europe						
China	2012	All (range across 6 provinces), NNS data	0.008 - 0.914		Wu at al 1012	Dietary exposure reported only from consumption of seafood
Korea	2014	Adults, NNS data	0.17 - 1.68		Heo *et al.* 2014	

** Estimated dietary exposure derived for countries with food consumption data for each age group and may not be all 13 countries (eg data for two countries only for infants)*

 # Where range is given, it is from minimum lower bound (LB) to maximum upper bound (UB) estimated dietary exposure across all countries in EU with food consumption data for that age group.

Table 11. Estimated dietary exposure to PFHxS

Country	Date	Population	Mean/median PFHxS dietary exposure[#] ng/kg bw/day	High (P95) PFHxS dietary exposure [#] ng/kg bw/day	Reference	Comment
EUROPE						
Europe (13 countries, ≥2 day records)*	2012	Adults 20-65 years	0.05 - 1.22	0.13 - 2.25	EFSA 2012	Limited number of food groups with data, UB estimates conservative due to high % non-detects
France	2011	Adult general population	0.00 - 0.38	0.00 - 0.7	Yamanda *et al.* 2014	Major contributor was fish and other seafood, esp freshwater fish
		High seafood consumers	0.06 - 0.67	0.27 - 1.72		
		Pregnant women (coastal)	0.02 - 0.87	0.02 - 1.33		
		Pregnant women (other)	0.00 - 0.51	0.01 - 0.98		
Belgium	2013	Adults 18-64 years	0.09 - 0.11	0.40 - 0.42	Klenow *et al.* 2013	Major contributors vary with country but include fruit and products, meat and meat products, eggs
		Children 3-9 years	0.29 - 0.33	0.92 - 0.97	(PERFOOD project)	
Czech Rep	2013	Adults 18-64 years	0.001 - 0.06	0.002 - 0.07		
		Children 3-9 years	0.001 - 0.11	0.003 - 0.14		
Italy	2013	Adults 18-64 years	0.02 - 0.09	0.07 - 0.15		
		Children 3-9 years	0.04 - 0.18	0.14 - 0.30		
Norway	2013	Adults 18-64 years	0.007 - 0.04	0.03 - 0.06		
		Children 3-9 years	0.01 - 0.07	0.04 - 0.12		
Spain	2012	Children 6-9 years	0.08 – 0.17		Domingo *et al.* 2012	
		Adolescents 10-19 years	0.02 – 0.04			
		Adults 20-65 years	0.02 – 0.06			
		Elderly > 65 years	0.02 – 0.06			

[*] Estimated dietary exposure derived for countries with food consumption data for each age group and may not be all 13 countries (eg data for two countries only for infants)

[#] Where range is given, it is from minimum lower bound (LB) to maximum upper bound (UB) estimated dietary exposure across all countries in EU with food consumption data for that age group.

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