

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

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# 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).

# 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).

# 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.

# Results

## Occurrence of PFOS, PFOA and PFHxS in foods

### Europe

#### 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.

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  PFOA  PFHxS | 79  79 (778)  75 | 100  96  100 | -  0.0002  - | -  0.10  - |
| Vegetables and vegetable products | PFOS  PFOA  PFHxS | 286 (1163)  285 (1162)  186 (1063) | 90  88  98 | 0.02  0.0039  0.0001 | 0.12  0.13  0.09 |
| Starchy roots and tubers | PFOS  PFOA  PFHxS | 303 (339)  303 (339)  88 | 99.7  99.7  100 | 0.0035  0.0009  - | 0.63  0.64  - |
| Legumes, nuts and oilseeds | PFOS  PFOA  PFHxS | 20 (157)  20 (157)  20 | 95  90  100 | 0.0001  0.0031  - | 0.11  0.15  - |
| Fruit and fruit products | PFOS  PFOA  PFHxS | 34 (136)  35 (139)  29 (133) | 68  54  79 | 0.032  0.0111  0.013 | 0.085  0.062  0.046 |
| Meat and meat products | PFOS  PFOA  PFHxS | 3215 (6460)  3221 (6494)  683 (3928) | 64  86  99 | 29.5  0.78  0.001 | 30.0  1.6  0.21 |
| Fish and other seafood | PFOS  PFOA  PFHxS | 2534 (4395)  2542 (4403)  1331 (3192) | 63  95  99 | 1.99  0.082  0.0096 | 2.4  0.69  0.49 |
| Milk and dairy products | PFOS  PFOA  PFHxS | 318 (2449)  319 (2450)  239 (2370) | 97  99  99.6 | 0.0007  0.0018  0.000002 | 0.11  0.12  0.077 |
| Eggs and egg products | PFOS  PFOA  PFHxS | 134 (816)  138 (820)  99 (781) | 88  89  99 | 0.034  0.066  0.0001 | 0.54  0.58  0.52 |
| Sugar and confectionary | PFOS  PFOA  PFHxS | 45 (156)  45 (156)  10 | 98  91  100 | 0.0035  0.0058  - | 0.053  0.049  - |
| Animal and vegetable fats & oils | PFOS  PFOA  PFHxS | 56 (161)  55 (160)  53 (158) | 98  96  98 | 0.28  0.0021  0.0003 | 0.56  0.31  0.21 |
| Fruit and vegetable juices | PFOS  PFOA  PFHxS | 1  1  1 | 100  100  100 | -  -  - | -  -  - |
| Alcoholic beverages | PFOS  PFOA  PFHxS | 6  6 (63)  6 (63) | 100  83  83 | -  0.0087  0.0048 | -  0.013  0.0065 |
| Herbs, spices and condiments | PFOS  PFOA  PFHxS | 8  8  8 | 100  100  100 | -  -  - | -  -  - |
| Food for infants & small children | PFOS  PFOA  PFHxS | 21  21  10 | 100  100  100 | -  -  - | -  -  - |
| Composite food | PFOS  PFOA  PFHxS | 45  45 (381)  38 | 100  98  100 | -  0.0004  - | -  0.071  - |
| Snacks, desserts & other foods | PFOS  PFOA  PFHxS | 46  46  46 | 100  100  100 | -  -  - | -  -  - |
| Drinking water | PFOS  PFOA  PFHxS | 372 (456)  367 (451)  300 (384) | 89  84  88 | 0.0005  0.001  0.0007 | 0.0025  0.0027  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.

1. 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  PFOA  PFHxS | 3215 (6460)  3221 (6494)  683 (3928) | 64  86  99 | **29.5**  0.78  0.001 | **30.0**  1.6  0.21 |
| Meat & meat products (unspec) | PFOS  PFOA  PFHxS | 15 (15)  15 (15)  15 (15) | 100  100  100 | 0  0  0 | 1.0  1.0  1.0 |
| Livestock meat | PFOS  PFOA  PFHxS | 232 (1418)  232 (1418)  183 (1369) | 91  95  99 | 0.0086  0.0061  0.0002 | 0.12  0.13  0.081 |
| Poultry | PFOS  PFOA  PFHxS | 150 (735)  150 (735)  136 (721) | 97  99  100 | 0.0097  0.0024  0 | 0.14  0.14  0.12 |
| Game mammals | PFOS  PFOA  PFHxS | 569 (569)  572 (572)  26 (26) | 71  91  96 | 0.87  0.4  0.016 | 1.5  1.2  0.72 |
| Game birds | PFOS  PFOA  PFHxS | 9 (9)  9 (9)  1 (1) | 100  100  100 | 0  0  0 | 0.38  0.37  0.053 |
| Edible offal, farmed animals | PFOS  PFOA  PFHxS | 1261 (1623)  1265 (1655)  145 (507) | 91  98  99 | 0.42  0.034  0.0041 | 1.9  1.4  0.62 |
| Edible offal, game animals | PFOS  PFOA  PFHxS | 882 (882)  881 (881)  90 (90) | 4  59  99 | **215**  **5.4**  0.012 | **215**  **8.1**  2.5 |
| Preserved meat | PFOS  PFOA  PFHxS | 39 (518)  39 (518)  36 (515) | 95  97  100 | 0.0003  0.0002  0 | 0.057  0.067  0.055 |
| Sausages | PFOS  PFOA  PFHxS | 43 (480)  43 (480)  36 (473) | 88  100  100 | **0.066**  0  0 | 0.14  0.1  0.061 |
| Pastes, pates & terrines | PFOS  PFOA  PFHxS | 15 (211)  15 (211)  15 (211) | 100  93  100 | 0  0.0085  0 | 0.05  0.069  0.041 |
| Fish and other seafood | PFOS  PFOA  PFHxS | 2534 (4395)  2542 (4403)  1331 (3192) | 63  95  99 | **1.99**  0.082  0.0096 | **2.4**  0.69  0.49 |
| Fish and other seafood (unspec) | PFOS  PFOA  PFHxS | 6 (21)  6 (21)  5 (20) | 33  50  80 | 0.52  0.029  0.013 | 0.66  0.18  0.16 |
| Fish meat (fillets) | PFOS  PFOA  PFHxS | 1982 (2978)  1993 (2989)  927 (1923) | 67  96  99.9 | **2.1**  0.10  0.00052 | **2.5**  0.64  0.46 |
| Fish offal | PFOS  PFOA  PFHxS | 410 (410)  410 (410)  308 (308) | 46  99  98 | **4.9**  0.021  0.07 | **5.5**  1.6  0.92 |
| Crustaceans | PFOS  PFOA  PFHxS | 78 (302)  73 (297)  43 (267) | 32  70  91 | **1.5**  0.15  0.03 | **1.5**  0.30  0.19 |
| Water molluscs | PFOS  PFOA  PFHxS | 58 (684)  60 (686)  48 (674) | 72  95  100 | 0.031  0.0032  0 | 0.55  0.54  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.

#### 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).

1. 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  Sweden  Spain | 2012  2010  2011 | 3 whole group  NS pastries  NS other  NS bakery  NS other | 0.052  0.021  0.022  0.0007  < 0.0017 | Cornelis *et al.*  2012  Vestergren *et al.*  2012  Domingo *et al.*  2012a |
| Vegetables and vegetable products | Belgium  Sweden  Belgium  Czech Reb  Italy  Spain | 2012  2010  2011  2011  2011  2011 | 36 whole group  NS incl root veg  NS whole group  NS whole group  NS whole group  NS whole group | 0.60  0.0041  0.0032  0.0007  0.0057  0.1 | Cornelis *et al.*  2012  Vestergren *et al.*  2012  Herzke *et al.*  2013  Herzke *et al.*  2013  Herzke *et al.*  2013  Domingo *et al.*  2012a |
| Starchy roots and tubers | Belgium  Sweden  Spain | 2012  20102011 | 6 whole group  NS potatoes  NS whole group | 6.18  0.0069  <0.005 | Cornelis *et al.*  2012  Vestergren *et al.*  2012  Domingo *et al.*  2012a |
| Legumes, nuts and oilseeds | Spain | 2011 | NS whole group | 0.0061 | Domingo *et al.*  2012a |
| Fruit and fruit products | Belgium  Sweden  Spain | 2012  2010  2011 | 11 whole group  NS whole group  NS whole group | 0.35  0.0022  <0.005 | Cornelis *et al.*  2012  Vestergren *et al.*  2012  Domingo *et al.*  2012a |
| Meat and meat products | Belgium  Sweden  Spain  Netherlands  Italy | 2012  2010  2011  2014  2013 | 7 pork  5 poultry  7 other  NS whole group  NS whole group 99 liver (horse, pig, cow, sheep chicken)  8 whole group | 0.17  0.63  0.055  0.025  0.034  <0.5 - 4.5  1.43 | Cornelis *et al.*  2012  Vestergren *et al.*  2012  Domingo *et al.*  2012a  Zafeiraki *et al.*  2016a  Guerannti *et al.*  2013 |
| Fish and other seafood | Belgium  Sweden  Spain  Greece  France  Finland  Italy | 2012  2010  2011  2011  2010  2009  2013 | 28 marine  26 freshwater  745 crust & mollusc  NS whole group  NS whole group  28 marine  4 crustacea  8 molluscs  NS molluscs  253 marine  23 freshwater  20 farmed  16 | 12.0  **174**  9.86  1.29  2.7  **0.82 - 20.37**  **5.15**  <0.49  0.04 - 0.2  0.31 - 7.5  **1.5 - 39**  <0.37  <LOD - 30.2 | Cornelis *et al.*  2012  Vestergren *et al.*  2012  Domingo *et al.*  2012a  Vassiliadou *et al.*  2015  Munschy *et al.*  2013  Koponen *et al.*  2014  Guerannti *et al.*  2013 |
| Milk and dairy products | Belgium  Sweden  Spain  Italy^  Italy | 2012  2010  2011  2011  2013 | 9 whole group  NS whole group  NS milk  NS other  67 cows milk  4 milk  8 cheese | 0.25  0.0056  <0.0069  <0.003  0 - 0.097  0.36  <LOD - 2.88 | Cornelis *et al.*  2012  Vestergren *et al.*  2012  Domingo *et al.*  2012a  Barbarossa *et al.*  2014  Guerannti *et al.*  2013 |
| Eggs and egg products | Belgium  Sweden  Spain  Netherlands  Greece | 2012  2010  2011  2013  2013 | 8  -  -  73  45 | 6.86  0.039  <0.0053  3.5##  1.1## | Cornelis *et al.*  2012  Vestergren *et al.*  2012  Domingo *et al.*  2012a  Zafeiraki *et al.*  2016b  Zafeiraki *et al.*  2016b |
| Sugar and confectionary | Sweden | 2010 | - | 0.0036 | Vestergren *et al.*  2012 |
| Animal and veg fats & oils | Belgium  Sweden  Spain | 2012  2010  2011 | 2  -  - | 0.033  0.013  0.0011 | Cornelis *et al.*  2012  Vestergren *et al.*  2012  Domingo *et al.*  2012a |
| Alcoholic beverages | Belgium | 2012 | 5 beer | 0.013 | Cornelis *et al.*  2012 |
| Food for infants & small children | Spain^  Italy^  France^  France^ | 2012  2013  2013  2010/2013 | 10 breast milk  16 infant formula  13 dry cereals  12 baby food  49 breast milk  48 breast milk  61 breast milk | 0.05  0.061  1.321  0.019  0.85  0.079  0.04 | Lorenzo *et al.*  2016  Guerannti *et al.*  2013  Antignac *et al.*  2013  Cariou *et al.*  2015 |
| Drinking water | Belgium  Spain | 2012  2011 | 4  30 | 0.005  0.0018 | Cornelis *et al.*  2012  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

1. 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  Sweden  Spain | 2012  2010  2011 | 3 whole group  NS pastries  NS other  NS bakery  NS other | 0.055  0.018  0.062  <0.11  <0.12 | Cornelis *et al.*  2012  Vestergren *et al.*  2012  Domingo *et al.*  2012a |
| Vegetables and vegetable products | Belgium  Sweden  Belgium  Czech Reb  Italy  Spain | 2012  2010  2011  2011  20112011 | 36 whole group  NS whole group  NS whole group  NS whole group  NS whole group  NS whole group | 0.65  0.022  0.0103  0.0019  0.0025  0.37 | Cornelis *et al.*  2012  Vestergren *et al.*  2012  Herzke *et al.*  2013  Herzke *et al.*  2013  Herzke *et al.*  2013  Domingo *et al.*  2012a |
| Starchy roots and tubers | Belgium  Sweden  Spain | 2012  2010  2011 | 6 whole group  NS potatoes  NS whole group | 0.67  0.057  <0.36 | Cornelis *et al.*  2012  Vestergren *et al.*  2012  Domingo *et al.*  2012a |
| Legumes, nuts and oilseeds | Spain | 2011 | NS whole group | <0.26 | Domingo *et al.*  2012a |
| Fruit and fruit products | Belgium  Sweden  Spain | 2012  2010  2011 | 11 whole group  NS whole group  NS whole group | 0.43  0.015  <0.360 | Cornelis *et al.*  2012  Vestergren *et al.*  2012  Domingo *et al.*  2012a |
| Meat and meat products | Belgium  Sweden  Spain | 2012  20102011 | 7 pork  5 poultry  7 other  NS whole group  NS whole group | 0.055  0.055  0.52  0.012  <0.3 | Cornelis *et al.*  2012  Vestergren *et al.*  2012  Domingo *et al.*  2012a |
| Fish and other seafood | Belgium  Sweden  Spain  Greece  Finland | 2012  2010  2011  2011  2009 | 27 marine  26 freshwater  652 crust & molluscs  NS whole group  NS whole group  28 marine  4 crustacea  8 molluscs  253 marine  23 freshwater  20 farmed | 0.59  0.78  3.34  0.05  2.6  <0.6  <0.6  <0.6  <0.39-1.8  <0.23  <0.37 | Cornelis *et al.*  2012  Vestergren *et al.*  2012  Domingo *et al.*  2012a  Vassiliadou *et al.*  2015  Koponen *et al.*  2014 |
| Milk and dairy products | Belgium  Sweden  Spain  Italy^ | 2012  2010  2011  2011 | 9  NS whole group  NS milk  NS other  67 cows milk | 0.12  0.029  0.39  0.19  0 - 0.032 | Cornelis *et al.*  2012  Vestergren *et al.*  2012  Domingo *et al.*  2012a  Barbarossa *et al.*  2014 |
| Eggs and egg products | Belgium  Sweden  Spain  Netherlands  Greece | 2012  2010  2011  2013  2013 | 8 whole group  NS whole group  NS whole group  73 median  45 median | 0.86  0.039  <0.39  1.1  0.5 | Cornelis *et al.*  2012  Vestergren *et al.*  2012  Domingo *et al.*  2012a  Zafeiraki *et al.*  2016b  Zafeiraki *et al.*  2016b |
| Sugar and confectionary | Sweden | 2010 | NS whole group | 0.013 | Vestergren *et al.*  2012 |
| Animal and veg fats & oils | Belgium  Sweden  Spain | 2012  2010  2011 | 2 whole group  NS whole group  NS whole group | 0.091  <LOQ  <0.140 | Cornelis *et al.*  2012  Vestergren *et al.*  2012  Domingo *et al.*  2012a |
| Alcoholic beverages | Belgium | 2012 | 5 beer | 0.006 | Cornelis *et al.*  2012 |
| Food for infants & small children | Spain^  Italy  Spain^  France^  France ^ | 2012  2013  2013  2013  2010/2013 | 10 breast milk  16 infant formula  13 dry cereals  12 baby food  49 breast milk  40 breast milk  48 breast milk  61 breast milk | 0.177  0.415  0.179  0.216  0.16  0.054  0.075  0.041 | Lorenzo *et al.*  2016  Guerannti *et al.*  2013  Guzmàn *et al.*  2016  Antignac *et al.*  2013  Cariou *et al.*  2015 |
| Drinking water | Belgium  Spain | 2012  2011 | 4  30 | 0.002  0.0024 | Cornelis *et al.*  2012  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

1. 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  Spain | 2010  2011 | NS pastries  NS other  NS bakery  NS other | <LOQ  <LOQ  <0.0006  <0.0006 | Vestergren *et al.*  2012  Domingo *et al.*  2012 |
| Vegetables and vegetable products | Sweden  Belgium  Czech Reb  Italy  Spain | 2010  2011  2011  2011  2011 | NS incl root veg  NS whole group  NS whole group  NS whole group  NS whole group | 0.0012  0.0003  <LOQ  <LOQ  0.0045 | Vestergren *et al.*  2012  Herzke *et al.*  2013  Herzke *et al.*  2013  Herzke *et al.*  2013  Domingo *et al.*  2012a |
| Starchy roots and tubers | Sweden  Spain | 20102011 | NS potatoes  NS whole group | <LOQ  <0.0019 | Vestergren *et al.*  2012  Domingo *et al.*  2012a |
| Legumes, nuts and oilseeds | Spain | 2011 | NS whole group | 0.0013 | Domingo *et al.*  2012a |
| Fruit and fruit products | Sweden  Spain | 2010  2011 | NS whole group  NS whole group | <LOQ  <0.0019 | Vestergren *et al.*  2012  Domingo *et al.*  2012a |
| Meat and meat products | Sweden  Spain | 2010  2011 | NS whole group  NS whole group | 0.0045  0.0032 | Vestergren *et al.*  2012  Domingo *et al.*  2012a |
| Fish and other seafood | Sweden  Spain  Greece | 2010  2011  2011 | NS whole group  NS whole group  28 marine  4 crustacea  8 molluscs | 0.0092  0.045  <0.18  <0.18  <0.18 | Vestergren *et al.*  2012  Domingo *et al.*  2012a  Vassiliadou *et al.*  2015 |
| Milk and dairy products | Sweden  Spain | 2010  2011 | NS whole group  NS milk  NS other | 0.001  <0.0026  <0.0011 | Vestergren *et al.*  2012  Domingo *et al.*  2012a |
| Eggs and egg products | Sweden  Spain  Netherlands  Greece | 2010 2011  2013  2013 | NS whole group  NS whole group  73 whole group  45 whole group | 0.0025  <0.002  1.1##  < 0.5## | Vestergren *et al.*  2012  Domingo *et al.*  2012a  Zafeiraki *et al.*  2016  Zafeiraki *et al.*  2016 |
| Sugar and confectionary | Sweden | 2010 | NS whole group | 0.0015 | Vestergren *et al.*  2012 |
| Animal and veg fats & oils | Sweden  Spain | 2010  2011 | NS whole group  NS whole group | <LOQ  <0.0007 | Vestergren *et al.*  2012  Domingo *et al.*  2012a |
| Food for infants & small children | Spain^  France^  France^ | 2012  2013  2010/2013 | 10 breast milk  16 infant formula  13 dry cereals  12 baby food  48 breast milk  61 breast milk | <LOD  0.034  0.265  <LOD  0.05  0.026 | Lorenzo *et al.*  2016  Antignac *et al.*  2013  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

### 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.

1. 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

1. 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  1999 | NS Pizza  NS Popcorn | <1.0  3.6 | Tittlemier *et al.*  2007 |
| Fruit, vegetables and products | Korea | 2011 | 78 fruit and veg | 0.001 LB | Heo *et al.*  2014 |
| Meat and meat products | Canada  Korea | 2004  2011 | NS Beef  NS Luncheon meat  39 whole group | <0.4 to 2.6  <0.4  <LOD | 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 | <0.5  <0.5  0.016-0.07  0.094-1.459  0.07 LB | Tittlemier *et al.*  2007  Wu *et al.*  2012  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^  Japan^  Korea^  China^ | 2013  2010  2010  2010  20082010 | 274 breast milk  30 breast milk  5 infant formula  30 breast milk  30 breast milk  5 infant formula | 0.072##  0.0935  0.0218  0.0645  0.0516  0.0281 | Kang *et al.*  2016  Yukiko *et al.*  2012 |
| Drinking water | Korea^ | 2011 | 34 tap water  8 bottled water | 0.0129  0.0002 | Heo *et al.*  2014 |
| 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, 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

1. 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, 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

### 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).

### 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]](#footnote-2) 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).

### 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 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.

## 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 (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, 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 (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 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).

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1. 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)  1 - 4  10 - 100 | 30 - 200 | EFSA 2008  German Total Diet Study  UK Total Diet Study |  |
| Europe  (13 countries, ≥2 day records)\* | 2012 | Infants  Toddlers  Other children  Adolescents  Adults  Elderly  Very elderly | 0.29 - 11  0.58 - 14  0.59 - 10  0.32 - 5.3  0.27 - 5.2  0.41 - 3.7  0.40 - 4.1 | 7.0 - 12  2.1 - 29  2.3 - 19  1.7 - 12  1.4 - 10  1.7 - 8.2  1.5 - 6.7 | EFSA 2012 | Major contributors were fish and other seafood, fruit and fruit products, meat and meat products across *all age groups (LB model)* |
| France | 2011 | Adult general population  High seafood consumers  Pregnant women (coastal)  Pregnant women (other) | 0.00 - 0.66  1.53 - 2.45  4.05 - 5.25  0.03 - 0.77 | 0.00 - 1.15  4.42 - 6.5  4.88 - 6.37  0.08 -1.42 | Yamanda *et al.*  2014 | Major contributor was fish and other seafood, esp freshwater fish |
| Belgium | 2012 | Children 3- 5 years  Adults ≥ 21 years | 57.1  24.2 | 96.6  40.9 | Cornelis *et al.*  2012 | Major contributors were potatoes, fish and other seafood, dairy products, eggs and fruit |
| Belgium  Czech Rep  Italy  Norway | 2013  2013  2013  2013 | Adults 18-64 years  Children 3-9 years  Adults 18-64 years  Children 3-9 years  Adults 18-64 years  Children 3-9 years  Adults 18-64 years  Children 3-9 years | 0.34 - 0.41  0.96 - 1.11  0.37 - 0.45  0.96 - 1.09  0.18 - 0.26  0.40 - 0.54  0.09 - 0.15  0.08 - 0.21 | 1.46 - 1.53  1.91 - 2.07  1.59 - 1.68  3.53 - 3.70  0.99 - 1.06  1.92 - 2.06  0.34 - 0.40  0.32 - 0.45 | Klenow *et al.*  2013  (PERFOOD project) | Major contributors vary with country but include fish and other seafood, fruit and products, meat and products, eggs, vegetables and products |
| 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  Adolescents 10-19 years  Adults 20-65 years  Elderly > 65 years | 4.24 - 4.48  1.57 - 1.65  1.80 - 2.26  1.92 - 2.29 |  | Domingo *et al.*  2012 |  |
| 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).

1. 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)  1 - 11.6  1 - 70 | 6 (indicative) | EFSA 2008  German Total diet study  UK Total Diet Study |  |
| Europe  (13 countries, ≥2 day records)\* | 2012 | Infants  Toddlers  Other children  Adolescents  Adults  Elderly  Very elderly | 0.16 - 11  0.20 - 17  0.10 - 13  0.07 - 5.4  0.08 - 4.3  0.11 - 4.3  0.10 - 4.1 | 0.46 - 15  0.44 - 32  0.28 - 20  0.20 - 10  0.22 - 7.7  0.21 - 7.2  0.19 - 5.9 | 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) |
| France | 2011 | Adult general population  High seafood consumers  Pregnant women (coastal)  Pregnant women (other) | 0.00 - 0.74  1.16 - 2.06  0.10 - 1.52  0.01 - 0.82 | 0.00 - 1.5  3.83 - 5.86  0.19 - 2.41  0.01 - 1.53 | Yamanda *et al.*  2014 | Major contributor was fish and other seafood, esp freshwater fish |
| Belgium | 2012 | Children 3- 5 years  Adults ≥ 21 years | 20.1  6.1 | 31.5  9.6 | Cornelis *et al.*  2012 | Major contributors were fruit, vegetables, potatoes, fish and other seafood |
| Belgium  Czech Rep  Italy  Norway | 2013  2013  2013  2013 | Adults 18-64 years  Children 3-9 years  Adults 18-64 years  Children 3-9 years  Adults 18-64 years  Children 3-9 years  Adults 18-64 years  Children 3-9 years | 0.18 - 0.23  0.28 - 0.39  0.02 - 0.19  0.04 - 0.33  0.13 - 0.20  0.25 - 0.38  0.08 - 0.11  0.15 - 0.20 | 0.84 - 0.89  0.85 - 0.97  0.05 - 0.23  0.12 - 0.42  0.32 - 0.39  0.55 - 0.69  0.18 - 0.21  0.34 - 0.39 | Klenow *et al.*  2013  (PERFOOD project) | Major contributors vary with country but include alcoholic beverages (adults), fruit and products, vegetables and products, meat and products |
| 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  Adolescents 10-19 years  Adults 20-65 years  Elderly > 65 years | 4.73 - 19.0  0.83 - 5.77  1.55 - 6.37  1.10 - 5.50 |  | Domingo *et al.*  2012 |  |
| 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.

1. 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  High seafood consumers  Pregnant women (coastal)  Pregnant women (other) | 0.00 - 0.38  0.06 - 0.67  0.02 - 0.87  0.00 - 0.51 | 0.00 - 0.7  0.27 - 1.72  0.02 - 1.33  0.01 - 0.98 | Yamanda *et al.*  2014 | Major contributor was fish and other seafood, esp freshwater fish |
| Belgium  Czech Rep  Italy  Norway | 2013  2013  2013  2013 | Adults 18-64 years  Children 3-9 years  Adults 18-64 years  Children 3-9 years  Adults 18-64 years  Children 3-9 years  Adults 18-64 years  Children 3-9 years | 0.09 - 0.11  0.29 - 0.33  0.001 - 0.06  0.001 - 0.11  0.02 - 0.09  0.04 - 0.18  0.007 - 0.04  0.01 - 0.07 | 0.40 - 0.42  0.92 - 0.97  0.002 - 0.07  0.003 - 0.14  0.07 - 0.15  0.14 - 0.30  0.03 - 0.06  0.04 - 0.12 | Klenow *et al.*  2013  (PERFOOD project) | Major contributors vary with country but include fruit and products, meat and meat products, eggs |
| Spain | 2012 | Children 6-9 years  Adolescents 10-19 years  Adults 20-65 years  Elderly > 65 years | 0.08 – 0.17  0.02 – 0.04  0.02 – 0.06  0.02 – 0.06 |  | Domingo *et al.*  2012 |  |

\* 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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1. The Environmental Health Standing Committee (enHealth) is a standing committee of the Australian Health Protection Principal Committee (AHPPC). [↑](#footnote-ref-2)