**Healthy eating index and diet diversity score as determinants of serum perfluoroalkyl acid (PFAA) concentrations in a national survey of Swedish adolescents**

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Daily consumption of different types of seafood was derived from the RiksmatenFlexQuestionnaire (RFQ) frequency registration of consumption of seafood groups (i.e. lean marine fish (e.g. cod, Alaska Pollock, saithe, hoki, plaice, tilapia and pangasius), processed fish products (e.g. fish sticks and Swedish fish balls), canned herring and mackerel, anchovies and sardines. (e.g. anchovies, sardines and sardelles), Baltic herring (fresh/canned), freshwater fish (e.g. burbot, pike, perch and pike-perch), canned tuna, salmonid fish (e.g. rainbow trout and salmon), large saltwater fish (e.g. shark, ray, fresh tuna, large halibut and swordfish), crab, and shellfish (e.g. mussels/clams, shrimps, crayfish and lobster/langoustine, excluding crab). The consumption frequency of seafood per year/month/week/day was converted to daily consumption (g/day) using average portion sizes derived from the RFD (n=3099) for each school grade (5th, 8th and 11th) and gender. For females, the average portion size of fish was 84.0, 83.5 and 67.5 g, respectively, for 5th, 8th and 11th grades, and 26.5, 26.0 and 25.5 g for shellfish, respectively. For males, the average portion size of fish for the same school grades was 90.5, 114.5 and 107.5 g, respectively, and 18.5, 28.0 and 47.5 g for shellfish

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Table S1. Daily fish and shellfish consumption portions (g/day) calculated separately for grade and gender from the RFQ frequency questionnaire on consumption of specific fish and shellfish types

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Frequency interval** | **No. times/year** | **5th grade** |  |  |  | **8th grade** |  |  |  | **11th grade** |  |  |  |
|  |  | *Fish (g/day)* |  | *Shellfish (g/day)* |  | *Fish (g/day)* |  | *Shellfish (g/day)* |  | *Fish (g/day)* |  | *Shellfish (g/day)* |  |
|  |  | Females | Males | Females | Males | Females | Males | Females | Males | Females | Males | Females | Males |
| Never | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1-3 times/year | 2 | 0.5 | 0.1 | 0.5 | 0.1 | 0.5 | 0.1 | 0.6 | 0.2 | 0.4 | 0.1 | 0.6 | 0.3 |
| 4-8 times/year | 6 | 1.4 | 0.4 | 1.5 | 0.3 | 1.4 | 0.4 | 1.9 | 0.5 | 1.1 | 0.4 | 1.8 | 0.8 |
| 9-11 times/year | 10 | 2.3 | 0.7 | 2.5 | 0.5 | 2.3 | 0.7 | 3.1 | 0.8 | 1.8 | 0.7 | 2.9 | 1.3 |
| 1-3 times/month | 24 | 5.5 | 1.7 | 6.0 | 1.2 | 5.5 | 1.7 | 7.5 | 1.8 | 4.4 | 1.7 | 7.1 | 3.1 |
| 1 time/week | 52 | 12.0 | 3.8 | 12.9 | 2.6 | 11.9 | 3.7 | 16.3 | 4.0 | 9.6 | 3.6 | 15.3 | 6.8 |
| 2 times/week | 104 | 23.9 | 7.6 | 25.8 | 5.3 | 23.8 | 7.4 | 32.6 | 8.0 | 19.2 | 7.3 | 30.6 | 13.5 |
| 3 times/week | 156 | 35.9 | 11.3 | 38.7 | 7.9 | 35.7 | 11.1 | 48.9 | 12 | 28.8 | 10.9 | 45.9 | 20.3 |
| >1 time/day | 365 | 84 | 26.5 | 90.5 | 18.5 | 83.5 | 26 | 114.5 | 28 | 67.5 | 25.5 | 107.5 | 47.5 |

Table S2. Odds ratios (OR)a and corresponding 95% confidence interval (CI) for the association between legacy serum PFAA concentrations and the healthy food index SHEIA15, and the diet diversity score RADDS, in RMA adolescents, including the sensitivity analysis.

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **SHEIA15** | |  |  | |  | **RADDS** | |  |  | |  |
|  | Base model analysisb | |  | Sensitivity analysisc | |  | Base model analysisb | |  | Sensitivity analysisc | |  |
|  | OR | 95% CI | p-value | OR | 95% CI | p-value | OR | 95% CI | p-value | OR | 95% CI | p-value |
| **lin-PFOA** | 0.967 | 0.839 – 1.118 | 0.6634 | 0.970 | 0.841 – 1.118 | 0.6714 | 0.973 | 0.844 – 1.122 | 0.7090 | 0.982 | 0.850 – 1.134 | 0.8019 |
| **PFNA** | 1.291 | 1.085 – 1.536 | 0.0040 | 1.290 | 1.085 – 1.534 | 0.0040 | 1.190 | 1.046 – 1.353 | 0.0079 | 1.189 | 1.047 – 1.352 | 0.0078 |
| **PFDA** | 1.297 | 1.083 – 1.553 | 0.0047 | 1.296 | 1.083 – 1.551 | 0.0047 | 1.204 | 1.068 – 1.357 | 0.0023 | 1.204 | 1.069 – 1.357 | 0.0023 |
| **PFUnDA** | 1.615 | 1.373 – 1.900 | <0.0001 | 1.614 | 1.372 – 1.899 | <0.0001 | 1.409 | 1.228 – 1.618 | <0.0001 | 1.408 | 1.226 – 1.618 | <0.0001 |
| **lin-PFHxS** | 0.950 | 0.797 – 1.133 | 0.5689 | 0.963 | 0.804 – 1.154 | 0.6824 | 1.065 | 0.893 – 1.157 | 0.8043 | 1.035 | 0.914 – 1.171 | 0.5923 |
| **lin-PFOS** | 1.215 | 1.050 – 1.405 | 0.0089 | 1.211 | 1.033 – 1.421 | 0.0185 | 1.168 | 1.026 – 1.331 | 0.0192 | 1.183 | 1.040 – 1.347 | 0.0109 |
| **br-PFOS** | 0.979 | 0.843 – 1.137 | 0.7782 | 0.965 | 0.825 – 1.130 | 0.6596 | 1.008 | 0.893 – 1.139 | 0.8927 | 1.017 | 0.903 – 1.145 | 0.7857 |

Notes: n=1098. The associations in both analysis were determined using ordinal logistic regression (OLR), whilst p-value was derived using Wald statistics.

a An OR <1 suggest a negative association while an OR>1 suggests a positive association.

b Adjusted for age, gender, BMI, participant/maternal birth country, maternal and paternal education level, alcohol consumption, snus use, smoking habits and months fully breastfed early in life.

*c*Adjusted for residence in area with previous high level contamination of PFAS in drinking water (residing vs not residing), as well as adjusted for the above-mentioned base model covariates.

Table S3. Odds ratios (OR)a and 95% confidence interval (CI) for associations between PFAA serum concentrations and habitual food consumption variablesb.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Covariate** | **lin-PFOA** |  | **PFNA** |  | **PFDA** |  | **PFUnDA** |  | **lin-PFHxS** |  | **lin-PFOS** |  | **br-PFOS** |  |
| (g/day) | OR (CI) | p | OR (CI) | p | OR (CI) | p | OR (CI) | p | OR (CI) | p | OR (CI) | p | OR (CI) | p |
| **Eggs** | 0.969 (0.847, 1.109) | 0.6448 | 1.062 (0.924, 1.221) | 0.3952 | 1.026 (0.894, 1.178) | 0.7129 | 1.058 (0.935, 1.197) | 0.3711 | 1.150 (1.014, 1.305) | 0.0296 | 1.143 (1.010, 1.293) | 0.0342 | 1.097 (0.974, 1.235) | 0.1280 |
| **Dairy** | 0.804 (0.703, 0.921) | 0.0016 | 0.738 (0.630, 0.864) | 0.0002 | 0.802 (0.704, 0.914) | 0.0010 | 0.888 (0.800, 0.987) | 0.0269 | 0.872 (0.768, 0.990) | 0.0347 | 0.801 (0.714, 0.898) | 0.0001 | 0.906 (0.802, 1.023) | 0.1094 |
| **Meats** | 0.908 (0.799, 1.033) | 0.1421 | 1.147 (1.002, 1.313) | 0.0472 | 0.956 (0.827, 1.105) | 0.5435 | 0.900 (0.763, 1.061) | 0.2082 | 1.178 (1.011, 1.373) | 0.0355 | 1.100 (0.945, 1.282) | 0.2187 | 1.145 (0.997, 1.315) | 0.0555 |
| **Fruits** | 1.001 (0.859, 1.166) | 0.9912 | 1.025 (0.876, 1.199) | 0.7572 | 1.017 (0.888, 1.164) | 0.8099 | 1.099 (0.971, 1.245) | 0.1354 | 0.972 (0.839, 1.125) | 0.6987 | 1.002 (0.879, 1.142) | 0.9736 | 0.954 (0.846, 1.075) | 0.4398 |
| **Vegetables** | 1.034 (0.904, 1.183) | 0.6268 | 1.233 (1.050, 1.446) | 0.0104 | 1.120 (0.968, 1.296) | 0.1295 | 1.251 (1.081, 1.448) | 0.0027 | 0.955 (0.823, 1.109) | 0.5495 | 1.078 (0.925, 1.256) | 0.3361 | 0.960 (0.833, 1.106) | 0.5711 |
| **Potatoes** | 0.960 (0.819, 1.125) | 0.6121 | 0.943 (0.803, 1.107) | 0.4712 | 0.928 (0.796, 1.081) | 0.3364 | 0.972 (0.818, 1.154) | 0.7441 | 0.972 (0.850, 1.111) | 0.6756 | 0.896 (0.781, 1.029) | 0.1201 | 0.939 (0.812, 1.087) | 0.3982 |
| **Cereals** | 0.845 (0.724, 0.985) | 0.0317 | 0.820 (0.713, 0.944) | 0.0056 | 1.013 (0.886, 1.159) | 0.8487 | 0.990 (0.863, 1.135) | 0.8860 | 0.971 (0.841, 1.121) | 0.6845 | 0.994 (0.874, 1.130) | 0.9262 | 0.997 (0.881, 1.128) | 0.9602 |
| **Sweets** | 1.077 (0.940, 1.238) | 0.2811 | 0.863 (0.756, 0.986) | 0.0297 | 0.905 (0.768, 1.066) | 0.2326 | 0.850 (0.752, 0.961) | 0.0093 | 0.954 (0.810, 1.123) | 0.5697 | 0.913 (0.793, 1.052) | 0.2076 | 0.915 (0.790, 1.059) | 0.2342 |
| **Pastry** | 0.852 (0.753, 0.964) | 0.0108 | 0.902 (0.778, 1.047) | 0.1759 | 0.988 (0.873, 1.118) | 0.8436 | 1.055 (0.924, 1.204) | 0.4294 | 0.937 (0.772, 1.138) | 0.5119 | 0.957 (0.803, 1.140) | 0.6238 | 0.942 (0.796, 1.116) | 0.4898 |
| **Seafood** | 0.943 (0.816, 1.091) | 0.4328 | 1.435 (1.216, 1.693) | <0.0001 | 1.479 (1.243, 1.760) | <0.0001 | 1.537 (1.312, 1.802) | <0.0001 | 1.038 (0.911, 1.183) | 0.5768 | 1.208 (1.027, 1.422) | 0.0226 | 0.993 (0.851, 1.159) | 0.9287 |

Notes: n = 1098 for all models. OR (CI) were derived using ordinal logistic regression and p-values were derived using Wald statistics.

*a* An OR <1 suggest a negative association while a OR >1 suggest a positive association.

*b* All models included age, body mass index (BMI), gender, participant/maternal birth country (BC), maternal and paternal education level (MEL/PEL), snus habits, smoking habits, alcohol consumption and months exclusively breastfed, as well as all of the habitual food variables (i.e. all food variables were added simultaneously to the base model).

Table S4. Odds ratiosa (OR) and 95% confidence interval (CI) for associations between PFAA serum concentrations and consumption of different types of seafoodb.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Covariate** | **lin-PFOA** |  | **PFNA** |  | **PFDA** |  | **PFUnDA** |  | **lin-PFHxS** |  | **lin-PFOS** |  | **br-PFOS** |  |
| (g/day) | OR (CI) | p | OR (CI) | p | OR (CI) | p | OR (CI) | p | OR (CI) | p | OR (CI) | p | OR (CI) | p |
| **Lean marine fish** | 0.998 (0.842, 1.183) | 0.9838 | 1.161 (0.995, 1.355) | 0.0587 | 1.257 (1.084, 1.459) | 0.0025 | 1.111 (0.975, 1.265) | 0.1157 | 0.998 (0.891, 1.117) | 0.9689 | 1.159 (1.035, 1.298) | 0.0105 | 1.038 (0.928, 1.160) | 0.5165 |
| **Processed fish** | 0.946 (0.844, 1.060) | 0.3353 | 0.933 (0.834, 1.045) | 0.2308 | 0.920 (0.813, 1.042) | 0.1886 | 0.849 (0.751, 0.960) | 0.0087 | 0.947 (0.848, 1.057) | 0.3302 | 0.853 (0.749, 0.972) | 0.0169 | 0.917 (0.822, 1.023) | 0.1198 |
| **Herring and mackerel** | 1.010 (0.978, 1.043) | 0.5378 | 1.032 (0.992, 1.074) | 0.1163 | 1.019 (0.979, 1.060) | 0.3665 | 1.058 (1.010, 1.108) | 0.0169 | 1.003 (0.964, 1.043) | 0.8863 | 1.015 (0.972, 1.060) | 0.5101 | 1.002 (0.961, 1.044) | 0.9277 |
| **Salmonid fish** | 1.023 (0.925, 1.147) | 0.5932 | 1.026 (0.922, 1.142) | 0.6333 | 1.035 (0.928, 1.156) | 0.5344 | 1.089 (0.970, 1.223) | 0.1472 | 0.983 (0.868, 1.113) | 0.7864 | 0.967 (0.856, 1.093) | 0.5918 | 1.018 (0.884, 1.173) | 0.8033 |
| **Canned tuna** | 0.999 (0.992, 1.005) | 0.6872 | 1.013 (1.007, 1.020) | 0.0001 | 1.001 (0.974, 1.028) | 0.9694 | 1.005 (0.987, 1.023) | 0.5770 | 1.009 (1.003, 1.015) | 0.0046 | 1.005 (0.998, 1.012) | 0.1431 | 1.002 (0.995, 1.009) | 0.5681 |
| **Anchovies etc.** | 0.555 (0.098, 3.156) | 0.5071 | 0.314 (0.030, 3.301) | 0.3348 | 0.787 (0.037, 16.94) | 0.8786 | 1.109 (0.025, 48.70) | 0.9574 | 3.082 (0.077, 122.9) | 0.5495 | 1.477 (0.167, 13.08) | 0.7258 | 1.164 (0.182, 7.456) | 0.8729 |
| **Baltic herring etc.** | 15.21 (0.401, 576.9) | 0.1423 | 7.621 (0.346, 168.1) | 0.1982 | 1.191 (0.062, 23.01) | 0.9078 | 1.860 (0.045, 76.93) | 0.7437 | 0.744 (0.105, 5.273) | 0.7675 | 1.362 (0.253, 7.342) | 0.7195 | 2.003 (0.480, 8.356) | 0.3403 |
| **Freshwater fish** | 0.997 (0.972, 1.022) | 0.8046 | 1.012 (0.984, 1.040) | 0.4140 | 1.018 (0.981, 1.057) | 0.3399 | 1.008 (0.977, 1.040) | 0.6243 | 0.994 (0.967, 1.021) | 0.6591 | 1.031 (0.994, 1.069) | 0.0988 | 1.019 (0.992, 1.047) | 0.1737 |
| **Large saltwater fish** | 3.512 (0.039, 313.1) | 0.5835 | 2.152 (0.350, 13.22) | 0.4080 | 0.587 (0.050, 6.924) | 0.6719 | 2.151 (0.698, 6.625) | 0.1822 | 1.331 (0.181, 9.779) | 0.7785 | 1.270  (0.139, 11.71) | 0.8307 | 1.620 (0.116, 22.72) | 0.7203 |
| **Crab** | 0.996 (0.968, 1.025) | 0.7934 | 1.013 (0.984, 1.043) | 0.3988 | 0.992 (0.954, 1.032) | 0.6926 | 0.981 (0.957, 1.005) | 0.1271 | 0.988 (0.943, 1.036) | 0.6277 | 1.005 (0.977, 1.035) | 0.7129 | 1.001 (0.977, 1.023) | 0.9464 |
| **Shellfish** | 0.949 (0.875, 1.029) | 0.2042 | 1.028 (0.938, 1.127) | 0.5543 | 1.131 (0.993, 1.288) | 0.0635 | 1.216 (1.072, 1.379) | 0.0024 | 1.099 (1.020, 1.185) | 0.0138 | 1.116 (1.001, 1.244) | 0.0488 | 1.025 (0.913, 1.150) | 0.6794 |

Notes: n = 1098 for all models. OR (CI) were derived using ordinal logistic regression and p-values were derived using Wald statistics.

*a* An OR <1 suggest a negative association while a OR >1 suggest a positive association.

*b* All models included age, body mass index (BMI), gender, participant/maternal birth country (BC), maternal and paternal education level (MEL/PEL), snus habits, smoking habits, alcohol consumption, months exclusively breastfed, the habitual food consumption variables eggs/dairy/meats/fruits/vegetables/potatoes/cereals/sweets/pastry as well as all of the individual fish groups.

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