SCIENTIFIC REPORT OF EFSA

RESULTS ON ACRYLAMIDE LEVELS IN FOOD FROM MONITORING YEARS 2007-2009 AND EXPOSURE ASSESSMENT[1]

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ABSTRACT

The current report describes the results from the European acrylamide monitoring in the period from 2007 to 2009. Twenty three Member States and Norway submitted a total of 10366 acrylamide results for the three-year period. In 2009, mean acrylamide levels ranged from 37 µg/kg for 'soft bread' to 1504 µg/kg for 'substitute coffee', while the highest 95th percentile and maximum levels were reported for 'substitute coffee' at 3976 and 'potato crisps' at 4804 µg/kg, respectively. A mixed effect model was used to evaluate time trend changes in acrylamide levels in defined food groups. To detect clear statistical trends the number of years covered should be extended. However, based on the three years of information available it could be identified that acrylamide decreased in 'crackers', 'infant biscuits' and 'gingerbread' over the three years, increased in 'crisp bread' and 'instant coffee', while showing no statistically significant change in six food groups. No European trend could be identified in eight food groups, while there was insufficient information available for 'wafers', 'coffee not specified' and 'muesli and porridge' for the model fit. Mean acrylamide exposure in Europe was estimated to range between 0.31 and 1.1 µg/kg b.w. per day for adults (>18 years), between 0.43 and 1.4 µg/kg b.w. per day for adolescents (11-17 years), between 0.70 and 2.05 µg/kg b.w. per day for children (3-10 years) and between 1.2 and 2.4 µg/kg b.w. per day for toddlers (1-3 years). Major contributors to exposure for adults were 'fried potatoes' (including 'French fries'), 'coffee', and 'soft bread' whereas for adolescents and children they were 'fried potatoes', 'soft bread' and 'potato crisps' or 'biscuits'.

KEY WORDS

Acrylamide, food, monitoring, trend, French fries, potato crisps, exposure assessment, coffee, mitigation measures.

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Summary

Commission Recommendation 2007/331/EC[4] of 3 May 2007 on the monitoring of acrylamide levels in food requires Member States to perform annually in 2007, 2008 and 2009 the monitoring of acrylamide levels in certain foodstuffs. The current report describes the results from this monitoring exercise and presents exposure estimates for the different target populations.

Member States were invited to analyse annually approximately 2000 food samples in the following main food categories: 'French fries', 'potato crisps', 'potato products for home cooking', 'bread', 'breakfast cereals', 'biscuits', 'roasted coffee', 'jarred baby foods', 'processed cereal-based baby foods' and 'other products'.

Twenty Member States and Norway submitted 3287 new results in 2009 for acrylamide levels in foodstuffs, with a minimum of 99 reported for 'processed cereal-based baby foods' and a maximum of 677 reported for 'other products'. The upper bound mean of acrylamide levels ranged from 37 µg/kg for 'bread soft' to 1504 µg/kg for 'substitute coffee'. The highest 95th percentile value was reported for 'substitute coffee' at 3976 and the highest maximum value for 'potato crisps' at 4804 µg/kg.

The 2009 results were compared with the 3728 results for 2008 and 3350 results for 2007. A mixed effect model was used to evaluate statistically significant changes. To detect clear statistical trends the number of years covered should be extended. However, based on the three years of information available it could be identified that acrylamide levels decreased in 'crackers', 'infant biscuits' and 'gingerbread' over the three years, increased in 'crisp bread' and 'instant coffee', whilst showing no statistically significant changes in 'potato crisps', 'oven fried potatoes', 'bread not specified', 'breakfast cereals', 'jarred baby foods' and 'processed cereal-based baby foods. No European trend could be identified in eight food groups, whilst there was insufficient information available for 'wafers', 'coffee not specified' and 'muesli and porridge'.

Exposure to acrylamide was estimated for different populations by combining pooled acrylamide occurrence values obtained through the monitoring program in 2007 to 2009 with individual dietary information derived from the EFSA Comprehensive European Food Consumption Database.

Exposure estimates were similar to previously reported estimates for European countries. The mean acrylamide intake for adults (>18 years) in Europe was estimated to range between 0.31 and 1.1 µg/kg b.w. per day and the 95th percentile between 0.58 and 2.3 µg/kg b.w. per day. 'Fried potatoes' (including 'French fries'), 'soft bread' and 'roasted coffee' were identified as the major contributors to overall adult acrylamide exposure. Mean acrylamide intake for adolescents (11-17 years) in Europe was estimated to range between 0.43 and 1.4 µg/kg b.w. per day and the 95th percentile between 0.94 and 3.1 µg/kg b.w. per day. 'Fried potatoes', 'soft bread' and 'biscuits' or 'potato crisps' depending on the survey were identified as the major contributors to overall adolescence acrylamide exposure. For children (3-10 years) mean intake was estimated to range between 0.70 and 2.05 µg/kg b.w. per day and 95th percentile between 1.5 and 4.2 µg/kg b.w. per day and for toddlers (1-3 years) between 1.2 and 2.4 µg/kg b.w. per day and 95th percentile between 2.4 and 6.5 µg/kg b.w. per day, respectively. In the children and toddler population the three major contributors to acrylamide exposure were 'fried potatoes', 'soft bread' or 'unspecified bread' and 'biscuits'.

The food industry developed the so-called 'toolbox' approach as a voluntary measure to provide guidance to producers and processors in identifying ways to lower acrylamide in their products. As in previous annual acrylamide reports (EFSA 2009 and 2010) it can be concluded likewise that the application of the acrylamide toolbox has had only limited success. To lower overall exposure it would be desirable to further reduce acrylamide levels in food groups contributing the most to

[4] Commission Recommendation 2007/331/EC of 3 May 2007 on the monitoring of acrylamide levels in food. OJ L 123/33, 12.5.2007, p. 1-8.

acrylamide exposure, like ‘fried potatoes’ (including ‘French fries’), ‘soft bread’, ‘roasted coffee’, ‘biscuits’.

To facilitate interpretation of results in future years and to detect clear trends the number of years covered needs to be extended, sampling should consistently cover the same products in different years and contain sufficient number of samples per food group in order to be able to distinguish random fluctuations from real observable trends.

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BACKGROUND AS PROVIDED BY THE EUROPEAN COMMISSION

The European Commission Recommendation 2007/331/EC on the monitoring of acrylamide levels in food of 3 may 2007 requires the Member States to perform annually in 2007, 2008 and 2009 the monitoring of acrylamide levels in certain foodstuffs. These data have to be transmitted directly to EFSA by 1 June each year.

TERMS OF REFERENCE AS PROVIDED BY THE EUROPEAN COMMISSION

In order to give the Commission an overview of the data collected during the years 2007, 2008 and 2009, EFSA is asked to compile the 2009 data in an updated occurrence report and compare them with the existing database for the years 2007 and 2008 compiled previously by EFSA. This would allow the Commission to identify whether or not the voluntary measures taken by the food industry have shown desirable effects.

REPORT

1. INTRODUCTION

In 2005, the European Food Safety Authority (EFSA) adopted a statement to endorse the risk assessment on acrylamide in food carried out by the Joint FAO/WHO Expert Committee on Food Additives (JECFA) in February 2005 (EFSA, 2005; FAO/WHO, 2005). JECFA concluded that the margin of acrylamide exposures for average and high consumers were low for a compound that is genotoxic and carcinogenic and that this may indicate a human health concern. These conclusions are confirmed in the latest risk assessment on acrylamide carried out by JECFA in February 2010 (FAO/WHO, 2010). Therefore, it was concluded that efforts to reduce acrylamide content in foodstuffs should be continued.

The food industry has investigated pathways of acrylamide formation. As a result, voluntary measures were developed, such as the so-called 'toolbox' approach, which provides guidance to help producers and processors to identify ways to lower acrylamide in their respective products (CIAA, 2006). This toolbox was updated in 2009 (CIAA, 2009). The toolbox proposes intervention steps to reduce acrylamide in the categories biscuits, crackers and crisp breads, bread product, breakfast cereals and fried potato products, such as potato crisps and French fries.

The collection of data on acrylamide levels in food over at least a three-year time span across the European Community has been advocated in order to have a clear picture of the levels of acrylamide in those foodstuffs that are known to contain high acrylamide levels and/or contribute significantly to the dietary intake of the whole population. Special attention should be given to products for specific vulnerable groups, such as infants and young children.

The European Commission Joint Research Centre's Institute for Reference Materials and Measurements (JRC-IRMM) established a database on acrylamide levels in food between 2003 and 2006 (Wenzl and Anklam, 2007).

In 2007, the European Commission issued a recommendation that Member States should undertake annual monitoring of acrylamide levels in foodstuffs for the years 2007, 2008 and 2009 in accordance with an agreed sampling procedure[5]. Member States should provide by 1 June each year the monitoring data of the previous year to EFSA, who will compile these data into a database.

A first report compared the results of the monitoring of acrylamide levels in 2007 to the previous results collected in 2003-2006 by JRC-IRMM (EFSA, 2009), while an updated report compared the monitoring results of 2008 to the ones of 2007 (EFSA, 2010). In the current report the results of the monitoring of acrylamide levels in 2009 are presented in detail and compared to the updated results covering the years 2007 and 2008. In addition, acrylamide exposure assessments based on the results from 2007 to 2009 are shown.

In 2010, the European Commission issued an updated recommendation that Member States should continue the annual monitoring of acrylamide levels in foodstuffs from year 2010 onwards[6].

[5] Commission Recommendation 2007/331/EC of 3 May 2007 on the monitoring of acrylamide levels in food. OJ L 123/33, 12.5.2007, p. 1-8.

[6] European Commission Recommendation 2010/307/EC of 2 June 2010 on the monitoring of acrylamide levels in food. OJ L 137/4, 3.6.2010 , p. 1-7.

2. MATERIALS AND METHODS

2.1. Sampling procedure

2.1.1. Sampling points and analytical procedures

The prescribed sampling procedure requires the sampling of products to be taken at market level (e.g. at supermarkets, smaller shops, bakeries, French fries, outlets and restaurants), or at the production sites. The analysis should be carried out before the expiry date of the sample.

Furthermore it is requested to use analytical methods that can achieve a limit of quantification (LOQ) of 30 µg/kg for bread and baby foods and 50 µg/kg for potato products, other cereal products, coffee and other products to ensure comparability in the analytical accuracy of results.

2.1.2. Products, sample numbers and frequencies

All 27 European Union Member States were invited to take samples according to a distribution based on population size with a minimum number of four per food group and Member State. In Table 1 the requested number of samples by food group is reported.

Table 1: Total number of samples to be taken in ten specified food groups.

Food group	Requested number of samples
French fries sold as ready to eat	202
Potato crisps	202
Pre-cooked French fries/potato products for home cooking	202
Bread	202
Breakfast cereals	202
Biscuits including infant biscuits	202
Roasted coffee	202
Jarred baby foods	202
Processed cereal-based baby foods	202
Other products	224

For 'French fries' it was recommended sampling twice during the year (in March and November) at small outlets, fast food chains and restaurants. For 'potato crisps' and 'pre-cooked French fries or potato products for home cooking' it was also recommended sampling twice a year. Analysis of each sample from the food group 'pre-cooked French fries or potato products for home cooking' should be carried out on the product after preparation (e.g. frying, baking). The choice of the bread samples should reflect the eating habits of each country and include also crisp bread. In the category 'breakfast cereals', muesli and porridge were excluded. Biscuits also included infant biscuits. Jarred baby foods should contain potato, root vegetables or cereals. The category 'other products' includes potato products, cereal products, coffee products, cocoa products and infant food other than those products specified in one of the other categories. This category would contain products like gingerbread, coffee substitutes and snacks.

2.2. Data handling

2.2.1. Descriptive statistics

For this updated report covering the 2009 sampling Member States transmitted data for 2009 as well as some new data for 2007 and 2008. Consequently in this report, the descriptive statistics for 2007 and 2008 data have been slightly amended from the previous reports to reflect the new submissions. In

total, 119 results submitted in 2009 were excluded from the database because either information on the sampling year was missing or the result could not be classified into any acrylamide food groups.

After the meeting of the Commission Expert Group on Industrial and Environmental Contaminants held in October 2009, the Commission requested five out of the ten food groups ('potato products for home cooking', 'bread', 'biscuits including infant biscuits', 'roasted coffee' and 'other products') to be subdivided into more refined subgroups (as presented in Table 7) in order to compare more specific groups in a trend analysis.

Not all the countries reported information on food preparation, on type of biscuits, type of bread, sampling information of potato products, type of cereals or degree of roasting.

As recommended in the EFSA scientific report "Management of left-censored data in dietary exposure assessment of chemical substances (EFSA, 2010b) and in the WHO report "Principles and methods for the risk assessment of chemicals in food' (WHO, 2009) the non quantified data were treated by the substitution method. Two scenarios were assumed for handling data below the limit of detection (LOD) or quantification (LOQ). First, according to a lower bound scenario, values below LOD and values between the LOD and the LOQ were set to zero. Secondly, according to an upper bound scenario, values below LOD and values between LOD and LOQ were set to the LOD or the LOQ value, respectively. Both lower bound and upper bound scenarios were used to report descriptive statistics for the characteristics of the data distribution.

Results that did not meet the specifications for LOD and LOQ given in the Commission Recommendation 2007/331/EC were kept in the dataset as the difference between lower and upper bound values (as presented in Tables 7, 8 and 9) were minor and thus the data with high LOD and LOQ did not significantly influence the outcome of the data evaluation.

2.2.2. Trend analysis

Acrylamide results from 2009 were compared with results from 2007 and 2008 at food group and subgroup level in order to evaluate their change over time across Europe. A mixed effect model (Verbeke and Molenberghs, 2000) using the log of the values was fitted. The mixed effect model was used to test whether there is a European trend (an overall European change over time) in each food group and subgroup.

Two scenarios were tested in the model. First, according to an upper bound scenario, values below LOD and values between the LOD and the LOQ were set to the LOD or the LOQ value, respectively. Secondly, according to a middle point scenario, values below LOD and values between LOD and LOQ were set to half of the LOD or the LOQ value, respectively. In this report, due to the similarities between the two scenarios, only the results from the analysis using the middle point scenario in the model are shown.

The mixed effect model contained an overall intercept and an overall time trend (being the same for all countries, also called marginal effects). A random intercept and slope (time effect) was also included in order to allow each country to have their own trend profile. It is important to note that this assumption is crucial when interpreting the results at European level.

The model building process was as follow:

The model (I) was written as follow:

$$y_{ij} = \beta_0 + b_{0i} + (\beta_1 + b_{1i}) \cdot Time_{ij} + \varepsilon_{ij}, \qquad \text{(I)}$$
$$\begin{pmatrix} b_{0i} \\ b_{1i} \end{pmatrix} \sim N\left(\begin{pmatrix} 0 \\ 0 \end{pmatrix}, \begin{pmatrix} \sigma^2_{b_0} & \sigma_{b_0 b_1} \\ \sigma_{b_0 b_1} & \sigma^2_{b_1} \end{pmatrix}\right),$$

where y_{ij} are the values detected in the sample (j) or either the limit of detection or quantification reported for the non detected value for country i, β_0 and β_1 are the so called marginal or fixed effect, b_{0i} and b_{1i} are the Member State specific random effects, which are assumed to be normally distributed with mean 0 and variances $\sigma^2_{b_0}$ and $\sigma^2_{b_1}$ respectively. $Time_{ij}$ is the year the sample was taken and ε_{ij} represents the error term, which was assumed to be also normally distributed with mean 0 and variance σ^2_{ε}.

Model I was fitted for each food group and sub group. In model I, the covariance related to the random effects of slope and intercept was tested. In case the covariance was positive or negative no European time trend could be determined. A positive covariance means that countries which started with high acrylamide values might show a larger trend effect over time than countries which started with lower acrylamide values. On the other hand, when a negative covariance is observed, countries starting with high values might show lower trend effect than those starting with lower values. An overall European trend could be ruled out, in case that the two random effects (intercept and slope) were correlated. In case the correlation between random effects of slope and intercept was zero a simpler model without the correlation effect, called model II was fitted.

$$y_{ij} = \beta_0 + b_{0i} + (\beta_1 + b_{1i}) \cdot Time_{ij} + \varepsilon_{ij}, \qquad \text{(II)}$$
$$\begin{pmatrix} b_{0i} \\ b_{1i} \end{pmatrix} \sim N\left(\begin{pmatrix} 0 \\ 0 \end{pmatrix}, \begin{pmatrix} \sigma^2_{b_0} & 0 \\ 0 & \sigma^2_{b_1} \end{pmatrix}\right),$$

In model II in which independence between the random effects was assumed the variability of the random slope was tested. Two possible scenarios occurred. First, the hypothesis that the variance of the random slope is zero was rejected which means that different trends over time across the Member States were observed. Therefore for those food groups or subgroups an overall European time trend should not be reported. Second, the hypothesis that the variance of the random slope is zero was not rejected, which means that the change over time across the Member States remained the same and the model could be simplified further to model III.

$$y_{ij} = \beta_0 + b_{0i} + \beta_1 \cdot Time_{ij} + \varepsilon_{ij}, \qquad \text{(III)}$$
$$b_{0i} \sim N\left(0, \sigma^2_{b_0}\right),$$

In case the variability of the random slope was equal to zero ($H_0 : \sigma^2_{b_1} = 0$) a third model (III) was fitted containing only random intercept and an overall European time trend for the food group or subgroup could be reported.

The exponential function of β_1 was used to calculate the increase or decrease of acrylamide content over the years.

2.2.3. Seasonal effect analysis

In the three food groups 'French fries', 'potato crisps' and 'potato products for home cooking' a seasonal effect was assessed across Europe. The same approach was conducted for the seasonal effect analysis as for the trend analysis. A mixed effect model was used, considering random intercept and in this case a seasonal random effect, allowing for correlation between both random effects. The followed model building process was the same as explained in section 2.2.2 related to the trend analysis. First, a model was fitted to assess the need for the correlation parameters and second, the need for a random seasonal effect was tested.

Before evaluating the seasonal effect in the different potato food groups, it was investigated whether the trend analysis confirmed a constant change over time.

2.2.4. Dietary exposure assessment

Acrylamide exposure was estimated by combining acrylamide occurrence values obtained through the monitoring program from 2007 to 2009 with dietary information derived from the EFSA Comprehensive European Food Consumption Database (hereafter Comprehensive Database). This database builds on existing information for adults and children at a detailed level. Through a procurement project 20 different Member States provided food consumption data at individual level to EFSA collected within the most recent national dietary surveys including the adult population (Merten et al., 2010). Food consumption data from other 10 different dietary surveys specifically focused on children (in particular toddlers from 1-3 years old) were gathered by means of the EFSA Article 36 project "Individual food consumption data and exposure assessment studies for children" (acronym EXPOCHI) (EXPOCHI Consortium, 2010; Huybrechts et al., 2010). In total, the Comprehensive Database contains detailed food consumption data from 32 different dietary surveys carried out in 22 different Member States (EFSA, 2011).

All food consumption data were codified according to the FoodEx classification system developed by the DATEX Unit in 2009 with the objective of simplifying the linkage between occurrence and food consumption data when assessing the exposure to hazardous substances. It contains 20 main food categories, which are further divided into subgroups having almost 160 items at the 2nd level and reaching about 1,800 end-points (food names or generic food names) at the 4th level (EFSA, 2010a).

Overall, the food consumption data gathered by EFSA in the Comprehensive Database are the most complete and detailed data currently available in the EU. However, the differences in the methodologies used to collect the data within the different dietary surveys make these data not fully suitable for country-to-country comparisons.

For calculating acrylamide exposure, food consumption and body weight data at the individual level were accessed in the Comprehensive Database. For each country, exposure estimates are presented per dietary survey and age class - infants (1-11 months), toddlers (12-35 months), other children (3-10 years), adolescents (11-17 years), adults (18-64 years), elderly (65-74 years) and very elderly (from 75 years). As suggested by the EFSA Working Group on Food Consumption and Exposure (EFSA, 2011) dietary surveys with only one day per subject were excluded when calculating acrylamide exposure, since one day is considered not adequate to assess chronic exposure. Exposure estimates were therefore calculated for 26 different dietary surveys carried out in 17 different Member States.

For sake of consistency, some of the food categories in the acrylamide occurrence database were merged to map to the food categories in the consumption database. Thus, 'French fries' was merged with 'deep fried potato products' to form the category 'fried potatoes', 'crackers' was merged with 'crisp bread' to form the category 'crisp bread', the three bread subgroups were merged to form the category 'unspecified bread', 'wafers' was merged with 'not specified biscuit' and 'gingerbread' to form the category 'biscuit'. Conversion factors retrieved from literature (Lantz et al., 2006, Guenther et al., 2007, Soares, 2006 and Granby et al., 2004) were used to convert different liquid types of coffee like e.g. instant coffee (conversion factor was 0.02), espresso (conversion factor was 0.217),

cappuccino (conversion factor was 0.036), drip filter coffee (conversion factor was 0.05), substitute coffee (conversion factor was 0.02) into dry powder. In the Finnish surveys all cereal products were reported as raw agricultural commodities and a conversion factor of 1.5 was applied to transform all milling products back to unspecified bread.

Exposure to acrylamide was estimated for different target populations by combining pooled acrylamide occurrence values from all Member States obtained through the monitoring program from 2007 to 2009 with individual dietary national consumption data from Member States derived from the EFSA Comprehensive European Food Consumption Database. The mean and the 95th percentile of the dietary acrylamide exposure by food category were calculated separately for each country for the whole population using consumption data recorded at individual level. Exposure estimates were calculated for two scenarios according to different assumptions concerning the occurrence levels assigned to the samples below the LOD or LOQ (lower and upper bound scenarios). The lower and upper bound means of the acrylamide contents for each food category were combined with the consumption information at individual level and each individual's body weight was used to express acrylamide exposure in µg/kg b.w. per day.

3. RESULTS

3.1. Data reported in 2007, 2008 and 2009

Table 2, 3 and 4 summarise the number of samples for which the individual Member States and Norway reported acrylamide values in 2007, 2008 and 2009 sorted into the 10 main food groups.

Table 2 shows that 22 Member States and Norway submitted 3350 results for the 2007 acrylamide monitoring exercise, Table 3 shows that 24 Member States and Norway submitted 3728 results for the 2008 acrylamide monitoring exercise, whereas Table 4 shows that 20 Member States and Norway submitted 3287 results for the 2009 acrylamide monitoring exercise to EFSA.

Approximately 52%, 42% and 40% of the results originated from Germany for 2007, 2008 and 2009 monitoring exercises, respectively. The number of samples per food group in 2007 varied between 87 for 'jarred baby foods' to 890 for 'other products'. The number of results sampled in 2008 ranged from 110 for 'processed cereal-based baby foods' to 890 for 'other products'. The number of results sampled in 2009 ranged from 99 for 'processed cereal-based baby foods' to 677 for 'other products'.

It can be observed from Tables 2 to 4 that the number of samples across the same main food groups is quite evenly distributed across the three monitoring years. However, the total minimum number of samples to be analysed each year per food group as recommended in the Commission recommendation was not submitted in any of the monitoring year from 2007 to 2009 for 'breakfast cereals', 'jarred baby food' and 'processed cereal based baby food'. On the other hand, the submitted total number of samples was above the minimum recommendations for the remaining seven main food groups.

Some Member States did not submit acrylamide results for all three monitoring years and two Member States did not submit any results at all. Among the submitting Member States, three did not submit the required minimum sample number per Member State as recommended in the Commission recommendation

Table 2: Number of samples per food group sampled by individual Member States and Norway in 2007

	ISO-code	Sampling year 2007										
		Total number of samples	**French fries as sold**	**Potato crisps**	**Precooked French fries/ potato products**	**Bread**	**Breakfast cereals**	**Biscuits including infant biscuits**	**Roasted coffee**	**Jarred baby foods**	**Processed cereal-based baby foods**	**Other products**
Austria	AT	49	0	4	10	4	4	6	4	2	5	10
Belgium	BE	178	19	5	0	31	27	20	10	0	4	62
Bulgaria	BG	45	4	4	4	4	4	4	5	4	5	7
Cyprus	CY	33	2	2	2	4	4	4	7	3	4	1
Czech Republic	CZ	130	42	10	5	5	5	15	5	5	4	34
Germany	DE	1757	427	121	25	143	14	302	134	0	1	590
Estonia	EE	50	2	13	2	4	4	4	4	4	4	9
Spain	ES	25	0	0	0	0	0	0	6	0	11	8
Finland	FI	70	0	14	8	10	2	24	6	0	0	6
France	FR	69	0	7	6	2	3	2	0	0	0	49
United Kingdom	GB	172	66	5	6	30	10	15	10	10	10	10
Greece	GR	20	1	4	1	2	2	2	2	2	3	1
Ireland	IE	93	20	6	2	18	6	21	5	7	3	5
Italy	IT	45	0	8	2	8	2	9	0	0	0	16
Lithuania	LT	40	4	4	4	4	4	5	4	4	4	3
Latvia	LV	38	1	4	5	4	4	5	4	4	4	3
Malta	MT	20	2	2	2	4	2	2	2	2	2	0
Netherlands	NL	73	6	6	12	8	6	15	6	6	4	4
Norway	NO	86	16	28	24	0	0	0	0	0	0	18
Poland	PL	119	7	7	7	14	14	14	14	14	14	14
Sweden	SE	67	8	8	8	8	4	4	4	15	4	4
Slovenia	SI	119	20	10	11	20	10	13	5	5	6	19
Slovakia	SK	52	0	8	4	5	4	8	6	0	0	17
Total number		**3350**	**647**	**280**	**150**	**332**	**135**	**494**	**243**	**87**	**92**	**890**

Table 3: Number of samples per food group sampled by individual Member States and Norway in 2008.

		Sampling year 2008										
	ISO-code	**Total number of samples**	**French fries as sold**	**Potato crisps**	**Precooked French fries/ potato products**	**Bread**	**Breakfast cereals**	**Biscuits including infant biscuits**	**Roasted coffee**	**Jarred baby foods**	**Processed cereal-based baby foods**	**Other products**
Austria	AT	56	4	3	6	6	4	6	10	4	2	11
Belgium	BE	176	21	10	0	21	15	34	18	0	0	57
Cyprus	CY	41	4	4	6	4	4	6	4	4	5	0
Czech Republic	CZ	195	85	5	0	10	6	20	5	6	1	57
Germany	DE	1571	237	175	27	107	3	318	165	22	12	505
Denmark	DK	105	17	9	10	4	5	8	16	4	2	30
Estonia	EE	57	6	3	6	10	3	9	3	4	2	11
Spain	ES	100	3	6	20	18	0	10	18	18	4	3
Finland	FI	70	0	16	3	10	1	23	3	3	0	11
France	FR	104	0	9	0	8	2	3	0	0	0	82
United Kingdom	GB	303	66	53	74	35	10	14	10	10	10	21
Greece	GR	70	5	13	4	6	8	9	6	6	4	9
Hungary	HU	104	24	8	2	9	12	13	7	10	9	10
Ireland	IE	60	11	9	4	4	4	7	6	4	5	6
Italy	IT	97	3	43	11	5	6	6	6	1	0	16
Lithuania	LT	40	4	4	4	4	4	4	4	4	4	4
Latvia	LV	42	0	6	6	6	3	3	4	4	4	6
Malta	MT	20	2	2	2	2	2	2	2	1	3	2
Netherlands	NL	77	6	6	12	9	6	9	7	4	13	5
Norway	NO	61	8	16	7	4	4	4	6	4	4	4
Poland	PL	138	14	14	14	14	14	12	14	14	14	14
Romania	RO	81	4	16	10	7	14	8	8	7	4	3
Sweden	SE	56	8	8	8	8	4	4	4	4	4	4
Slovenia	SI	41	4	4	4	4	0	8	4	4	4	5
Slovakia	SK	63	0	16	8	5	2	7	11	0	0	14
Total number		**3728**	**536**	**458**	**248**	**320**	**136**	**547**	**341**	**142**	**110**	**890**

Table 4: Number of samples per food group sampled by individual Member States and Norway in 2009.

		Sampling year 2009										
	ISO-code	**Total number of samples**	**French fries as sold**	**Potato crisps**	**Precooked French fries/ potato products**	**Bread**	**Breakfast cereals**	**Biscuits including infant biscuits**	**Roasted coffee**	**Jarred baby foods**	**Processed cereal-based baby foods**	**Other products**
Austria	AT	52	6	5	3	7	3	6	6	4	2	10
Belgium	BE	198	20	8	0	31	5	36	20	0	0	78
Cyprus	CY	48	2	6	10	5	5	6	4	6	3	1
Czech Republic	CZ	198	84	9	5	13	5	21	5	4	4	48
Germany	DE	1324	153	102	74	105	30	332	71	9	16	432
Denmark	DK	102	20	13	7	9	10	19	12	1	2	9
Estonia	EE	40	2	3	6	4	3	6	4	6	2	4
Spain	ES	88	16	16	8	14	6	10	3	10	3	2
France	FR	8	0	0	0	0	0	0	1	0	0	7
United Kingdom	GB	299	66	53	74	35	10	15	11	10	10	15
Greece	GR	27	8	14	2	0	0	0	0	0	0	3
Hungary	HU	88	8	16	7	6	10	9	13	14	0	5
Ireland	IE	69	11	19	4	4	4	8	7	4	3	5
Italy	IT	218	25	42	6	32	19	38	22	12	5	17
Lithuania	LT	40	4	4	4	4	4	5	4	4	4	3
Netherlands	NL	67	6	6	8	10	4	15	4	4	7	3
Norway	NO	81	8	18	5	10	6	7	8	4	13	2
Poland	PL	140	14	14	14	14	14	14	14	14	14	14
Romania	RO	79	8	15	4	4	9	13	9	8	7	2
Sweden	SE	60	8	8	8	12	4	4	4	4	4	4
Slovakia	SK	61	0	17	8	5	2	6	10	0	0	13
Total number		**3287**	**469**	**388**	**257**	**324**	**153**	**570**	**232**	**118**	**99**	**677**

3.2. Reported LOD and LOQ

In Table 5 the number of samples below the limits of detection (≤LOD) and quantification (≤LOQ) are reported, as well as the minimum and maximum reported values for LOD and LOQ for each food category.

Table 5: Number of samples below the limits of detection (≤LOD) and quantification (≤LOQ) are reported and range of the reported LOD and LOQ in µg/kg per food category in 2009.

		N	Minimum µg/kg	Maximum µg/kg
Biscuits	≤LOD	26	0.1	75
	≤LOQ	142	0.1	100
	Quantified	402		
Bread	≤LOD	11	1	75
	≤LOQ	97	2	132
	Quantified	216		
Breakfast cereals	≤LOD	10	20	75
	≤LOQ	24	2	100
	Quantified	119		
Cereal-based baby food	≤LOD	25	1	75
	≤LOQ	29	2	50
	Quantified	45		
Coffee	≤LOD	9	75	75
	≤LOQ	16	0.1	50
	Quantified	207		
French fries	≤LOD	10	20	75
	≤LOQ	21	2	100
	Quantified	438		
Jarred baby foods	≤LOD	17	6	75
	≤LOQ	49	0.1	50
	Quantified	52		
Other products	≤LOD	15	4	75
	≤LOQ	171	2	500*
	Quantified	491		
Potato crisps	≤LOD	16	6	75
	≤LOQ	15	0.1	40
	Quantified	357		
Potato products for home cooking	≤LOD	6	10	75
	≤LOQ	32	18	50
	Quantified	219		

*This high LOQ was reported only for five samples of spices in the 'not specified' subgroup of 'other products'

The minimum and maximum values for LOD and LOQ ranged from 0.1 to 75 µg/kg for the non detected samples (≤ LOD) and from 0.1 to 500 µg/kg for the non quantified samples (≤ LOQ). The minimum and maximum values for LOD and LOQ ranged from 0.1 to 36 µg/kg and 0.1 to 132 µg/kg, respectively, for the quantified samples (>LOQ). In some food groups like 'cereal based baby food' or 'jarred baby food' the range for LOD is higher than the range for LOQ, because some Member States did not report the LOQ value.

Fourteen countries reported using liquid chromatography-tandem mass spectrometry (LC-MS/MS) for the analysis of acrylamide and one reported the use of liquid chromatography-mass spectrometry (LC-MS). Two countries reported the use of gas chromatography-mass spectrometry (GC-MS) and two the use of tandem mass spectrometry (GC-MS/MS). One country reported the use of liquid

chromatography-high resolution mass spectrometry (LC-HRMS) and one country reported the use of electron capture detector-gas chromatography (GC/ECD). One country reported the use of four methods (GC-MS, LC-MS/MS, LC-DAD (liquid chromatography-diode array detection), LC-MS).

Eleven countries out of 21 in 2009 reported the participation in one or more proficiency tests organised by the Food Analysis Performance Assessment Scheme (FAPAS) of the Central Science Laboratory (now FERA), York (UK) with satisfactory results.

To better illustrate the percentage of numerical values above the LOQ and below LOD or between the LOD and the LOQ, the respective frequencies shown in Table 5 have been plotted in Figure 1 and compared to results of 2008 and 2007.

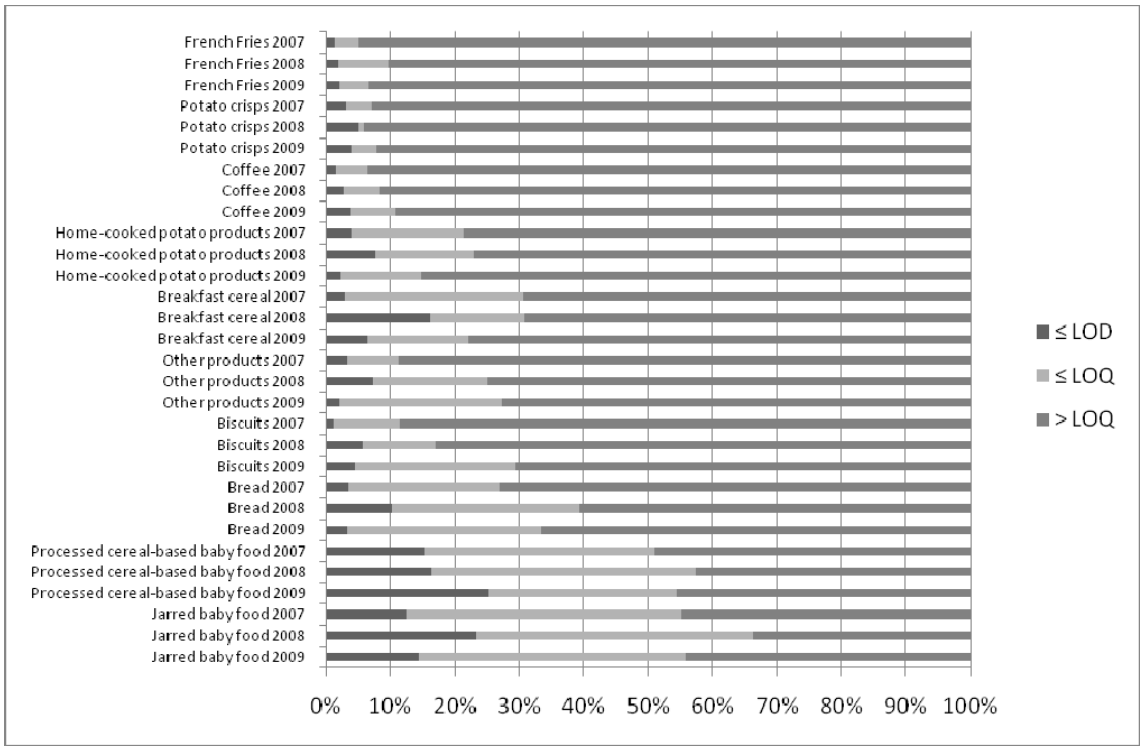

Figure 1: Percentage of values below LOD, between LOD and LOQ and above the LOQ per food category for the pooled data from all Member States in 2007, 2008 and 2009.

Eight out of 10 food categories show more than 60% of values above the LOQ with 'French fries', 'potato crisps' and 'coffee' showing more than 90% above the LOQ. Only the food categories 'jarred baby foods' and 'cereal-based baby food' show percentages of values above the LOQ of lower than 50%. In the majority of the food groups the percentage of quantified (>LOQ) samples slightly decreases between 2007 and 2008 and then decrease again between 2008 and 2009.

3.3. Statistical descriptors of the reported acrylamide content

In Tables 6, 7 and 8 the descriptive statistics for the data collected in 2007, 2008 and 2009, respectively, are given at food group and subgroup level.

With the exception of the maximum value, a range is provided when there was a difference between the estimated lower and upper bound acrylamide content calculated from the data reported by the Member States.

Table 6: Sample size (N), 5th percentile (P05), 25th percentile (P25), median, arithmetic mean, 75th percentile (P75), 90th percentile (P90), 95th percentile (P95) and maximum for results covering foods sampled in 2007.

	N	P25[#] µg/kg	Median[#] µg/kg	Mean[#] µg/kg	P75[#] µg/kg	P90[#] µg/kg	P95[#] µg/kg	Max µg/kg
Biscuits								
Crackers	69	102	195	291-292	307	900	1024	1526
Infant	97	47-55	100	197-204	180	440	714	2300
Not specified	291	62-65	173	299-303	355	673	960	4200
Wafers	38	54	118	206-210	258	478	694	1378
Bread								
Bread crisp	155	36-45	116	221-226	300	480	740	2430
Bread soft	127	0-25	14-30	54-68	53-56	114	230	910
Non specified	54	0-41	53-58	172-190	150	310	794	2565
Breakfast cereals	134	0-52	59-100	130-150	171	310	420	1600
Cereal-based baby food	92	0-25	0-38	48-69	65-100	176	220	353
Coffee								
Instant	51	90	188	357	776	826	898	1047
Not specified	41	100	183	259-261	293	486	916	1158
Roasted	153	127	197	245-251	309	480	772	958
French fries	647	140	246	354-357	440	740	1072	2668
Jarred baby foods	87	0-14	0-30	22-44	36-71	86-94	94-100	162
Other products								
Gingerbread	357	88	226	423-425	597	1140	1460	3615
Muesli and porridge	48	76	156	205-210	282	509	586	805
Not specified	424	25-48	119-134	232-244	272	570	879	2529
Substitute coffee	61	108	334	772-775	875	2600	2900	4700
Potato crisps	280	190	413	574-576	786	1200	1596	4180
Home-cook potato product								
Deep fried	54	50-57	182	344-354	500	838	1450	1661
Not specified	82	0-40	150	266-277	317	639	886	2175
Oven baked	8	153	260	380-385	638	941	941	941

[#] Range indicates lower bound and upper bound values.

The mean values ranged between 22 and 44 µg/kg for 'jarred baby foods' and between 772 and 775µg/kg for 'substitute coffee' for foods sampled in 2007. The highest P95 and maximum values were reported for 'substitute coffee' at 2900 and 4700 µg/kg, respectively.

Table 7: Sample size (N), 5th percentile (P05), 25th percentile (P25), median, arithmetic mean, 75th percentile (P75), 90th percentile (P90), 95th percentile (P95), and maximum for results covering foods sampled in 2008.

	N	P25[#] µg/kg	Median[#] µg/kg	Mean[#] µg/kg	P75[#] µg/kg	P90[#] µg/kg	P95[#] µg/kg	Max µg/kg
Biscuits								
Crackers	134	71	185	203-206	283	362	597	1042
Infant	88	0-29	64	98-110	148	250	280	1200
Not specified	276	49-62	121-126	213-223	244-250	600	760	1940
Wafers	49	72	109	251-254	181	645	1230	2353
Bread								
Bread crisp	92	59	107	229-231	297	590	770	1538
Bread soft	211	0-21	5-30	31-46	43-51	83	127	528
Non specified	17	0-10	0-19	11-23	19-30	34	86	86
Breakfast cereals	136	0-46	55-75	140-156	190	318	540	2072
Cereal-based baby food	110	0-18	0-25	35-51	28-50	95	159	660
Coffee								
Instant	58	293	482	499-502	709	851	929	1373
Not specified	11	0-30	210	278-286	380	720	734	734
Roasted	267	104	164	200-204	240	341	524	1524
French fries	536	99-100	220	281-285	376	595	784	2466
Jarred baby food	142	0-12	25	16-35	19-40	55-75	73-85	297
Other products								
Gingerbread	258	85	227	432-436	591	1009	1572	3307
Muesli and porridge	19	0-22	0-30	20-41	50-60	70	112	112
Not specified	529	0-25	46-60	160-173	179-186	485	645	2592
Substitute coffee	84	264	702	988	1278	2300	2800	7095
Potato crisps	458	225	436	626-630	790	1417	1900	4382
Home-cooked potato products								
Deep fried	39	0-30	152	220-228	348	588	710	1220
Not specified	101	0-29	52-75	175-191	170	400	718	3025
Oven baked	108	63	172	275-276	419	618	866	1439

[#] Range indicates lower and upper bound values.

The mean values ranged between 11 and 23 µg/kg for 'bread not specified' and between 626 and 630 µg/kg for 'potato crisps' for foods sampled in 2008. The highest P95 and maximum values were reported for 'substitute coffee' at 2800 and 7095 µg/kg, respectively.

Table 8: Sample size (N), 5th percentile (P05), 25th percentile (P25), median, arithmetic mean, 75th percentile (P75), 90th percentile (P90), 95th percentile (P95) and maximum for results covering foods sampled in 2009.

	N	P25[#] µg/kg	Median[#] µg/kg	Mean[#] µg/kg	P75[#] µg/kg	P90[#] µg/kg	P95[#] µg/kg	Max µg/kg
Biscuits								
Crackers	99	0-50	98	195-208	300	550	865	1320
Infant	51	0-50	69-80	88-108	160	196	270	430
Not specified	330	0-33	74-76	128-140	173	295	455	2640
Wafers	90	147	213	244-246	305	493	615	725
Bread								
Bread crisp	130	89-92	186	219-223	332	418	499	860
Bread soft	110	0-13	9-27	27-37	35-42	61	90	364
Non specified	84	0-18	0-49	54-76	27-50	113	310	1460
Breakfast cereals	153	21-60	85-87	132-142	160	272	403	1435
Cereal-based baby food	99	0-10	0-25	55-70	43-75	196	230	710
Coffee								
Instant	46	440	584	591-595	761	933	1009	1470
Not specified	14	93	237	551	709	1087	2929	2929
Roasted	172	125	193	225-231	276	386	500	2223
French fries	469	103	247	326-328	404	630	810	3380
Jarred baby food	118	0-11	0-25	32-47	36-50	65-75	106	677
Other products								
Gingerbread	302	56-59	131-132	376-384	424	1055	1682	4095
Muesli and porridge	92	0-40	0-50	53-82	66-100	150	250	484
Not specified	249	0-50	83-100	182-204	266-291	500	604	1650
Substitute coffee	34	279	1148	1502-1504	2555	3400	3976	4300
Potato crisps	388	172	394	689-693	899	1712	2329	4804
Home-cooked potato products								
Deep fried	49	46-50	201	234-241	308	624	729	1238
Not specified	136	32-49	104	257-265	386	670	914	2762
Oven baked	72	80	189	317	386	782	1152	1665

[#] Range indicates lower bound and upper bound values.

The mean values ranged between 27 and 37 µg/kg for 'bread soft' and between 1502 and 1504 µg/kg for 'substitute coffee' for foods sampled in 2009. The highest P95 was reported for 'substitute coffee' at 3976 µg/kg and the highest maximum value was reported for 'potato crisps' at 4804µg/kg.

Generally, with the exception of 'cereal based baby food' and 'jarred baby food' the difference between the descriptive statistics based on lower-bound and upper-bound scenarios was small, because of the low number of samples with acrylamide values below the LOD or between the LOD and LOQ.

3.4. Trend analysis in acrylamide levels of foods sampled from 2007 to 2009

Acrylamide results from 2009 are compared with results from 2007 and 2008 at food group and subgroup level in order to evaluate their change over time across Europe. A mixed effect model was used to test whether there is an overall European change over time in any food groups and subgroups.

The mixed effect model contained an overall intercept and an overall time trend (being the same for all countries, also called marginal effects). A random intercept and slope (time effect) was also included in the model in order to allow each country to have their own trend profile. It is important to note that this assumption is crucial when interpreting the results at European level. In the model-building

process a European trend could be ruled out in model I when the two random effects correlated and in model II when the hypothesis that the random slope variance was zero was rejected.

Analyses of variance for the respective food and food subgroups resulting in a p-value lower than 0.05 suggest that there is a statistically significant difference.

3.4.1. Food Group 1 (French fries sold as ready to eat)

The final model needs a random slope and it shows a correlation (negative covariance) with the random intercept. This result indicates that different trends are observed across the Member States. Eleven countries show a tendency towards higher acrylamide values whereas five countries show a tendency towards lower values. Thus, for this food group, reporting an overall European trend would be misleading.

3.4.2. Food Group 2 (Potato crisps)

The final model obtained after testing variance parameters in the most complex model (correlation is zero) does not contain a random slope, but only random intercept. Thus, an overall European trend could be tested. The acrylamide levels in 'potato crisps' show no statistically significant change over time (p-value=0.6711) in Europe.

3.4.3. Food Group 3 (Pre-cooked French fries, potato products for home cooking)

Food Group 3 (Pre-cooked French fries, potato products for home cooking) was analysed separately for each subgroup (*oven baked*, *deep fried* and *not specified*).

The final model for the 'oven baked pre-cooked French fries, potato products for home cooking' subgroup, obtained after having tested variance parameters in the most complex model (correlation is zero), does not contain a random slope but only random intercept. Thus, an overall European trend could be tested. The acrylamide levels in this subgroup show no statistically significant change over time (p-value=0.4795) in Europe.

The final model for the 'deep fried pre-cooked French fries, potato products for home cooking' subgroup contains a random slope and shows a correlation (negative covariance) with the random intercept. Two countries show a tendency towards higher acrylamide values and two countries show a tendency towards lower values. Thus, for this subgroup, reporting an overall European trend would be misleading.

The final model for the 'not specified pre-cooked French fries, potato products for home cooking' shows no correlation between the two random effects of intercept and slope, but contains a random slope. Three countries show a tendency towards higher acrylamide values whereas five countries show a tendency towards lower values. For this sub food group reporting an overall European trend would be misleading.

3.4.4. Food Group 4 (Bread)

Food Group 4 (Bread) was analysed separately for each subgroup (*crisp bread*, *soft bread* and *not specified*).

The final model for the subgroup '*crisp bread*' obtained after having tested variance parameters in the most complex model (correlation is zero) does not contain a random slope, but contains only random intercept. Thus, an overall European trend can be estimated. The acrylamide levels in this subgroup show a statistically significant increase (16.7% from 2007 to 2008 and 36.3 % from 2007 to 2009) over time (p-value=0.0279) in Europe.

The final model for the '*soft bread'* subgroup shows a correlation between the random effects (negative covariance) of slope and intercept. In this case different changes over time across the Member States are observed and an overall European trend cannot be determined. Five countries show a tendency towards higher acrylamide values whereas five countries show a tendency towards lower values.

The final model for the '*non specified bread'* subgroup contains only random intercept after having tested the variance parameters in the most complex model (correlation is zero). The overall European linear trend fitted for this subgroup shows no statistically significant change over time (p-value=0.269).

3.4.5. Food Group 5 (Breakfast cereals; excluding muesli and porridge)

The final model for the '*breakfast cereals*` group contains only random intercept after having tested the variance parameters in the most complex model (correlation is zero). The overall European linear trend fitted for this subgroup shows no statistically significant change over time (p-value=0.5353).

3.4.6. Food Group 6 (Biscuits)

Food Group 6 (Biscuits) was analysed separately for each subgroup (*crackers*, *wafers*, *infant biscuits* and *not specified*).

The final model for the '*crackers'* subgroup contains only random intercept after having tested the variance parameters in the most complex model (correlation is zero). The overall linear European trend was statistically significantly decreasing (20% from 2007 to 2008 and 35 % from 2007 to 2009) over time (p-value=0.0247).

The final model for the '*wafers'* subgroup does not contain enough information to fit any of the models to determine a European trend as the vast majority of the information is provided by one Member State.

The final model for the '*infant biscuits'* subgroup contains only random intercept after having tested the variance parameters in the most complex model (correlation is zero). The overall linear European trend indicates that the levels for acrylamide might be decreasing (29% from 2007 to 2008 and 49 % from 2007 to 2009) over time (p-value=0.0013).

The final model for the 'not specified' subgroup shows borderline p-values (p-value=0.0471) when testing the hypothesis of needing the most complex model structure containing both random effects (intercept and slope) and allowing them to be correlated (negative covariance). This indicates the need of having longer period information to correctly proceed in such a situation. No European trend is observed, since the change over time seems to vary between countries. Four countries show a tendency towards higher acrylamide values whereas eight countries show a tendency towards lower values.

3.4.7. Food Group 7 (Coffee dry)

Food Group 7 (coffee) was analysed separately for each subgroup (*roasted coffee (dry)*, *instant coffee (dry)* and *not specified*).

The final model for the 'roasted coffee' subgroup after having tested the variance parameters in the most complex model (correlation is zero) needs a random slope. This result indicates that different trends are observed across the Member States. Thus, for this sub group, reporting an overall European trend would be misleading. Seven countries show a tendency towards higher acrylamide values whereas four countries show a tendency towards lower values.

The final model for the 'instant coffee' sub group after having tested the variance parameters in the most complex model (correlation is zero) contains only random intercept. The overall linear European trend indicates that the acrylamide levels might be increasing (90% from 2007 to 2008 and 370 % from 2007 to 2009) over time (p-value<0.0001)

In the case of the 'not specified' subgroup no analysis results are reported, because information on more than one year was only available from one Member State.

3.4.8. Food Group 8 (Jarred baby foods)

The final model obtained for this food group after having tested the variance parameters in the most complex model (correlation is zero) contains only random intercept. The overall European trend over time shows no statistically significant change for the three-year period (p-value=0.9569).

3.4.9. Food Group 9 (Processed cereal-based baby foods)

The final model obtained for this food group after having tested the variance parameters in the most complex model (correlation is zero) contains only random intercept. The overall European trend over time shows no statistically significant change for the three-year period (p-value=0.5491).

3.4.10. Food Group 10 (Others)

Food Group 10 (others) was analysed separately for each subgroup (substitute coffee (dry), gingerbread, muesli and porridge and other products).

The final model for the first and the last subgroups (substitute coffee (dry) and other products) contains both random effects (intercept and slope) which were uncorrelated and needs a random slope. Thus, for these two subgroups no overall European trend can be concluded, since different changes over time are observed across the Member States. For 'substitute coffee' three countries show a tendency towards higher acrylamide values whereas one country show a tendency towards lower values.

The final model for the 'gingerbread' subgroup contains only random intercept after having tested the variance parameters in the most complex model (correlation is zero). In terms of the time change, a decreasing linear trend (15% from 2007 to 2008 and 27 % from 2007 to 2009) is observed (p-value=0.0031).

The final model for the 'muesli and porridge' subgroup does not contain enough information to fit any of the models to determine a European trend as the vast majority of the information is provided by one Member State. A simple linear model fitted for that country indicates a decrease in acrylamide levels over the three years (p-value= <0.0001).

The acrylamide upper bound median content of each food group and sub-group sampled from 2007 to 2009 are shown for illustrative purposes in Table 9 together with an overview of the models used for the European trend analysis.

Table 9: Sample size (N), median upper bound values across the years 2007-2009 and European trend analysis across food sub-group.

Food Group	2007		2008		2009		RI[(1)]	RI+RS[(2)]	Time Effect[(3)]
	N	Median µg/kg	N	Median µg/kg	N	Median µg/kg			
Biscuits									
Crackers	69	195	134	185	99	98	✓		Decrease
Infant	97	100	88	64	51	80	✓		Decrease
Not specified	291	173	276	126	330	76		✓	Not applicable
Wafers	38	118	49	109	90	213	Not enough information		
Bread									
Bread crisp	155	116	92	107	130	186	✓		Increase
Bread soft	127	30	211	30	110	27		✓	Not applicable
Non specified	54	58	17	19	84	49	✓		NSSC*
Breakfast cereals	134	100	136	75	153	87	✓		NSSC*
Cereal-based baby food	92	38	110	25	99	25	✓		NSSC*
Coffee									
Instant	51	188	63	482	46	584	✓		Increase
Not specified	41	183	11	210	14	237	Not enough information		
Roasted	153	197	267	164	172	193		✓	Not applicable
French fries	647	246	536	220	469	247		✓	Not applicable
Jarred baby foods	87	30	142	25	118	25	✓		NSSC*
Other products									
Gingerbread	357	226	258	227	302	132	✓		Decrease
Muesli and porridge	48	156	19	30	92	50	Not enough information		
Not specified	424	134	529	60	249	100		✓	Not applicable
Substitute coffee	61	334	84	702	34	1148		✓	Not applicable
Potato crisps	280	413	458	436	388	394	✓		NSSC*
Home-cook potato product									
Deep fried	54	182	39	152	49	201		✓	Not applicable
Not specified	82	150	101	75	136	104		✓	Not applicable
Oven baked	8	260	108	172	72	189	✓		NSSC*

(1) Final model contains only Member State's specific intercept (random intercept)
(2) Final model contains Member State's specific intercept (random intercept) and slope (random slope)
(3) Overall European trend obtained in the final model
*NSSC: No statistically significant change

The mixed effects model results in Table 9 show that for three out of the 22 food groups ('wafers', 'not specified coffee' and 'muesli and porridge') not enough information was provided to assess

change over time. For eight out of 22 food groups, the final model contains both random effects (intercept and slope), making a trend analysis at European level not applicable at this stage. Five food groups contain only random intercept, showing a decreasing trend for three food groups ('crackers', 'infant biscuits' and 'gingerbread') whereas showing an increasing trend for the other two groups ('crisp bread' and 'instant coffee'). The remaining six food groups ('potato crisp', 'precooked French fries and home cooked potato products oven baked', 'not specified bread', 'breakfast cereals', 'jarred baby foods,' 'processed cereal-based baby foods') are showing no statistically significant change over time.

3.5. Seasonal effect analysis on acrylamide formation in potato products

In total 3151 results on acrylamide content of 'French fries', 'potato crisps' and 'potato products for home cooking' provided information on the sampling seasons. Data were split into two groups. The first group contains data for food sampled between January and June. The second group contains data for food sampled between July and December. Taking into account the results previously obtained, as there are different trends over time across the years among Member States for 'French fries', 'deep fried potato products for home cooking' and 'not specified potato products for home cooking', the seasonal effect was evaluated only for 'potato crisps' and 'oven baked potato products for home cooking'. A mixed effect model containing random intercept and another random effect associated with the season was also used in order to rule out different seasonal effects among Member States.

In Table 10 results of median upper bound acrylamide contents in potato products per sampling period are shown for illustrative purposes together with an overview of the models used to analyse the seasonal effect.

Table 10: Sample size (N), median upper bound acrylamide content values in potato products in two different seasons from 2007 to 2009 and season effect analysis

Food group	January-June		July-December		RI[(1)]	RI+RS[(2)]	Season Effect[(3)]
	N	Median µg/kg	N	Median µg/kg			
French fries	613	263	847	233		✓	Not applicable
Potato crisps	521	464	531	360	✓		Decrease
Home-cooked potato products							
Deep fried	70	230	70	113		✓	Not applicable
Oven baked	86	201	102	173	✓		NSSC*
Not specified	103	90	208	108		✓	Not applicable

(1) Final model contains only Member State's specific intercept (random intercept)
(2) Final model contains Member State's specific intercept (random intercept) and slope (random slope)
(3) Overall seasonal effect obtained in the final model
*NSSC: No statistically significant change

Table 10 shows that the models for 'potato crisps' and 'oven baked potato products for home cooking' have only random intercept indicating that there are no differences among Member States in terms of seasonal effects. For 'potato crisps' the levels of acrylamide in the first half of the year are higher than in the second half of the year (p-value<0.0001), while for the 'oven baked potato products for home cooking' no statistically significant difference in acrylamide levels (p-value=0.3543) is detected between the first and second half of the year.

3.6. Acrylamide dietary exposure

In Table 11 the mean lower bound and upper bound values of the pooled acrylamide occurrence results (2007-2009) from all Member States are shown per food category reclassified according to the EFSA Comprehensive Food Consumption Database to match available food consumption information (EFSA, 2011). Table 12 gives an overview of the different dietary surveys per Member State used to calculate the acrylamide exposure estimates.

Table 11: Sample size (N), Lower (LB) and upper bound mean (UB) acrylamide content according to the food categories in the EFSA Comprehensive Food Consumption Database

EFSA FOODEX Food category	N	LB mean µg/kg	UB mean µg/kg
Biscuits	1991	304	311
Fried potatoes	1794	318	322
Potato crisps	1126	635	638
Potato oven baked	188	296	296
Crisp bread	679	221	226
Soft bread	448	37	50
Unspecified bread	980	117	127
Breakfast cereals	423	134	149
Infant biscuits	236	137	148
Substitute coffee dry	179	1012	1013
Roasted coffee dry	592	219	224
Instant coffee dry	160	480	482
Jarred baby foods	347	23	41
Cereal based baby foods	301	46	63
Muesli and porridge	159	95	116

In Annex 1, the mean and 95th percentile food consumption (g/day) by food category (summary statistics) are shown for illustrative purpose by Member State, survey and age class for the total population.

Exposure to acrylamide was estimated for different target populations by combining pooled acrylamide occurrence values from all Member States obtained through the monitoring program from 2007 to 2009 with individual dietary national consumption data from Member States derived from the EFSA Comprehensive European Food Consumption Database. For each country, exposure estimates are presented per dietary survey and age class: infants (1-11 months), toddlers (12-35 months), other children (3-10 years), adolescents (11-17 years), adults (18-64 years), elderly (65-74 years) and very elderly (from 75 years).

Table 12: Dietary surveys used for acrylamide exposure estimates included in the EFSA Comprehensive European Food Consumption Database

Country (survey)	Name of survey in tables	Name of the dietary survey (Acronym)	Survey period	Age range (years)	Method (replicates)
Belgium	BE1	Regional Flanders	2002-03	2.5 to 6.5	Food record (3)
	BE2	Diet National 2004	2004 – 05	> 15	24 h dietary recall
Bulgaria	BG2	NUTRICHILD	2007	< 5	24-hour recall (2)
Cyprus	CY	Childhealth	2003	2 to 18	Dietary record (3)
Czech Republic	CZ	SISP04	2003 - 04	> 4	24-hour recall (2)
Denmark	DK	Danish Dietary Survey	2000 - 02	4 to 75	Food record (7)
Finland	FI1	FINDIET 2007	2007	25 to 74	48-hour recall (1)
	FI2	DIPP	2003-06	1, 3 and 6	Food record (3)
	FI3	STRIP	2000	7 to 8	Food record (4)
France	FR	INCA2	2005 – 07	3 to79	Food record (7)
Germany	DE1	DONALD	2006-08	1 to 10	Dietary record (3)
	DE2	National Nutrition Survey	2005 – 07	14 to 80	24-hour recall (2)
United Kingdom	GB	NDNS	2000 - 01	19 to 64	Food record (7)
Greece	GR	Regional Crete	2004-05	4 to 6	Dietary record (3)
Hungary	HU	National Repr Surv	2003	> 18	Food record (3)
Ireland	IE	NSFC	1997 – 99	18 to 64	Food record (7)
Italy	IT	INRAN-SCAI 2005–06	2005 – 06	> 0.1	Food record (3)
Latvia	LV	EFSA_TEST	2008	7 to 66	24-hour recall (2)
Netherlands	NL1	RIKILT	2005-06	2 to 6	Food record (3)
	NL2	VCP2003	2003	19 to 30	24 h dietary recall
Spain	ES1	enKid	1998-00	1 to 14	24-hour recall (2)
	ES2	Regional Basque Country	2004-05	4 to 14	24-hour recall (2)
	ES3	AESAN	1999 -	17 to 60	Food record (3)
	ES4	AESAN-FIAB	2009	18 to 60	24-hour recall (2)
Sweden	SE1	NFA	2003	3 to 4	24-hour recall (4)
	SE2	RIKSMATEN 1997-98	1997 - 98	18 to 74	Food record (7)

In Tables 13-16 the resulting lower bound and upper bound mean and 95th percentile exposure estimates (µg/kg b.w. per day) to acrylamide are shown by Member State, survey and age class. These estimates assume that the tested products are representative for the whole food categories and that no other food category contains acrylamide.

Table 13: Estimated mean and high percentile (95th) exposure (lower and upper bound) to acrylamide (µg/kg b.w. per day) per Member State and survey for the adult (18-64 years), elderly (65-74 years) and very elderly (from 75 years and older) age classes.

Age class	MS	N	Mean exposure µg/kg b.w. per day	95th percentile exposure µg/kg b.w. per day
Adults	BE2	1304	0.36-0.39	0.95-0.99
Elderly	BE2	518	0.28-0.31	0.76-0.82
Very elderly	BE2	712	0.32-0.35	0.84-0.87
Adults	CZ	1666	0.73-0.77	1.59-1.65
Adults	DE2	10419	0.31-0.34	0.79-0.83
Elderly	DE2	2006	0.29-0.32	0.72-0.76
Very elderly	DE2	490	0.31-0.34	0.81-0.84
Adults	DK	2822	0.76-0.80	1.50-1.56
Elderly	DK	309	0.91-0.95	1.74-1.84
Very elderly	DK	20	1.02-1.07	2.19-2.26
Adults	ES3	410	0.42-0.45	1.09-1.13
Adults	ES4	981	0.55-0.57	1.18-1.23
Adults	FI1	1575	0.49-0.52	1.04-1.09
Elderly	FI1	463	0.49-0.52	1.06-1.14
Adults	FR	2276	0.39-0.42	0.87-0.92
Elderly	FR	264	0.28-0.31	0.57-0.62
Very elderly	FR	84	0.26-0.29	0.55-0.58
Adults	GB	1724	0.61-0.65	1.19-1.24
Adults	HU	1074	0.75-0.79	1.52-1.58
Elderly	HU	206	0.69-0.73	1.26-1.31
Very elderly	HU	80	0.79-0.83	1.53-1.58
Adults	IE	958	0.54-0.58	1.22-1.26
Adults	IT	2313	0.54-0.57	1.16-1.20
Elderly	IT	290	0.50-0.53	1.12-1.17
Very elderly	IT	228	0.50-0.54	1.10-1.15
Adults	LV	1306	0.42-0.45	1.09-1.15
Adults	NL1	750	0.50-0.53	1.25-1.30
Adults	SE2	1210	0.47-0.51	0.93-0.98

Table 13 shows that the mean exposure (upper bound) for the adult elderly and very elderly population in the different countries varies from 0.31 to 1.07 µg/kg b.w. per day. High exposure at the 95th percentile (upper bound) varies from 0.58 to 2.26 µg/kg b.w. per day.

Table 14: Estimated mean and high percentile (95th) exposure (lower and upper bound) to acrylamide (µg/kg b.w. per day) per Member State and survey for the adolescents' (11-17 years) age class.

Age class	MS	N	Mean exposure µg/kg b.w. per day	95th percentile exposure µg/kg b.w. per day
Adolescents	BE2	584	0.47-0.50	1.24-1.30
Adolescents	CY	303	0.71-0.74	1.51-1.56
Adolescents	CZ	298	1.29-1.36	2.92-3.06
Adolescents	DE2	1011	0.32-0.35	0.88-0.93
Adolescents	DK	479	0.94-1.00	1.97-2.05
Adolescents	ES4	86	0.69-0.72	1.76-1.79
Adolescents	ES1	209	0.77-0.82	1.98-2.10
Adolescents	ES2	651	0.55-0.59	1.31-1.33
Adolescents	FR	973	0.39-0.43	0.89-0.94
Adolescents	IT	247	0.81-0.86	1.80-1.87
Adolescents	LV	470	0.74-0.78	1.91-1.99
Adolescents	SE1	1018	0.66-0.71	1.61-1.71

Table 14 shows that mean exposure (upper bound) for the adolescents (11-17 years) in the different countries varies from 0.43 to 1.36 µg/kg b.w. per day. High exposure at the 95th percentile (upper bound) varies from 0.94 to 3.06 µg/kg b.w. per day.

Table 15: Estimated mean and high percentile (95th) exposure (lower and upper bound) to acrylamide (µg/kg b.w. per day) per Member State and survey for the other children (3-10 years) age class.

Age class	MS	N	Mean exposure µg/kg b.w. per day	95th percentile exposure µg/kg b.w. per day
Other children	BE1	625	1.95-2.05	3.60-3.71
Other children	BG2	433	1.64-1.74	4.05-4.22
Other children	CZ	389	1.75-1.84	3.68-3.84
Other children	DE1	211	1.09-1.17	2.04-2.16
Other children	DE1	226	1.13-1.21	2.23-2.32
Other children	DE1	223	1.14-1.21	2.18-2.31
Other children	DK	490	1.36-1.47	2.59-2.71
Other children	ES1	156	1.31-1.37	3.35-3.43
Other children	ES1	399	0.86-0.93	1.88-1.98
Other children	FI2	933	1.39-1.45	2.72-2.83
Other children	FI3	250	0.82-0.90	1.84-1.96
Other children	FR	482	0.68-0.73	1.39-1.50
Other children	GR	839	1.34-1.38	3.07-3.15
Other children	IT	193	1.21-1.29	2.91-3.00
Other children	LV	189	0.96-1.02	2.29-2.39
Other children	NL2	957	0.99-1.06	1.98-2.06
Other children	SE1	1473	1.02-1.13	2.78-3.13

Table 15 shows that the mean exposure (upper bound) for the other children (3-10 years) in the different countries varies from 0.7 to 2.05 µg/kg b.w. per day. High exposure at the 95th percentile (upper bound) varies from 1.5 to 4.22 µg/kg b.w. per day.

Table 16: Estimated mean and high percentile (95th) exposure (lower and upper bound) to acrylamide (µg/kg b.w. per day) per Member State and survey for the toddler (12-35 months) and infant (1-12 months) age classes.

Age class	MS	N	Mean exposure µg/kg b.w. per day	95th percentile exposure µg/kg b.w. per day
Toddlers	BE1	36	2.25-2.37	4.35-4.48
Infants	BG2	860	1.10-1.29	3.69-3.97
Toddlers	BG2	428	2.01-2.13	4.46-4.58
Toddlers	DE1	92	1.52-1.79	3.04-3.21
Toddlers	DE1	85	1.50-1.71	3.73-3.94
Toddlers	DE1	84	1.57-1.82	3.20-3.47
Toddlers	ES1	17	1.59-1.69	6.11-6.48
Toddlers	FI2	497	1.26-1.37	3.06-3.25
Infants	IT	16	0.54-0.73	1.22-2.20
Toddlers	IT	36	1.24-1.35	3.15-3.21
Toddlers	NL2	322	1.07-1.16	2.35-2.44

Table 16 shows that for infants (1-12 months) the mean exposure (upper bound) in the two countries varies from 0.73 to 1.29 µg/kg b.w. per day. High exposure at the 95th percentile (upper bound) varies from 2.2 to 3.97 µg/kg b.w. per day.

For toddlers (12-35 months) the mean exposure (upper bound) in the different countries varies from 1.16 to 2.37 µg/kg b.w. per day. High exposure at the 95th percentile (upper bound) varies from 2.44 to 6.58 µg/kg b.w. per day.

In Tables 17 to 20 the food group specific contributions in percentage of the overall total mean exposure by Member State, survey and target population are shown.

Table 17 shows that in the adult (18-64 years), elderly (65-74 years) and very elderly (from 75 years and older) population the three major contributors to acrylamide exposure are generally 'fried potatoes', 'soft bread' and 'roasted coffee'.

Table 17: Food group specific contribution in percentage of the total mean acrylamide exposure by Member State and survey for the adult (18-64 years), elderly (65-74 years) and very elderly (75 years and older) population

Age class	MS	N	Biscuit	Fried potato	Potato crisps	Oven potato	Crisp bread	Soft bread	Unspec. bread	Breakfast cereals	Substitute coffee	Roasted coffee	Instant coffee	Muesli
Adults	BE2	1304	11.2	31.1	9.4	0.2	1.4	20.7	5.4	2.6	0.8	13.6	1.7	1.6
Elderly	BE2	518	11.0	26.6	2.4	0.2	1.7	26.2	2.7	0.6	3.4	21.2	1.1	3.0
Very elderly	BE2	712	11.8	26.0	1.3	0.1	1.4	23.4	2.3	0.5	7.8	17.8	1.7	5.8
Adults	CZ	1666	8.0	54.3	5.1	0.0	3.7	13.1	10.6	0.5	0.5	3.0	0.9	0.3
Adults	DE2	10419	6.1	26.7	5.3	2.0	4.0	21.6	10.4	1.2	0.5	19.8	0.2	2.1
Elderly	DE2	2006	5.7	27.5	0.8	0.8	5.3	25.0	9.3	1.0	1.1	21.4	0.3	1.8
Very elderly	DE2	490	5.2	34.8	0.8	0.7	4.7	22.3	9.4	1.4	1.6	17.4	0.2	1.3
Adults	DK	2822	0.3	59.2	2.9	0.0	0.8	13.5	8.8	1.0	0.0	13.3	0.0	0.4
Elderly	DK	309	0.2	67.7	0.2	0.0	0.8	11.2	5.6	0.5	0.0	13.3	0.0	0.4
Very elderly	DK	20	0.4	71.5	0.4	0.0	0.8	9.5	7.1	0.3	0.0	9.8	0.0	0.2
Adults	ES3	410	12.1	58.6	4.6	0.0	0.3	14.5	4.4	2.8	0.1	1.3	1.1	0.2
Adults	ES4	981	9.5	64.6	5.8	0.0	0.0	11.3	4.0	1.5	0.1	0.5	2.6	0.2
Adults	FI1	1575	0.0	19.3	2.4	0.0	1.2	0.0	59.3	3.9	0.0	13.7	0.0	0.1
Elderly	FI1	463	0.0	21.6	0.5	0.0	1.0	0.0	59.4	6.5	0.0	11.1	0.0	0.0
Adults	FR	2276	7.6	12.9	1.6	3.8	5.3	17.5	8.2	1.3	0.4	39.9	0.5	1.0
Elderly	FR	264	2.9	7.8	0.4	3.4	6.1	29.0	4.7	0.7	1.9	41.4	0.8	0.8
Very elderly	FR	84	2.5	9.8	0.0	2.9	9.4	30.0	4.8	0.2	0.5	38.5	1.1	0.3
Adults	GB	1724	6.3	41.3	8.5	17.3	2.0	10.2	4.8	5.0	0.0	0.7	0.0	3.6
Adults	HU	1074	2.7	62.3	1.0	0.0	3.3	12.9	13.4	0.3	0.3	3.5	0.2	0.1
Elderly	HU	206	3.4	63.1	1.1	0.0	2.6	12.9	13.8	0.1	0.2	2.8	0.1	0.0
Very elderly	HU	80	3.9	64.9	0.0	0.0	3.1	12.3	13.9	0.2	0.0	1.7	0.1	0.0
Adults	IE	958	10.1	46.1	6.9	3.8	2.4	15.5	4.8	5.3	0.0	0.7	2.7	1.6
Adults	IT	2313	10.3	40.1	1.0	0.0	5.3	13.3	17.3	0.5	0.1	11.9	0.0	0.1
Elderly	IT	290	9.5	47.7	0.0	0.0	5.7	15.2	10.2	0.2	0.5	10.9	0.0	0.1
Very elderly	IT	228	10.9	46.6	0.0	0.0	6.8	17.2	8.2	0.2	0.6	9.3	0.0	0.0
Adults	LV	1306	9.8	41.1	5.6	1.5	0.7	20.7	5.9	4.9	1.4	6.4	1.5	0.6
Adults	NL1	750	10.4	38.6	13.4	1.8	3.7	18.3	1.8	0.3	0.1	8.9	0.5	2.2
Adults	SE2	1210	5.0	35.2	5.3	4.1	9.7	11.7	0.2	1.5	0.0	14.0	0.0	13.1

Table 18: Food group specific contribution in percentage of the total mean acrylamide exposure by Member State and survey for the adolescent (11-17 years) population.

Age class	MS	N	Biscuit	Fried potato	Potato crisps	Oven potato	Crisp bread	Soft bread	Unspec. bread	Breakfast cereals	Infant biscuit	Substitute coffee	Roasted coffee	Instant coffee	Muesli
Adolescents	BE2	584	17.1	32.3	16.4	0.3	1.3	18.2	4.6	6.7	0.2	0.1	1.3	0.1	1.4
Adolescents	CY	303	3.6	30.9	14.1	18.5	1.5	5.9	18.1	6.6	0.0	0.0	0.0	0.9	0.0
Adolescents	CZ	298	14.8	54.1	3.6	0.0	3.2	10.0	12.4	1.0	0.0	0.1	0.0	0.1	0.5
Adolescents	DE2	1011	6.9	26.4	10.7	2.7	4.1	23.7	15.8	4.1	0.0	0.0	2.3	0.0	3.3
Adolescents	DK	479	0.7	60.1	7.7	0.0	0.6	14.3	13.2	2.9	0.0	0.0	0.2	0.0	0.3
Adolescents	ES4	86	11.4	59.9	10.8	0.0	0.0	11.5	3.5	2.0	0.0	0.0	0.1	0.7	0.0
Adolescents	ES1	209	2.7	64.4	7.9	0.0	1.4	14.8	5.9	2.6	0.0	0.0	0.3	0.0	0.1
Adolescents	ES2	651	21.6	28.3	16.4	0.7	1.4	19.2	6.5	5.1	0.0	0.0	0.2	0.3	0.4
Adolescents	FR	973	20.2	24.8	3.9	4.3	5.6	17.4	12.5	7.6	0.0	0.1	2.2	0.1	1.4
Adolescents	IT	247	16.5	42.6	3.3	0.0	5.6	11.4	18.0	0.8	0.1	0.1	1.4	0.0	0.1
Adolescents	LV	470	12.8	40.7	17.8	0.8	0.7	14.9	5.2	5.4	0.0	0.0	0.9	0.3	0.4
Adolescents	SE1	1018	5.4	42.7	12.2	4.9	6.6	11.1	2.5	3.3	0.0	0.0	0.0	0.0	11.3

Table 18 shows that in the adolescent population (11-17 years) two out of the three major contributors to acrylamide exposure are ‘fried potatoes’ and ‘soft bread’ as in the adult population. The third biggest contributor was in some surveys ‘biscuit’ and in others’ potato crisps’.

Table 19: Food group specific contribution in percentage of the total mean acrylamide exposure by Member State and survey for the 'other children' (3-10 years) population.

Age class	MS	N	Biscuit	Fried potato	Potato crisps	Oven potato	Crisp bread	Soft bread	Unspec. bread	Breakfast cereals	Infant biscuit	Substitute coffee	Roasted coffee	Instant coffee	Jarred baby food	Cereal baby food	Muesli
Other children	BE1	625	12.6	59.8	3.2	0.0	0.6	9.9	6.1	3.5	3.6	0.0	0.2	0.0	0.0	0.0	0.5
Other children	BG2	433	6.3	65.4	0.6	0.3	4.2	14.9	7.7	0.4	0.1	0.0	0.0	0.0	0.1	0.0	0.1
Other children	CZ	389	16.0	54.0	3.9	0.0	2.8	9.0	11.2	2.2	0.0	0.3	0.0	0.1	0.2	0.0	0.3
Other children	DE1	211	10.6	40.0	11.5	0.0	2.3	11.9	15.3	4.3	0.1	0.0	0.0	0.0	1.1	0.5	2.4
Other children	DE1	226	9.9	41.4	11.5	0.0	1.9	10.1	17.8	3.6	0.0	0.1	0.0	0.0	0.9	0.4	2.5
Other children	DE1	223	11.1	41.4	10.2	0.3	1.8	11.1	17.3	3.2	0.0	0.1	0.0	0.0	1.0	0.0	2.5
Other children	DK	490	1.0	55.1	5.5	0.0	0.9	18.6	14.3	4.1	0.0	0.0	0.0	0.0	0.0	0.0	0.3
Other children	ES1	156	3.4	64.8	10.3	0.0	0.8	10.1	5.0	5.0	0.0	0.0	0.0	0.0	0.0	0.5	0.0
Other children	ES2	399	26.3	26.3	16.5	0.2	1.1	17.0	6.0	6.3	0.0	0.0	0.0	0.0	0.0	0.0	0.3
Other children	FI2	933	5.5	40.9	3.3	0.0	3.8	0.0	43.0	3.2	0.0	0.0	0.1	0.0	0.1	0.1	0.0
Other children	FI3	250	10.0	38.0	6.2	3.5	2.2	12.2	0.5	3.8	0.0	0.0	0.0	0.0	0.3	0.0	23.1
Other children	FR	482	30.6	23.1	3.9	3.0	5.7	12.9	10.3	8.9	0.0	0.1	0.2	0.0	0.6	0.0	0.7
Other children	GR	839	12.6	50.2	10.9	0.0	3.8	0.0	19.4	2.7	0.0	0.0	0.0	0.0	0.3	0.0	0.0
Other children	IT	193	16.9	45.8	2.9	0.0	5.3	11.5	13.0	1.3	1.4	0.1	1.1	0.0	0.4	0.0	0.2
Other children	LV	189	18.7	33.0	10.7	0.4	1.8	11.6	7.2	13.2	0.0	2.3	0.4	0.1	0.0	0.0	0.7
Other children	NL2	957	18.6	17.6	15.7	0.6	5.8	10.2	25.1	2.2	2.1	0.0	0.0	0.0	0.4	0.3	1.3
Other	SE1	1473	7.2	28.9	8.2	3.5	7.4	8.8	1.7	3.1	0.0	0.0	0.0	0.0	0.0	1.4	29.8

children

Table 20: Food group specific contribution in percentage of the total mean acrylamide exposure by Member State and survey for the toddlers (12-35 months) and infants (1-11 months) population.

Age class	MS	N	Biscuit	Fried potato	Potato crisps	Oven potato	Crisp bread	Soft bread	Unspec. bread	Breakfast cereals	Infant biscuit	Substitute coffee	Roasted coffee	Instant coffee	Jarred baby food	Cereal baby food	Muesli
Toddlers	BE1	36	10.8	62.6	2.6	0.0	0.6	10.7	6.2	2.0	4.1	0.0	0.2	0.0	0.0	0.0	0.4
Infants	BG2	860	15.3	41.0	0.1	0.0	3.3	4.6	6.5	0.0	0.3	0.0	0.0	0.0	26.8	2.0	0.0
Toddlers	BG2	428	11.7	58.5	1.4	0.7	6.3	11.2	7.6	0.1	0.4	0.0	0.0	0.0	1.7	0.4	0.1
Toddlers	DE1	92	11.3	40.5	2.5	0.0	1.9	8.0	8.0	0.7	0.2	0.0	0.0	0.0	22.9	2.3	1.9
Toddlers	DE1	85	7.2	47.3	3.1	0.0	2.7	9.4	9.1	0.6	0.1	0.0	0.0	0.0	15.9	3.2	1.5
Toddlers	DE1	84	8.1	44.4	1.9	0.0	3.9	9.0	8.2	0.3	0.9	0.0	0.0	0.0	18.9	3.5	1.0
Toddlers	ES1	17	1.9	56.0	13.1	0.0	1.5	5.3	7.8	4.0	0.0	0.0	0.0	0.0	0.0	10.4	0.0
Toddlers	FI2	497	2.7	21.4	0.2	0.0	1.5	0.1	63.1	4.3	0.0	0.0	0.0	0.0	2.7	4.1	0.0
Infants	IT	16	0.0	26.5	0.0	0.0	0.0	0.5	6.3	0.0	10.1	0.0	0.0	0.0	53.4	3.2	0.0
Toddlers	IT	36	19.2	36.6	2.5	0.0	4.3	7.7	11.7	0.4	9.7	0.0	0.0	0.0	7.9	0.0	0.0
Toddlers	NL2	322	18.5	16.2	11.4	0.5	6.7	10.6	27.3	2.8	2.4	0.0	0.0	0.0	0.9	1.1	1.5

Table 19 shows that in the other children population (3-10 years) the three major contributors to acrylamide exposure are ‘fried potatoes’, ‘soft bread’ and ‘biscuits’.

Table 20 shows that in the infant population (12-35 months) the three major contributors to acrylamide exposure are ‘fried potatoes’ ‘jarred baby food’, and ‘biscuits’ or ‘infant biscuits.

In the toddlers population (12-35 months) the three major contributors to acrylamide exposure are ‘fried potatoes’, ‘soft bread’ or ‘unspecified bread’ and ‘biscuits’.

4. DISCUSSION

In March 2006, a joint workshop was organised by the European Commission and the CIAA for governments, industries and academia to discuss up to date knowledge of acrylamide formation, results of recent studies and projects and opportunities, gaps and constraints in attempting to reduce the formation of acrylamide. One of the aims of the workshop was to update the toolbox approach to improve industrial processes in relation to acrylamide formation (CIAA, 2005). The toolbox updated document was published in October 2006 (CIAA, 2006). Following the workshop, a number of actions were agreed in the Expert Committee on Environmental and Industrial Contaminants of the European Commission to ensure that voluntary measures, such as the toolbox approach, were effectively applied by food operators and the results monitored. These actions included the development of the European monitoring program as issued on 3 May 2007 and the development and distribution of sector-specific brochures in collaboration with CIAA giving guidance to small- and medium-sized food operators on how to minimise acrylamide formation. The brochures or pamphlets were designed for several categories: biscuits, crackers, crisp breads, bread products, breakfast cereals and fried potato products, such as potato crisps and French fries.

4.1. Uncertainty in trend analysis

The Commission initiated the acrylamide data collection to ascertain whether or not the voluntary measures taken by the food industry have shown desirable effects resulting in a reduction of acrylamide formation in food. A three-year sampling frame (from 2007 to 2009) was initially requested with sampling by EU Member States in each year covering products with similar specification wherever possible.

In assessing the results, it is clear that a three-year sampling frame was too short to distinguish random fluctuations from real trends. The variance in acrylamide levels between countries, within countries and between individual foods constituting the nominated food groups was large for some food groups. Consequently, it was not possible to identify a statistically significant uniform European trend in eight out of 22 food groups with non uniform trends across Member States. Even for those countries in which a large amount of information was collected, the variability observed remains large pointing to issues with the short sampling frame used to evaluate acrylamide trend levels.

Factors that exacerbated the difficulties in interpreting the results included the low sample numbers in some food groups further split into sub groups, differences in analytical methods used, inconsistent sampling and possibly differences in recipe composition and processing techniques not covered by the sampling frame. It was further not clear how much effort competent authorities had so far allocated to enforcement activities in the different Member States or the knowledge of and level of adoption of the toolbox across different size industry players.

In general, more years will be needed to be able to gather evidence to distinguish random fluctuations from real trends. To facilitate interpretation of results in future years it will be important to consistently sample the same products in different years and to collect sufficient number of samples per food group.

4.2. Potato products

The area of potato products has drawn much attention because of their important contribution to the acrylamide exposure in adults as well as children, based both on a high consumption of the products and on a relatively high content of acrylamide. Different tools have been identified to lower the acrylamide formation in heated potato food, including selection of potato variety, potato storage regime, process control through thermal input and pre processing, final preparation and colour control. The acrylamide monitoring program covers three main potato food groups: ‘potato crisps’, ‘French fries’ and ‘pre-cooked French fries and home cooked potato products’.

Potato crisps were identified as a food product with potential for high levels of acrylamide formation (Tareke et al. 2002). Given their popularity as a snack food, particularly among younger age groups, it is considered important to reduce its acrylamide content. A strong correlation (0.97) was found between acrylamide formation and the concentration of reducing sugars (Matthäus et al., 2004; Williams, 2005). Controlling the sugar content is currently the primary measure employed by the industry to reduce acrylamide levels in crisps. One potential way to achieve this goal is by selecting potato varieties with low levels of reducing sugars (CIAA, 2009).

For samples of potato crisps in 2009, as reported by Member States to EFSA, the median acrylamide level was 394 µg/kg. In comparison to the data from 2007 (median level of 413 µg/kg) and 2008 (median level of 436 µg/kg), 'potato crisp' show no statistically significant change over the last three years. The values reported between 2007 and 2009 are all within the range of values reported in literature for acrylamide in potato crisps where mitigation measures were applied. Monitoring data from the "Lebensmittelchemisches Institut der Deutschen Süsswarenindustrie" in Germany showed a decrease in acrylamide content of potato crisps from about 1000 µg/kg in 2002 to 300-500 µg/kg in 2008 (Matissek, 2008). From a Spanish analysis dated March 2008, Arribas-Lorenzo and Morales (2009) reported an average level of 740 µg/kg for samples of potato crisps. When comparing German samples from May-June 2002 with the same period in 2003, Foot et al. (2007) reported a significant decline in acrylamide levels of potato crisps from around 1000 µg/kg to around 600 µg/kg. However, they suggested that a level of 500 µg/kg measured leading up to July 2006 seemed to be the minimum level possible with the then available mitigation tools and that new practical tools and long-term developments for lowering sugar/asparagine levels were needed. A promising mitigation method involves the use of asparaginase, an enzyme that converts asparagine to aspartic acid. Trials at pilot plant scale confirmed the laboratory findings that asparaginase significantly reduces the acrylamide level in dough-based potato products like formed potato crisps (CIAA, 2006). The same effect was not found for sliced or chipped potato products. For the enzyme to be effective it must be able to reach the asparagine, which is difficult if the cell remains intact. As the sample results provided for the monitoring exercise 2007-2009 did not provide further information on the starting material no further investigation could be undertaken with regard to an eventual decrease in any subcategory of potato crisps. However, the new European Commission Recommendation 2010/307/EC[7] requires that Member States in future monitoring provide further information on whether potato crisps have been produced from fresh potatoes or pre-fabricates (potato dough).

As indicated by the Union of the European Potato Processing Industry (UEITP), Foot et al. (2007) reported a decrease between 2002 and 2006 in mean acrylamide content in French fries cooked according to the on-pack instructions. When comparing the current results for 'French fries' and 'pre-cooked French fries and potato products for home cooking deep fried' in 2009 to results sampled in 2008 and 2007 no consistent trend could be observed in Europe across those three years. A few Member States showed a slight downwards trend, while others showed a slight upwards trend. There was no statistically significant change in acrylamide levels in the food subgroup 'pre-cooked French fries and potato products for home cooking oven baked' between the three years.

It looks like 'French fries' (median level of 247 µg/kg in 2009) and 'potato products for home cooking deep fried' (median level of 201 µg/kg in 2009) are at least in some Member States still above what seems to be achievable with potatoes low in reducing sugars and the use of low final oil temperatures. The median acrylamide content in 147 French fries samples from restaurants in the area of Zurich was 76 µg/kg after following some simple instructions (Foot et al., 2007). The problem is that the acrylamide level is also influenced by the end user: a low content of reducing sugars is an important first step, but the final product can still be heated at too high temperatures or for too long. Similar advice with respect to browning, frying and baking temperatures is given to consumers by various

[7] European Commission Recommendation 2010/307/EC of 2 June 2010 on the monitoring of acrylamide levels in food. OJ L 137/4, 3.6.2010 , p. 1-7.

consumer organisations. However, domestic or restaurant preparation of French fries cannot be controlled or standardised as strictly as is the case for processing conditions applied in the food industry, e.g. in the production of potato crisps (Dybing et al., 2005).

Biedermann et al. (2010), reporting on the Swiss acrylamide monitoring program from 2007 to 2009, concluded that no significant improvements could be seen even for products for which substantial potential for improvement was known. Furthermore they concluded that further progress will presuppose activity and leadership by authorities to avoid the risk of loosing previous achievements and to protect responsible manufacturers against others.

In order to get a better overview of the reasons for varying acrylamide levels in comparable products Member States are required to examine production and processing methods used by food business operators (EC, 2011). Investigations are recommended if acrylamide levels in the different food groups exceed prescribed indicative values. The competent authorities should assess the extent to which currently known mitigation strategies, e.g. those proposed in the Codex code of Practice for acrylamide and the CIAA acrylamide toolbox, have been implemented by the food business operator.

To minimise losses from spoilage and shrinkage, potatoes are stored at low temperatures. However, low temperatures tend to increase sugar levels, in a process known as cold sweetening, particularly if stored below 6°C. This means that potatoes stored over the winter season and processed in spring may have higher acrylamide content than potato products processed immediately after harvesting. Storage of tubers at higher temperatures reduces sugar levels (Foot et al., 2007). Cultivars used in the crisps trade tend to be stored for longer periods of time than those used for French fries (Cummins et al., 2009).

In the present study, a seasonal effect in acrylamide content could not be determined for 'French fries' and 'potato products for home cooking'. However, for 'potato crisps' the higher acrylamide content in products sampled between January and June (median of 464 µg/kg), compared to products sampled between July and December (median of 360 µg/kg) was statistically significant. Controlling storage conditions of tubers is one of the measures added to the toolbox approach (CIAA, 2009).

4.3. Cereals and cereal products

A second large group of products contributing to acrylamide exposure in both adults and children is the cereals and cereal products group and, in particular, 'soft bread' and 'biscuit'. In 2007, during the joint workshop organised by the European Commission and the CIAA, it was concluded that there had been only limited success in reducing acrylamide formation in cereals and cereal products in relation to recipe formulation and processing conditions (Konings et al., 2007). However, there were some promising leads for the future, for example, the use of the enzyme asparaginase, which is now listed as a separate tool in the acrylamide toolbox (CIAA, 2009).

Four food groups belonging to the broad group of cereal products were sampled in the present study: 'biscuits', 'breakfast cereals', 'cereal based baby food' and 'bread'. In order to create more comparable datasets the 'bread' and 'biscuit' groups were subdivided into more detailed food groups.

'Soft bread' showed different changes in acrylamide content across the Member States over the years 2007 to 2009 and no European trend could be determined. However, an increasing trend in acrylamide values of 36.3 % over the three years was shown in 'crisp bread', but this food group was a minor contributor to the overall mean acrylamide exposure.

The only overall trends towards a decrease in acrylamide levels across the three years were observed in 'crackers' (35 %), 'infant biscuits'(49 %), and 'gingerbread'(27 %). Results from monitoring activities in the Netherlands have shown a similar decrease in gingerbread type products, particularly for Dutch spiced cakes analysed in 2006, probably because of a change in raising agent (Konings et al., 2007). The food group 'not specified biscuits' showed divergent trends in the different Member

States. Splitting the biscuit group into more distinct product subgroups in the future could facilitate assessment of time trends.

When comparing results from 'breakfast cereals' and 'cereal based baby food' in 2009 to results sampled in 2008 and 2007 the observed trend in Europe showed no statistically significant change across those three years.

It looks like further efforts in reducing acrylamide in bread products, and in particular 'soft bread', are necessary as 'soft bread' is a major contributor to acrylamide exposure ranging from 10 to 30 % in the adult population. Claus et al. (2008a) demonstrated that surface application of cysteine to the dough of wheat bread and bread rolls prior to baking showed acrylamide lowering potential and mixing of cysteine into the dough led to remarkably lower acrylamide levels in the finished product. According to a review of cereal products by Claus et al. (2008b), the most promising field for acrylamide reduction is the addition of low molecular weight additives such as polyphenols, which so far have not been applied in cereal products. Such additives ideally combine acrylamide reduction with little or no changes in product technology or, most importantly, sensory quality.

4.4. Coffee

For coffee which is also an important contributor to acrylamide exposure, although only in the adult population, results of laboratory scale experiments have led to the conclusion that only limited process options are available to reduce acrylamide levels without affecting the quality in respect to the consumer acceptance of the product (CIAA, 2009, Guenther et al., 2007). Lantz et al. (2006) arrived at a similar conclusion when investigating the factors affecting the acrylamide level in the chain from green coffee to the beverage. Also, process conditions resulting in low acrylamide levels, like darker roasting and longer roast time, tend to produce high levels of furan, another process contaminant. Consequently, no mitigation measure is yet proposed in the toolbox. On the other hand, preliminary results from lab/pilot plant studies show a possible significant reduction in green coffee asparagine levels after asparaginase treatment.

'Substitute' and 'instant 'coffee' show the highest, respectively the third highest mean acrylamide levels reported in the 2009 monitoring exercise. The highest 95th percentile values were reported for 'substitute' coffee samples collected from 2007 to 2009. When the values from the three coffee groups, 'roasted', 'substitute' and 'instant' coffee in 2009 were compared to those in 2008 and 2007 no European trend could be determined for the 'roasted' and 'substitute' coffee groups. The trend analysis for 'instant 'coffee showed an increase in acrylamide levels over the three years.

Fortunately, neither the 'substitute' nor the 'instant' coffee group were major contributors to the overall mean acrylamide exposure (less than 2.7 %). On the other hand, 'roasted coffee' was the third most important contributor to adult dietary exposure strengthening the need to identify mitigation measures for this food group.

4.5. Dietary exposure

The mean acrylamide exposure for adults (>18 years) in Europe was estimated to range between 0.31 and 1.1µg/kg b.w. per day. High exposure at the 95th percentile varied from 0.58 to 2.3 µg/kg b.w. per day. These results are similar to the range reported in the latest JECFA acrylamide risk assessment report (JECFA, 2010) in which mean and 95th-97.5th percentile estimates ranged between 0.2 and 1 µg/kg b.w per day and 0.6 to 1.8 µg/kg b.w per day, respectively, for the general adult population. Mean and 97.5th percentile exposure in the Belgian population (>15 years) was estimated at 0.4 µg/kg b.w. per day and 1.6 µg/kg b.w per day, respectively, with French fries, coffee, bread and biscuits as the main contributors (Claeys et al., 2010). In general, values between 0.3 to 2 µg/kg b.w per day have been reported in European countries for the average adult exposure and between 0.6 and 3.5 µg/kg b.w

per day for 90th to 97.5th percentiles (Svensson et al., 2003; Boon et al., 2005; Dybing et al., 2005; Mills et al., 2008).

In this study 'fried potatoes' (including French fries), 'soft bread' and 'roasted coffee' were identified as the major contributors to the overall adult acrylamide exposure. JECFA (2010) identified French fries, potato crisps, bread and biscuits as the main contributors for the general adult population. The difference could be due to the fact that the present study evaluated adults and adolescents separately. In other European studies food that contributed most to the acrylamide intake were in general French fries, coffee, bread, biscuits and potato crisps.

In this study the mean acrylamide exposure for adolescents in Europe was estimated to range between 0.43 and 1.4 µg/kg b.w. per day. High exposure at the 95th percentile varied from 0.94 to 3.1 µg/kg b.w. per day. Two out of the three major contributors to adolescent acrylamide exposure were 'fried potatoes' and 'soft bread' as in the adult population. The third biggest contributor was in some surveys 'biscuit' and in others 'potato crisps'. 'Coffee' was not a major contributor anymore in this target population. Matthys et al., (2005) estimated Flemish adolescents mean acrylamide exposure to 0.51 µg/kg b.w. per day and the 95th percentile to 1.09 µg/kg b.w. per day. In the Netherlands, Konings et al., (2003) estimated mean exposure for the age group 7-18 years old to be 0.71 µg/kg b.w. per day and the 95th percentile to be 0.9 µg/kg b.w. per day.

JECFA (2010) estimated, based on the few data available, that children exposure was two times higher than those of adults (Bolger et al., 2010). In the present study, based on data from 17 different surveys, mean exposure for children (3 to 10 years old) and toddlers (13-36 months old) were estimated to range between 0.70 and 2.05 µg/kg b.w. per day and 1.2 to 2.4 µg/kg b.w. per day, respectively, with 95th percentiles ranging between 1.5 and 4.2 µg/kg b.w. per day and 2.4 and 6.5 µg/kg b.w. per day, respectively. These results confirm the JECFA estimates of children exposure. In the children population (1-10 years) the three major contributors to acrylamide exposure were 'fried potatoes', 'soft bread' or 'unspecified bread' and 'biscuits'. In the Netherlands, Boon et al., (2005) estimated mean exposure for the age group 1-6 years old at 1.1 µg/kg b.w. per day and 95th percentile at 2 µg/kg b.w. per day.

Unfortunately, only two surveys of infants are included in the Comprehensive Database and their mean exposure was estimated to range between 0.73 and 1.3 µg/kg b.w. per day with the 95th percentile between 2.2 and 4 µg/kg b.w. per day. Major contributors were 'jarred baby food', 'fried potatoes' and 'biscuits' or 'infant biscuits'. In Sweden, Fohgelberg et al., (2005) estimated the mean acrylamide exposure between seven and twelve months of age to be 0.5 µg/kg b.w. per day.

It should be kept in mind that any exposure assessment is confronted with a number of uncertainties associated with the food consumption and occurrence data (Kroes et al., 2002). In this study, the mapping between consumption and occurrence data, the different ways that categorisation into more or less detailed food groups was done in the 26 different surveys, the conversion factors applied (liquid coffee to dry powder for most surveys and milling powder to bread for one Member State) and the fact that the variability in preparation and processing conditions was not accounted for are all additional sources of uncertainty associated with the estimated acrylamide exposure.

5. CONCLUSIONS

In this update report when comparing data from 2007 to 2009 a trend in Europe towards lower acrylamide values could only be found in three out of 22 food groups (all biscuit groups), whereas an increasing trend was found in 'crisp bread' and 'instant coffee'. There were no statistically significant differences in six groups, whereas in eight groups changes of acrylamide levels over time differed between Member States. The remaining three food groups did not contain enough information to perform any statistical analysis at European level.

Exposure estimates for the different target populations reported from this study were all within similar ranges of estimates previously reported for European countries.

As in previous annual acrylamide reports (EFSA 2009 and 2010) it can likewise be concluded that the application of the acrylamide toolbox has had only limited success. To lower overall exposure it would be desirable to further reduce acrylamide levels in food groups contributing the most to acrylamide exposure like, 'fried potatoes' (including 'French fries'), 'soft bread' and 'roasted coffee', 'biscuits' and 'jarred baby foods'. To clearly detect a trend the number of years covered must be extended. To facilitate interpretation of results in future years it will be important to consistently sample the same products in different years and to collect sufficient number of samples per food group in order to be able to distinguish random fluctuations from real trends.

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7. ANNEX

Mean and 95th percentile food consumption (g/day) in the total population by Member State, survey and age class as recorded in the Comprehensive European Food Consumption Database.

Table 1: Mean food consumption (g/day) in total population by Member State, survey and age class as recorded in the Comprehensive Database

Age class	MS	N	Biscuit	Fried potato	Potato crisps	Oven potato	Crisp bread	Soft bread	Unspec. bread	Breakfast cereals	Infant biscuit	Substitute coffee	Roasted coffee	Instant coffee	Jarred baby food	Cereal baby food	Muesli
Adolescents	BE2	584	16.4	30.8	7.6	0.3	1.7	111.3	11.1	13.6	0.4	0.0	1.8	0.1	0.0	0.0	3.9
Adults	BE2	1304	9.2	26.3	3.9	0.2	1.6	112.7	11.5	4.5	0.2	0.2	16.9	1.0	0.0	0.0	3.5
Elderly	BE2	518	7.9	18.8	0.9	0.2	1.7	117.7	4.8	0.9	0.0	0.8	21.3	0.5	0.0	0.0	5.6
Very elderly	BE2	712	8.8	18.9	0.5	0.1	1.4	112.0	4.2	0.9	0.1	1.8	19.1	0.9	0.0	0.0	12.0
Toddlers	BE1	36	11.1	63.0	1.2	0.0	0.9	67.6	16.4	4.5	9.1	0.0	0.2	0.0	0.0	0.0	1.1
Other children	BE1	625	14.4	66.5	1.8	0.0	1.0	69.9	16.7	8.4	8.4	0.0	0.2	0.0	0.2	0.0	1.6
Infants	BG2	860	5.3	14.0	0.0	0.0	1.7	10.7	5.8	0.0	0.3	0.0	0.0	0.0	65.0	3.2	0.0
Toddlers	BG2	428	9.2	45.7	0.5	0.7	7.0	57.0	14.9	0.2	0.7	0.0	0.0	0.0	9.2	1.3	0.1
Other children	BG2	433	5.7	56.7	0.2	0.2	5.1	83.2	17.1	0.8	0.3	0.0	0.0	0.0	0.4	0.1	0.2
Adolescents	CY	303	4.0	34.7	8.1	23.6	2.3	44.2	51.3	16.6	0.0	0.0	0.1	0.8	0.0	0.0	0.0
Other children	CZ	389	22.8	77.0	2.7	0.0	5.5	80.9	41.0	5.7	0.0	0.2	0.1	0.1	2.0	0.2	1.3
Adolescents	CZ	298	28.1	101.0	3.4	0.0	8.9	125.3	58.3	3.7	0.0	0.1	0.1	0.2	0.8	0.0	3.2
Adults	CZ	1666	14.1	96.1	4.5	0.0	9.2	151.6	48.1	1.8	0.0	0.3	7.6	1.1	0.3	0.0	1.6
Adolescents	DE2	1011	4.7	17.6	3.6	2.0	3.9	104.5	26.6	6.0	0.0	0.0	2.3	0.0	0.0	0.0	6.3
Adults	DE2	10419	4.9	21.2	2.1	1.7	4.5	111.2	20.7	2.1	0.0	0.1	22.6	0.1	0.0	0.0	4.5
Elderly	DE2	2006	4.4	20.8	0.3	0.7	5.7	123.0	17.6	1.6	0.0	0.3	23.3	0.2	0.0	0.0	3.7
Very elderly	DE2	490	4.2	27.5	0.3	0.6	5.5	115.2	18.7	2.4	0.0	0.4	19.8	0.1	0.0	0.0	2.9
Toddlers	DE1	92	7.4	26.2	0.9	0.0	1.7	32.8	13.0	1.0	0.2	0.0	0.0	0.0	107.6	6.9	3.3
Other children	DE1	211	9.0	33.0	4.9	0.0	2.4	64.8	32.9	7.9	0.2	0.0	0.0	0.0	5.4	1.1	5.5
Toddlers	DE1	85	4.6	29.5	1.0	0.0	2.3	38.8	14.9	0.9	0.1	0.0	0.0	0.0	74.5	9.1	2.8
Other children	DE1	226	8.6	34.8	5.4	0.0	2.3	56.2	39.7	6.9	0.0	0.0	0.0	0.0	4.4	1.1	6.2
Toddlers	DE1	84	5.6	27.6	0.6	0.0	3.4	36.8	13.5	0.5	0.9	0.0	0.0	0.0	83.2	9.9	1.8
Other children	DE1	223	9.4	35.6	5.0	0.2	2.2	62.3	39.5	6.5	0.0	0.1	0.0	0.0	6.0	0.2	6.1
Other children	DK	490	1.2	64.5	3.3	0.0	1.6	138.3	42.2	10.1	0.0	0.0	0.0	0.0	0.0	0.0	0.9
Adolescents	DK	479	1.2	93.3	5.8	0.0	1.2	141.0	51.0	9.3	0.0	0.0	0.6	0.0	0.0	0.0	1.3
Adults	DK	2822	0.5	109.6	2.5	0.0	2.0	157.5	40.1	3.8	0.0	0.0	35.1	0.0	0.0	0.0	1.9
Elderly	DK	309	0.5	144.0	0.2	0.0	2.4	153.6	29.9	2.3	0.0	0.0	39.9	0.0	0.0	0.0	2.6
Very elderly	DK	20	0.9	174.9	0.4	0.0	2.7	148.7	43.1	1.6	0.0	0.0	34.0	0.0	0.0	0.0	1.5
Adults	ES3	410	12.2	56.2	2.1	0.0	0.4	90.7	11.0	5.6	0.0	0.0	1.8	0.7	0.0	0.0	0.6

Age class	MS	N	Biscuit	Fried potato	Potato crisps	Oven potato	Crisp bread	Soft bread	Unspec. bread	Breakfast cereals	Infant biscuit	Substitute coffee	Roasted coffee	Instant coffee	Jarred baby food	Cereal baby food	Muesli
Adolescents	ES4	86	16.6	82.0	7.8	0.0	0.0	103.0	12.4	5.6	0.0	0.0	0.2	0.6	0.0	0.0	0.2
Adults	ES4	981	11.5	76.1	3.4	0.0	0.0	86.0	11.9	3.7	0.0	0.0	0.9	2.1	0.0	0.0	0.5
Toddlers	ES1	17	1.5	41.6	5.3	0.0	1.8	27.4	16.0	5.3	0.0	0.0	0.0	0.0	0.0	41.6	0.0
Other children	ES1	156	3.9	71.0	5.1	0.0	1.2	68.1	13.3	10.8	0.0	0.0	0.1	0.0	0.0	2.4	0.1
Adolescents	ES1	209	3.4	80.7	4.8	0.0	2.4	120.2	18.6	7.0	0.0	0.0	0.5	0.0	0.0	0.4	0.2
Other children	ES2	399	20.5	20.0	6.3	0.2	1.2	84.3	11.6	10.4	0.0	0.0	0.0	0.0	0.0	0.0	0.6
Adolescents	ES2	651	20.8	26.7	7.9	0.9	1.8	118.9	15.5	10.2	0.0	0.0	0.2	0.2	0.0	0.0	1.0
Adults	FI1	1575	0.0	23.5	1.4	0.0	2.1	0.1	184.0	10.0	0.0	0.0	24.3	0.0	0.0	0.0	0.3
Elderly	FI1	463	0.0	26.5	0.3	0.0	1.7	0.1	185.5	16.9	0.0	0.0	19.7	0.0	0.0	0.0	0.1
Toddlers	FI2	497	1.2	9.1	0.0	0.0	0.9	0.3	67.8	3.9	0.0	0.0	0.0	0.0	8.8	9.2	0.0
Other children	FI2	933	4.6	33.6	1.3	0.0	4.5	0.2	89.5	5.7	0.0	0.0	0.1	0.0	0.3	0.4	0.0
Other children	FI3	250	7.9	28.4	2.4	2.9	2.4	60.3	1.1	6.2	0.0	0.0	0.1	0.0	2.0	0.1	48.2
Other children	FR	482	15.3	11.7	1.0	1.5	4.2	44.0	13.0	9.3	0.0	0.0	0.2	0.0	1.5	0.0	1.0
Adolescents	FR	973	12.7	16.4	1.2	3.0	5.1	74.5	20.2	10.3	0.0	0.0	2.3	0.0	0.0	0.0	2.4
Adults	FR	2276	6.8	11.6	0.7	3.6	6.5	101.4	18.3	2.4	0.0	0.1	50.3	0.3	0.0	0.0	2.5
Elderly	FR	264	1.9	5.3	0.2	2.4	5.7	126.6	8.0	0.9	0.0	0.4	40.2	0.4	0.0	0.0	1.3
Very elderly	FR	84	1.5	5.8	0.0	2.0	8.5	119.1	7.8	0.3	0.0	0.1	34.2	0.5	0.0	0.0	0.4
Adults	GB	1724	9.8	61.5	6.3	27.8	4.0	99	18.2	16.4	0.3	0.0	1.5	0.0	0.0	15.2	
Other children	GR	839	11.9	46.6	5.1	0.0	5.1	0.2	45.7	5.5	0.0	0.0	0.0	0.0	2.1	0.0	0.0
Adults	HU	1074	4.9	108.5	0.8	0.0	8.0	145.8	59.0	1.1	0.0	0.2	8.7	0.2	0.0	0.0	0.5
Elderly	HU	206	5.7	104.2	0.9	0.0	6.2	138.1	58.2	0.2	0.0	0.1	6.8	0.1	0.0	0.0	0.2
Very elderly	HU	80	6.6	113.9	0.0	0.0	7.9	141.2	61.2	0.6	0.0	0.0	4.3	0.1	0.0	0.0	0.0
Adults	IE	958	13.7	61.3	4.5	5.5	4.5	133.3	16.0	15.1	0.0	0.0	1.3	2.4	0.0	0.0	5.9
Infants	IT	16	0.0	5.3	0.0	0.0	0.0	0.7	3.5	0.0	4.5	0.0	0.0	0.0	62.3	3.6	0.0
Toddlers	IT	36	10.6	19.0	0.8	0.0	3.4	25.5	15.8	0.4	10.7	0.0	0.0	0.0	31.4	0.0	0.0
Other children	IT	193	16.4	44.7	1.7	0.0	7.4	73.7	33.2	2.9	2.4	0.0	1.7	0.0	1.5	0.0	0.7
Adolescents	IT	247	23.2	57.3	1.9	0.0	10.3	101.1	61.5	2.3	0.1	0.1	3.0	0.0	0.0	0.0	0.5
Adults	IT	2313	12.7	48.5	0.6	0.0	8.9	105.2	52.9	1.1	0.1	0.0	20.8	0.0	0.0	0.0	0.4
Elderly	IT	290	11.0	55.0	0.0	0.0	9.8	114.2	30.2	0.4	0.0	0.2	18.6	0.0	0.0	0.0	0.2
Very elderly	IT	228	12.1	51.7	0.0	0.0	10.3	123.9	23.9	0.6	0.0	0.2	14.7	0.0	0.2	0.0	0.1
Other children	LV	189	17.4	24.2	5.1	0.3	2.3	72.0	17.4	26.4	0.0	0.7	0.5	0.1	0.0	0.0	1.6
Adolescents	LV	470	15.7	41.0	10.3	1.1	1.1	115.4	15.2	13.5	0.0	0.0	1.6	0.3	0.0	0.0	1.3

Age class	MS	N	Biscuit	Fried potato	Potato crisps	Oven potato	Crisp bread	Soft bread	Unspec. bread	Breakfast cereals	Infant biscuit	Substitute coffee	Roasted coffee	Instant coffee	Jarred baby food	Cereal baby food	Muesli
Adults	LV	1306	10.3	36.2	3.0	1.8	1.0	142.6	16.4	10.9	0.0	0.4	9.6	1.1	0.0	0.0	1.9
Adults	NL1	750	12.8	47.8	8.2	2.5	6.4	143.8	5.3	0.7	0.1	0.1	15.9	0.4	0.0	0.1	7.3
Toddlers	NL2	322	9.5	8.2	2.9	0.3	4.9	33.5	34.3	3.0	2.6	0.0	0.0	0.0	3.6	2.7	2.0
Other children	NL2	957	12.3	11.4	5.1	0.4	5.2	42.1	41.0	3.0	2.9	0.0	0.0	0.0	1.8	0.8	2.1
Adults	SE2	1210	5.8	40.4	3.0	4.9	15.9	86.0	0.7	3.7	0.0	0.0	22.9	0.0	0.0	0.0	41.3
Other children	SE1	1473	6.2	25.7	3.8	3.4	8.7	51.0	3.9	5.8	0.0	0.0	0.0	0.0	0.0	4.7	61.1
Adolescents	SE1	1018	5.0	37.8	5.6	4.7	8.2	64.3	5.6	6.5	0.0	0.0	0.1	0.0	0.0	0.0	28.1

Table 2: 95th percentile of food consumption (g/day) in total population by Member State, survey and age class as recorded in the Comprehensive Database

Age class	MS	N	Biscuit	Fried potato	Potato crisps	Oven potato	Crisp bread	Soft bread	Unspec. bread	Breakfast cereals	Infant biscuit	Substitute coffee	Roasted coffee	Instant coffee	Jarred baby food	Cereal baby food	Muesli
Adolescents	BE2	584	74.0	125.0	40.0	0.0	12.0	240.0	75.5	60.0	0.0	0.0	9.4	0.0	0.0	0.0	25.0
Adults	BE2	1304	47.0	126.0	22.5	0.0	10.6	256.0	66.9	30.0	0.0	0.0	56.3	1.6	0.0	0.0	17.5
Elderly	BE2	518	37.5	102.0	0.0	0.0	12.0	239.0	37.5	0.0	0.0	0.3	53.1	4.5	0.0	0.0	24.7
Very elderly	BE2	712	39.5	110.5	0.0	0.0	8.0	229.0	26.0	0.0	0.0	1.3	46.3	5.0	0.0	0.0	100.0
Toddlers	BE1	36	45.8	128.3	10.0	0.0	7.3	146.0	76.3	43.3	29.7	0.0	0.0	0.0	0.0	0.0	0.0
Other children	BE1	625	43.3	149.0	10.0	0.0	6.0	133.3	69.2	35.0	26.7	0.0	1.0	0.0	0.0	0.0	0.7
Infants	BG2	860	30.5	66.3	0.0	0.0	13.5	57.9	24.4	0.0	0.0	0.0	0.0	0.0	256.3	22.1	0.0
Toddlers	BG2	428	35.0	125.3	0.0	0.0	29.5	117.8	47.6	0.0	0.0	0.0	0.0	0.0	80.0	0.0	0.0
Other children	BG2	433	31.3	168.8	0.0	0.0	30.0	166.4	60.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Adolescents	CY	303	20.0	103.3	30.0	100.0	13.3	111.7	141.7	50.0	0.0	0.0	0.0	5.0	0.0	0.0	0.0
Other children	CZ	389	75.0	183.3	25.0	0.0	21.7	161.1	116.9	50.0	0.0	0.0	0.0	0.0	0.0	0.0	12.5
Adolescents	CZ	298	100.0	277.4	35.0	0.0	36.5	290.0	153.2	27.5	0.0	0.0	0.0	1.0	0.0	0.0	20.0
Adults	CZ	1666	65.0	248.9	45.0	0.0	33.3	340.0	163.5	0.0	0.0	0.0	24.5	6.0	0.0	0.0	0.1
Adolescents	DE2	1011	30.0	110.5	20.0	0.0	25.0	237.5	132.0	40.0	0.0	0.0	13.8	0.0	0.0	0.0	40.0
Adults	DE2	10419	30.0	114.0	12.5	0.0	30.0	250.0	100.0	20.0	0.0	0.0	57.3	0.0	0.0	0.0	30.0
Elderly	DE2	2006	25.0	110.5	0.0	0.0	35.0	253.8	88.5	10.0	0.0	0.0	48.8	0.0	0.0	0.0	31.5
Very elderly	DE2	490	25.0	120.0	0.0	0.0	35.0	247.0	94.0	20.0	0.0	3.8	40.0	0.0	0.0	0.0	30.0
Toddlers	DE1	92	34.5	80.9	6.7	0.0	10.0	70.8	53.5	6.7	1.7	0.0	0.0	0.0	440.3	31.7	17.9
Other children	DE1	211	37.3	92.3	33.3	0.0	16.7	153.7	97.8	40.6	0.0	0.0	0.0	0.0	6.7	0.0	35.2
Toddlers	DE1	85	20.3	102.0	10.0	0.0	18.7	96.0	47.7	8.3	0.0	0.0	0.0	0.0	317.2	44.5	21.4
Other children	DE1	226	35.0	96.6	40.7	0.0	13.7	126.7	111.3	34.7	0.0	0.0	0.0	0.0	0.0	0.0	33.0
Toddlers	DE1	84	20.0	88.4	4.3	0.0	16.0	92.0	48.6	2.0	4.3	0.0	0.0	0.0	375.7	48.2	8.3
Other children	DE1	223	32.5	96.7	36.7	0.0	12.7	132.7	106.7	29.3	0.0	0.0	0.0	0.0	13.0	0.0	36.5
Other children	DK	490	6.9	153.2	15.0	0.0	7.4	238.4	111.9	32.1	0.0	0.0	0.0	0.0	0.0	0.0	7.4
Adolescents	DK	479	6.9	238.7	27.9	0.0	5.6	258.5	135.7	33.1	0.0	0.0	2.9	0.0	0.0	0.0	9.1
Adults	DK	2822	3.4	267.2	15.0	0.0	8.5	278.4	108.9	21.9	0.0	0.0	90.0	0.0	0.0	0.0	14.0
Elderly	DK	309	3.4	315.4	2.1	0.0	9.1	264.5	77.0	15.5	0.0	0.0	80.0	0.0	0.0	0.0	9.1
Very elderly	DK	20	9.4	407.7	4.3	0.0	11.2	216.9	137.0	13.9	0.0	0.0	71.4	0.0	0.0	0.0	15.1
Adults	ES3	410	58.0	168.7	15.0	0.0	0.0	200.0	56.3	35.0	0.0	0.0	6.0	4.0	0.0	0.0	0.0
Adolescents	ES4	86	72.0	186.2	80.0	0.0	0.0	222.5	41.2	30.0	0.0	0.0	2.0	2.7	0.0	0.0	0.0
Adults	ES4	981	52.0	177.8	20.0	0.0	0.0	192.2	45.6	28.7	0.0	0.0	4.0	5.3	0.0	0.0	0.0

Age class	MS	N	Biscuit	Fried potato	Potato crisps	Oven potato	Crisp bread	Soft bread	Unspec. bread	Breakfast cereals	Infant biscuit	Substitute coffee	Roasted coffee	Instant coffee	Jarred baby food	Cereal baby food	Muesli
Toddlers	ES1	17	25.0	100.0	75.0	0.0	30.0	115.0	120.0	60.0	0.0	0.0	0.0	0.0	0.0	269.5	0.0
Other children	ES1	156	30.0	217.5	25.0	0.0	0.0	150.0	60.0	60.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Adolescents	ES1	209	22.5	225.0	30.0	0.0	7.5	305.0	82.5	40.0	0.0	0.0	2.5	0.0	0.0	0.0	0.0
Other children	ES2	399	65.0	79.5	31.5	0.0	9.0	165.0	50.0	40.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Adolescents	ES2	651	75.0	98.7	44.0	0.0	15.0	250.0	64.3	57.5	0.0	0.0	2.0	0.0	0.0	0.0	0.0
Adults	FI1	1575	0.0	114.6	0.0	0.0	11.1	0.0	348.5	40.4	0.0	0.0	57.5	0.0	0.0	0.0	0.0
Elderly	FI1	463	0.0	119.0	0.0	0.0	8.0	0.0	350.2	50.2	0.0	0.0	44.3	0.0	0.0	0.0	0.0
Toddlers	FI2	497	6.3	53.6	0.0	0.0	5.3	1.3	130.1	21.9	0.0	0.0	0.0	0.0	52.9	70.0	0.0
Other children	FI2	933	20.0	94.5	8.0	0.0	15.4	0.0	162.3	21.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other children	FI3	250	30.0	93.8	15.0	25.0	11.3	127.5	0.0	26.3	0.0	0.0	0.0	0.0	0.0	0.0	186.3
Other children	FR	482	48.9	35.7	5.7	8.9	15.6	114.1	42.0	36.4	0.0	0.0	0.0	0.0	0.0	0.0	5.7
Adolescents	FR	973	56.6	53.6	7.1	22.2	19.8	187.8	70.4	49.3	0.0	0.0	11.2	0.0	0.0	0.0	14.3
Adults	FR	2276	36.0	42.9	4.3	26.6	27.3	242.9	69.6	17.1	0.0	0.1	170.2	1.8	0.0	0.0	14.3
Elderly	FR	264	12.4	28.6	0.0	17.7	22.9	263.2	33.4	0.0	0.0	0.1	111.6	2.0	0.0	0.0	0.0
Very elderly	FR	84	12.9	25.0	0.0	17.7	32.1	260.5	26.7	0.0	0.0	0.1	95.5	3.0	0.0	0.0	0.0
Adults	GB	1724	39.7	158.3	25.0	98.1	16.6	201.9	58.5	62.1	1.8	0.0	8.3	0.0	0.0	0.0	84.6
Other children	GR	839	46.7	133.3	26.7	0.0	26.7	0.0	106.7	30.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Adults	HU	1074	33.3	250.0	0.0	0.0	26.7	288.0	147.0	6.7	0.0	0.0	28.9	0.0	0.0	0.0	0.0
Elderly	HU	206	33.3	250.0	0.0	0.0	21.7	240.0	145.4	0.0	0.0	0.0	21.7	0.0	0.0	0.0	0.0
Very elderly	HU	80	33.3	258.3	0.0	0.0	27.5	274.3	142.3	0.0	0.0	0.0	19.9	0.0	0.0	0.0	0.0
Adults	IE	958	46.1	186.3	19.6	45.7	15.2	273.1	47.2	56.9	0.0	0.0	7.5	11.1	0.0	0.0	30.4
Infants	IT	16	0.0	21.0	0.0	0.0	0.0	11.0	22.5	0.0	18.7	0.0	0.0	0.0	260.0	45.3	0.0
Toddlers	IT	36	45.3	84.5	0.0	0.0	13.9	90.0	88.4	6.7	32.0	0.0	0.0	0.0	186.7	0.0	0.0
Other children	IT	193	60.0	141.4	10.0	0.0	31.0	180.0	118.8	21.0	16.0	0.0	5.4	0.0	0.0	0.0	0.0
Adolescents	IT	247	76.7	163.4	10.0	0.0	34.7	230.0	182.8	15.0	0.0	0.0	14.1	0.0	0.0	0.0	0.0
Adults	IT	2313	50.0	152.1	0.0	0.0	32.4	250.0	161.4	7.5	0.0	0.0	52.1	0.0	0.0	0.0	0.0
Elderly	IT	290	48.0	156.1	0.0	0.0	35.7	250.0	102.9	0.0	0.0	0.3	51.7	0.0	0.0	0.0	0.0
Very elderly	IT	228	48.0	159.1	0.0	0.0	38.0	270.0	88.7	0.0	0.0	0.8	39.6	0.0	0.0	0.0	0.0
Other children	LV	189	75.0	100.0	37.5	0.0	7.5	195.0	112.5	130.0	0.0	0.0	4.6	0.0	0.0	0.0	0.0
Adolescents	LV	470	75.0	175.0	50.0	0.0	0.0	275.0	112.5	90.0	0.0	0.0	10.0	2.0	0.0	0.0	0.0
Adults	LV	1306	50.0	150.0	22.5	0.0	0.0	345.0	135.0	100.0	0.0	0.0	27.0	5.6	0.0	0.0	0.0
Adults	NL1	750	57.0	211.9	40.0	0.0	32.5	292.5	44.6	0.0	0.0	0.0	56.5	2.1	0.0	0.0	40.0

Age class	MS	N	Biscuit	Fried potato	Potato crisps	Oven potato	Crisp bread	Soft bread	Unspec. bread	Breakfast cereals	Infant biscuit	Substitute coffee	Roasted coffee	Instant coffee	Jarred baby food	Cereal baby food	Muesli
Toddlers	NL2	322	29.0	48.5	15.0	0.0	22.6	100.0	102.5	22.1	15.0	0.0	0.0	0.0	27.4	21.5	4.9
Other children	NL2	957	40.5	60.0	22.5	0.0	26.6	113.8	122.5	22.5	15.0	0.0	0.0	0.0	0.0	0.0	7.4
Adults	SE2	1210	20.0	117.9	17.9	37.4	49.3	170.0	0.0	18.6	0.0	0.0	53.6	0.0	0.0	0.0	214.3
Other children	SE1	1473	23.0	100.0	20.0	31.3	33.0	115.3	21.4	22.8	0.0	0.0	0.0	0.0	0.0	0.0	350.0
Adolescents	SE1	1018	21.5	137.5	30.0	43.8	33.8	136.3	26.7	29.0	0.0	0.0	0.0	0.0	0.0	0.0	150.0