SCIENTIFIC REPORT submitted to EFSA

Long-term dietary exposure to chromium in young children living in different European countries[1]

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Abstract

Long-term dietary exposure to chromium in young children living in 12 different European countries was estimated using both the deterministic observed individual means (OIM) and the stochastic beta-binomial normal (BBN) approach. For this, food consumption data of children aged 1 up to 14 years were combined with chromium concentration data in food as supplied by EFSA. Food consumption data were all categorised according to a harmonised system to allow for linkages with chromium concentration data in a standardised way. The results showed differences in exposure between countries and that the exposure decreased with age. Exposure levels were higher using the deterministic model compared to the stochastic model, although the latter model could not be applied to data from some countries because of a lack of required normality. Food groups 'milk/dairy drinks' and 'cereals' contributed most to the exposure in almost all countries. The study also showed that, food consumption data collected in different European countries can be categorised in a standard way to allow for harmonised exposure modelling. Due to the lack of a Tolerable Upper Intake Level for chromium, it is unclear if the exposure levels calculated for the different countries pose a possible health risk.

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Summary

Long-term dietary exposure to chromium in young children living in 12 different European countries was estimated using food consumption data for children aged 1 up to 14 years combined with chromium concentrations in food as supplied by EFSA. Food consumption data were all categorised according to a harmonised system to allow for linkages with chromium concentration data in a standardised way. Two approaches were used to calculate long-term exposure to chromium: the deterministic observed individual means (OIM) and the stochastic beta-binomial normal (BBN) approach. The BBN model separates the within-person variation from the between-person variation to estimate exposure and can model covariates, such as age. This approach has been proven very useful for estimating long-term exposure. However, for some countries the BBN model could not be used due to lack of required normality of the transformed exposure data. In those cases the OIM approach was used, although this model cannot deal with within-person variation and results in more conservative estimates of exposure in the right tail of the exposure distribution than the BBN model.

Results of the calculations showed differences in exposure between countries and a decreased exposure with age. Using the BBN model for children 1 to 10 years of age, the national long-term exposures to chromium from food across the 12 European countries, using lower bound concentrations, ranged from 1.8 to 5.1 µg/kg bw per day for median consumers, and from 3.4 to 16 µg/kg bw per day for 99th percentile consumers. Exposure levels in younger children were higher compared to older children within this age group. The lower bound estimates for children aged 11 to 14 years were 1.2 to 1.9 µg/kg bw per day for median consumers and 2.3 to 4.5 µg/kg bw per day for 99th percentile consumers. Using upper bound concentrations, the exposures at the median and 99th percentile levels were on average a factor 1.4 higher for both age groups. Estimated exposure levels were higher using the OIM model compared to the BBN model, particularly for high percentiles. The food groups 'milk/dairy drinks' and 'cereals' contributed most to the exposure in almost all countries. An exception was the Spain-enKid study, in which the food group 'foods special dietary uses' was the most important source of exposure.

Methodological issues of an exposure study linking different national food consumption databases to one "European" chromium concentration database were addressed in the discussion. Not all age groups were present in all countries which might have partly influenced the overall results. Due to the uncertainties related to the chromium exposure assessment presented here, as well as the exclusion of chromium exposure via food supplements, the exposure results should be interpreted with caution and do not necessarily represent the total chromium intake at the national level.

Since there is no Tolerable Upper Intake Level (UL) established for chromium, it was not possible to determine if the exposure levels calculated for the different countries pose a possible health risk.

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Background

In order to carry out their risk assessments, the EFSA Panels on additives, flavourings, processing aids and materials in contact with food (AFC), on contaminants in the food chain (CONTAM), on Biological Hazards (BIOHAZ) and on additives and products or substances used in animal feed (FEEDAP) expressed the need to have reliable and detailed individual food consumption data for children and, in particular, of young children. In addition, a requirement for specific exposure assessment studies was identified in the same population groups. One of these studies should estimate the dietary exposure to chromium.

Chromium, as chromium (III) chloride and its hexahydrate, and as chromium (III) sulphate and its hexahydrate, is authorised in the EU as a mineral which may be added to food[3]. However, chromium is not authorised yet as a feed additive in the EU, neither is it listed in the corresponding EU legal text as an undesirable substance in feed[4]. Recent and reliable data on human exposure and, in particular, of vulnerable groups would be of value for an assessment of the use of chromium as a feed additive.

Keywords

Dietary exposure, long-term exposure, children, chromium, Europe

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[3] OJ L 404, 30.12.2006, p.26

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1. Introduction

In this report, we describe the long-term exposure to chromium in children living in 12 different European countries, including Belgium, Cyprus, Czech Republic, Denmark, Finland, France, Germany, Greece, Italy, Netherlands, Spain and Sweden. Chromium intake can be adverse to human health on the long run (EFSA, 2009a), making a long-term exposure assessment most suitable.

For this exposure assessment food consumption data of children aged 1 up to 14 years were combined with concentration data. To estimate the long-term exposure we used the software Monte Carlo Risk Assessment (MCRA) (de Boer and van der Voet, 2007). In this program, different models to assess the long-term dietary exposure to chemicals have been implemented.

The exposure calculations performed for chromium were identical to those reported earlier for lead (Boon et al., 2010). We therefore refer to this report for a description of

- the food consumption data,
- the grouping of the foods consumed in food group, including consumption details per food group
- the methodology used (betabinomial-normal (BBN) and observed individual means (OIM) approaches) to assess the long-term dietary exposure to chromium.

Only issues specifically relevant for chromium will be addressed in this report.

2. Materials and methods

2.1. Chromium concentration data

The chromium occurrence data were supplied to EFSA through a call for data on selenium and chromium levels in food and beverages (EFSA/DATEX/2008/013) issued by EFSA in September 2008 with a closing date of November 2008. EFSA received a total of 23,750 results from food testing from six Member States (Austria, Cyprus, France, Germany, Ireland and United Kingdom). Germany was the major contributor providing 69% of the data followed by Ireland (10%), Cyprus (9%) and France (6%). The data covered the period 2000 to 2008. The concentration data included data on total chromium. Chromium occurs in the environment primarily in two valence states: trivalent chromium (III) and hexavalent chromium (VI). Chromium in foods (and supplements) is mainly in the trivalent form (EVM, 2003). It is therefore likely that chromium included in the concentration database is predominantly of this form. However, whether this is true could not be established.

The data were processed by EFSA in exactly the same way as was done for lead (Boon et al., 2010). EFSA supplied two mean chromium concentrations per food group: lower bound (LB) and upper bound (UB) mean chromium concentration. The LB mean concentrations were calculated by assigning zero to the samples with a level below limit of reporting (LOR), determination (LOD) or quantification (LOQ). The UB mean concentrations were calculated by assigning LOR, LOD or LOQ to the samples with a level below the respective limits. For an overview of the concentration data used in the assessment, see Table 1.

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Table 1. Mean chromium concentration per food group[(a)] as used in the long-term exposure assessments[(b)]

Food group		Mean chromium concentration (mg/kg)	
Nr	Name	LB	UB
1	Composed foods-cereal based mixed dishes and cereal-based desserts[(c)]	0.091	0.095
2	Vegetables excl. dried vegetables[(c)]	0.034	0.052
3	Nuts/seeds	0.128	0.148
4	Coffee/tea in concentrated and in powdered form	0.001	0.003
5	Chocolate (products)	0.356	0.365
6	Fruit excl. dried fruit[(c)]	0.016	0.035
7	Dried fruit	0.000	0.000
8	Fresh and dried herbs, spices, seasonings and condiments	0.352	0.363
10	Waters	0.003	0.006
11	Sugar, sweeteners and sugar products (e.g. sugar based confectionery, chewing gum and decorations)	0.083	0.114
12	Fats, oils and fat emulsions (also e.g. rice milk (no soy milk))	0.039	0.052
13	Composed foods: meat based mixed dishes	0.061	0.062
14	Composed foods: fish based mixed dishes	0.065	0.081
15	Dried vegetables	0.000	0.000
16	Pulses/legumes	0.076	0.082
17	Soy milk/soy based dessert	0.028	0.032
18	Milk/dairy drinks	0.069	0.083
19	Cheese	0.076	0.092
20	Dairy based products	0.034	0.081
21	Salt	0.053	0.386
22	Fish	0.065	0.081
23	Molluscs	0.215	0.231
24	Cephalopods	0.128	0.128
25	Crustaceans	0.063	0.066
26	Other seafood (echinoderms)	0.123	0.123
27	Beer/malt beverages	0.147	0.403
28	Wine/substitutes	0.029	0.059
29	Other alcoholic beverages	0.008	0.036

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Food group		Mean chromium concentration (mg/kg)	
Nr	Name	LB	UB
30	Fruit juices/nectars	0.020	0.028
31	Vegetable juices/nectars	0.206	0.208
32	Soft drinks/edible ices	0.014	0.038
33	Cereals/cereal products (no cereal based desserts or cereal based mixed dishes)(b)	0.084	0.110
34	Other food for special dietary uses(b)	12.805	12.814
35	Infant formulae, follow up formulae, food for young children and infant formulae and follow up formulae for medical purposes(b)	0.051	0.068
37	Miscellaneous foods(b)	0.063	0.073
38	Liver/kidney	0.020	0.044
39	Offal except liver/kidney	0.013	0.044
40	Types of vegetarian substitutes for meat/fish	0.000	0.000
41	Fresh meat	0.039	0.067
42	Processed meat	0.000	0.000
45	Eggs	0.021	0.036

(a) No information was available on the years in which the foods categorised in the food groups were analysed for chromium.

(b) Following two scenarios of assigning chromium concentrations to non-detect samples (LB: lower bound; UB: upper bound)

(c) These food groups have been renamed in Tables 3, 5, 7 and 8: nr 1 = composed foods cereal; nr 2 = vegetables; nr 6 = fruit; nr 33 = cereals; nr 34 = foods special dietary uses; nr 35 = infant formulae; nr 37 = miscellaneous.

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Chromium exposure via the intake of food supplements was not included due to reasons of comparability. However, only a limited number of countries had consumption levels of food supplements in their database.

No information was available regarding the composition of the 42 communal food groups in relation to the foods analysed. This issue will therefore not be addressed here, although it is important for a correct interpretation of the chromium exposure results.

2.2. Risk characterisation of the long-term exposure

Chromium (III) is involved in the regulation of normal glucose, protein, and fat metabolism. However, as concluded by the EFSA FEEDAP Panel, there is at present no conclusive evidence supporting essentiality or non-essentiality of chromium (III) as a trace element (EFSA, 2009b). Chromium (III) can therefore best be classified as a nutritionally or pharmacologically beneficial element. The body has several systems for reducing some amount of chromium (VI) to chromium (III). However, at certain levels of intake chromium becomes toxic, with the respiratory tract as its major target organ. Chromium (III) is much less toxic than chromium (VI) (EPA, 1992).

The toxicity of chromium compounds has been evaluated by various authorities including the Scientific Committee on Food (SCF, 2003), the UK Expert group on Vitamin and Minerals (EVM, 2003), the US Food and Nutrition Board (FNB, 2001) and the World Health Organization (WHO) (WHO, 1996). Due to limited data availability on toxicity, none of these authorities has set a tolerable upper safety limit, except for the WHO. This organization considered that supplementation of chromium in adults should not exceed 250 µg/day (WHO, 1996).

However, as noted by both the EFSA Panel on Food Additives and Nutrient Sources added to Food (ANS) (EFSA, 2009a) and the one on Additives and Products or Substances used in Animal Feed (FEEDAP) (EFSA, 2009b), the most recent available literature on carcinogenicity studies in rats and mice indicate that chromium (III) may be a genotoxic compound under *in vivo* conditions. Due to this, we did not compare the exposure to chromium to a safe upper limit.

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3. Results

3.1. Long-term dietary exposure to chromium using the BBN approach

3.1.1. Long-term exposure for age range of 1 to 10 years of age

In Table 2, the estimated long-term dietary exposure to chromium in children covering the age 1 to 10 years in the different countries is listed for the lower bound (LB) and upper bound (UB) concentration scenarios. These exposure results were calculated using the betabinomial-normal (BBN) approach (see for details Boon et al. (2010)). The exposure to chromium was highest in the youngest children and decreased with age. In the LB concentration scenario, the P99 of exposure ranged from 3.4 µg/kg bw per day in 10-year olds from Czech Republic to 16.6 µg/kg bw per day in 1-year olds from Germany (2007 study). The P99 of exposure in the UB concentration scenario was on average about a factor 1.4 higher than in the LB concentration scenario, resulting in a range from 4.6 µg/kg bw per day in 10-year olds from Spain-Basque to 22 µg/kg bw per day in 1-year olds from Germany (2007 study).

Table 3 lists for each country the three food groups contributing most to the long-term exposure distribution of chromium for children within the age range of 1 to 10 years for both concentration scenarios. Please note that the ages present in this age range differ per country. In the LB concentration scenario, the two most important food groups that contributed to the exposure were ‘milk/dairy drinks’ and ‘cereals’. An exception was the Spain-enKid study, in which food group ‘foods special dietary uses’ was the most important source of exposure.

Other important sources of exposure were food groups ‘chocolate (products)’, ‘vegetables’, and ‘composed foods cereal’ (Table 3). In the UB concentration scenario, the two food groups ‘milk/dairy drinks’ and ‘cereals’ contributed most to the exposure in all countries, including Spain-enKid study (Table 3).

3.1.2. Long-term exposure for age range of 11 to 14 years

The percentiles of long-term dietary exposure to chromium in children aged 11 to 14 years are listed in Table 4 for both concentration scenarios. In this age group, the P99 of exposure ranged from 2.3 µg/kg bw per day in 14-year olds from Cyprus to 4.5 µg/kg bw per day in 11-year olds from the Czech Republic for the LB concentration scenario. Corresponding levels for the UB concentration scenario were 3.0 µg/kg bw per day in 14-year olds from, again, Cyprus and 6.4 µg/kg bw per day in 11-year olds from, again, the Czech Republic.

The contribution of the three most important food groups to the long-term exposure is listed in Table 5 for all countries and both concentration scenarios. As in younger children, also in the older children food groups ‘milk/dairy drinks’ and ‘cereals’ contributed most in all countries, except for the Spain-enKid study where again the food group ‘foods special dietary uses’ contributed most to the exposure. In the UB concentration scenario, the same food groups appeared as in the LB concentration scenario (Table 5).

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Table 2. Percentiles of long-term dietary exposure to chromium in children aged 1 to 10 years living in different European countries(a)

	Age (years) and exposure (µg/kg bw per day)																			
	Mean LB concentrations										Mean UB concentrations									
Country	1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6	7	8	9	10
P50 of exposure																				
Belgium		4.9	4.4	3.9	3.4	3.1						6.6	5.9	5.3	4.7	4.2				
Czech Republic				3.1	2.9	2.6	2.4	2.2	2.0	1.9				4.6	4.2	3.9	3.6	3.3	3.0	2.8
Denmark				3.4	3.3	3.2	3.0	2.7	2.4	2.2				4.9	4.7	4.4	4.2	3.9	3.5	3.1
Finland-DIPP(b,c)	4.3	4.2	4.0	3.9	3.7	3.6					6.3	6.1	5.8	5.6	5.4	5.1				
Finland-STRIP(d)							3.1	3.1									4.2	4.2		
France			3.7	3.3	3.1	2.8	2.6	2.4	2.2	2.0			5.1	4.7	4.3	3.9	3.6	3.3	3.0	2.8
Germany-2008(b)	4.8	4.1	3.4	2.9	2.6	2.3	2.1	2.0	1.9	1.8	7.0	6.1	4.7	3.8	3.5	3.3	3.1	2.9	2.7	2.6
Germany-2007(b)	5.0	4.1	3.5	3.0	2.7	2.4	2.2	2.1	2.0	1.9	6.9	5.8	4.9	4.2	3.8	3.4	3.2	3.0	2.8	2.7
Germany-2006(b)	4.5	3.8	3.2	2.8	2.5	2.3	2.2	2.1	2.0	1.9	6.3	5.3	4.5	4.0	3.6	3.3	3.1	3.0	2.8	2.7
Greece				3.1	2.8	2.6								4.0	3.7	3.4				
Italy	4.1	3.8	3.4	3.1	2.9	2.6	2.4	2.2	2.0	1.8	5.6	5.1	4.7	4.3	3.9	3.6	3.3	3.0	2.7	2.5
Netherlands		4.0	3.6	3.4	3.1	2.8						5.6	5.2	4.7	4.3	4.0				
Spain-Basque				3.7	3.4	3.1	2.8	2.6	2.3	2.1				5.1	4.6	4.2	3.8	3.5	3.2	2.9
Spain-enKid(b)	5.1	4.6	4.2	3.8	3.4	3.1	2.8	2.5	2.3	2.1	7.0	6.3	5.7	5.2	4.7	4.2	3.8	3.5	3.1	2.8
Sweden(b)			4.0	3.8	3.5	3.2	2.9	2.6	2.3	2.0			5.5	5.3	4.9	4.3	3.9	3.7	3.3	2.6
P95 of exposure																				
Belgium		7.6	6.7	6.0	5.3	4.7						9.9	8.9	7.9	7.1	6.3				
Czech Republic				4.9	4.5	4.1	3.8	3.4	3.2	2.9				7.1	6.5	6.0	5.5	5.1	4.7	4.3
Denmark(b)				5.4	5.3	5.0	4.7	4.3	3.9	3.4				7.5	7.3	6.9	6.5	6.0	5.4	4.8
Finland-DIPP(b,c)	9.2	8.8	8.5	8.2	7.9	7.6					13	12	12	11	11	10				
Finland-STRIP(d)							4.4	4.4									5.9	5.9		
France			6.1	5.6	5.1	4.7	4.3	4.0	3.7	3.4			8.2	7.5	6.9	6.3	5.8	5.3	4.9	4.4
Germany-2008(b)	9.9	8.3	7.0	6.0	5.3	4.8	4.4	4.1	3.8	3.6	14	12	9.3	7.6	6.9	6.6	6.2	5.7	5.4	5.2
Germany-2007(b)	11	9.4	7.9	6.8	6.1	5.5	5.1	4.8	4.5	4.2	16	13	11	9.5	8.6	7.8	7.2	6.8	6.4	6.0
Germany-2006(b)	9.3	7.8	6.6	5.8	5.2	4.8	4.5	4.3	4.1	4.0	13	11	9.3	8.1	7.3	6.8	6.4	6.1	5.8	5.6
Greece				4.9	4.5	4.1								6.4	5.8	5.4				
Italy	6.7	6.1	5.6	5.1	4.7	4.2	3.9	3.5	3.2	3.0	9.0	8.3	7.5	6.9	6.3	5.8	5.3	4.8	4.4	4.0
Netherlands		6.0	5.4	5.0	4.6	4.2						8.1	7.9	7.3	6.7	6.2				
Spain-Basque				5.2	4.8	4.4	4.0	3.6	3.3	3.0				7.1	6.4	5.8	5.3	4.8	4.4	4.0

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	Age (years) and exposure (μg/kg bw per day)																			
	Mean LB concentrations										Mean UB concentrations									
Country	1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6	7	8	9	10
Spain-enKid[b]	8.2	7.4	6.7	6.1	5.5	5.0	4.5	4.1	3.7	3.4	11	10	9.0	8.1	7.3	6.7	6.0	5.4	4.9	4.4
Sweden[b]			6.3	5.9	5.5	5.0	4.6	4.1	3.6	3.1			8.4	8.1	7.4	6.6	6.0	5.6	5.1	3.9
P99 of exposure																				
Belgium		9.0	8.1	7.1	6.4	5.7						12	11	9.4	4.4	7.4				
Czech Republic				5.9	5.4	4.9	4.5	4.1	3.8	3.4				8.4	7.8	7.1	6.6	6.1	5.6	5.1
Denmark				6.6	6.4	6.1	5.7	5.2	4.7	4.2				9.1	8.7	8.3	7.8	7.2	6.5	5.7
Finland-DIPP[b,c]	13	12	12	11	11	10					18	17	16	15	15	14				
Finland-STRIP[d]							5.1	5.2									6.8	6.8		
France			7.4	6.9	6.3	5.8	5.3	4.9	4.4	4.1			10	9.2	8.4	7.8	7.1	6.6	6.0	5.5
Germany-2008[b]	13	11	9.4	8.1	7.1	6.4	5.9	5.4	5.1	4.9	18	16	12	10	9.3	8.7	8.2	7.5	7.2	6.9
Germany-2007[b]	16	13	11	9.4	8.4	7.8	7.2	6.7	6.3	6.0	22	18	15	13	12	11	10	9.5	8.9	8.4
Germany-2006[b]	13	11	9.0	7.9	7.0	6.4	6.1	5.9	5.6	5.4	17	15	13	11	9.8	9.1	8.6	8.1	7.9	7.6
Greece				5.9	5.5	5.0								7.6	7.0	6.4				
Italy	8.2	7.5	6.8	6.2	5.7	5.2	4.7	4.3	3.9	3.6	11	10	9.1	8.4	7.7	7.0	6.4	5.9	5.4	4.9
Netherlands		7.0	6.4	5.9	5.4	5.0						9.4	8.6	8.0	7.3	6.7				
Spain-Basque				6.1	5.5	5.0	4.6	4.2	3.8	3.5				8.1	7.3	6.7	6.1	5.6	5.0	4.6
Spain-enKid[b]	10	9.0	8.2	7.4	6.7	6.1	5.5	5.0	4.5	4.1	13	12	11	9.8	8.8	8.0	7.2	6.6	5.9	5.3
Sweden[b]			7.6	7.1	6.6	6.1	5.5	4.9	4.4	3.8			10	9.6	8.8	7.8	7.1	6.7	6.0	4.7

[a] Following two scenarios of assigning chromium concentrations to non-detect samples (LB: lower bound; UB: upper bound). Exposures were calculated using the statistical model betabinomial-normal (BBN)

[b] Daily exposure distributions for both the LB and UB concentration scenario were not transformed to normality in a satisfactory way. Exposure results may therefore be not correct.

[c] The exposure for ages not present in the consumption databases of Finland (DIPP study) and Sweden were estimated by interpolation.

[d] Chromium intake was not a function of age at *p*-level 0.05.

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Table 3. Contribution of the different food groups(a) to the long-term exposure to chromium in children within the age range of 1 to 10 years living in different European countries(b)

Country/age range (years)	Top 3 food groups contributing most to the dietary exposure to chromium per scenario					
	Mean LB concentrations			Mean UB concentrations		
	1	2	3	1	2	3
Belgium 2-6	Milk/dairy drink 36%	Cereals 19%	Vegetables 7%	Milk/dairy drink 32%	Cereals 18%	Vegetables 8%
Czech Republic 4-10	Cereals 26%	Milk/dairy drink 22%	Chocolate (product) 8%	Cereals 23%	Milk/dairy drink 18%	Vegetables 9%
Denmark 4-10	Milk/dairy drink 38%	Cereals 21%	Vegetables 8%	Milk/dairy drink 32%	Cereals 20%	Vegetables 9%
Finland-DIPP(c) 1-6	Milk/dairy drink 43%	Cereals 11%	Vegetables 11%	Milk/dairy drink 36%	Vegetables 12%	Cereals 10%
Finland-STRIP 7-8	Milk/dairy drink 35%	Cereals 25%	Composed food cereal 6%	Milk/dairy drink 31%	Cereals 24%	Dairy based product 8%
France 3-10	Milk/dairy drink 24%	Cereals 23%	Chocolate (product) 8%	Cereals 22%	Milk/dairy drink 21%	Dairy based product 10%
Germany-2008(c) 1-10	Milk/dairy drink 29%	Cereals 23%	Vegetables 7%	Milk/dairy drink 25%	Cereals 21%	Vegetables 8%
Germany-2007(c) 1-10	Milk/dairy drink 32%	Cereals 22%	Vegetables 7%	Milk/dairy drink 27%	Cereals 20%	Vegetables 8%
Germany-2006(c) 1-10	Milk/dairy drink 27%	Cereals 22%	Infant formulae 9%	Milk/dairy drinks23%	Cereals 21%	Infant formulae 8%
Greece 4-6	Milk/dairy drink 30%	Cereals22%	Composed food cereal 8%	Milk/dairy drink 28%	Cereals 22%	Vegetables 7%
Italy 1-10	Cereals 29%	Milk/dairy drink 25%	Vegetables 8%	Cereals 28%	Milk/dairy drink 22%	Vegetables 10%
Netherlands 2-6	Milk/dairy drink 37%	Cereals 19%	Chocolate (product) 8%	Milk/dairy drink 33%	Cereals 18%	Chocolate (product) 7%
Spain-Basque 4-10	Milk/dairy drink 35%	Cereals 21%	Chocolate (product) 7%	Milk/dairy drink 31%	Cereals 21%	Dairy based product 8%
Spain-enKid(c) 1-10	Food special dietary use 26%	Milk/dairy drink 26%	Cereals 13%	Milk/dairy drink 24%	Food special dietary use 21%	Cereals 14%
Sweden (3-10)	Milk/dairy drink 32%	Cereals 20%	Composed food cereal 12%	Milk/dairy drink 28%	Cereals 18%	Composed food cereal 9%

(a) For a more elaborate description of (some of) the food groups see Table 1.

(b) Following two scenarios of assigning lead concentrations to non-detect samples (LB: lower bound; UB: upper bound). Contributions were calculated with the statistical model betabinomial-normal (BBN)

(c) Daily exposure distributions for both the LB and UB concentration scenario were not transformed to normality in a satisfactory way. Contribution may therefore not be correct.

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Table 4. Percentiles of long-term dietary exposure to chromium in children aged 11 to 14 years living in three European countries(a)

Country	Age (years) and exposure (µg/kg bw per day)							
	Mean LB concentrations				Mean UB concentrations			
	11	12	13	14	11	12	13	14
P50 of exposure								
Cyprus	1.5	1.3	1.2	1.2	1.9	1.8	1.6	1.5
Czech Republic(b)	1.8	1.6	1.5	1.4	2.7	2.5	2.3	2.1
Spain-Basque	1.9	1.8	1.6	1.5	2.5	2.4	2.3	2.1
Spain-enKid(b)	1.9	1.8	1.6	1.5	2.6	2.4	2.2	2.1
Sweden(a)	1.9	1.6	1.3		2.6	2.2	1.9	
P95 of exposure								
Cyprus	2.4	2.2	2.0	1.9	3.1	2.9	2.7	2.5
Czech Republic(b)	3.4	3.1	2.8	2.6	5.0	4.5	4.2	3.8
Spain-Basque	2.8	2.6	2.5	2.3	3.7	3.5	3.3	3.1
Spain-enKid(b)	3.2	3.0	2.7	2.5	4.3	4.0	3.7	3.4
Sweden(b)	3.3	2.8	2.4		4.5	3.9	3.3	
P99 of exposure								
Cyprus	2.9	2.7	2.5	2.3	3.8	3.5	3.3	3.0
Czech Republic(b)	4.5	4.1	3.7	3.4	6.4	5.8	5.4	4.9
Spain-Basque	3.3	3.1	2.9	2.7	4.3	4.1	3.9	3.6
Spain-enKid(b)	4.0	3.7	3.4	3.1	5.3	4.9	4.6	4.2
Sweden	4.3	3.6	3.0		5.7	4.9	4.1	

(a) Following two scenarios of assigning chromium concentrations to non-detect samples (LB: lower bound; UB: upper bound). Exposures were calculated with the statistical model betabinomial-normal (BBN)

(b) Daily exposure distributions for both concentration scenarios were not transformed to normality in a satisfactory way. Exposure results may therefore not be correct.

3.1.3. Transformation to normality

An important prerequisite to use the BBN model to assess the long-term exposure using food consumption data collected during a limited number of days, is that the daily exposure distribution is transformed into a normal distribution (see Boon et al (2010) for more details). This can be checked using the normal quantile-quantile (q-q) plot, a graphical method to compare two probability distributions by plotting their quantiles against each other (de Boer et al., 2009), incorporated in MCRA for this purpose.

Based on the q-q plot, the transformed exposure data for the age group 1 to 10 years could be considered reasonably normal for both concentration scenarios for the majority of databases except for Finland (DIPP study), Germany (all three years) and Spain (enKid study). For these countries we expect the BBN model to give no adequate exposure assessment. For the 11 to 14 year-olds the data from Cyprus, Spain (Basque study) and Sweden met the assumption of normality. In all cases where the assumption of normality was violated, the q-q plot deviated from the straight line in the right tail of the distribution (as e.g. shown in the right panel of Figure 1 in Boon et al., 2010).

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Table 5. Contribution of the different food groups[(a)] to the long-term exposure to chromium in children in the age of 11 to 14 years living in different European countries[(b)]

Country / age range (years)	Top 3 food groups contributing most to the dietary exposure to chromium					
	Lower bound scenario			Upper bound scenario		
	1	2	3	1	2	3
Cyprus 11-14	Milk/dairy drinks 28%	Cereals 25%	Vegetables 9%	Milk/dairy drinks 25%	Cereals 25%	Vegetables 11%
Czech Republic[(c)] 11-14	Cereals 30%	Milk/dairy drinks 18%	Vegetables 10%	Cereals 26%	Milk/dairy drinks 14%	Vegetables 10%
Spain-Basque 11-14	Milk/dairy drinks 29%	Cereals 24%	Chocolate (products) 7%	Milk/dairy drinks 25%	Cereals 23%	Dairy based products 7%
Spain-enKid[(c)] 11-14	Foods special dietary use 34%	Milk/dairy drinks 18%	Cereals 17%	Foods special dietary use 27%	Cereals 18%	Milk/dairy drinks 18%
Sweden 11-13	Milk/dairy drinks 32%	Cereals 21%	Composed foods cereal 8%	Milk/dairy drinks 28%	Cereals 20%	Soft drinks/ edible ices 9%

(a) For a more elaborate description of (some of) the food groups see Table 1.
b) For two scenarios (lower and upper bound) of assigning chromium concentrations to non-detect samples. Contributions were calculated with the statistical model betabinomial-normal (BBN)
(c) Daily exposure distribution for both concentration scenarios were not transformed to normality in a satisfactory way. Contributions may therefore not be correct.

3.2. Long-term dietary exposure to chromium using the OIM approach

In Table 6, the estimated long-term dietary exposure to chromium in children covering the age ranges of 1 to 2, 3 to 10 and 11 to 14 years in the different countries are listed for the LB and UB concentration scenarios. These exposures were calculated using the OIM approach (Boon et al., 2010). As in the BBN approach, the exposure to chromium was highest in the youngest age group and decreased with age. In the LB concentration scenario, the P99 of exposure for 1- to 2-year olds ranged from 7.1 µg/kg bw per day in Italy to 30 µg/kg bw per day in Germany (2007 study). For 3 to 10 year-olds, exposure levels were 5.2 µg/kg bw per day in Finland (STRIP study) and Spain (Basque study), and 23 µg/kg bw per day in Spain (enKid study); and for 11 to 14 year-olds 2.9 µg/kg bw per day in Cyprus and 11 µg/kg bw per day in Spain (enKid study). P99 levels of exposure calculated using mean UB concentrations were on average a factor 1.3 higher, as was also the case using the BBN model (Table 2). Table 7 lists for each country the three food groups contributing most to the long-term exposure distribution of chromium for the three age groups and the LB concentration scenario. As with the BBN model, the food groups contributing most to the exposure were ‘milk/dairy drinks’ and ‘cereals’. For Spain (enKid study) the food group ‘foods special dietary uses’ emerged as the most important source of exposure in the age groups 3-10 and 11-14 years (Table 7). Other important food groups (with a contribution to the exposure of more than 10%) were ‘vegetables’ (Italy), ‘infant formulae’ (Germany), and ‘composed foods cereal’ (Sweden). In the UB scenario, the same food groups as in the LB concentration scenario proved to be the most important (Table 8).

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Table 6. Percentiles of long-term dietary exposure to chromium in children in the age classes 1 to 2, 3 to 10 and 11 to 14 years living in different European countries (a)

	Age range (years) and exposure (µg/kg bw per day)					
	Mean LB concentrations			Mean UB concentrations		
Country	1-2	3-10	11-14	1-2	3-10	11-14
P50 of exposure						
Belgium	5.9	3.8		6.4	5.2	
Cyprus			1.3			1.7
Czech Republic		2.3	1.6		3.4	2.3
Denmark		2.8			4.0	
Finland-DIPP	4.4	3.9		6.4	5.6	
Finland-STRIP		3.2			4.3	
France		2.6			3.6	
Germany-2008	3.5	2.5		4.9	3.6	
Germany-2007	3.4	2.4		4.6	3.5	
Germany-2006	3.3	2.5		4.7	3.5	
Greece		2.9			3.8	
Italy	4.1	2.4		5.6	3.2	
Netherlands	4.0	3.2		5.6	4.5	
Spain-Basque		2.7	1.7		3.8	2.3
Spain-enKid	3.6	2.8	1.5	5.4	3.8	2.1
Sweden		3.0	1.8		4.2	2.5
P95 of exposure						
Belgium	6.3	6.0		8.1	8.0	
Cyprus			2.2			2.9
Czech Republic	-	4.2	3.3		6.2	4.8
Denmark	-	4.7			6.5	
Finland-DIPP	10	6.9		15	9.7	
Finland-STRIP		4.5			5.8	
France		4.4			6.0	
Germany-2008	17	4.2		23	6.0	
Germany-2007	19	5.8		26	7.8	
Germany-2006	17	4.2		23	5.7	
Greece	-	4.6			5.9	
Italy	6.4	4.3		8.7	5.8	
Netherlands	6.4	5.1		8.7	6.9	
Spain-Basque		4.3	2.6		5.8	3.5
Spain-enKid	6.9	5.2	2.7	9.2	6.7	3.8
Sweden		5.1	3.1		6.9	4.2
P99 of exposure						
Belgium	9.2	7.4		12	9.9	
Cyprus			2.9			3.8
Czech Republic		5.5	3.7		8.1	5.7
Denmark		6.1			8.3	
Finland-DIPP	15	15		20	21	
Finland-STRIP		5.2			7.3	
France		6.1			7.9	
Germany-2008	22	6.8		28	9.3	
Germany-2007	30	14		42	18	
Germany-2006	18	11		25	15	
Greece		5.5			7.0	
Italy	7.1	7.4		9.2	7.8	

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Country	Age range (years) and exposure (µg/kg bw per day)					
	Mean LB concentrations			Mean UB concentrations		
	1-2	3-10	11-14	1-2	3-10	11-14
Netherlands	8.3	6.6		10	11	
Spain-Basque		5.2	3.3		6.9	4.2
Spain-enKid	7.4	23	11	9.6	25	12
Sweden		6.4	3.6		8.5	4.8

(a) Following two scenarios of assigning chromium concentrations to non-detect samples (lower and upper bound). Exposures were calculated using the deterministic OIM approach.(OIM = observed individual means).

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Table 7. **Contribution of the different food groups[a] to the long-term exposure to chromium for the lower bound concentration scenario of assigning chromium concentrations to non-detect samples [b]**

	Top 3[c] food groups contributing most to the dietary exposure to chromium								
	1-2 years			3-10 years			11-14 years		
Country	1	2	3	1	2	3	1	2	3
Belgium	Milk/dairy drinks 35%	Cereals 17%	Chocolate (products) 8%	Milk/dairy drinks 36%	Cereals 19%	Vegetables 7%			
Cyprus							Milk/dairy drinks 28%	Cereals 25%	Vegetables 9%
Czech Republic				Cereals 26%	Milk/dairy drinks 22%	Chocolate (products) 8%	Cereals 30%	Milk/dairy drinks 18%	Vegetables 10%
Denmark				Milk/dairy drinks 38%	Cereals 21%	Vegetables 8%			
Finland-DIPP	Milk/dairy drinks 42%	Vegetables 14%	Cereals 11%	Milk/dairy drinks 44%	Cereals 12%	Vegetables 9%			
Finland-STRIP				Milk/dairy drinks 35%	Cereals 12%	Composed foods cereal 6%			
France				Milk/dairy drinks 24%	Cereals 23%	Chocolate (products) 8%			
Germany-2008	Milk/dairy drinks 35%	Cereals 18%	Infant formulae 14%	Cereals 27%	Milk/dairy drinks 24%	Chocolate (products) 9%			
Germany-2007	Milk/dairy drinks 38%	Cereals 18%	Infant formulae 12%	Milk/dairy drinks 27%	Cereals 24%	Chocolate (products) 9%			
Germany-2006	Milk/dairy drinks 31%	Cereals 19%	Infant formulae 18%	Cereals 25%	Milk/dairy drinks 24%	Chocolate (products) 9%			
Greece				Milk/dairy drinks 30%	Cereals 22%	Composed foods cereal 8%			

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Country	Top 3[c] food groups contributing most to the dietary exposure to chromium								
	1-2 years			3-10 years			11-14 years		
	1	2	3	1	2	3	1	2	3
Italy	Milk/dairy drinks 37%	Cereals 23%	Vegetables 5%	Cereals 31%	Milk/dairy drinks 22%	Vegetables 9%			
Netherlands	Milk/dairy drinks 39%	Cereals 18%	Chocolate (products) 7%	Milk/dairy drinks 36%	Cereals 20%	Chocolate (products) 9%			
Spain-Basque				Milk/dairy drinks 34%	Cereals 21%	Chocolate (products) 6%	Milk/dairy drinks 28%	Cereals 23%	Chocolate (products) 7%
Spain-enKid	Milk/dairy drinks 41%	Cereals 11%	Miscellaneous 6%	Foods special dietary uses 29%	Milk/dairy drinks 24%	Cereals 14%	Foods special dietary uses 29%	Milk/dairy drinks 18%	Cereals 17%
Sweden				Milk/dairy drinks 32%	Cereals 20%	Composed foods cereal 12%	Milk/dairy drinks 32%	Cereals 21%	Composed foods cereal 8%

(a) For a more elaborate description of (some of) the food groups see Table 1.
(b) Contributions were calculated for three different age groups using the OIM approach (OIM = observed individual means)
(c) Top 3 of food groups included for all countries the food groups that contributed more than 10% to the total long-term exposure.

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Table 8. **Contribution of the different food groups[(a)] to the long-term exposure to chromium for the upper bound concentration scenario of assigning chromium concentrations to non-detect samples [(b)]**

	Top 3[(c)] food groups contributing most to the dietary exposure to chromium per age class								
	1-2 years			3-10 years			11-14 years		
Country	1	2	3	1	2	3	1	2	3
Belgium	Milk/dairy drinks 35%	Cereals 17%	Vegetables 10%	Milk/dairy drinks 32%	Cereals 18%	Vegetables 8%			
Cyprus							Milk/dairy drinks 25%	Cereals 25%	Vegetables 11%
Czech Republic				Cereals 23%	Milk/dairy drinks 18%	Vegetables 9%	Cereals 26%	Milk/dairy drinks 14%	Vegetables 10%
Denmark				Milk/dairy drinks 32%	Cereals 20%	Vegetables 9%			
Finland-DIPP	Milk/dairy drinks 35%	Vegetables 15%	Dairy based products 10%	Milk/dairy drinks 37%	Cereals 11%	Vegetables 10%			
Finland-STRIP				Milk/dairy drinks 31%	Cereals 24%	Dairy based products 8%			
France				Cereals 22%	Milk/dairy drinks 21%	Dairy based products 10%			
Germany-2008	Milk/dairy drinks 31%	Cereals 17%	Infant formulae 14%	Cereals 24%	Milk/dairy drinks 20%	Dairy based products 8%			
Germany-2007	Milk/dairy drinks 33%	Cereals 18%	Infant formulae 12%	Milk/dairy drinks 23%	Cereals 23%	Dairy based products 8%			
Germany-2006	Milk/dairy drinks 27%	Infant formulae 17%	Cereals 17%	Cereals 23%	Milk/dairy drinks 20%	Dairy based products 8%			
Greece				Milk/dairy drinks 28%	Cereals 22%	Vegetables 7%			

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Country	Top 3[c] food groups contributing most to the dietary exposure to chromium per age class								
	1-2 years			3-10 years			11-14 years		
	1	2	3	1	2	3	1	2	3
Italy	Milk/dairy drinks 33%	Cereals 22%	Fruit 6%	Cereals 29%	Milk/dairy drinks 19%	Vegetables 10%			
Netherlands	Milk/dairy drinks 34%	Cereals 17%	Dairy based products 9%	Milk/dairy drinks 31%	Cereals 18%	Dairy based products 9%			
Spain-Basque				Milk/dairy drinks 30%	Cereals 20%	Dairy based products 8%	Milk/dairy drinks 25%	Cereals 22%	Dairy based products 6%
Spain-enKid	Milk/dairy drinks 36%	Cereals 11%	Dairy based products 10%	Foods special dietary uses 23%	Milk/dairy drinks 23%	Cereals 14%	Foods special dietary uses 27%	Cereals 18%	Milk/dairy products 17%
Sweden				Milk/dairy drinks 28%	Cereals 18%	Composed foods cereal 9%	Milk/dairy drinks 28%	Cereals 20%	Soft drinks/ edible ices 9%

(a) For a more elaborate description of (some of) the food groups see Table 1.
(b) Contributions were calculated for three different age groups using the OIM approach (OIM = observed individual means)
(c) Top 3 of food groups included for all countries the food groups that contributed more than 10% to the total long-term exposure.

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4. Discussion

In this document, we report on the long-term dietary exposure to chromium in children aged 1 to 14 years living in 12 different European countries. For this we used national/regional individual food consumption data collected among children during at least two days using either the 24-h recall method or the dietary record method. We addressed children because they are known to have a higher exposure level than adults given their higher consumption levels per kg body weight. Furthermore there are few data published in children. Chromium concentrations were obtained from EFSA and were used to assess the country-specific exposure.

The dietary exposure to chromium was calculated in a harmonised way and the exposure results presented in this report can thus be regarded as an important step forward in harmonising exposure calculations within Europe. However, as discussed in a recent report on the exposure to lead (Boon et al., 2010), there are different methodological issues related to an exposure study addressing different national food consumption databases and one “European” chemical concentration database. Since this discussion is also applicable to the study described in this report, we refer to this report for an elaborate discussion on this. Here we only highlight the most important aspects to be considered in the framework of the results presented in this report.

To link the consumption data with the chromium concentration data, 42 communal food groups were used. These food groups were very diverse, for example food group ‘vegetables’ contained all types of raw and processed vegetables, including potatoes. Assigning one mean chromium concentration to all foods belonging to a food group very likely affected the exposure. Linking food consumption and concentration data is a very crucial step in dietary exposure assessments.

In this project, 14 different food consumption databases were used. These databases were collected using different dietary assessment methods and cover different age ranges. Another important difference between the surveys is the way in which the primary dietary information was aggregated in food items and food (sub) groups, which resulted in differences in assigning consumed foods to the 42 communal food groups. Due to these differences it is difficult to compare the food consumption data and the resulting exposure levels between countries.

4.1. Chromium concentration data

A careful evaluation of the exposure assessment includes a critical examination of the concentration data. Concentration data were supplied by EFSA that received the chromium occurrence data from six Member States. Of these data 69% was submitted by Germany, followed by Ireland (10%), Cyprus (9%) and France (6%). The concentration data used for this exposure assessment did therefore not cover all European countries involved in the present study. No information is currently available about possible differences in chromium concentrations in food items in different European countries. It is therefore, not possible to assess how representative these data are to assess the chromium intake at a national level for the 14 different European countries. Another important factor affecting the representativity of the concentration data is how well the commodities analysed covered the foods that are expected to contain chromium. No information was available on this.

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Other factors to be considered to evaluate the reliability of exposure assessments produced using the concentration data from this assessment are:

- The grouping of the analysed commodities in the different food groups in relation to the grouping of the consumed foods.
- The effect of differences in LODs/LOQs/LOR between the data suppliers on the exposure results.
- The effect of the valence state of chromium as analysed in the food to establish population risk. Chromium is a beneficial nutrient involved in sugar and fat metabolism. Normal dietary intake of chromium for humans might be suboptimal according to Anderson (1997). However, it is known that chromium is rather toxic in valence state IV and not in state III (Mertz, 1998). Valence state information was not available for the evaluation.

In summary, the exposure results presented in this report should be interpreted with caution and do not necessarily represent the intake of chromium at the national level.

4.2. Long-term exposure to chromium

Exposure to chromium was calculated using national/regional food consumption databases and one ‘European’ chromium concentration database. Because of this, differences in exposure between countries were due to differences in consumption data, including real national differences in consumption patterns, but also partly due to methodological differences, differences in age ranges covered in these studies, and differences in the level of detail with which the food consumption data were collected. This last difference affected the categorisation of foods consumed in the different food categories and thus the resulting exposure levels. Due to all of this, it is difficult to compare the exposures between countries.

Generally however we can conclude from the results that the exposure to chromium was highest in the youngest children and decreased with age. Countries with the highest exposure levels were Germany and Finland. Furthermore, the main sources of exposure were, for almost all countries, the food groups ‘milk/dairy drinks’ and ‘cereals’. This was not due to high levels of chromium present in these food groups, but due to high levels of consumption of these food groups in children living in Europe.

It is known that cereals (whole grain products, such as whole grain bread and miscellaneous cereals) are an important source of exposure to chromium together with meat, pulses and spices (NIH, 2005). In our survey also ‘milk/dairy drinks’ emerged as one of the most important sources of exposure to chromium, which was unanticipated since chromium levels are normally low in this product category (Cocho et al., 1992). However, due to a high level of consumption of ‘milk/dairy drinks’ by children, this food group became an important source of exposure to chromium.

In the Spain enKid study, the food group ‘foods special dietary uses’ was an important source of exposure, due to a high concentration of chromium assigned to this food group (Table 1) and a high mean consumption level among Spanish consumers (115 g/d). In the total survey however, only two children up to age 10 consumed foods belonging to this food group. Their chromium intake levels were much higher than those of children not consuming foods belonging to this food group (Figure 1). Removing these two children from the analysis, the

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P99 of chromium exposure decreased for this age group by 10% in both concentration scenarios, using the BBN model. The food group 'milk/dairy drinks' became in both cases the food group contributing most (35% LB; 31% UB) to the exposure, followed by 'cereals' (19% LB; 17 UB). These contributions were in line with those of the other countries. These analyses without the two children consuming foods belonging to the food group 'foods special dietary uses' are presented to show the effect of a few very high exposure results on the exposure assessment. Whether removal of these exposure results from the analysis is an option depends on whether these exposure results may be wrong or not representative of the population studied.

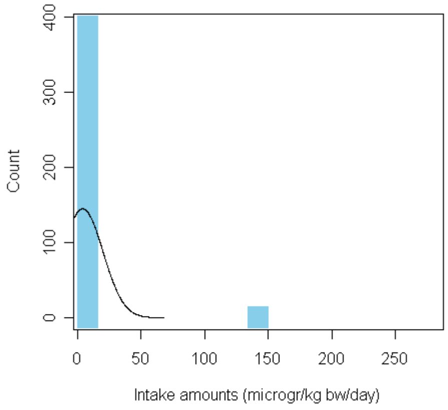

Figure 1. Distribution of positive intake amounts of chromium of children aged 1 to 10 years in the Spain enKid-study. All children had a positive intake of chromium.

In this exposure assessment, we did not include the intake of chromium via food supplements. Chromium is a widely used supplement[6] and therefore the intake may have been underestimated. In a number of databases, such as the Italian, intake of food supplements was included. To estimate the effect of not including food supplements in the assessment, we calculated the exposure to chromium for 1 to 10 year-olds living in Italy using a mean chromium concentration level of 25.2 mg/kg, as supplied by EFSA for both concentration scenarios. The mean consumption of food supplements in this age group was 0.30 g/d, and consumption of food supplements occurred on 4.4% (= 33 days) of all possible consumption days (= 756 days). The P99 of long-term exposure to chromium increased, on average, by 29% (range of 38% in 1 year-olds to 20% in 10 year-olds) in the LB concentration scenario and 22% (range of 28% in 1 year-olds to 15% in 10 year-olds) in the UB concentration scenario. How large the real underestimation in dietary exposure will be depends, among others, on whether the food supplements ingested contain chromium. In this example, we assumed that all supplements contained chromium, but in reality this may not be the case. A quick look at food supplements available in Italy highlighted the presence of chromium(III) picolinate in food supplements to promote weight loss. These supplements were not present in the food list used in the present study in children. Furthermore, inclusion of children consuming food supplements in the exposure calculations resulted in the introduction of relatively high intake levels (so-called outliers) in the exposure distribution. Due to this, the distribution became skewed, making the use of the BBN approach to assess the long-term exposure no longer feasible (Figure 2).

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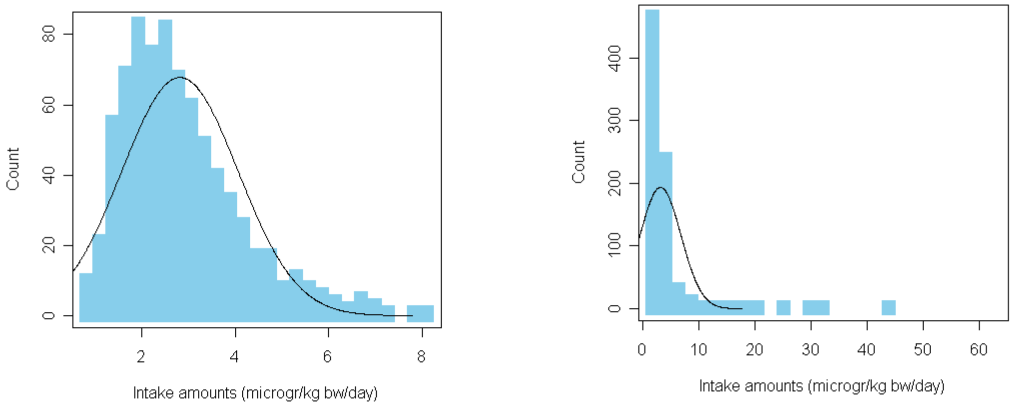

Figure 2. Distribution of positive intake amounts of chromium of children aged 1 to 10 years living in Italy. In the left panel the intake was estimated without, and in the right panel with food supplements included in the assessment. All children had a positive intake of chromium.

4.3. Dietary exposure assessment

We used two approaches to calculate the long-term exposure to chromium: the observed individual means (OIM) and the beta-binomial normal (BBN) approach. For a discussion on these approaches see section 4.4 of the lead report (Boon et al., 2010). As for lead, BBN is the preferred method to estimate the long-term exposure to chromium. This model separates the within-person variation from the between-person variation to estimate the exposure. This approach has been proven very useful for the estimation of long-term exposure (Hoffmann et al., 2002; Dodd et al., 2006). Another advantage of the BBN model is that it can model covariates, such as age. This is important when assessing the exposure in children, because it is known that the exposure decreases with age. However, we showed that for some countries BBN could not be used in a satisfactory way, due to lack of normality of the transformed exposure data. In those cases, the exposure results may be wrong. We therefore also used the OIM approach. In this approach, the within-person variation is not dealt with, resulting in more conservative estimates of exposure in the right tail of the exposure distribution compared to models that do, such as BBN.

BBN did not result in an adequate fit of the exposure data of Finland (DIPP study), Germany, and Spain (enKid study) for 1 to 10 year-olds, and those of the Czech Republic and Spain (enKid study) for 11 to 14 year-olds. The reason for this was, in case of Germany and Finland, a mixture distribution with an increase in exposure at the right tail of the exposure distribution (see Figure 2 of Boon et al (2010) for two examples). For the Spain enKid study normality was not reached due to the consumption of foods belonging to the food group ‘foods special dietary uses’ in both age groups, resulting in very high intake levels (Figure 1). Removal of these children from the analysis resulted in a satisfactorily fit of the data in both age groups (Figure 3).

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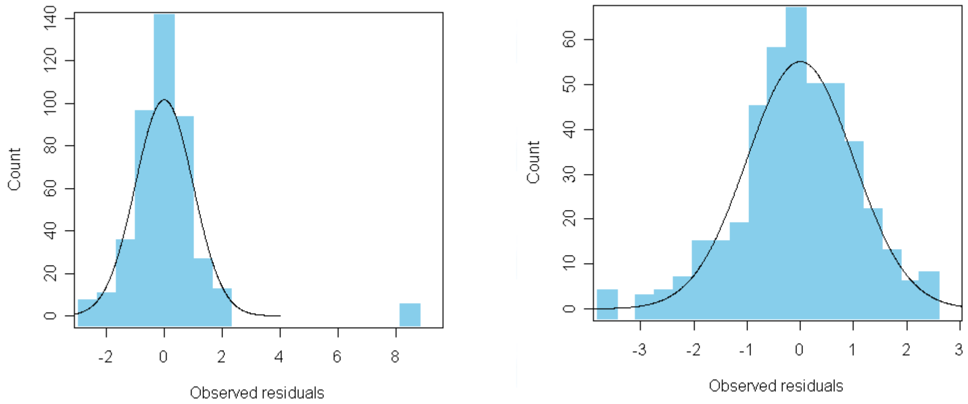

Figure 3. **Distribution of intake amounts of chromium of children aged 1 to 10 years in the Spain enKid study after transformation with (left panel) and without (right panel) the food group 'foods special dietary uses' included in the assessment.**

4.4. Conclusion and recommendations for future analysis

In this study, we calculated the long-term dietary exposure to chromium in children for different European countries and regions using the same chromium concentration data and the same models to assess the exposure. To establish this, the foods recorded in the different surveys were categorised in a harmonised way, so that the consumption data could be linked to the chromium concentration levels. The results showed that the chromium exposure differed between the participating countries as well as between the different age groups, with very likely higher chromium exposures in younger children. Due to lack of a Tolerable Upper Intake Level (UL) for this mineral, it is unclear whether the exposure levels calculated for the different countries pose a possible health risk.

Due to the uncertainties related to the chromium exposure assessment presented here, as well as the exclusion of chromium exposure via food supplements, the exposure results presented in this report should be interpreted with caution and do not necessarily represent the total chromium intake at the national level.

Based on the work performed so far and the restrictions and uncertainties encountered, we recommend to refine the risk assessment of the dietary exposure to chromium in young children in European countries by:

- Gaining insight in the grouping of the analysed commodities in the different food groups, and to improve consequently the linkage between food consumed and those analysed;
- Gaining insight in the representativity (but also the forms of chromium analysed) of the chromium concentration data used in the assessment, since the data available for this assessment were derived from a limited number (six) of Member States, with more than 50% from only one Member State (Germany);
- Developing a long-term model, such as the BBN model, that can deal with non-normally distributed transformed exposure data, including cofactor and covariable analysis.

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6. Glossary / Abbreviations

BBN	Betabinominal-normal
bw	Body weight
EFSA	European Food Safety Authority
LB	Lower bound
LOD	Limit of detection
LOQ	Limit of quantification
LOR	Limit of reporting
MCRA	Monte Carlo Risk Assessment
OIM	Observed individual means
Q-q plot	Quantile-quantile plot
UB	Upper bound
WHO	World Health Organization

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