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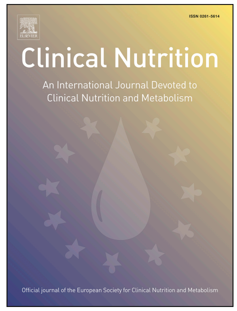

Micronutrient intake adequacy in children from birth to 8 years. Data from the Childhood Obesity Project.

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INTRODUCTION[1]

Although vitamin and mineral deficiencies adversely affect a third of the world's population [1], Europe is considered to be a developed region in which nutrition is assumed to be adequate to satisfy population requirements. However, several national dietary surveys [2] as well as a review performed by Roman-Viñas in 2011 [3] revealed a high prevalence of inadequate micronutrient intake within adults across Europe. Still, few cross-national nutrition surveys focusing on children have been conducted throughout Europe. In 2001, Serra-Majem [4] compiled conclusions from several studies all across European countries in children aged 6 to 18 years, and in 2004, several national nutrition surveys in children aged 1 to 14 years were reviewed by the European Nutrition and Health Report of the European Academy of Nutritional Sciences [5,6]. Both works concluded that children from different countries (Austria, Belgium, Denmark, Finland, Germany, Greece, Hungary, Italy, Norway, Portugal, Spain and United Kingdom) lacked adequate consumption of several micronutrients, most frequently vitamin D, calcium, iron and zinc. Recently, a meta-analysis from Mensink et al. [2] using dietary survey data from Belgium, Denmark, France, Germany, The Netherlands, Poland, Spain and the United Kingdom also found important inadequacies in micronutrients intake in children when assessing them using a single set of dietary recommendations and using a single method to determine the adequacy of intake.

The disparity in methods utilized for assessing the dietary intake of micronutrients and its adequacy as well as the different dietary recommendations utilized by each study [2,4–6] make the assessment of micronutrient intake adequacy across Europe a challenge. In 2000,

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[1] **Abbreviations:** EAR: Estimated Average Requirements, CHOP: EU Childhood Obesity Project, FAO/WHO/UNU EARs: Estimated Average Requirements from the FAO, WHO and United Nations University joint expert consultation, IOM: American Institute of Medicine, IQR: Interquartile range, PA: Probability of Adequate Intake, SD: standard deviation.

the American Institute of Medicine (IOM) published guidelines describing how dietary recommendations should be applied when evaluating the adequacy of micronutrients intake at the individual and population levels [7]. Although many researchers do not follow the IOM guidelines and continue assessing the adequacy of intake by different methods [8], from the literature reviewed, the IOM methodology was the most used to evaluate the adequacy of nutrient intake in Europe [3,9,10]. Additionally, there are no studies available that prospectively collected micronutrient intake data from healthy children from different European countries using the same standardized methodology; and nor has been analyzed the adequacy of intake from all countries together. This type of research has been previously conducted for adolescents from 13 to 16 years of age by the HELENA study, which found consumptions quite under those recommended for vitamin D, folate, iodine and fluoride at those ages [11].

The current evolution in eating habits and the previous findings of deficiency in micronutrient intake in European children justify further exploration of micronutrient adequacy in European children. This paper aims to provide longitudinal prospective high quality information about the adequacy of micronutrient intake in a European cohort of children whose dietary intake was assessed from birth to 8 years of age with standardized dietary assessment methods throughout all the participating countries.

MATERIALS and METHODS

Study design

This study was a prospective observational trial designed to analyze the adequacy of micronutrients in relation to dietary recommendations in a multicenter European sample of children. It was a secondary study analyzing data of the EU Childhood Obesity Project (CHOP), a multicenter, double-blinded, randomized and controlled clinical trial in which 5 European countries (Germany, Belgium, Italy, Poland and Spain) were represented. Healthy term breastfed or formula fed infants were enrolled within the first two months of life, at a mean age of 2 weeks, and were followed regularly until they were 8 years old. More details on CHOP study have been published elsewhere [12].

Study population

All CHOP study participants still taking part in the study and for whom at least one food diary was available between 3 months and eight years of age, were eligible for the assessment of the adequacy of micronutrient intake.

Methods

Dietary intake was recorded by parents or caretakers with 3-day weighted/estimated food records (2 week days + 1 weekend day, consecutive) at 3, 6 and 12 months and at 2, 3, 4, 5, 6 and 8 years of life using food scales (Unica 66006; Soehnle, Murrhardt, Germany) and/or a brief atlas of food pictures to estimate serving portions (self-designed by the CHOP study nutritionists and showed internal validity, data not-published). Nutritionists checked the food diaries through parent's interviews following standard operating procedures [13,14], and converted grams into nutrients with a software specifically developed for the study. This tool contained information from food composition tables and manufacturers from all participating countries. Fortified foods and products were also included in the software but were not identified separately. The standard operating procedures guaranteed uniform interpretation and quantification of food record information and its conversion into nutrients, increasing the quality of the data. We did not consider the consumption of supplements nor medications. Further details on the CHOP study methodology regarding nutritional assessment have been published elsewhere [13,14].

The adequacy of micronutrient intake was assessed with the Estimated Average Requirement (EAR) cut-point method at the group level and with a quantitative evaluation at the individual level, both according to the IOM methodology described in their guidelines [7]. The international Estimated Average Requirements of nutrients developed by the FAO, the WHO and the United Nations University joint experts consultation, i.e., the FAO/WHO/UNU EARs [15] were the most appropriate for comparison of our study sample. When

FAO/WHO/UNU EARs were not available, the EARs were drawn from the IOM (phosphorus, magnesium, iodine and vitamin D) [16–18]. The results of the group assessment were expressed as the prevalence of adequacy, N (%) of participants with intakes over the EAR. A prevalence of adequacy below 80% was considered inadequate in our population, according to the criteria and reasons described by Roman-Viñas et al.[3].

The quantitative evaluation of adequacy at the individual level was only applicable to assess the adequacy of micronutrients that had a normal intake distribution and a coefficient of within-person variation under 70, as bounded in the method guidelines [7]. The results of the individual assessments were shown as the probability of adequate intake (%). The probability of adequate intake (PA) was calculated by converting the ratio obtained through the IOM method (similar to a z-score) into a probability, using the equivalence provided by the standard normal distribution tables, and subtracting that value from 100. A PA over 80% was considered adequate, according to the method and assuming an error of 0.20 [7]. In addition, PA was categorized into high PA (PA>80%), medium PA (PA=50-80%) and low PA (PA<50%), and the prevalence of children in each group was determined for each micronutrient at each time point. A micronutrient was considered to be consumed inadequately in our population when the prevalence of children in the low PA category was over 20% and adequately when children in the high PA category was over 80%. All options in between those were considered uncertain.

As the EAR for zinc was set by kg of weight, weight measurements obtained during the study visits were used to calculate zinc adequacy. Weight was determined at each time point (3, 6 and 12 months and 2, 3, 4, 5, 6 and 8 years of life) with a baby or adult scale (Seca 336 baby scales [precision ±10 g] at ages ≤24 months and Seca 702 scales from >2 years; Seca, Hamburg, Germany) by trained personnel and following the WHO recommendations based on the Lohman reference manual [19]. Weight was expressed in Kg. Not all children participating in the dietary intake information collection attended to all study visits, thus the number of observations for adequacy of zinc intake was somewhat lower than for other nutrients.

Statistical analysis

The descriptive results are expressed as the mean ± standard deviation (SD) or medians with interquartile range (IQR) (25^{th}, 75^{th} percentile) according to the distribution of parameters. The frequency of categorical variables is presented as N (%). IBM SPSS software version 22.0 (IBM Corp., Armonk, NY, USA) was used for statistical analysis.

Ethics

The CHOP study protocol and amendments were designed following the CONSORT Statement (guidelines for clinical trials) and were in agreement with the Declaration of Helsinki. The study protocol and its amendments were submitted and accepted by the Ethics Committees at each of the centers where the study was conducted. All parents or legal representatives of the participating infants received written information and signed an informed consent form before any data were obtained. Additional informed consents were obtained after each new amendment to the original protocol and also from the children at 8 years of age.

RESULTS

The number of children participating in the CHOP study, from recruitment until 8 years of age, as well as a detail of the number of subjects from whom dietary intake information was available at each time point have been described in **Figure 1**. The number of children with dietary intake data available decreased from 904 children at 3 months to 396 at 8 years, with a 13.3% of the children with dietary information available at all time points (3, 6 and 12 months and 2, 3, 4, 5, 6 and 8 years); and 578 children with dietary information available at least at 5 different time points.

General characteristics of the study sample as anthropometric details and macronutrients intake are described in **Table 1** for each time point. Detailed micronutrients intake at each time point is provided as supplementary material (Supplementary material Tables 1 and 2). Gender differences in micronutrient intakes were assessed, and after adjusting by total energy intake, girls showed a higher consumption of zinc and vitamin D at 2 years and higher iodine intake at 3 years of age.

The prevalence of adequate adherence to recommendations at the group level was assessed for calcium, phosphorus, iron, zinc, magnesium and iodine (**Table 2**) as well as for vitamin B_{12}, folate, vitamin A and vitamin D (**Table 3**). The EAR cut-point method analysis showed a mean prevalence of adequacy above 90% of the population for phosphorus, magnesium, vitamin B_{12} and vitamin A; the prevalence was between 80 and 90% for calcium and zinc. The micronutrients with a prevalence of adequacy under 80% of the population were iron, iodine, folate and vitamin D. Vitamin D was the most poorly consumed micronutrient, with only a 1-5% prevalence of adequacy.

As age-specific intake of some micronutrients was severely skewed, probability of adequate intake at individual level (PA) could not be assessed for vitamins A and D, for zinc at 12 months, for iodine at 2 and 4 years and for vitamin B_{12} at 12 months and at 3 and 6 years. **Table 4** shows the mean PA for each micronutrient at each time point. It was high for phosphorus, calcium, magnesium and vitamin B_{12}, medium for iron and zinc, and low for iodine and folate.

After categorizing PA into three groups, we determined that prevalence of low PA for iron, iodine and folate were over 20% at almost all time points and were therefore considered to be consumed inadequately. For phosphorus, magnesium and vitamin B_{12}, almost 80% of the children were classified as having a high PA at almost all time points; thus, the intake of these nutrients was adequate in our population. Calcium and zinc adequacy was variable, as it was adequate at some time points, inadequate at others, and uncertain sometimes, with a prevalence of low PA under 20% and of high PA under 80%; therefore, these micronutrients were not completely inadequately consumed but not adequately consumed either. **Figure 2** shows the prevalence of children in each PA category for each micronutrient at each time point.

DISCUSSION

In the present work, we have described the adequacy of micronutrients intake in a cohort of children from five European countries. The analyses at the group level revealed that children had inadequate intake of iron, iodine, folate and vitamin D. The probability of adequate intake at the individual level provided similar results, showing high risk of inadequate consumption for iron, iodine and folate in this European cohort and mild risk for calcium and zinc. Phosphorus, magnesium and vitamins A and B_{12} were consumed adequately at all the time points.

The assessment of the probability of adequacy at the individual level is considered the most accurate method to assess micronutrient intake adequacy [20]. Although its application is methodologically more complicated than the assessment at group level, the outcome is a continuous probability of adequacy that permits to set the desired cut-point. The assessment at the group level only permits the determination of the number of children with an intake over or under the EAR, so the probability of erroneous conclusion with this method is of 50%. Based on the results, with either one or the other method, concerns arose for iron, calcium, vitamin D, folate, iodine and zinc intakes.

Iron intake was inadequate during most of the study period, with the lowest prevalence of adequacy at 8 years, moment at which the EARs considerably increase.

Calcium intake was adequate during the first year of life, and around the cut-off point during the rest of the study period. Calcium intake began to decrease from 6 months of life, coinciding with the beginning of weaning [21] when milk is progressively substituted by other foods. As calcium is responsible for bone structure, we speculate that a fraction of the CHOP children might be at risk of having poor bone mineralization from 3 years onwards when children may have completed the weaning period and calcium rich sources intake is highly replaced for other food groups.

Vitamin D intake was inadequate in 95% of the children, which is consistent with previous findings in the European population [2]. This is in line with the widespread prevalence of biochemical vitamin D deficiency, which is considered as a re-emerged major health problem worldwide [22]. Although, skin exposure to UVB radiation is the main source of vitamin D for humans [23,24], improving vitamin D intake through diet should be promoted, as for example by the consumption of supplemented milk and dairy products.

At this point, considering that most important sources of iron are meat and animal products, and that most important sources of calcium and vitamin D are milk and dairy; and taking into account that overall protein, vitamin B_{12} and vitamin A (which main sources are milk and animal products as well) have been adequately consumed in our sample, further investigations should clarify the reasons of the proportion of children with iron, calcium and/or vitamin D inadequacies and whether they occur at the same time in the same subjects, as well as their relevance on health.

Folate had a very low prevalence of adequacy, decreasing with age from 40 to 5%. The low proportion of children with folate adequacy was less concerning at 6 months, when intake of vegetables, legumes and supplemented cereals are presumably more easily controlled by parents. At later time points, children's dietary choices may led to a decrease in vegetable and legume consumption and consequently in folate intake.

A third of the world's population is estimated to have a low iodine intake [25], and thus, fortification of food-grade salt with iodine is mandatory in many countries. However, iodine deficiency remains a problem [26], and approximately 50% of the European population is estimate to remain mildly iodine deficient [27]. In our sample, the prevalence of iodine adequacy was 30 to 40%. Although the addition of table salt was not recorded and this prevents us to draw any conclusion, our results showed a mean iodine consumption of 60-70 µg/day, coinciding with the EAR of 65 µg, what allows to speculate that the children with inadequate intake in our sample may have been very close to the cut-point. Indeed, there were no reported cases of goiter or mental growth retardation.

Finally, severe zinc deficiency is uncommon in Europe, but marginal insufficiency is likely to be more prevalent [28], with possible associations to immune system dysfunction and restricted physical development [29]. In our sample, zinc adequacy was considered uncertain, as the PA was 50 to 80%. We should consider that PA detects the risk of inadequate consumption, but not the magnitude of the deficient intake. Therefore, these children with uncertain zinc PA could have mild deficiencies of intake, with no clinical relevance. Further investigations should explore whether those children with uncertain deficiency are more likely to have more infections episodes.

The clinical relevance and implications of all the intake deficiencies found should be explored one by one in order to adapt future dietary recommendations. Further nutrition policies should be adapted accordingly to improve feeding practices quality and to prevent later consequences of deficiencies on health. Supplementation of dairy products others than milk with vitamin D as well as scholar education programs or the implantation of scholar canteen menus ensuring meals with high content of the most deficient micronutrients could be some useful actions to be taken.

Several studies have addressed the assessment of micronutrient intake adequacy in individual countries [30,31] or in vulnerable populations either for disease, pregnancy [32], socioeconomic status or challenging geographical environment [33]. Many others have focused only on investigating a specific disease in which diet may have a role [34]. However, few studies assessing micronutrient intake adequacy in different countries have been published in healthy children [2,5] and no studies neither in children nor adults used standardized methodology for dietary intake data collection.

To our knowledge, our study is the first analyzing prospective dietary intake data collected longitudinally along all the childhood in the same sample of healthy children, using standardized dietary collection methods and assessing the micronutrient adequacy with two methods described by the IOM [20].

Mensink et al. [2] performed a metaanalysis with data from several cross-country epidemiologic studies assessing nutritional intake of different age groups of population at one single time point (including around 1000 children aged 1 to 3 years and around 4800 aged 4 to 10 years). Dietary intake data was collected with different methods in all that studies, being mainly obtained through either 1 single 24h recall, or 2, 3, 4 or 7 days of estimated or weighted food records or from dietary histories with a reference period of 4 weeks. Nutritional information utilized to report micronutrient adequacy by Roman-Viñas et al. [3] for adult and elderly population and by Elmadfa [5] in children aged 1 to 14 years was obtained from the European Nutrition and Health Report, an European funded project, which get dietary intake information from 25 different countries, with different assessment methods.

Our findings coincided with those of Mensink et al. [2], who also found a low intake of vitamin D at all ages and of calcium, iron and iodine in some countries (including Poland, Germany and Belgium). Our results were also consistent with Elmadfa et al. [5], who found a low adequacy of vitamin D, folate and iron intake, and also higher calcium adequacy in younger children in comparison to older children. Although Roman-Viñas results were from adult population, they also reported a high prevalence of inadequacy in calcium, iodine, folate and vitamin D [3]. Thus, our results obtained with a standardized methodology, though a smaller sample, coincided with those previously published.

Our analysis has several possible limitations, mainly because it was a secondary outcome from a study initially designed with another aim. One is that we did not analyze the consumption of supplements or medications. As described by Mensink et al., supplement consumption increased the intake of some micronutrients in their study sample, but in most cases, supplements made little difference to the proportion of individuals reaching or not dietary recommendations [2]. So as we are focused in micronutrient adequacy and not in intake description, error burden might not modify our conclusions.

In addition, it has to be pointed out that a cut-off point has to be set to define adequate or inadequate micronutrient intake in a population group. Publications reviewed set this cut-off at 80%, as a consensus [3]. However, the clinical relevance of having a micronutrient intake prevalence of adequacy of 79% or 81% is null, and we cannot discard to have defined as “deficient” a dietary intake which is not expected to have any relevant consequence on health.

Finally, another possible limitation is the study sample size, which progressively decreased along time, what in fact is expected in long term follow-ups. Despite our population size, the accuracy of our methods provided robust results in line with those published before in bigger samples. Although this sample size does not allow direct extrapolation of our results to the whole European population, our results provide validity to previous publications using less accurate methodology but on a huge representative sample of population. Therefore, findings found in the present work together with the previous ones reinforce the scientific evidence for the described micronutrient inadequacies in European children.

In summary, our accurate dietary intake and adequacy assessment methodology applied to a longitudinal prospective high quality data from a small sample size, found iron, calcium, vitamin D, folate, iodine and zinc to be inadequately consumed in childhood, as described previously by some epidemiologic studies. Further studies should be performed to elucidate health consequences of these common micronutrient deficiencies. Even more, it would be worth exploring the dietary sources and food patterns that lead children to such nutrient deficiencies in order to perform further dietary recommendations to the population.

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The authors declare not conflicts of interest.

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functioning. J Nutr 2003;133:1473S–6S.

306 **TABLE 1**. Description of the sample: anthropometry and macronutrients intake details

307 (Mean ±SD).

Age	N	Weight (kg)	Length/ height (cm)	Energy (kcal/day)	Protein (g/day)	Fat (g/day)	Carbo- hydrates (g/day)
At birth	1678	3.3 ±0.35	50.5 ±2.5	-	-	-	-
3 m	904	6.0 ±0.6	60.5 ±2.1	574.1 ±108.0	13.1 ±4.4	29.6 ±6.0	63.7 ±12.4
6 m	839	7.8 ±0.9	67.3 ±2.3	696.3 ±133.9	19.5 ±6.8	28.2 ±7.0	90.9 ±21.3
12 m	822	9.8 ±1.1	75.6 ±2.6	874.6 ±171.5	32.2 ±9.6	31.9 ±8.1	114.5 ±26.8
2 y	745	12.4 ±1.4	88.0 ±3.2	1104.0 ±229.5	44.9 ±12.8	42.0 ±11.8	136.6 ±32.6
3 y	527	14.7 ±1.8	96.0 ±3.8	1212.1 ±233.2	46.7 ±11.8	46.8 ±12.6	151.6 ±35.2
4 y	503	16.9 ±2.1	103.2 ±4.0	1310.6 ±236.5	49.7 ±12.6	51.5 ±13.5	163.0 ±33.9
5 y	445	19.4 ±2.9	110.4 ±4.3	1384.1 ±258.2	51.7 ±13.3	54.2 ±14.1	173.4 ±39.6
6 y	468	22.1 ±3.8	117.2 ±4.9	1467.4 ±244.1	54.7 ±12.4	57.6 ±14.0	183.8 ±38.4
8 y	396	28.6 ±6.1	129.6 ±5.7	1590.3 ±284.9	60.7 ±15.0	64.9 ±16.9	191.9 ±40.6

m: age in months. y: age in years. SD: standard deviation.

308 **TABLE 2.** Prevalence of children with adequate intake for each mineral (%)[1].

Age	n	Ca[2]	P[3]	Fe[2]	Zn[2,4]	Mg[3]	I[3]
3 m	904	91.9	-[a]	-[a]	67.5	-[a]	-[a]
6 m	839	96.2	-[a]	78.9	95.2	-[a]	-[a]
12 m	822	90.0	91.8	81.3	89.5	84.2	42.7
2 y	745	84.6	96.8	68.1	88.0	97.3	31.9
3 y	527	81.0	98.5	74.2	82.0	99.6	27.3
4 y	503	79.1	98.6	75.0	90.8	91.5	28.6
5 y	445	80.9	99.3	80.9	86.1	93.9	30.6
6 y	468	80.1	99.6	87.2	82.3	97.0	29.9
8 y	396	83.6	99.7	42.7	86.8	99.0	28.0

[1] Prevalence of adequacy calculated with the EAR cut-point method from the American Institute of Medicine.

[2] Estimated Average Requirements (EAR) from the Food and Agriculture Organization of the United Nations, the World Health Organization and the United Nations University joint experts' consultation (FAO/WHO/UNU EARs) were utilized to calculate adequacy.

[3] Estimated Average Requirements from the American Institute of Medicine (IOM EARs) were utilized for the calculation of adequacy.

[4] As Estimated Average Requirements for zinc were established according to body weight, the number of subjects for whom zinc adequacy could be estimated was slightly different, namely 899, 829, 812, 733, 512, 491, 439, 462 and 394 at 3, 6, 12 months and at 2, 3, 4 5, 6 and 8 years, respectively.

[a] Indicates that adequacy could not be estimated because EAR were not available for that nutrient at that time point.

m: age in months. y: age in years, Ca: calcium, P: phosphorus, Fe: iron, Zn: zinc, Mg: magnesium, I: iodine.

TABLE 3. Prevalence of children with adequate intake of each vitamin (%)[1].

Age	n	Vit B_{12}[2]	Folate[2]	Vit A[2]	Vit D[3]
3 m	904	91.6	70.2	99.9	-[a]
6 m	839	94.9	88.0	99.9	-[a]
12 m	822	90.3	40.0	98.7	16.5
2 y	745	95.6	33.3	97.0	3.4
3 y	527	96.4	39.8	97.5	0.6
4 y	503	92.4	17.5	98.0	0.6
5 y	445	98.0	25.4	96.2	0.4
6 y	468	97.9	34.8	96.6	0.4
8 y	396	93.9	5.8	95.7	0.8

[1] Prevalence of adequacy calculated with the EAR cut-point method from the American Institute of Medicine.

[2] Estimated Average Requirements (EAR) from the Food and Agriculture Organization of the United Nations, the World Health Organization and the United Nations University joint experts' consultation (FAO/WHO/UNU EARs) were utilized for the calculation of adequacy.

[3] Estimated Average Requirements from the American Institute of Medicine (IOM EARs) were utilized for the calculation of adequacy.

[a] Indicates that adequacy could not be calculated because EAR were not available for that nutrient at that time point.

m: age in months. y: age in years, Vit B_{12}: vitamin B_{12}, Vit A: vitamin A, Vit D: vitamin D.

TABLE 4. Mean probability of adequate intake of each micronutrient (Mean ±SD)[1].

Age	n	Ca[2]	P[3]	Fe[2]	Zn[2,4]	Mg[3]	I[3]	Vit B_{12}[2]	Folate[2]
	904	92.8 ±21.5	-[a]	-[a]	61.9 ±31.0	-[a]	-[a]	93.4 ±21.0	61.2 ±28.9
6 m	839	95.0 ±14.4	-[a]	73.6 ±28.6	92.5 ±15.7	-[a]	-[a]	94.9 ±15.9	82.3 ±26.4
12 m	822	84.3 ±22.2	87.9 ±19.9	77.0 ±25.0	-[b]	79.2 ±24.9	43.6 ±30.9	-[b]	41.7 ±34.1
2 y	745	79.1 ±25.8	92.6 ±14.7	66.3 ±26.1	77.2 ±20.4	93.4 ±12.8	-[b]	86.5 ±15.8	38.3 ±32.4
3 y	527	76.3 ±26.9	94.8 ±11.3	71.1 ±27.1	75.2 ±23.7	97.2 ±8.1	36.6 ±28.9	-[b]	43.2 ±33.7
4 y	503	75.8 ±28.5	94.9 ±11.1	70.9 ±25.5	82.2 ±19.7	85.6 ±20.2	-[b]	85.3 ±18.8	23.1 ±28.8
5 y	445	75.1 ±27.6	95.8 ±9.4	75.9 ±24.9	79.1 ±23.6	88.4 ±17.9	39.4 ±29.0	89.6 ±17.8	29.4 ±31.4
6 y	468	75.1 ±26.8	97.5 ±7.2	80.6 ±21.7	75.0 ±24.5	91.5 ±14.7	40.8 ±26.0	-[b]	37.4 ±34.0
8 y	396	79.5 ±25.4	98.1 ±6.6	43.0 ±39.3	79.2 ±23.8	95.6 ±10.3	40.9 ±26.9	84.1 ±17.0	9.9 ±19.7

[1] Probability of adequacy calculated with the EAR method for individuals from the American Institute of Medicine. The ratio obtained through the IOM method was converted into a probability using normal z-score tables.

[2] Estimated Average Requirements (EAR) from the Food and Agriculture Organization of the United Nations, the World Health Organization and the United Nations University joint experts' consultation (FAO/WHO/UNU EARs) were utilized to calculate adequacy.

[3] Estimated Average Requirements from the American Institute of Medicine (IOM EARs) were utilized to calculate adequacy.

[4] As EAR for zinc are established according to body weight, the number of subjects for whom zinc adequacy could be estimated was slightly different, namely 899, 829, 812, 733, 512, 491, 439, 462 and 394 at 3, 6 and 12 months, and at 2, 3, 4, 5, 6 and 8 years, respectively.

m: age in months. y: age in years, Ca: calcium, P: phosphorus, Fe: iron, Zn: zinc, Mg: magnesium, I: iodine, Vit B_{12}: vitamin B_{12}.

[a] Indicates that adequacy could not be estimated because EAR were not available for that nutrient at that time point.

[b] Indicates that adequacy could not be estimated because that micronutrient intake was not normally distributed at that time point.

FIGURE CAPTIONS

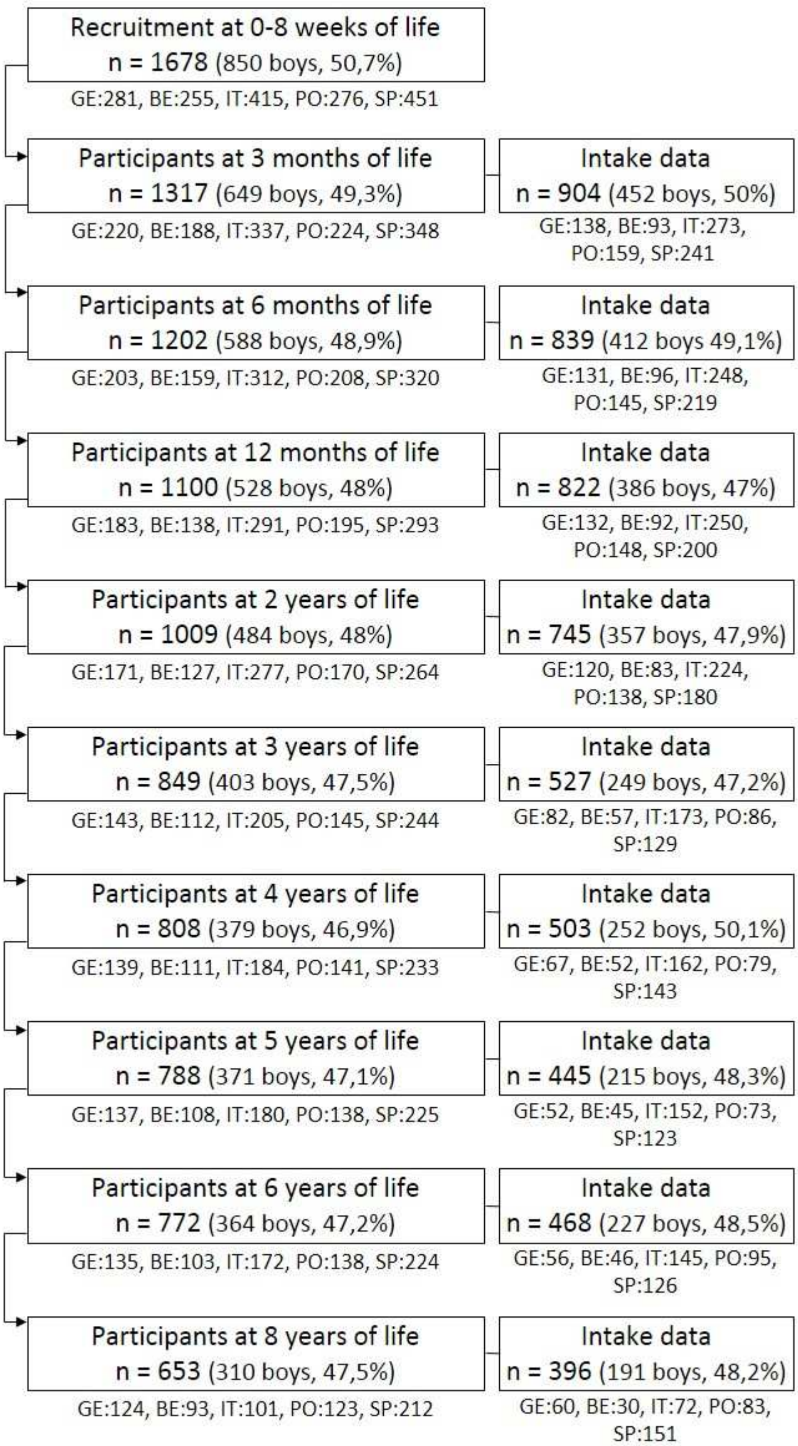
FIGURE 1. Number of children with dietary intake data available at each time point.

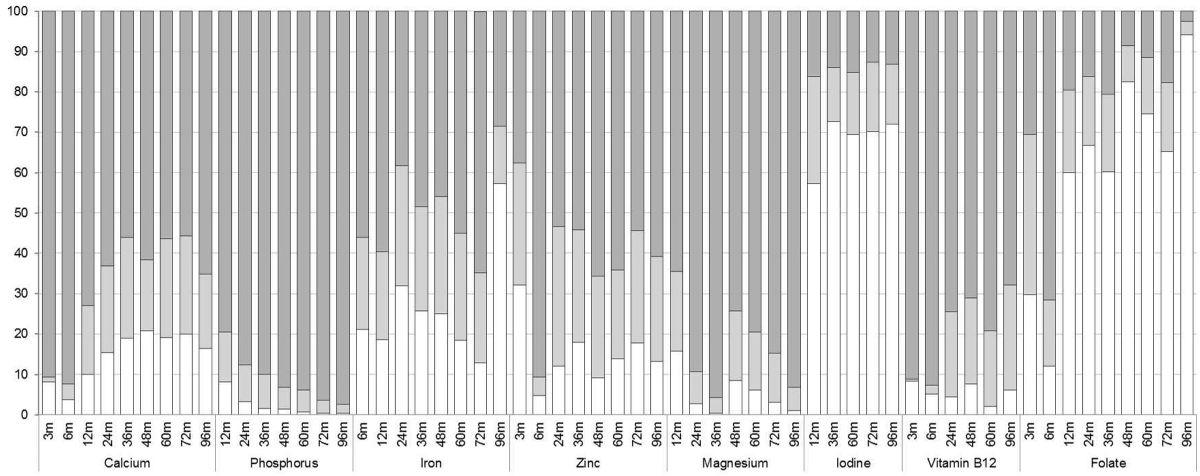
Foot note: On the left side, children participating in the Childhood Obesity Project at each time point, from recruitment to 8 years of age, are shown. On the right side, children who had available dietary intake data at the corresponding time point are shown. BE: Belgium, GE: Germany, IT: Italy, PO: Poland, SP: Spain.

FIGURE 2. Prevalence of children in each probability of adequate intake category for each micronutrient at each time point.

Foot note: □ low PA (PA<50%), ■ medium PA (PA=50-80%), ■ high PA (PA>80%).

PA: Probability of adequate intake. Prevalence of children (%) in each PA category. When the prevalence of children with low PA was over 20%, the intake of that micronutrient was considered inadequate in our sample. m: age in months.


Recruitment at 0-8 weeks of life
n = 1678 (850 boys, 50,7%)
GE:281, BE:255, IT:415, PO:276, SP:451
Participants at 3 months of life
n = 1317 (649 boys, 49,3%)
GE:220, BE:188, IT:337, PO:224, SP:348
Intake data
n = 904 (452 boys, 50%)
GE:138, BE:93, IT:273, PO:159, SP:241
Participants at 6 months of life
n = 1202 (588 boys, 48,9%)
GE:203, BE:159, IT:312, PO:208, SP:320
Intake data
n = 839 (412 boys 49,1%)
GE:131, BE:96, IT:248, PO:145, SP:219
Participants at 12 months of life
n = 1100 (528 boys, 48%)
GE:183, BE:138, IT:291, PO:195, SP:293
Intake data
n = 822 (386 boys, 47%)
GE:132, BE:92, IT:250, PO:148, SP:200
Participants at 2 years of life
n = 1009 (484 boys, 48%)
GE:171, BE:127, IT:277, PO:170, SP:264
Intake data
n = 745 (357 boys, 47,9%)
GE:120, BE:83, IT:224, PO:138, SP:180
Participants at 3 years of life
n = 849 (403 boys, 47,5%)
GE:143, BE:112, IT:205, PO:145, SP:244
Intake data
n = 527 (249 boys, 47,2%)
GE:82, BE:57, IT:173, PO:86, SP:129
Participants at 4 years of life
n = 808 (379 boys, 46,9%)
GE:139, BE:111, IT:184, PO:141, SP:233
Intake data
n = 503 (252 boys, 50,1%)
GE:67, BE:52, IT:162, PO:79, SP:143
Participants at 5 years of life
n = 788 (371 boys, 47,1%)
GE:137, BE:108, IT:180, PO:138, SP:225
Intake data
n = 445 (215 boys, 48,3%)
GE:52, BE:45, IT:152, PO:73, SP:123
Participants at 6 years of life
n = 772 (364 boys, 47,2%)
GE:135, BE:103, IT:172, PO:138, SP:224
Intake data
n = 468 (227 boys, 48,5%)
GE:56, BE:46, IT:145, PO:95, SP:126
Participants at 8 years of life
n = 653 (310 boys, 47,5%)
GE:124, BE:93, IT:101, PO:123, SP:212
Intake data
n = 396 (191 boys, 48,2%)
GE:60, BE:30, IT:72, PO:83, SP:151


100
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3m 6m 12m 24m 36m 48m 60m 72m 96m
Calcium
12m 24m 36m 48m 60m 72m 96m
Phosphorus
6m 12m 24m 36m 48m 60m 72m 96m
Iron
3m 6m 24m 36m 48m 60m 72m 96m
Zinc
12m 24m 36m 48m 60m 72m 96m
Magnesium
12m 36m 60m 72m 96m
Iodine
3m 6m 24m 48m 60m 96m
Vitamin B12
3m 6m 12m 24m 36m 48m 60m 72m 96m
Folate