European Journal of Nutrition & Food Safety
5(4): 281-296, 2015, Article no.EJNFS.2015.026
ISSN: 2347-5641

SCIENCEDOMAIN ***international***
www.sciencedomain.org

Nutritional Risk Assessment of Eleven Minerals and Trace Elements: Prevalence of Inadequate and Excessive Intakes from the Second French Total Diet Study

Esther Kalonji[1*], Véronique Sirot[1], Laurent Noel[2], Thierry Guerin[2], Irène Margaritis[1] and Jean-Charles Leblanc[1]

[1]Risk Assessment Department, French Agency for Food, Environmental and Occupational Health & Safety (ANSES), 14 Rue Pierre et Marie Curie, F-94701 Maisons-Alfort, France.
[2]CIME Unit, Food Safety Laboratory, French Agency for Food, Environmental and Occupational Health & Safety (ANSES), 23, Avenue du Général de Gaulle, F-94706 Maisons-Alfort, France.

Authors' contributions

This work was carried out in collaboration between all authors. Author EK analyzed the data and wrote the manuscript. Author VS was in charge of the scientific coordination of the TDS, calculated the intakes and wrote the manuscript. Authors LN and TG were in charge of the analytical part of the TDS: they analyzed the TDS samples and provided composition data. Author IM read and amended the manuscript. Author JCL was the main coordinator of the TDS, he read and amended the manuscript. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/EJNFS/2015/18193

Original Research Article

Received 8th April 2015
Accepted 11th June 2015
Published 13th July 2015

ABSTRACT

Aims: Adequate coverage of nutrient requirements is a real health concern and surveillance of the nutritional status of a population is a key element for public policies. This study aimed at providing a reliable nutritional risk assessment of the French population based on prevalences of inadequate and excessive intakes of eleven minerals and trace elements.
Methodology: Intakes from foods (dietary supplements excluded) were estimated by combining composition data from the second national Total Diet Study (TDS2/2007-2009) and consumption data from the Individual and National Study on Food Consumption. Results were compared with those from other TDSs.
Results: Sodium intakes exceeded World Health Organization (WHO) guidance values, respectively for 74% of adults, and for 76% of children. For calcium and magnesium, the prevalence of inadequate intakes in adults and children ranged from approximately 50 to 70% to

**Corresponding author: Email: esther.kalonji@anses.fr;*

over 80% in teenagers. Prevalences of inadequacy were 13% in adults and 18% in children for selenium, and 40% in children and 74% in 16-17 year-old girls for iron.

Conclusion: These substantial risks of inadequate intakes should be considered in the light of nutritional status biomarkers. Furthermore, effort to reduce excessive intakes of sodium in the French population should be maintained.

Keywords: Minerals; trace elements; total diet study; prevalence of inadequacy.

1. INTRODUCTION

Minerals and trace elements play numerous biological roles in humans, and today there is clear evidence that both deficiencies and excessive intakes can undermine physiological functions and lead to certain conditions including numerous metabolic disturbances (impairments of the hormonal and immune system, impaired wound healing and nervous system development, musculoskeletal disorders, growth retardation, appetite and digestive disorders, etc.), chronic diseases (osteomalacia and osteoporosis, diabetes, cardiovascular disease, cancers, etc.) and even an increase in mortality rates [1-3].

Consequently, fulfilling mineral and trace element requirements is a real concern from a public health viewpoint. Roman-Vinas et al. [4] recently showed, applying the same nutritional values to analyse national surveys, that the mean prevalence of inadequacy in adults is below 11% for zinc and iron in European Union countries. In addition, calcium, selenium, and iodine are among nutrients showing a higher prevalence of inadequate intakes in Europe (above 20%). Mean sodium intakes of European adult populations range from about 3-5 g/day [5], which is over the amounts required for normal function. In France, studies on nutritional status concern few minerals and trace elements [6,7] and their results seem not systematically corroborate inadequacy estimations [8].

Under these conditions, appropriate knowledge of the nutritional status of different population groups and the identification of critical nutrients are key elements for building regulatory and public health policies to insure adequate nutrient intakes. In addition, the general surveillance over time of the nutritional status of these populations helps evaluate the effectiveness of public measures and adjust nutritional recommend-dations (for example the setting of food-based dietary guidelines) [9].

Data from nutritional and clinical surveys are used to describe the nutritional status of a population or of a specific group of individuals. For a given nutrient, this assessment is based on the existence of a clinical deficiency or insufficiency as evidenced by reliable biomarkers [10-13]. In the absence of consistent data to characterize a population's nutritional status, the development of nutritional indicators is useful to identify situations of inadequate intakes, and is now considered as a reliable method to estimate the probability of physiological inadequacy, thanks to the quality of composition and consumption data [14]. In this respect, Total Diet Studies (TDS) have the advantage of providing a realistic estimation of nutrient intakes via foods by yielding more refined data representing an average dietary pattern for the population (baskets representing food consumption) and by considering foods in a "table-ready" state in order to take into account the impact of home cooking [15,16].

The first French TDS (TDS1) was undertaken between 2000 and 2004 by the French National Institute for Agricultural Research (INRA), in collaboration with the French Food Safety Agency (AFSSA) and gave a comprehensive appraisal of dietary exposure to or intakes of mycotoxins, as well as inorganic contaminants and minerals [17]. In 2006, AFSSA undertook a second TDS (TDS2) which included a larger number of target nutrients and substances, some of which had already been analyzed in the first study.

The aim of the present work was to provide a reliable nutritional risk assessment of the French population, including prevalences of inadequacy and excessive intakes, based on data from this second TDS. Eleven minerals and trace elements were considered: calcium (Ca), magnesium (Mg), sodium (Na), iron (Fe), potassium (K), selenium (Se), manganese (Mn), copper (Cu), zinc (Zn), lithium (Li), and molybdenum (Mo). Some of these nutrients required increased surveillance, for example Na for which TDS1 and other surveys (Individual and

National Food Consumption survey, INCA1 and INCA2) had revealed that intakes exceed the reference value, or for example Ca, Mg and Fe for which intakes lower than the nutritional reference values have been identified.

This work also presented a comparison between TDS1 and TDS2 data.

2. MATERIALS AND METHODS

2.1 Food Sampling

The methodology of food sampling has already been described [18]. To summarize, core foods (n=212) were selected as representative of the population's diet. The selection of these foods was based on two main criteria: (i) the foods most consumed by adults and/or children with a consumer rate of at least 5% according to the INCA2 survey, and (ii) foods which are the main known or assumed contributors to exposure, if they were not selected by the first criterion. The core foods covered about 90% of the whole diet.

Metropolitan France was divided into eight major regions and food samples (n=1319) were collected in the regions where they were most consumed, according to the INCA2 data. When available, each food item was collected during two different seasons to take account of possible differences in composition.

In order to be representative of French food consumption habits, each food sample was a composite sample of up to 15 subsamples of equal weight of the same food, taking into account the market share of the different brands, the origin, species, processing and packaging, if relevant, flavouring, etc [18]. Subsamples were prepared as consumed by the population (i.e. peeled, cooked, etc.) according to the cooking habits recorded in the consumption survey (including salt added during cooking), then pooled in composite samples that were analyzed.

2.2 Analysis of the Food Samples/ Composition Data

The analytical methods used and the occurrence data have been described in detail [19-22]. Analysis were performed by the French National Reference Laboratory for heavy metals in foodstuffs of animal origin (ANSES Laboratory for Food Safety) in compliance with good laboratory practice, internal quality procedures and the ISO/IEC 17025 standard [23].

To ensure and confirm the analytical accuracy of the multi-elemental method used, the laboratory regularly participated in proficiency test schemes as external quality controls (EQC). The EQC results have already been discussed in detail elsewhere [24].

2.3 Food Consumption Data

The consumption data used came from the second individual and national study on food consumption (INCA2). This survey was carried out from December 2005 to May 2007 to take into account consumption differences over year's periods. A total of 2624 adults aged 18-79 years and 1455 children aged 3-17 years were recruited as representative of the population in France through stratification [25-27]. To assess food consumption, subjects were asked to complete a 7-day food diary to describe their intakes: food name, home-made or industrial origin, brands, etc. Portion sizes for each food consumed were estimated through photographs compiled in a manual [28] or with household measurements (such as a spoon). Moreover, certain individual characteristics were also recorded, including body weight, age, gender, region and city, socio-professional status, etc.

Individual intakes from potential under- and over-reporters were excluded from the analyses. Under- and over-reporters were identified using the Goldberg cut-off value for energy intake [29]. Basal metabolic rate for each subject was calculated by the Schofield equations [30], using individual age, sex, height and weight [30]. A total of 1918 adults and 1444 children were considered in this work.

2.4 Nutritional Intake Assessment

The assessment of nutritional intakes (excluding food supplements) consisted in combining the national consumption data with the composition data from the analyses for each subject of the INCA2 survey according to the following formula:

$$I_{i,j} = \sum_{k=1}^{n} C_{i,k} \times L_{k,j}$$

where $I_{i,j}$ is the daily intake of nutrient j for subject i, $C_{i,k}$ is the mean daily consumption level of food k by subject i (k=1 to n), $L_{k,j}$ is the level of nutrient j in food k. Each food consumed by a subject was assigned a mean composition level calculated for the two samples from each sampling wave from its region. If the food was not sampled in the region, then it was assigned the average of the mean levels from all the regions sampled.

Mean intakes were calculated for different population subgroups (4-6 year old, 7-10, 11-14, 15-17, 18 and over, women of childbearing age (18-45 year old), subjects over 65) as well as 5th and 95th percentiles (P5, P95) for the whole adult (aged 18 to 79 years) and child (aged 4 to 17 years) populations.

Comparisons of the results with the first French TDS were performed using T-tests, using SAS version 9.2 (SAS Institute Inc., Cary, NC, USA).

2.5 Nutritional Situation Assessment: Comparisons with Reference Values

2.5.1 Prevalence of inadequate intake estimation

In this study, individual intakes were compared to French nutritional reference values, namely, estimated average requirement (EAR), population reference intake. French population reference intakes (ANC - *apports nutritionnels conseillés*) have been established for a given nutrient as the level of intake necessary to cover the requirements of virtually the entire healthy population (97.5%) [10]. By convention, the ANC is defined as the estimated average requirements (EAR)[1] plus almost two standard deviations of 15% each. Thus, nutrient intakes below the ANC are not necessarily a reflection of an inadequacy. Consequently, the EAR, which applies to individuals, has been used as the relevant criterion for the estimation of the prevalence of inadequate intakes in a population. The EAR cut-point method was used to approximate the proportion of the population with adequate intakes. The EAR values used were calculated using the following formula: EAR = 0.77 x ANC for all nutrients except magnesium, for which the EAR = 0.83 x ANC [14], and iron, for which a probabilistic method was used with a risk curve derived from the estimation of the requirement distribution [31]. This method allows to assess the probability for each subject to cover its needs using the risk curve and the estimated intake. Then the probability for the whole population to be at risk of inadequacy is calculated. When only a range for the population reference intake or EAR was found in the literature, the mean value of this range was used for comparison with intake. For zinc, two EAR values were defined depending on the composition of the diet, as diet is known to modify intestinal absorption of this trace element [32]. Our calculations considered the EAR corresponding to a 30% intestinal absorption rate, which is the value proposed in the case of a diet relatively rich in animal products.

Percentages of the population whose intakes were below the requirements (or who had a prevalence of inadequate intakes) were calculated with their confidence interval (CI_{95}).

2.5.2 Prevalence of excessive intake estimation

Individual intakes were compared to tolerable upper intake levels (UL) when they exist. The values defined at European level (EFSA) or if not available, in France, were given preference [10, 33]. If neither France nor EFSA had defined an UL for a nutrient, similar values proposed by agencies abroad were considered.

Concerning sodium, the intake limit recommended by the WHO (5 g of salt per day, or about 2000 mg of sodium for adults) [34] has been used, as data are insufficient to establish an UL for this mineral. For children, WHO recommends to extrapolate this value according to the energy requirements. Hence, for a 3 year old child whose energy needs are 1200 kcal/day, the intake limit recommended will be 1.2 g/day (3 g/day NaCl).

Percentages of the population whose intakes exceeded the reference value (UL or guidance) were calculated with their CI_{95}.

3. RESULTS

For each mineral or trace element studied, the results were displayed considering an estimation of nutrient intakes, allowing the identification of main food contributors (Tables 1 and 2), and estimation of prevalence of insufficient and excessive intakes (Table 3). Specific data concerning different age groups were also presented (Tables 4 and 5).

---
[1] *The estimated average requirements result from values acquired from an experimental group consisting of a limited number of individuals and corresponding to average individual requirements.*

Table 1. Mean estimated intake of minerals by the French adult population (18-79 y) from the different food groups

Food group	Ca (mg/day)	Mn (µg/day)	Mg (mg/day)	Cu (µg/day)	Zn (µg/day)	Li (µg/day)	Na (mg/day)	Mo (µg/day)	Se (µg/day)	K (mg/day)	Fe (µg/day)
Bread and dried bread products	29	623	34	125	609	0.74	802	15.1	2.9	229	1255
Breakfast cereals	3.8	13	1.1	3	17	0.02	4	0.4	0.1	8.2	48
Pasta	6.2	114	10	111	139	1.55	81	3.3	1.0	18	250
Rice and wheat products	2.5	60	4.1	35	81	1.04	38	2.8	0.6	12	75
Croissant-like pastries	3.6	36	2.9	11	62	0.06	52	1.0	0.2	20	156
Sweet and savoury biscuits and bars	2.9	35	4.1	15	49	0.08	32	1.3	0.2	29	122
Pastries and cakes	11	54	6.2	24	106	0.25	72	2.3	0.8	53	315
Milk	88	2	10	8	324	0.27	36	3.8	2.1	138	35
Ultra-fresh dairy products	92	15	11	9	318	0.40	38	4.0	2.0	145	47
Cheese	150	5	8.2	15	541	0.10	172	2.0	0.7	35	28
Eggs and egg products	7.5	6	2.4	11	197	0.16	32	1.1	0.8	29	265
Butter	2.0	0	0.3	2	8	0.14	21	0.5	0.4	3.6	6
Oils	0.1	0	0.02	0	2	0.00	0.07	0.1	0.2	0.1	2
Margarine	0.5	0	0.07	0	3	0.01	7.6	0.1	0.1	1.6	3
Meat	5.7	5	14	36	2018	0.18	34	0.8	1.2	179	786
Poultry and game	4.4	4	11	23	395	0.09	31	1.2	1.1	112	259
Offal	0.2	4	0.4	162	91	0.01	2	1.4	0.5	5.1	78
Delicatessen meats	3.7	11	7.1	37	612	0.18	297	1.9	0.9	106	417
Fish	2.4	6	4.6	9	55	0.13	35	0.3	2.0	42	65
Crustaceans and molluscs	4.1	18	2.7	20	194	0.22	17	1.0	0.8	8.7	81
Vegetables (excluding potatoes)	36	170	20	70	251	2.36	93	8.4	2.8	279	562
Potatoes and potato products	8.0	61	14	50	137	0.89	48	3.0	1.4	220	198
Pulses	1.8	26	2.3	14	56	0.31	7.7	6.8	0.1	14	80
Fruit	14	115	17	80	110	1.09	2.0	5.2	3.4	256	180
Dried fruits, nuts and seeds	1.4	39	3.3	21	62	0.03	7.3	1.9	0.1	20	41
Ice creams, sorbets and frozen desserts	6.2	15	2.9	13	34	0.09	5.0	0.7	0.2	22	338
Chocolate	6.2	45	5.7	32	60	0.04	3.7	0.8	0.1	29	352
Sugars and sugar derivatives	1.5	26	1.0	4	11	0.09	1.0	0.7	0.5	13	29
Water	102	4	18	72	56	16.72	16	2.3	17.3	4.6	36
Non-alcoholic beverages	8.1	44	6.9	16	20	0.72	4.5	1.3	2.9	84	60
Alcoholic beverages	15	109	14	14	121	1.09	2.8	4.1	3.6	103	296
Coffee	54	125	26	698	73	8.31	4.5	1.2	5.5	254	54

Other hot beverages	31	138	5.5	58	64	6.76	7.1	1.1	3.2	33	95
Pizzas, quiches and savoury pastries	21	36	4.9	15	180	0.24	104	1.8	0.4	41	146
Sandwiches and snacks	6.0	37	3.8	12	204	0.16	79	1.2	0.4	32	135
Soups and broths	11	45	6.5	37	75	2.49	156	1.9	1.8	103	119
Mixed dishes	15	63	9.3	43	481	0.79	145	4.6	0.9	89	363
Dairy-based desserts	18	23	5.5	19	89	0.12	13	1.2	0.5	43	259
Compotes and cooked fruit	6.7	14	0.9	7	6	0.04	0.2	0.6	0.4	16	17
Seasonings and sauces	2.9	11	2.6	6	23	0.18	152	0.4	0.3	24	60
Miscellaneous foods	0.05	0	0.07	0	1	0.00	0.1	0.0	0.0	0.1	2
Total	786	2158	304	1936	7935	48.2	2653	93.9	64.4	2854	7715

Table 2. Mean estimated intake of minerals by the French child population (3-17 y) from the different food groups

Food group	Ca (mg/day)	Mn (µg/day)	Mg (mg/day)	Cu (µg/day)	Zn (µg/day)	Li (µg/day)	Na (mg/day)	Mo (µg/day)	Se (µg/day)	K (mg/day)	Fe (µg/day)
Bread and dried bread products	17	290	16	59	286	0.36	388	7.2	1.4	109	593
Breakfast cereals	17	33	3.4	9	55	0.06	15	1.2	0.3	27	254
Pasta	6.9	127	11	125	154	1.72	91	3.7	1.1	20	276
Rice and wheat products	2.5	59	4.1	33	78	0.96	35	2.6	0.6	12	76
Croissant-like pastries	6.0	59	4.7	18	103	0.10	86	1.7	0.4	33	263
Sweet and savoury biscuits and bars	5.3	71	8.0	31	93	0.16	51	2.5	0.4	51	255
Pastries and cakes	13	61	7.4	29	139	0.26	84	2.6	0.8	59	387
Milk	174	5	20	14	645	0.56	71	7.6	4.1	274	70
Ultra-fresh dairy products	86	12	10	9	293	0.38	35	3.8	1.9	132	44
Cheese	85	3	4.6	8	309	0.07	97	1.2	0.4	20	17
Eggs and egg products	5.0	4	1.6	7	131	0.11	21	0.7	0.5	20	173
Butter	1.4	0	0.2	2	5	0.10	15	0.3	0.3	2.5	4
Oils	0.1	0	0.01	0	2	0.00	0.05	0.0	0.2	0.04	1
Margarine	0.2	0	0.032	0	2	0.01	4.1	0.1	0.1	0.8	2
Meat	4.0	4	11	28	1618	0.14	26	0.6	0.9	138	639
Poultry and game	3.1	3	7.4	14	260	0.05	20	0.8	0.7	77	153
Offal	0.1	1	0.2	53	31	0.00	0.6	0.5	0.1	2.0	34
Delicatessen meats	3.2	8	5.2	25	451	0.15	214	1.2	0.6	79	289
Fish	1.9	9	4.0	7	48	0.14	36	0.5	1.3	37	53
Crustaceans and molluscs	1.7	4	0.9	7	48	0.07	6.0	0.4	0.3	2.9	29
Vegetables (excluding potatoes)	21	102	12	40	159	1.38	59	5.7	1.6	155	334
Potatoes and potato products	8.3	58	13	45	132	0.85	53	2.8	1.3	203	187
Pulses	1.6	23	2.0	13	50	0.27	6.9	6.2	0.1	12	74

Fruit	6.5	69	9.2	39	58	0.50	1.1	2.3	1.6	133	92
Dried fruits, nuts and seeds	0.6	16	1.3	9	25	0.01	3.0	0.8	0.0	7.9	16
Ice creams, sorbets and frozen desserts	8.0	19	3.8	16	44	0.11	6.3	0.9	0.3	28	432
Chocolate	13	104	10	54	105	0.08	7.6	1.4	0.3	56	453
Sugars and sugar derivatives	1.0	11	0.8	2	7	0.04	1.5	0.5	0.2	6.3	24
Water	56	3	7.5	53	38	6.78	9.8	1.5	11.0	3.3	27
Non-alcoholic beverages	12	69	9.7	21	27	1.11	6.2	1.5	4.1	123	83
Alcoholic beverages	0.2	1	0.2	0	1	0.01	0.046	0.0	0.1	1.5	3
Coffee	1.5	3	0.6	17	2	0.20	0.1	0.0	0.1	6.0	1
Other hot beverages	16	24	4.3	19	78	0.48	7.2	0.8	0.6	37	128
Pizzas, quiches and savoury pastries	20	33	4.5	14	167	0.22	97	1.7	0.4	38	135
Sandwiches and snacks	5.1	31	3.2	10	178	0.13	66	1.0	0.3	27	116
Soups and broths	5.6	23	3.4	19	40	1.19	85	1.0	0.9	52	64
Mixed dishes	19	67	10	41	420	0.72	163	4.4	1.0	94	321
Dairy-based desserts	23	30	7.9	29	123	0.16	17	1.6	0.7	62	389
Compotes and cooked fruit	7.5	19	1.2	8	9	0.06	0.2	0.9	0.5	22	23
Seasonings and sauces	2.2	9	2.0	5	20	0.15	113	0.4	0.2	26	53
Miscellaenous foods	0.002	0	0.003	0	0	0.00	0.003	0.0	0.0	0.003	0
Total	659	1465	227	929	6431	19.84	1998	74.7	41.5	2186	6566

Table 3. Intakes of minerals by the French adult and child populations, and percentage of the populations not reaching the requirements or exceeding the limitation values

Nutrient	Nutrients Intakes						Reference values	% Inadequate intakes	
	Adults			Children				Adults	Children
	P5*	Mean	P95†	P5	Mean	P95		%<EAR or %>UL [CI 95%]	%<EAR or %>UL [CI 95%]
Calcium (mg/d)	345	786	1419	298	659	1118	RDA=700 to 1200 [10]	50 [48 ; 52]	68 [66 ; 70]
							UL = 2500 [33]	0.05 [-0.05 ; 0.1]	0
Manganese (mg/d)	1.07	2.16	3.55	0.71	1.46	2.56	no requirement value	-	-
							UL = 10 [10]	0	0
Magnesium (mg/d)	180	304	457	136	227	342	RDA = 6 (mg/kg bw/d) [10]	65 [63 ; 67]	53 [51 ; 56]
							UL = 700 [10]	0.05 [-0.06 ; 0.2]	0
Copper (mg/d)	0.73	1.94	4.11	0.5	0.93	1.73	RDA = 0.8 to 2 [10]	33 [31 ; 35]	73 [71 ; 76]
							UL = 5 [33]	2.6 [1.9 ; 3.3]	0.8 [0.4 ; 1.3]
Zinc (mg/d)	4.09	7.93	13.3	3.5	6.43	10.7	RDA = 3 to 19 [10]	26 [24 ; 28]	48 [46 ; 51]
							UL = 25 [33]	0.08 [-0.05 ; 0.2]	0.5 [0.1 ; 0.8]
Lithium (µg/d)	14.9	48.2	93.6	9	19.8	38.6	no requirement value	-	-
							no UL	-	-

Sodium (g/d)	1.3	2.65	4.5	1.08	2	3.41	no requirement value	-	-
							WHO guidance value = 2[34]	74 [72 ; 76]	76 [74 ; 76]
Molybdenum (µg/d)	49.1	93.9	155	40.3	74.7	130	no requirement value	-	-
							UL = 600 [33]	0	0.08 [-0.07 ; 0 2]
Selenium (µg/d)	34.6	64.4	100.7	23.8	41.5	66.2	RDA = 20 to 70 [10]	13 [12 ; 15]	18 [17 ; 20]
							UL = 90 to 300 [33]	0	0.08 [-0.07 ; 0 2]
Potassium (mg/d)	1635	2854	4333	1303	2186	3278	no requirement value	-	-
							no UL	-	-
Iron (mg/d)	4.03	7.71	12.6	3.4	6.57	11.1	EAR = 2.73 to 17.51 [31]	36 [34;37]	40 [38 ; 42]
							UL = 28 [10]	0	0

RDA, recommended daily allowance;
*EAR, estimated average requirement (for each individual, depending on their gender and age, intakes were compared to EAR calculated as 0.77*RDA except for magnesium: 0.83*RDA);*
UL, upper safety level.
**, fifth percentile;†,ninety-fifth percentile.*

Table 4. Mean total intakes of minerals in the different subgroups of the French population

	Ca, mg/day	Mn, mg/day	Mg, mg/day	Cu, mg/day	Zn, mg/day	Li, µg/day	Na, g/day	Mo, µg/day	Se, µg/day	K, g/day	Fe, mg/day
4-6 years old	633	1.13	192	0.70	5.24	16.25	1.52	63.1	35.3	1.91	5.18
7-10 years old	680	1.44	226	0.91	6.35	18.53	1.96	76.3	40.5	2.19	6.60
11-14 years old	676	1.62	244	1.03	7.01	21.65	2.21	78.8	44.5	2.32	7.19
15-17 years old	635	1.68	245	1.08	7.17	23.48	2.32	80.5	46.1	2.33	7.30
Women of childbearing age (18-45 years old)	719	1.78	257	1.62	6.57	41.99	2.17	77.6	58.0	2.41	6.53
Older subjects (>64 years old)	742	2.24	297	1.89	7.44	49.31	2.74	96.4	64.4	2.86	7.37

Table 5. Mean iron intakes in different subgroups of the French population and prevalence of inadequate intake

	n	Intake, mg/day	Prevalence of inadequate intake, %	CI 95%
Adults				
Men 18-64 y	649	9.12	13	[11;15]
Women 18-54 y	792	6.61	67	[65;69]
Men 65-75 y	102	8.65	17	[12;22]
Women 55-75 y	323	6.50	28	[25;31]
> 75 y	52	6.98	29	[20;37]
Children				
4 to 6 y	242	5.18	33	[31;35]
7 to 9 y	236	6.67	26	[23;29]
10 to 12 y	295	6.74	36	[32;40]
Boys 13-15 y	164	8.17	39	[32;45]
Girls 13-15 y	212	6.53	64	[58;69]
Boys 16-17 y	144	8.37	47	[40;55]
Girls 16-17 y	151	6.44	74	[70;79]

CI, confidence interval; y, years old.

3.1 Main Food Contributors to Intakes

Bread and bread products appeared to be one of the major contributors to the intake of iron (16% in adults, 9% in children), manganese (29% in adults, 20% in children), magnesium (11% in adults, 7% in children), molybdenum (16% in adults, 10% in children), sodium (30% in adults, 19% in children), and zinc (8% for adults only). Milk also appeared to be a major contributor to different nutritional intakes. For children, it contributed to 26% of calcium intake. For adults, milk brought 11% of the total intake of calcium after cheese (19%) and other dairy products (12%), and water (13%). For children, milk was also a major vector of potassium (13%), zinc (10%), selenium (10%), molybdenum (10%), and magnesium (9%). Among beverages, coffee was estimated to contribute significantly to intake of copper (36%), lithium (17%), potassium (9%), selenium (9%), and magnesium (9%) in adults, and water appeared to contribute significantly to intake of lithium (35% in adults, 34% in children) and selenium (27% in adults, 26% in children). For adults and children, meats, including beef, mutton and lamb, and pork, contributed to 10% of total iron intake and 25% of total zinc intake. For adults and children, delicatessen meats appeared to contribute to sodium (11%) and zinc (8%) intakes. Of note, vegetables (excluding potatoes) contributed to potassium (10%) and magnesium (7%) intakes in adults.

3.2 Prevalence of Excessive Intake Estimation

Generally increasing with age (Table 4), sodium intakes exceeded WHO recommended intake limit, respectively for 74% [72-76] of adults, and for 76% [74-79] of children. Intakes reached 2.65 g/d on average in adults (P95=4.5 g/d) and 2 g/d in children (P95=3.41 g/d). Moreover, 2.6% [1.9-3.3] of adults and 0.8% [0.4-1.3] of children had copper intakes exceeding the upper safe limit. In addition, 0.5% [0.1-0.8] of children had zinc intakes higher than the upper safe limit.

For the other nutrients, the prevalence of excessive intakes was equal to zero or statistically insignificant (Ca, Mn, Mg, Mo, Se, Fe).

3.3 Prevalence of Inadequate Intake Estimation

Mean calcium intakes were assessed at 786 mg/d in adults and 659 mg/d in children (P5 at 345 and 298 respectively). For magnesium, mean intakes were 304 mg/d in adults and 227 mg/d in children (P5 at 180 and 136 respectively).

Then for both nutrients, prevalences of inadequate intakes in adults and children ranged from about 50 to 70%, whereas prevalences of inadequate intakes of iron and selenium remained lower (13 to 40%). Indeed, intakes differed greatly between population subgroups (Table 4) and, due to different EARs, the highest prevalences affected specific subgroups of the population. For instance, 60% [47-72] of elderly people (>75 years) did not reach the EAR defined for the selenium intake (data not shown). About 86% [83-88] of teenagers aged 10-17 had a calcium intake lower than their EAR, and more than 80% of teenagers aged 12-17 had a magnesium intake lower than their EAR. For those three nutrients, the prevalence increased with age in children, and was higher for girls than boys.

Concerning iron, prevalence of inadequate intake ranged from 64 to 74% in females aged 13 to 54 (Table 5), with mean intakes estimated between 6.44 and 6.61 mg/d. Among other adult and child subgroups, the prevalence remained between 13 and 47%. Highest mean intakes were reached by 18-64 y old men (9.12 mg/d).

For copper and zinc, prevalences of inadequate intakes varied from 26% (adult zinc intakes) to 73% (child copper intakes).

For sodium, lithium, manganese, potassium and molybdenum no estimation of inadequate intakes was calculated because no requirement values have been set for these nutrients.

4. DISCUSSION

Results of this 2nd French TDS can be compared with the results of the 1st French TDS conducted in 2001 [17] as the methods used were the same for both consumption surveys, for the sampling method and the analysis performed. Compared with the results of the 1st French TDS, the intakes of lithium, copper and magnesium appeared to be significantly higher (until 2 times higher, P<0.0001 to 0.003). Concerning copper and lithium this may be due mainly to higher concentrations measured in foods. For magnesium, this trend was already observed with the INCA1 and INCA2 surveys [26,27]. In adults, calcium intake also significantly increased since TDS1 (P<0.0001), in accordance with the consumption level of dairy products [26], whereas in children calcium intake significantly decreased (P<0.0001) with dairy product consumption [27]. Manganese intakes were slightly but significantly higher in TDS2, for adults as well as children (P<0.0001), in spite of equivalent concentrations in foods. For some nutrients, differences in intakes in the two studies might be explained by differences in food group coverage within the diet. For instance, in TDS1, almost all kinds of pulses, which are a major vector food for molybdenum, were included in the sampling plan (and in the intake assessment) while in TDS2 only about 62% of the pulses consumed in France were covered [18]. Then intake of molybdenum could have been underestimated in the present study. In both studies, zinc and sodium intakes of children are similar. Iron intakes were not estimated in TDS1; in TDS2, the mean intakes were lower (around 40%) than those estimated by combining the INCA2 consumption data with national nutritional composition data (not published), certainly due to incomplete dietary coverage and most likely also due to lower levels in foods or to analytical uncertainty. For sodium, the mean intake levels were in the same range as those estimated during TDS1, given the analytical uncertainty related to sample preparation, and were slightly below those estimated by combining the INCA2 consumption data with national nutritional composition data (not published), due to incomplete coverage of the total diet. The mean intakes of zinc are around the same levels as those estimated during TDS1, but slightly lower than those estimated by INCA2 (20-25%), which is consistent with incomplete coverage of the diet.

Mean adult intakes of calcium, sodium, molybdenum, potassium and selenium were in the same range of those reported in other European and non-European TDSs (Table 6). For manganese and zinc, TDS results were heterogeneous, with French TDS2 intakes being the median. Magnesium intakes were about 30% higher in French TDS2 than in the American TDS [35] and the Italian TDS [36]. Copper intakes in French TDS2 were up to 100% higher than those reported for other TDSs. Iron intakes in French TDS2 were 30-40% lower than those reported for other TDSs. These differences may be explained by differences in food consumption levels and iron concentrations in the different food groups. For instance, the iron content of corn flakes is about 10-20 times higher in the USA than in Europe (France and Spain) [37]. Moreover, consumption of corn flakes is also higher (12-13 g/day for adults in the USA vs 4.9 in France) [26]. Moreover, the iron content of alcoholic beverages reported in the Spanish study [38], which contributed to 13.9% of the total intake, was 6.5 mg/kg, whereas in the French TDS2 it was equal to 1.1 mg/kg, with a 4% contribution to the total intake. Finally, while the intakes of meat, seafood products and eggs were similar between adults in the Italian and French populations, their contributions to the total iron intake were higher in Italy than in France (48% versus 23%). These differences might be due to higher iron content in animal products in Italy.

Table 6. Comparison of mean intakes of minerals and trace elements (mg/day) in adults according to total diet studies from different countries

	France Leblanc et al. (2005) [17]	Ireland (2011) [39]	UK Rose et al. (2010) [40]*	USA Egan et al. (2002)[35]	Australia FSANZ (2011) [41]	New Zealand NZFSA (2009) [42]	Italy Lombardi-Boccia et al. (2003) [36]	Italy Turconi et al. (2009) [43]	Japan Aung et al. (2006)[44]	Lebanon Nasreddine et al. (2010)[45]	Spain Urieta et al. (1996)[38]
Calcium	786		-	512-796	695-1170	-	738	-	-		-
Magnesium	304		-	184-262	-	-	262	-	-		-
Manganese	2.16		67* 4.69	[LB 1.88; UB 2.93]	3.94-5.38	-	-	1.38 [0.45-2.19]	2.72	2.04	-
Copper	1.94		17.23* 1.21	[LB 0.73 ; UB 1.36]	1.22-1.89	-	1.2	1.14 [0.73-1.96]	0.78	1.10	-
Zinc	7.93		140.7* 9.85	7.6-12.7	7.8-14.8	-	10.6	12.0 [7.5-19.8]	6.75	10.97	11.6
Lithium	0.48		-	-	-	-	-	-	-		-
Sodium	2653		-	1682-2739	-	2049-3405	3812	-	-		-
Molybdenum	0.09		1.61-1.64* 0.11	-	0.076-0.12	-	-	0.079 µg [0.032-0.106]	0.13		-
Potassium	2854		-	1853-2683	2960-4440		2913	-	-		-
Selenium	0.06	0.05-0.09	0.83-0.95* 0.06-0.07	[LB 0.074 ; UB 0.126]	0.097-0.17	0.056-0.082	0.104	-	-		-
Iron	7.71		-	9.0-.13.9	8.7-14.8	-	12.7	11.0 [6.41-19.45]	-	13.0	11.3

***,** *values specifically expressed in µg/kg bw/day, assuming a mean body weight of 70 kg*

In the absence of data related to the physiological and nutritional status of a population, an estimation of the prevalence of adequate intakes (probability of adequacy) only is possible thanks to statistical methods. Among the several available methods, the EAR cut-point method was chosen as the most relevant to estimate the inadequacy of most nutrient intakes [46-48]. Furthermore, this approach requires a decision to be made on acceptable or non-acceptable prevalence of inadequate intakes. A maximum desirable prevalence of inadequate intakes (or acceptable prevalence of inadequacy) was set by WHO and the Food and Agriculture Organization (FAO) at 2-3% of a population; in other words, the population is in a satisfactory nutritional situation when most individuals in the population, i.e. 97-98%, fulfil the EAR values [49]. In line with these recommendations, Food Standards Australia New Zealand (FSANZ) considers that when 3% or less of a population has nutrient intakes below the EAR, this population group as a whole can be considered to have adequate intakes of this nutrient [50]. In addition, prevalence of inadequate intake values were put into perspective with regard to the type of data used to define the EARs (endpoint criteria, uncertainties, etc.). Touvier et al. chose a high threshold for prevalence of inadequacy to qualify a population group as “at risk” [14,51]. Indeed, the population groups for which the CI_{95} of the prevalence of inadequacy for a nutrient included a value equal to or above 70%, and did not include the 50% value, were considered as “particularly at risk” for this nutrient. Hence, the same value of prevalence of inadequacy may be considered as a reflection of a risk of inadequacy or not according to the interpretation of the criteria used. Thus, the heterogeneity of the methods used to estimate the prevalence of inadequacy and of the interpretation criteria shall be kept in mind when comparing conclusions in terms of public health objectives drawn on prevalence of inadequacy data from different studies and different countries [13]. Consequently, there is a need to harmonise methodologies worldwide, or at least at European level as recently stressed by some authors [4,48], even if a scientific consensus on the judgment criteria to be used to interpret these prevalences of adequate intake is difficult to reach, considering the nutritional specificities of the populations and population subgroups concerned and the public health goals pursued.

The results of TDS2 regarding dietary intakes of trace elements showed that some prevalences of inadequate intakes may appear to be relatively high, notably for calcium, iron, magnesium and copper. This can be partly due to food sampling in this study only covering about 90% of the French population's diet. Moreover, due to the short observation period of 7 days, the total variance has been over-estimated [52]. We can hypothesize that the dietary intakes at the low percentiles may be slightly under-estimated and the prevalences of inadequacy slightly overestimated.

Moreover, it should be noted that conclusions cannot be drawn from prevalences of inadequate intakes, which are only probabilities of inadequacy, as to the risk or to the lack of risk for the general population. They varied greatly between subgroups and according to gender (Table 4). For example, for calcium, only children over 9, adolescents and women over 55 were particularly at risk of inadequacy (data not shown). Several data showed that teenagers consumed less dairy products than younger children [27,53]. Moreover, women in the perimenopause period may not adapt their diet to their increased needs in calcium. However, as useful indicators, these prevalences of inadequate intakes highlight the need to acquire biological data based on appropriate biomarkers in order to fully assess a population or population subgroup’s nutritional status, in particular for magnesium and copper.

The estimated prevalence of inadequate intakes for iron ranged from 13% to 74%, depending on the age group and gender. Prevalences were notably higher among young girls (64% [58,69] for 13-15 year-olds and 74% [70,79] for 16-17 year-olds) and pre-menopausal women (67% [65,69]). These high prevalences should be compared with the much lower incidences of iron deficiency-induced anaemia and iron reserve depletion in the general population (around 2 to 11% for adults) [9]. These data suggest that it is necessary to identify causes of anaemia (intake-related and/or physiological). Indeed, the prevalences of inadequate intakes were calculated mainly on the basis of population reference intakes published in 2001. These values were established on the basis of the relevant literature available at the time, which sometimes relied on observations in the population. For some nutrients, such as magnesium, which do not seem to pose any particular public health risk, recent and relevant data suggest that the requirements should be reassessed. For instance, Hunt and Johnson suggest lower needs, of about 180 mg/day (versus an EAR of 6 mg/kg bw/day, i.e. 360 mg/day assuming a body weight of 60 kg), estimated on the basis of balance studies [54]. However, the relationship between magnesium intakes, status biomarkers and pathologies (cardiovascular disease, type 2 diabetes and osteoporosis) is not fully understood and a diagnosis of moderate deficiency is hard to establish [55]. Consequently, the high prevalences of inadequacy in magnesium in TDS2, concordant with the literature [14,51,55], must be considered in the light of factors likely to influence needs (genetics, whole diet, specific nutrients, physical activity, etc.).

However, the nutritional intakes from food supplement consumption were not included in the TDS2 analysis. While food supplement use is liable to increase intakes for several minerals, food supplement consumers are not necessarily those with the lowest intakes from food sources [56-58]. The cumulated intakes from the whole diet, including fortified foods and supplements, may lead to exceeding the upper safety limits, as recently shown by several authors [57,58], especially for minerals and trace elements for which high intakes are already close to the upper safe limit (copper, zinc, selenium…).

Some excessive intakes have already been detected in the general population without taking into account supplements (Table 4). In the few cases where observed tolerable upper intake levels were exceeded, the excess levels were extremely low and sometimes insignificant. Concerning sodium, the high excess levels of the WHO guideline value underline the need to continue efforts to reduce intake. Such objectives can be achieved by general modifications in consumption habits (food choices, added salt, etc.) and the gradual reduction of salt in manufactured products, as recommended by public health programs, namely the PNNS in France [59].

5. CONCLUSION

The data compiled from this second TDS showed that substantial prevalences of inadequacy have been identified in some sub-groups, such as children and the elderly. Our conclusions are based on data using a reliable and robust estimation approach, insofar as they confirm the conclusions of previous studies. However, there is a considerable need to put these estimated intakes into perspective with regard to biological data. The TDS results might be useful to encourage examination of certain nutrients in more detail with a view to policy development. In TDS2, only the general population over 3 years of age were included. Undeniably, studies focusing on physiological sub-groups (infants, toddlers, pregnant and lactating women, etc.) as well as on sub-groups with various specificities (geographic location, low income, dietary habits, etc.) would be needed in the medium term in terms of risk evaluation in a public health objective.

ACKNOWLEDGEMENTS

This study was supported by public funds from the French Ministries in charge of Food, the Environment, Health and Consumer Affairs.

The authors would like to thank the experts from the ANSES Expert Committee on Human nutrition for their comments during the risk assessment process, namely J.M. Bard, J. Belegaud, O. Bruyère, J.M. Chardigny, S. Charrières, V. Coxam, P. Crenn, J. Delarue, F. Feillet, J.P. Girardet, A. Lapillonne, P. Legrand, F. Mariotti, A. Martin, C. Moulis, A. Quignard-Boulangé, D. Rieu, P. Sauvant, S. Schneider, A. Servin, D. Tomé, D. Turck (Chair) & M.P. Vasson. We are particularly grateful to F. Mariotti & A. Martin for their valuable comments and suggestions on aspects of method and data analysis.

COMPETITING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. WHO, Trace elements in human nutrition and health (A report of a re-evaluation of the role of trace elements in human health and nutrition), 1996; Geneva, Switzerland.
2. Institute of Medecine, Dietary reference intakes: The essential guide to nutrient requirements; 2006. Available:http://books.nap.edu/openbook.php?record_id=11537
3. Martin A. The "apports nutritionnels conseilles (ANC)" for the French population. Reprod Nutr Dev. 2001;41(2): 119-28.
4. Vinas BR, Barba LR, Ngo J, Gurinovic M, Novakovic R, Cavelaars A, et al., Projected

prevalence of inadequate nutrient intakes in Europe. Ann Nutr Metab. 2011;59(2-4): 84-95.
5. EFSA, Opinion of the Scientific Panel on Dietetic Products, Nutrition and Allergies on a request from the Commission related to the Tolerable Upper Intake Level of Sodium. The EFSA Journal. 2005;209:1-26; 2005. EFSA: Parma, Italy.
6. Castetbon K, Vernay M, Malon A, Salanave B, Deschamps V, Roudier C, et al., Dietary intake, physical activity and nutritional status in adults: The French nutrition and health survey (ENNS, 2006-2007). Br J Nutr. 2009;102(5):733-43.
7. Castetbon K, Mejean C, Deschamps V, Bellin-Lestienne C, Oleko A, Darmon N, et al., Dietary behaviour and nutritional status in underprivileged people using food aid (ABENA study, 2004-2005). J Hum Nutr Diet. 2011;24(6):560-71.
8. ANSES. Avis de l’Agence nationale de sécurité sanitaire de l’alimentation, de l’environnement et du travail relatif à l’évaluation des apports en vitamines et minéraux issus de l'alimentation non enrichie, de l’alimentation enrichie et des compléments alimentaires dans la population française : Estimation des apports usuels, des prévalences d'inadéquation et des risques de dépassement des limites de sécurité. In press; 2015.
9. INVS. Étude nationale nutrition santé ENNS, 2006 - Situation nutritionnelle en France en 2006 selon les indicateurs d’objectif et les repères du. Programme National Nutrition Santé (PNNS), INVS: Saint-Maurice. France. 2007;77.
10. Martin A, Azaïs-Braesco V, Bresson JL, Couet C, Cynober L, Guéguen L, et al., Apports nutritionnels conseillés pour la population française, ed. Tec & Doc; 2001, Paris: Lavoisier.
11. Arnaud MJ, Update on the assessment of magnesium status. Br J Nutr. 2008;99(3): 24-36.
12. Zimmermann MB, Methods to assess iron and iodine status. Br J Nutr. 2008;99(3):2-9.
13. Mensink GBM, Fletcher R, Gurinovic M, Huybrechts I, Lafay L, Serra-Majem L, et al., Mapping low intake of macronutrients across Europe. Br J Nutr. 2013;110:755-773.
14. Touvier M, Lioret S, Vanrullen I, Bocle JC, Boutron-Ruault MC, Berta JL, et al., Vitamin and mineral inadequacy in the French population: estimation and application for the optimization of food fortification. Int J Vitam Nutr Res. 2006;76(6):343-51.
15. EFSA. Joint Guidance of EFSA, FAO and WHO - Towards a harmonised Total Diet Study approach: A guidance document, 2011;1-66.
16. Moy G, Vannort RW. Total Diet Studies. Springer; 2013.
17. Leblanc JC, Guerin T, Noel L, Calamassi-Tran G, Volatier JL, Verger P. Dietary exposure estimates of 18 elements from the 1st French Total Diet Study. Food Addit Contam. 2005;22(7):624-41.
18. Sirot V, Volatier JL, Calamassi-Tran G, Dubuisson C, Menard C, Dufour A, et al., Core food of the French food supply: second Total Diet Study. Food Addit Contam Part A Chem Anal Control Expo Risk Assess. 2009;26(5):623-39.
19. Chekri R, Noel L, Millour S, Vastel C, Kadar A, Sirot V, et al., Calcium, magnesium, sodium and potassium levels in foodstuffs from the second French Total Diet Study. J Food Comp Anal. 2012;25: 97-107.
20. Millour S, Noel L, Chekri R, Vastel C, Kadar A, Sirot V, et al., Strontium, silver, tin, iron, tellurium, gallium, germanium, barium and vanadium levels in foodstuffs from the second french total diet study. J Food Comp Anal. 2012;25:108-129.
21. Noel L, Chekri R, Millour S, Vastel C, kadar A, Sirot V, et al., Li, Cr, Mn, Co, Ni, Cu, Zn, Se and Mo levels in foodstuffs from the Second French TDS. Food Chem. 2012;132:1502-1513.
22. Millour S, Noël L, Kadar A, Chekri R, Vastel C, Sirot V, et al., Pb, Hg, Cd, As, Sb and Al levels in foodstuffs from the 2nd French total diet study. Food Chem. 2011;126:1787–1799.
23. ISO/IEC. General requirements for the competence of calibration and testing laboratories. ISO/IEC 17025. Geneva, Switzerland: International Organization for Standardisation; 2005.
24. Millour S, Noël L, Chekri R, Vastel C, Kadar A, Guérin T. Internal quality controls applied in inductively coupled plasma mass spectrometry multi-elemental analysis for the 2nd french total diet study. Accredit Qual Assur. 2010;15:503-513.

25. Dufour A, Lafay L, Volatier JL. La mesure des consommations alimentaires par l'éude INCA2 (The measurement of food consumption by the INCA2 study), in méthodes de sondage (Sampling Methods), D.H. P Guilbert, A Ruiz-Gazen and Y Tille, Editor. Dunod: Paris, France. 2008;132-137.
26. Dubuisson C, Lioret S, Touvier M. Dufour A, Calamassi-Tran G, Volatier JL, et al., Trends in food and nutritional intakes of French adults from 1999 to 2007: results from the INCA surveys. Br J Nutr. 2010; 103(7):1035-48.
27. Lioret S, Dubuisson C, Dufour A, Touvier M, Calamassi-Tran G, Maire B, et al., Trends in food intake in French children from 1999 to 2007: results from the INCA (étude Individuelle Nationale des Consommations Alimentaires) dietary surveys. Br J Nutr. 2010;103(4):585-601.
28. Hercberg S, Deheeger M, Preziosi P. Portions Alimentaires : Manuel Photos pour l'Estimation des Quantites (Food Portions: Photo Manual for Quantity Estimation); 1994. Paris: PolyTechnica.
29. Goldberg GR, Black AE, Jebb SA, Cole TJ, Murgatroyd PR, Coward WA, et al., Critical evaluation of energy intake data using fundamental principles of energy physiology. 1. Derivation of cut-off values to identify under-recording. Eur J Clin Nutr. 1991;45(569-581).
30. Schofield WN. Predicting basal metabolic rate, new standards and review of previous work. Hum Nutr Clin Nutr. 1985;39:5-41.
31. Institute of Medicine, Iron, in Dietary Reference Intake for vitamin A, vitamin K, arsenic, boron, chromium, copper, iodine, iron, manganese, molybdenum, nickel, silicon, vanadium, and zinc, N. A. Press, Editor. National Academy Press: Washington DC, USA. 2001;290-393.
32. Arnaud J. Zinc, in apports nutritionnels conseillés pour la population française, 3e édition, Tec & Doc, Editor. Lavoisier: Paris, France. 2001;155-158.
33. SCF. Tolerable upper intake levels for vitamins and minerals; 2006.
34. WHO, Reducing salt intake in populations. Report of a WHO forum and technical meeting, Paris, France; 2007. Paris, France.
35. Egan SK, Tao SS, Pennington JA, Bolger PM. US Food and Drug Administration's Total Diet Study: Intake of nutritional and toxic elements, 1991-96. Food Addit Contam. 2002;19(2):103-25.
36. Lombardi-Boccia G, Aguzzi A, Cappelloni M, Di Lullo G, Lucarini M. Total-diet study: dietary intakes of macro elements and trace elements in Italy. Br J Nutr. 2003;90 (6):1117-21.
37. USFDA. National Nutrient Database for Standard Reference. Available:http://ndb.nal.usda.gov/ndb/foods/list. 2012.
38. Urieta I, Jalon M, Eguilero I. Food surveillance in the Basque Country (Spain). II. Estimation of the dietary intake of organochlorine pesticides, heavy metals, arsenic, aflatoxin M1, iron and zinc through the total diet study, 1990/91. Food Addit Contam, 1996;13(1):29-52.
39. FSA. Report on a Total Diet Study carried out by the food safety authority of Ireland in the period. 2001-2005;2011.
40. Rose M, Baxter M, Brereton N, Baskaran C. Dietary exposure to metals and other elements in the 2006 UK Total Diet Study and some trends over the last 30 years. Food Addit Contam Part A Chem Anal Control Expo Risk Assess. 2010;27(10): 1380-404.
41. FSANZ. The 23rd Australian Total Diet study; 2011. Available:http://www.foodstandards.gov.au/_srcfiles/FSANZ%2023rd%20ATDS_v8_.pdf,
42. NZFSA. 2009; New Zealand Total Diet Study; 2009. Wellington, New Zealand. Available:http://www.nzfsa.govt.nz/science/research-projects/total-diet-survey/2009.htm
43. Turconi G, Minoia C, Ronchi A, Roggi C. Dietary exposure estimates of twenty-one trace elements from a Total Diet Study carried out in Pavia, Northern Italy. Br J Nutr. 2009;101(8):1200-8.
44. Aung NN, Yoshinaga J, Takahashi JI. Dietary intake of toxic and essential trace elements by the children and parents living in Tokyo Metropolitan Area, Japan. Food Addit Contam. 2006;23(9):883-94.
45. Nasreddine L, Nashalian O, Naja F, Itani L, Parent-Massin D, Nabhani-Zeidan M, et al., Dietary exposure to essential and toxic trace elements from a total diet study in an adult lebanese urban population. Food Chem Toxicol. 2010;48(5):1262-9.
46. Medicine Io. Dietary Reference Intakes : Applications in dietary assessment.

Washington, DC: National Academy Press; 2000.
47. de Lauzon B, Volatier JL, Martin A. A Monte Carlo simulation to validate the EAR cut-point method for assessing the prevalence of nutrient inadequacy at the population level. Public Health Nutr. 2004; 7(7):893-900.
48. Vinas BR, Majem LS, Barba LR, Ngo J, Alvarez AG, Wijnhoven TMA, et al., Overview of methods used to evaluate the adequacy of nutrient intakes for individuals and populations. Brit J Nut. 2009; 101(2): S6-S11.
49. WHO/FAO, Guidelines on food fortification with micronutrients; 2007: WHO.
50. FSANZ. 22nd Australian total diet study. A total diet study of five trace elements: iodine, selenium, chromium, molybdenum, and nickel; 2008. FSZANZ. Available:http://www.foodstandards.gov.au/scienceandeducation/publications/22ndaustraliantotaldietstudy/,
51. Moshfegh A, Goldman J, Ahuja J, TR hodes D, La Comb R. What we eat in America, NHANES 2005-2006: Usual nutrient intakes from food and water compared to 1997 dietary reference intakes for vitamin D, calcium, phosphorus, and magnesium. U.S. department of Agriculture, Agricultural Research Service; 2009.
52. Goedhart PW, van der Voet H, Knüppel S, Dekkers ALM, Dodd KW, Boeing H, et al., A comparison by simulation of different methods to estimate the usual intake distribution for episodically consumed foods. Supporting Publications. 2012;299:65. 2012. Available:www.efsa.europa.eu/publications
53. Baird DL, Syrette J, Hendrie GA, Riley MD, Bowen J, Noakes M. Dairy food intake of Australian children and adolescents 2-16 years of age: 2007 Australian National Children's Nutrition and Physical Activity Survey. Public Health Nutr. 2012;1-14.
54. Hunt CD, Johnson LK. Magnesium requirements: new estimations for men and women by cross-sectional statistical analyses of metabolic magnesium balance data. Am J Clin Nutr. 2006;84(4):843-52.
55. Rosanoff A, Weaver CM, Rude RK. Suboptimal magnesium status in the United States: are the health consequences underestimated? Nutr Rev. 2012;70(3):153-64.
56. Robson PJ, Siou GL, Ullman R, Bryant HE. Sociodemographic, health and lifestyle characteristics reported by discrete groups of adult dietary supplement users in Alberta, Canada: findings from the tomorrow project. Public Health Nutr. 2008; 11(12):1238-47.
57. Bailey RL, Fulgoni VL, 3rd Keast DR, Dwyer JT. Dietary supplement use is associated with higher intakes of minerals from food sources. Am J Clin Nutr. 2011; 94(5):1376-81.
58. Shakur YA, Tarasuk V, Corey P, O' Connor DL. A comparison of micronutrient inadequacy and risk of high micronutrient intakes among vitamin and mineral supplement users and nonusers in Canada. J Nutr. 2012;142(3):534-40.
59. Ministère du travail de l'emploi et de la santé. Programme National Nutrition Santé 2011-2015. Available:http://www.sante.gouv.fr/IMG/pdf/PNNS_2011-2015.pdf. 2011.