Determining the Dietary Pattern and Biochemical Markers Among Women and Children in Hebron and Gaza City

A2Z Project - 2010

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A2Z: The USAID Micronutrient and Child Blindness Project consolidates, builds, and expands on USAID's long-term investment in micronutrients, child survival, and nutrition. A2Z takes proven interventions to scale, introduces innovation, expands services, and builds sustainable programs to increase the use of key micronutrient and blindness interventions to improve child and maternal health. With work in vitamin A supplementation of children, newborn vitamin A, food fortification, maternal and child anemia control, monitoring and evaluation, and health systems strengthening, A2Z's focus countries have included Bangladesh, Cambodia, ECSA region, India, Nepal, Philippines, Tanzania, Uganda and West Bank.

A2Z provides technical assistance to the Palestinian Authority to increase the provision of essential micronutrients in the Palestinian diet, thereby reducing the risk of micronutrient deficiencies in the West Bank. ANERA implements A2Z activities in close cooperation with the Palestinian Ministry of Health (MOH).

Research Participants

Dr. Ziad Abdeen	Director, Nutrition and Health Research Institute, Al-Quds University, Jerusalem.
Lindsay Allen	Center Director, ARS, USDA Western Human Nutrition Research Center, Davis, CA.
Alicia Carriquiry	Statistics Professor, Department of Statistics, Iowa State University. Ame, IA.
Dr. Omar Dary	Food Fortification Specialist, A2Z/The USAID Project of Micronutrients and Child Blindness, Washington D.C.
Radwan Qasrawi	Head of Information System, Nutrition and Health Research Institute, Al-Quds University, Jerusalem.
Dr. Asa'd Ramlawi	General Director, Primary Health Care and Public Health, Ministry of Health, Palestinian Authority
Ala' Abu Alrub	Director, Nutrition Department, Ministry of Health, Palestinian Authority
Dr. Rand Salman	A2Z Project Director

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EXECUTIVE SUMMARY

In 2005, the Palestinian Authority decided to mandate the fortification of wheat flour with eight vitamins (Vitamins A and D, B-1, B-2, niacin, B-6, folic acid, and B-12), and two minerals (iron and zinc) as a strategy to reduce risk of micronutrient deficiencies due to reduction in the consumption of milk, eggs, meat, poultry and fish. The same year, a study to determine micronutrient status and nutritional adequacy was carried out in Hebron and Gaza City to justify and adjust the fortification formula. Dietary data was collected from children aged 3-7 and women of reproductive age (ages 18-50) of Hebron and Gaza City, as representatives of the poorest sections of the Palestinian society. Serum samples were also collected from the same age groups and were frozen deeply until the determination of biomarkers associated to micronutrient status. Usual intakes and biomarkers were estimated in 2009.

The nutrient analysis revealed that for children and women of reproductive age in Hebron and Gaza City the largest nutritional inadequacies are for vitamin A, vitamin B-12, iron, zinc and calcium. Children older than 6 years of age and women might also be deficient for the vitamins B-1, B-2, B-6 and niacin, although biochemical confirmation is still pending. Women were more affected than children, especially for vitamin D and iron. Folate status was found to be good, although some women would still require additional intakes of folic acid to raise the serum folate levels to values that are being linked to prevention of neural tube defects. Based on the estimated intake data, it appears that supply of vitamin E and vitamin C are adequate for the Palestinian population, as well as vitamin D status in children.

Data suggests that higher levels of vitamin B-1, vitamin B-12 and zinc would be useful in the fortification formula of wheat flour. Adjustments in the contents of folic acid and vitamin D should be done based on future determinations of serum folate and serum vitamin D, respectively. The levels of the other micronutrients are appropriate for the current circumstances.

There is no sensitive biomarker for calcium deficiency but dietary data indicate that intakes of calcium are highly inadequate for the three groups studied, and probably for the entire population. Rising of calcium intakes would require the introduction of several strategies, such as promoting the production and consumption of milk and derivates, and supplementation and calcium fortification of food and beverages beyond wheat flour.

Consumption of fortified wheat flour would reduce prevalence of the micronutrient inadequacies on large segments of the Palestinian population. Nevertheless, it is estimated that additional sources of vitamin A would still be needed for children, as well as iron for women of reproductive age. Poor children of school age would also require some additional amounts of all micronutrients, but in much lower amounts than in the absence of fortified wheat flour. Use of supplements with several micronutrients instead of only iron and folic acid seems to be appropriate during pregnancy due to the large magnitude of deficiencies in women of reproductive age that were found in this study.

Formulation of foods both for school feeding as well as for market-driven fortification should be regulated taken in consideration the micronutrient supply through fortified wheat flour; limitation in the use of vitamin A and folic acid seems to be necessary.

Determination of the nutritional status of children 1-3 years old deserves special consideration because it is a group at high risk and because fortified wheat flour would benefit them less because of low consumption of products containing this food. Therefore, continuation of the programs of supplementation with vitamin A and D, and iron during infancy should continue. Use of powder supplements for home-fortification to improve the micronutrient density of the foods used to complement breast-feeding should also be considered.

The results of this study confirmed that the multiple fortification of wheat flour was a good decision as a public health measure in the Palestinian territories.

The combination of the dietary intake research and the nutritional status assessment analyses provided an excellent and possibly first example of the complimentary value of having data on both nutrient intakes and biochemical markers of status. The dietary data is important for estimating the prevalence of inadequate intakes of specific nutrients and for identifying potential fortification vehicles (e.g. wheat flour), the amount of micronutrients that are needed to be added to such foods in order to correct the intake gaps, and the calculation of the impact of different levels of fortification on the prevalence of inadequate or excessive intakes of each nutrient. The biochemical data was necessary to detect the high prevalence of vitamin D deficiency in women and to confirm the prevalence of most deficiencies predicted from the food intake data. The biochemical values also provide a baseline for monitoring changes in the biochemical data after fortification. A final important point is that potential users of such information are usually more readily convinced by biomarker values than by nutrient intake data. Therefore it is advised that future monitoring and evaluation and nutritional surveillance initiatives should include both the use of dietary information as well as key biomarkers of nutritional status. In addition to serum levels, the determination of the nutritional value of breast milk might be a useful way to assess the impact of wheat flour fortification as well as to estimate the nutritional status of breast-fed infants. The capability to carry out this type of work should be ensured as part of the policies in public health nutrition.

INTRODUCTION

The human being is a species located at the top of the food chain, and therefore individuals must receive many substances that are key for metabolic functions already preformed from the diet. Those substances include the macronutrients (carbohydrates, fats and proteins), the micronutrients (vitamins and minerals), and many other compounds whose functions are starting to be identified. Macronutrients are sources of energy, and some components of them, such as essential[1] fatty acids from fats and essential amino acids from proteins, provide important building blocks for hormones, enzymes, cells, and tissues. The micronutrients, although required in comparatively minute amounts, have important and basic roles. **Tables 1** and **2** summarize functions and consequences of some vitamins and minerals, respectively.

Table 1. Functions of some vitamins and consequences of their deficiencies

Name	Functions	Consequences of deficiency
Vitamin A	- Genetic expression - Growth and fetal development - Immunity - Vision	- Immunodeficiency - Night blindness, xerophthalmia - Stunting - Death
Vitamin D*	- Genetic modulator - Bone formation	- Rickets - Osteoporosis - Little protection against some cancers
Vit.B-1, B-2, Niacin, B-6	- Oxido-reduction (energy) - Detoxification - Synthesis of macromolecules	- Low use of energy from foods - Metabolic alterations - Beri-beri (B-1), ariboflavinosis (B-2), pellagra (niacin).
Folate	- Hemoglobin synthesis - Cell replication and maintenance - Fetal development - Metabolic equilibrium	- Neural tube defects - Anemia - Cancer promotion - Chronic diseases
Vitamin B-12	- Hemoglobin synthesis - Brain development and maintenance - Metabolic equilibrium	- Neural tube defects - Anemia - Mental decay in the elderly - Chronic diseases

* A portion of this vitamin can be synthesized by the human skin by exposure to sun light, but in countries far from the Equatorial line, as the West Bank, or when the body is covered by clothes, it is insufficient.

A few of the negative consequences of some of the micronutrient deficiencies are easy to be detected, such as night blindness and xerophthalmia with vitamin A, goiter with iodine, and most nutritional anemias with iron, and the correction of these abnormalities are directly associated and sensitive–although not absolutely specific- with the correction of the corresponding deficiency. For many years in public health nutrition, this situation has prompted the interest for implementing interventions to improve the nutritional status of these micronutrients. Most recently, folate has been added to this group for its role in the prevention of neural tube defects, and in some degree zinc for its association to reduction in severity of some morbidity conditions.

1 The word essential means that the nutrient cannot be synthesized by human metabolism.

Furthermore, the status of those micronutrients can be easily established using simple biomarkers. However, the difficulties to detect functional consequences of the deficiency, or the lack of simple biomarkers for assessing status, do not mean that the insufficiency of the other micronutrients has little importance. The optimal expression of the genetic inheritance of any individual requires the adequate provision of all micronutrients, including essential fatty acids and amino acids, and the sufficient supply of other compounds and energy from foods.

Table 2. Functions of some minerals and consequences of their deficiencies

Name	Functions	Consequences of deficiency
Iodine	- Genetic regulator (hormones) - Brain development - Metabolic control	- Reduction of IQ - Mental retardation, cretinism - Deaf and mutism - Goiter
Iron	- Oxygen transport (hemoglobin) - Oxygen storage (myoglobin) - Oxido-reduction (energy) - Detoxification	- Anemia - Physical weakness - Permanent mental retardation - Immunodeficiency
Zinc	- Genetic stability - Conversion of - carotene in retinol - Immunity	- Stunting - Immunodeficiency - Stability of the genetic material
Calcium*	- Hard structures (bones, teeth) - Membrane function - Cell communication	- Rickets - Osteoporosis - Pregnancy toxemia

* Calcium is needed in larger amounts than the other minerals, mainly for being part of bones and teeth.

A way to determine if the population is receiving adequate amounts of nutrients is measuring the intake of all of these nutrients from diet. Although biomarkers of nutritional status are preferred as the strongest evidence of deficiency (or in some cases even excesses), dietary data continues to be important for various reasons: (a) to confirm that abnormal values in the biomarkers are due to abnormal intakes of the associated nutrients and not because other reasons, such as low bioavailability of disease; (b) to identify the main food sources of nutrients (and the lack of them), as well as for determining the potential foods that might be used as a micronutrient carriers (food fortification vehicles); (c) to calculate the potential impact of different levels of fortification on the prevalence of inadequate or excessive intakes of each nutrient; and (d) to estimate the degree of nutritional adequacy of the diet for most nutrients, many of which are difficult to be studied using biomarkers. In any case, the ideal situation is to use the combination of biomarker analysis and dietary intakes, and it was the strategy selected by the Palestinian Authority with the support of the USAID micronutrient projects, MOST and A2Z, to justify and to design its wheat flour fortification program.

In 2005, the Palestinian Authority decided to go ahead with the addition of several micronutrients for wheat flour, even before the specific adequacy of the diet was known based on the fact, for a large proportion of the population, the traditional Palestinian diet had lost its food diversity and was increasingly centered only in wheat flour, rice, chick peas, and occasionally some vegetables and foods of animal origin. Therefore, the delivery of many micronutrients was considered poor for the simple analysis of the micronutrient sources as described in **Table 3.**

Table 3. Supply of micronutrients by food§

NUTRIENTS	Milk	Meat/ Fish/ Poultry	Eggs	Refined Cereals, Sugars, Oils	Fruits and vegetables	Beans, peanuts
Vitamin A	√√√	√	√√	-	(√ √)	-
Vitamin B-2	√√	√√	√	-	√	√
Folate	-	√	√	-	√√	√√√
Vitamin B-12	√√	√	√√	-	-	-
Vitamin C	-	-	-	-	√√√	-
Iodine	√	√	√	-	-	-
Iron	-	√√√	-	-	-	(√)
Zinc	-	√√√	√	-	-	(√)
Calcium	√√√	√	√	-	(√)	(√)

§ Each check mark means good supply. Those check marks inside parenthesis are for denoting that the supply is good, but there may be low bioefficacy due to low bioavailability or bioconversion.

The same year, the Ministry of Health (MOH) of the Palestinian Authority organized a dietary and biomarker study in Hebron and the City of Gaza, where the poorest nutritional conditions were feared. The idea was that the results of this study would provide information to justify and adjust the fortification formula. Thus, the Nutrition and Health Research Institute of the Al-Quds University was made responsible for carrying out a 24-hour recall study in children 3-7 years old and in their non-pregnant mothers of 18-50 years old.

The study did not include younger children, although younger children face the highest risk of suffering nutritional deficiencies because the wheat flour fortification program would benefit them in a modest manner, and because this group requires especial complementary foods regardless, and hence should be studied separately. The Directorate of Primary Health Care of the (MOH) took responsibility of obtaining blood samples from the same individuals interviewed in the dietary survey.

Hemoglobin levels and other hematological parameters were immediately determined in automatic cell counters in Hebron and Gaza City, and the serum was separated and stored in cryovials. Serum samples were frozen and translated to the Central Public Health Laboratory in Ramallah to be placed in a -70°C freezer until a suitable laboratory were identified for the determination of biomarkers. Under these storage conditions, most biomarkers are stable for many years. In 2009, samples were transferred still frozen to the Nutritional Biochemistry Laboratory of USDA Western Human Nutrition Research Center in California, and the results confirmed that the measured biomarkers were in a good state.

Ten percent of the households in this study were visited twice for the dietary assessment with the purpose of estimating the intra-individual variation and calculating the usual intakes based in the actual intakes. A 24-hour recall survey captures daily food consumption. Daily consumption is a noisy estimator of the usual or habitual consumption, which is the measure of interest to policy makers, health researchers and other practitioners in public health nutrition. The usual or habitual intake of the nutrients is typically defined as the long-run average nutrient intake by the individual. However, the repeated values were insufficient for making the needed adjustment for many of the nutrients, and the preliminary report presented in 2005 by the Nutrition and Health Research Institute of the Al-Quds University[2] showed the actual intakes rather than the usual intakes. In 2008, Alicia Carriquiry, the main researcher who developed the concept, formulas and programs for estimating usual intakes based on a sub-sample of the whole sample was hired to analyze the data. She was able to make some adjustments and this document presents the best intake estimations that are possible to have as usual intakes with the collected data. She also modeled the potential additional intakes due to the fortification of wheat flour, using the fortification formula adopted in 2005.

Although the results presented in this document are specific for children 3-7 years old and women of reproductive age of Hebron and Gaza City in 2005, they illustrate very well the nutritional profile of most of the Palestinian society in the current political and economic conditions, and they provide good guidance about the micronutrients that deserve preferential attention with a public health interest, as well as for supporting any monitoring, evaluation and surveillance of the population nutritional situation. Results obtained in this study can be used for comparison with the information to be collected on future national surveys.

Furthermore, this document presents the first case in the developing world, and perhaps in the world, of the combined use of dietary information and biomarkers to justify a food fortification formula, and to assess the potential impact of wheat flour fortification for several vitamins and minerals. The concepts and procedures developed in this experience may be useful for many other countries to examine the pertinence of their own program and predict the population benefits of them.

2 Abdeen Z, van de Haar F, Qasrawi R. Key Results of the Baseline Nutritional Survey of Women of Childbearing Age and Children. Hebron-West Bank and Gaza-Gaza Strip. September 2005.

METHODOLOGY

The dietary and biochemical study carried out in 2005 in Hebron and Gaza City had four objectives:

1. Confirm the appropriateness of having selected wheat flour as a micronutrient carrier;
2. Determine the usual nutrient intake distribution for children 3-7 years old and non-pregnant women of reproductive age (18-50 years old);
3. Model the potential additional intakes of the micronutrients added to the wheat flour accordingly with the formulation approved in 2005 for the same age groups; and
4. Measure a few biomarkers that are associated to the nutritional status to support the inferences made using the dietary intakes.

In order to fulfill these objectives, a 24-hour intake recall (24-H-RQ) was carried out in Hebron and Gaza City, from August 5 to August 26, 2005. Venous blood samples, after night fasting, were obtained by biomedical personnel of the Ministry of Health in the same individuals interviewed for the dietary assessment. Hematological parameters were measured immediately in automatic cell counters in the medical centers with that equipment both in Hebron and in Gaza City. Serum was separated, stored in triplicate in cryovials and shipped to the Central Public Health Laboratory (CPHL) in the City of Ramallah to be placed under -70°C until transference to a suitable laboratory for the determination of biomarkers.

The surveys were reviewed and approved by the Committee on Human Subjects Research of the Al-Quds University **(Annex 1).** Secondary data analysis was approved by the Committee on Human Subjects Research, Emory University, from the Rollins School of Public Health. The overall study was authorized by the Directorate of Primary Health Care and Public Health of the Ministry of Health of the Palestinian Authority. Administrative and logistic support was given by CARE working in the West Bank and Gaza under a specific contract given by MOST.

Completion of the estimation of usual intakes and the analysis of biomarkers were hired by A2Z in 2008 with the Department of Statistics of the Iowa State University, and in 2009 with the ARS, USDA Western Human Nutrition Research Center in Davis, California, respectively. Additional data analysis of the dietary results was provided by researchers of the Nutrition and Health Research Institute, of the Al-Quds University. ANERA and A2Z facilitated the coordination for all these activities.

Dietary Assessment

The Nutritional Survey was a voluntary cross-sectional population study, following a multi-cluster random sampling based on the census carried out by the Palestinian Center Bureau of Statistics in 1997. Households were the primary response unit. Valid dietary data were collected from 366 pairs, children (36-83 months old) and his/her non-pregnant mothers (18-50 years old), from the 397 randomly-selected households that were visited, about half in Hebron and half in Gaza City. The population came from urban and non-urban settings, including refugee camps, but was restricted to persons living in private dwellings.

A 24-H-RQ questionnaire was developed specifically for the survey and was administered by trained fieldworkers. A training manual and a food intake booklet were developed and employed, as appropriate, for the administration of the questionnaire. The multiple pass 24-hour recall interviews were structured into three steps (passes) to maximize respondent recall of foods eaten. The first step, the (quick list), involved respondent supplying a broad description of all food and beverage items consumed on the previous day. In the second step, a detailed description of each food or beverage item on the quick list was ascertained through a series of questions and prompts (generated by interviewers) which were specific to each item. The third and final step was to review of the recall. A pilot exercise was carried out in the two locations, both for one urban and one non-urban cluster. The pilot study incorporated the exercise for the validation of the questionnaires. Once the pilot had been completed, the director, the coordinator, the team leader and the fieldworkers jointly addressed any points that needed to be attended to before the survey proper began. If no problem areas were identified during the pilot phase of the survey, then the survey proper was started immediately.

Data quality control was of primary concern and the difficulty of maintaining this control was compounded by the following factors: data collection was done over three weeks, many people were involved in data collection, and staffs were based throughout the Hebron and Gaza regions. A number of different data quality control initiatives were thus required, including ongoing staff training and monitoring, equipment calibration, on-going review data and telephone checks. The overall supervision was given by Ziad Abdeen, who also acted as the Principal Investigator. Technical assistance was provided by the Department of International Nutrition of the Emory University (Rafael Flores, Frits van der Haar, and Vilma Tyler). **Annex 2** provides details of the implementation of the field component of the dietary survey, and **Annex 3** includes the example of the questionnaires that were used.

Data Entry and Intake Analysis

The questionnaires were sent to Center of Information System of the Nutrition and Health Research Institute of the Al-Quds University, where they were checked by a nutritionist and the data was then entered. The Epi-Info (Version 6.0 for Windows) was used for data entry and analyses under the supervision of the Principal Investigator.

For data entry, a template was created for each questionnaire using a database program. The template defined the name (field name), the type (character or numeric) as well as the length (the maximum number of characters for the field) of each variable and, for numeric variables, the number of decimal places. Each subject was represented on a single record, but provision was made for "multiple answer options" as appropriate. Experienced data entry staff keyed the data and the senior nutritionist then checked the entered data for any obvious errors, and a printout of the data was made. The printout together with the original questionnaires were then sent to the senior project coordinator who checked the entered data manually, namely compared the data on the questionnaires with that of the printouts and marked any differences on the printouts with a red pen. The chief analyst then went through any discrepancies and corrected them. The data for the specific cluster was then added to the main database. Once the data for all clusters were entered, checked and corrected the data was then cleaned.

Food and beverages from the 24-H-RQ were matched to food composition data to calculate nutrient intake. The primary source of food composition information was the SurvNet Composition Database, which contains the composition of approximately 6,000 foods and was compiled by USDA. If a direct match with information in the SurvNet was not available and the frequency of use was high relative to other foods, additional nutrient composition data was sought from overseas database (British and Israeli) as applicable. The Al-Quds University has created a large data base of nutritional composition of many recipes and their ingredients, and in some cases specific recipes have been sent to commercial laboratories to determine the nutritional content. Essentially, a local nutrient composition database has been established for Palestinians use.

When a food or beverage could not be completely described by the respondent (for example the person had milk but did not know the type) it was matched to a composite of the various types of milk weighted to reflect use reported in the survey.

If a recipe could not be supplied for a mixed food, it was matched to a standard recipe. Preparation of "standard recipes" was carried out by examination of appropriate recipes from top selling Middle Eastern cookbooks. Modifications were made to standard recipe ingredients to correspond with frequent responses to the ingredient probe questions (e.g. type of fat, milk, yogurt and/or cheese used). These modified recipes were matched to mixed food items where the respondent, although unable to supply the entire recipe, had been able to give some ingredient information in response to the probe questions. The nutrient composition of these recipes, allowing for weight and nutrient loss in cooking, was estimated then.

Calculation of the Usual Intakes

The datasets of nutrient intakes were sent to Alicia Carriquiry, from the department of Statistics of the Iowa State University and the main developer of the C-SIDE software to correct for day-to-day variation in nutrient intakes, and principal advisor for estimating nutrient intakes of the Institute of Medicine of the United States. The data included 175 children aged 36 to 71 months, 191 children 72 months or older, and 359 women 18 to 49 years old.

The 24-hour recall instruments used in this survey captured daily intake of nutrients. However, the quantity of interest is the usual or habitual intake of the nutrient. The usual intake cannot be observed directly, because it would require measuring daily nutrient intake on a large sample of individuals and over a very large period (depending on the nutrient). Instead, the usual procedure is to measure the daily intakes on a large sample of persons, but also using a subsample for estimating the intra (or within)-individual variation that then is used to adjust the intake distribution of the whole population.

To do so, the team used the approach called the ISU Method proposed by Nusser et al. (1996). The ISU Method is based on the approach proposed earlier by the National Research Council (NRC, 1986) and consists in adjusting daily intakes by removing the within-person variance from the variance of observed person-level mean intakes. The estimated usual intake distribution that results from implementation of the method has the correct mean, variance and shape, and in particular allows reliable estimation of the prevalence of inadequate nutrient intakes (Beaton, 1994; Carriquiry, 1999). For a more extensive discussion of the ISU Method, please refer to IOM (2000) or to Carriquiry (2003).

To implement the ISU Method, it is necessary to have at least a sub-sample of individuals with at least two independent measurements of their daily nutrient intake. This is due to the fact that in order to adjust daily intakes, it is necessary to estimate both the between-person and the within-person variances in daily intake. The within-person variance in nutrient intake cannot be estimated unless multiple observations are available on at least a subset of individuals.
The design of the present study included a second observation on a sub-sample of 10% of subjects and thus permitted estimation of both the within and the between person variances. However, the

sub-sample of children of both age categories was very small (13 and 25 children, respectively, of age groups 3 to 6 years, and 6 years or older). The sub-sample of women who were administered a second recall while larger, was still rather reduced. Because of these small sub-sample sizes as compared with the within individual variation, estimates of the within-person variances might not be reliable. Thus, the team combined the internal variance estimates with estimates obtained from the much larger sample of children aged 6 years or older and of women aged 18 to 50 (not pregnant or lactating) collected in the National Health and Nutrition Examination Survey of the USA (NHANES) 2003-2004. The combined estimate of the ratio of the within-person variance in intake to the total variance in intake was obtained by taking a weighted average of the internal and the external variance ratios. In the analysis of the data for children, a weight of 150 was allocated to the external estimate and a weight equal to the actual sample size (175 and 191, respectively, for children aged 3-6 and 6 or more years). In the case of women, weight of 300 was used for the external estimate and a weight of 345 (the actual sample size after removal of outliers as described in **Annex 4**) for the internal estimate. In all cases, therefore, slightly more weight was given to the internal estimate than to the estimate obtained from US children or from US women (as appropriate). **Table 4** below shows the external variance estimates used for children and for women.

Table 4. Ratio of the within-person to the total variance in intakes for children 3-9 years and for women aged 18-50 years old computed from the 2003-2004 (NHANES).

Nutrient	Variance Ratio	
	Children 3-9 years	Women 18-50
Energy	0.6580	0.5763
Protein	0.6152	0.6849
Total fat	0.7233	0.6731
Saturated fat	0.7167	0.69036
Monounsaturated fat	0.7373	0.66636
Polyunsaturated fat	0.78228	0.72488
Cholesterol	0.71205	0.75722
Carbohydrates	0.7271	0.5480
Fiber	0.6769	0.5520
Beta-carotene	0.7000	0.7000
Vitamin A (RAE)	0.6645	0.7118
Vitamin E	0.79599	0.6602
Vit B-1 (Thiamin)	0.6794	0.6934
Vit B-2 (Riboflavin)	0.5943	0.5998
Vit. B-3 (Niacin)	0.7035	0.6732

Nutrient	Variance Ratio	
	Children 3-9 years	Women 18-50
Vit. B-9 (Folate; DFE)	0.7154	0.6567
Vitamin B-6	0.6539	0.6160
Vitamin B-12	0.7222	0.7193
Vit. C	0.6843	0.6876
Iron	0.7376	0.6158
Zinc	0.6942	0.7193
Calcium	0.6170	0.6926
Magnesium	0.61534	0.50253
Copper	0.72125	0.59764
Potassium	0.63271	0.56408
Sodium	0.6647	0.65935
Phosphorus	0.55826	0.58912

Where possible, the prevalence of inadequacy was estimated. The usual intake is typically inadequate when it does not meet the person's requirement for the nutrient. In its 1986 report, the NRC proposed what is called the probability approach to estimating the prevalence of nutrient inadequacy. This approach requires that one must know the risk of inadequacy associated to each level of usual intake of a nutrient as well as the proportion of persons in a group with usual intakes at each of those levels. Beaton (1994) and Carriquiry (1999) proposed a simpler approach to estimating prevalence that requires only an estimate of the usual nutrient intake distribution and of the estimated average requirement (EAR)[3] of the nutrient in the group. This approach, called the EAR cut-point method, relies on the following assumptions: (a) intakes and requirements are independent; (b) the requirement distribution is symmetric around its mean; and (c) the variance of requirements in the group is higher than the variance of usual intakes. Thus, the method cannot be applied to nutrients without an EAR (e.g., calcium), or to energy (because requirements are highly correlated with intake) or to iron (because the distribution of requirements is not symmetric). **Table 5** presents the EAR values that were used for analyzing the data of most micronutrient intakes.

Table 5. Estimated Average Requirement (EAR) values of common vitamins and minerals, as specified in WHO/FAO (2006) and that are derived from the FAO/WHO RNI recommended values (2004).

Micronutrient	Children 3-6 years old	Children 6-9 years old	Women 18-50 years old
Vitamin A (RAE) (μg)[¥]	321	357	357
Vitamin D (μg)	5	5	5
Vitamin E (mg)	4.0	5.6	6.3
Vit B-1 (Thiamin) (mg)	0.48	0.72	0.92

3 The Estimated Average Requirement (EAR) is defined as the average (median) daily nutrient intake level estimated to meet the needs of half the healthy individuals in a particular age or gender group. The Recommended Nutrient Intake (RNI), with a similar meaning to the Recommended Daily Allowance (RDA), is derived from the EAR, by estimating the intake that is 2 standards deviation farther than the EAR, and therefore a daily intake that satisfies the nutritional need of 97.5% of the population.

Micronutrient	Children 3-6 years old	Children 6-9 years old	Women 18-50 years old
Vit. B-2 (Riboflavin) (mg)	0.48	0.72	0.92
Vit. B-3 (Niacin) (mg)	6	9	11
Vitamin B-6 (mg)	0.48	0.80	1.08
Vit. B-9 (Folate; DFE) (μg)	160	240	320
Vitamin B-12 (μg)[ω]	1.0	1.5	2.0
Vit. C (mg)	25	29	35
Iodine (μg)	64	64	107
Iron (mg)[€]	5	7	26
Zinc (mg)[£]	8	9	8
Calcium (mg)[§]	500	583	833

¥ Intake of β-carotene from fruits and roots was considered with a conversion factor of 12:1 (β-carotene:retinol), from green leafy vegetables of 24:1. Carotenoids pro-vitamin A different to β-carotene were transformed as having half the conversion factor of the latter.

ω If coming from liver and other very rich sources, bioavailability was reduced to ¼.

€ For a diet that is 5% bioavailable. Iron from meat, poultry and fish was considered as 10% bioavailable; i.e. the EAR values present in the table were reduced by half.

£ For a diet that is low bioavailability. Iron from meat, poultry and fish was considered as double bioavailable; i.e. the EAR values present in the table were reduced by half.

§ These values are the Adequate Intake (AI).

In order to obtain an estimate of the prevalence of inadequate calcium intake, we used the method proposed by Foote et al. (2004). This approach relies on the assumption that the adequate intake (AI[4]) is high enough so those individuals with usual intakes above the AI are very likely to be meeting their requirements. What is more difficult to assess is the status of individuals with usual intakes below the AI. Foote and colleagues (2004) propose that usual intakes below 25% of the AI are inadequate with probability 1, usual intakes between 25% and 50% of the AI are inadequate with probability 0.75, usual intakes between 50% and 75% of the AI are inadequate with probability 0.5 and finally, usual intakes between 75% and 100% of the AI are inadequate with probability equal to 0.25. An approximated prevalence of inadequate calcium intakes can then be computed as the weighted average of those probabilities, where the weights are given by the frequency of persons in the group with usual calcium intakes in each of those categories.

We used the probability approach to estimate the iron intakes. This requires that we compute the weighted average of the risks of inadequacy at each usual iron intake level. Tables with risk estimates are given in IOM (2000) but these were computed assuming a higher bio-availability of iron than what we assume is present in the diet of Palestinian children and women. We adapted the IOM tables to the case where bio-availability of dietary iron is 5%. Table 6 below shows the values we used here for calculations.

4 Adequate Intake (AI) is a recommended intake value based on observed or experimentally determined approximations or estimates of nutrient intake by group or group of apparently healthy people that are assumed to be adequate. This value does not derive from EAR value.

Table 6. Probability of inadequacy at various levels of usual iron intake for children aged 3 to 9 years old and women aged 18 to 49 years. Bio-availability of dietary iron is assumed to be 5%.

Estimated percentile of requirement	Children 3 to 9	Females 18 to 49
2.5	4.79	15.91
5	5.9	17.57
10	7.38	19.62
20	9.47	22.39
30	11.27	24.73
40	13.03	26.86
50	14.8	29.05
60	16.74	31.54
70	18.97	34.67
80	21.89	38.95
90	26.32	46.98
95	30.42	55.76
97.5	34.27	65.63

As a reference, the Tolerable Upper Intake Levels (UL[5]) of some micronutrients that may have adverse effects due to excessive intakes for the three age groups that were studied are presented in **Table 7.**

Table 7. Estimated Tolerable Upper Intake Levels (UL) values of common vitamins and minerals added to foods, as specified in WHO/FAO (2006)

Micronutrient	Children 3-6 years old	Children 6-9 years old	Women 18-50 years old
Vit. A (RE), only as retinol (μg)	600	900	3000
Vit. D (μg)	50	50	50
Vit. E (mg)	200	300	1000
Vit. B-3 (Niacin), only as nicotinic acid (mg)	10	15	35
Vit. B-6 (mg)	30	40	100
Vit. B-9, only as folic acid (μg) ¥	300	400	1000
Vit. C (mg)	400	650	2000
Iron (mg)	40	40	45
Zinc (mg)	7	12	45
Calcium (mg)	2500	2500	3000
Iodine (μg)	200	300	1100
Fluoride (mg)	1.3	2.2	10.0

¥ These amounts of folic acid in terms of Dietary Folate Equivalents are 1.7 larger, that is: 510, 680, and 1700 μg, respectively.

Note: Other micronutrients that are commonly incorporated to foods and that are not included in the table because they do not have UL values.

5 The Tolerable Upper Intake Levels (UL) are the highest average daily nutrient intake levels unlikely to pose risk of adverse health effects to almost all apparently healthy individuals in an age- and sex-specific population group.

Modeling of Additional Intakes from Consumption of Fortified Wheat Flour

The estimated additional amounts of vitamins and minerals in fortified wheat flour before being used to prepare foods **(Table 8)** was used to modify the nutritional composition of all the foods that contain wheat flour by estimating the additional amount of micronutrients based on the proportion of flour in the food while estimating losses during food preparation as assumed in the software. Folate is added to flour as folic acid, therefore the folic acid values were multiplied by 1.7 to adjust for the higher bioavailability of folic acid compared to food folate.

Using the actual consumption of wheat flour for all the foods that contain it, and as observed in the original survey, we re-calculated the intake of all nutrients and also re-estimated the usual nutrient intake distributions that would be observed should the food be fortified as was simulated and assuming that food intake patterns do not change. This simulation approach permits estimating the changes that would be observed in usual intakes if wheat flour is fortified.

Table 8. Predicted additional content of micronutrient at bakeries or household level before being used to prepare foods

Micronutrient	Factory Mean Content (mg/kg)	Estimated losses to homes (%)	Content at Homes (mg/kg)
Vitamin A (RAE)	1.5	20 %	1.2
Vitamin D	0.023	20 %	0.018
Vit. B-1 (Thiamin)	2.9	30 %	2.0
Vit. B-2 (Riboflavin)	3.6	15 %	3.1
Vit. B-3 (Niacin)	35	15 %	30
Vitamin B-6	3.6	15 %	3.1
Vit. B-9 (as folic acid; DFE)	2.5	15 %	2.1
Vitamin B12	0.004	15 %	0.003
Iron (from ferrous sulfate)	34	0 %	34
Zinc (from zinc oxide)	20	0 %	20

¥ The content of folic acid was multiplied by 1.7 considering the higher bioavailability of this compound over natural sources of folate. The table shows the values transformed into Dietary Folate Equivalents (DFE).

Blood Collection and Determination of Biomarkers

After night fasting, Venous blood samples were obtained using standard phlebotomy by biomedical personnel of the Ministry of Health in the same individuals interviewed for the dietary assessment. Needles of 23 gauges were used, and for small children butterflies needles were applied occasionally. Blood was collected in vacutainer tubes, one with lithium heparin for total blood destined to be used in the cell counters, and other without anti-clotting for serum collection. Blood-containing tubes were immediately wrapped with aluminum foil to prevent exposure to direct natural light. Within 4 hours after the blood samples were drawn, they were transported to each district stationary laboratory in an ice-box containing frozen ice packs.

At each district, a complete blood cell count (CBC) was carried out utilizing full automated apparatus. Blood calibrators were used with each CBC run as a component of quality control and the readings were recorded. Serum samples were separated from clotted blood by centrifugation. Collected serum was stored in triplicate in 0.5 mL-cryovials and kept at -20ºC. At the end of the collection period, samples were shipped to the Central Public Health Laboratory (CPHL) in the City of Ramallah to be placed in a freezer at -70ºC. Replicates of some of the samples were sent frozen using an international courier to the nutritional biochemistry laboratory of the USDA, ARS, USDA Western Human Nutrition Research Center in Davis, California.

Biomarker determinations were done by Drs. Settareh Shahab-Ferdows and Lindsay Allen. Available samples for analysis were: from Hebron, 92 non-pregnant mothers and 93 children age 3 to 7 years; and from Gaza City, 71 non-pregnant mothers and 105 children age 3 to 7 years. The reduced number of samples for each group determined that all samples from each age group be combined for each location; further inference for other strata was not possible.

Priorities were determined with A2Z in terms of the best use of samples from mothers and children and the cost of the analyses. Thus, vitamin A determination was not done in the children samples because in 2003-4 a national survey for this nutrient took place (MARAM, 2004). Anemia in women is highly prevalent, and therefore samples were dedicated to biomarkers other than those associated to iron status. **Table 9** shows the biomarkers that were measured, the methods, and the cut-off points used as indicative of nutritional inadequacy.

Table 9. Biomarkers, cut-off points for inferring nutritional deficiency and used analytical methods.

Biomarker; interpretation	Children 3-7 years old	Women 18-50 years old	Analytical Method
Hemoglobin; anemia (WHO)	< 115 g/L	< 120 g/L	Complete blood cell count
Hematocrit; anemia (WHO)	< 35%	< 36 %	Complete blood cell count
Ferritin; iron deficiency (WHO)	< 15 μg/L	< 15 μg/L	ELISA
Serum retinol; population deficiency when > 15% (IVACG)	< 20 μg/dL (< 0.70 μmol/L)	< 30 μg/dL (< 1.05 μmol/L)	HPLC
Serum 25(OH)vit.D; very deficient risk of rickets and osteomalacia	< 27.5 μmol/L	< 27.5 μmol/L	Sorin Radioassay
Serum 25(OH)vit.D; insufficient	< 50 μmol/L	< 50 μmol/L	
Serum folate; low intake and nutritional deficiency	< 10 nmol/L	< 10 nmol/L	Radioassay
Serum folate; risk of pregnancy affected with neural tube defects	-	< 16 nmol/L	
Serum vitamin B-12; deficiency (WHO, IOM)	< 221 pmol/L	< 221 pmol/L	Radioassay
Serum vitamin B-12; marginal status (WHO, IOM)	221-300 pmol/L	221-300 pmol/L	
Serum zinc; deficiency (IZiNCG)	< 65 μg/L	-	ICP-MS
CRP (an acute phase protein); Infection or inflammation	> 10 mg/L	> 10 mg/L	Clinical Chemistry Analyzer, Immulite

RESULTS

Geographic and Demographic Context

The West Bank and the Gaza Strip are physically separated by the State of Israel. Mobility between the West Bank and the Gaza Strip remains very difficult; they have indeed become two different regions in diet, habits, and daily life.

The total area of West Bank and Gaza is 6187 square kilometers, almost all of which is land. Of this, 94 percent, 5,822 square kilometers, lies in the West Bank; the 6% remaining is the Gaza Strip. The West Bank and Gaza has three types of landscape: The coastal area of the Gaza Strip and the North and South parts of the West Bank. The coastal area of the Gaza Strip, strip together with the plains of the Northern West Bank, contains the most fertile land. One of the main crops, especially in Gaza, is citrus fruit. In the West Bank, olive trees provide both the main crop and a cultural symbol. West Bank mountains and hills are largely rocky, but suitable for many different kinds of trees. Almonds and apples also flourish and the small, high valleys provide wheat, barley and lentils, as well as tomatoes, melons, maize and other vegetables. In the Jordan Valley, which is well bellow sea level but very dry, agriculture depends on irrigation from local streams and the Jordan River, although the growing season is extended because of the warmer climate.

The fortification of flour with micronutrients in the West Bank and Gaza is a response to a public health emergency. While fortification is likely to have immediate and significant benefits, the ultimate impact of fortification on Palestinian micronutrient status and health depends on a complex interplay of many factors. These include the population exposure or flour consumption by the target populations; the formulation and quality control of micronutrient doses during flour production; micronutrient stability during storage, distribution and preparation of food, and micronutrient bioavailability. These may differ for each micronutrient. Moreover, other factors such as changed micronutrient intake in response to diet improvement, public health education, and political and economic developments may necessitate adjustment of the formulation.

This dietary and biochemical survey was carried out in the two poorest regions under Palestinian administration, Hebron in the Southern part of the West Bank, and Gaza City in the North of the Gaza Strip. These two areas were selected because the nutritional needs there are the largest, and any potential benefit due to wheat flour fortification would also be easily detected. Both communities are increasingly receiving donated foods from different international organizations, and the diet is now highly depending on wheat flour, rice, chick peas, oil and sugar. Reduction in the consumption of milk products, eggs, meat and other foods of animal origin, plus fresh vegetables and fruits, are clear signs that the diet is far from normal and nutritionally appropriate.

Table 10 Summarizes main characteristics of the population sample that was surveyed in August of 2005.

Table 10. Demographic characteristics of the studied population.

Parameter	n	%
Gender of Children		
Female	182	49.7 %
Male	184	50. 3%
Households per District		
Hebron	183	50.0 %
Gaza	183	50.0 %
Locality of the Households		
Urban	207	56.6 %
Rural	120	32.8 %
Refugee Camp	39	10.7 %
Refugee Status		
Yes	124	33.9 %
No	242	66.1 %
Mother Education		
Less than high school	186	50.8 %
High school	148	40.4 %
More than high school	32	8.7 %
Father Education		
Less than high school	197	53.8 %
High school	113	30.9 %
More than high school	56	15.3 %

Dietary Profile

Results of the survey confirmed that diet of the population in Hebron and Gaza City lacks of sufficient diversity, and therefore inadequate to provide the amounts the different nutrients that are required for the human being. **Table 11**presents the per cent of households that were using during the day of the visit the main groups of foods. **Table 12** shows the main sources of energy for children and women of both locations.

Table 11. Percent of homes using the main groups of foods during the day of the visit in 2005

Food Group	Children (3-7 years old)		Women (18-50 years old)	
	Hebron	Gaza	Hebron	Gaza
Bread, mainly pita	95 %	97 %	87 %	91 %
Other cereal products	66 %	57 %	62 %	50 %
Beverages	89 %	66 %	91 %	78 %
Sugar and sweets	43 %	88 %	27 %	79 %

Food Group	Children (3-7 years old)		Women (18-50 years old)	
	Hebron	Gaza	Hebron	Gaza
Olive oil and salad dressings	49 %	10 %	37 %	9 %
Legumes, beans, and peas	27 %	48 %	32 %	37 %
Vegetables	87 %	88 %	85 %	76 %
Fruits	59 %	52 %	61 %	58 %
Meat, poultry, fish	52 %	58 %	61 %	60 %
Milk and milk products	50 %	39 %	48 %	28 %
Eggs	37 %	31 %	33 %	29 %

Table 12. Main food sources of energy for children and women of Hebron and Gaza City in 2005

Food Group	Children (3-7 years old)	Women (18-50 years old)
Wheat flour and bread	23 %	24 %
Rice	9 %	11 %
Sugar and sweets	8 %	4 %
Fruits	7 %	7 %
Sandwich falafel (chick-peas)	7 %	5 %
White potato and chips	6 %	3 %
Cooked vegetables	6 %	3 %
Chicken	5 %	6 %
Eggs	4 %	5 %
Milk and milk products	4 %	4 %
Meat	3 %	7 %

The analysis of the tables suggests that dietary profile of children and women was similar, which was as expected because the consumption of the family diet. However, it is clear that children in both regions were consuming more sugar and sweets, and potato chips than the women. Another interesting finding was that sugar is consumed widely in Gaza City, and vegetable fats and oils in Hebron. Consumption of foods from animal origin (milk and derivatives, eggs, and meat, poultry and fish) was low in both communities. This dietary profile is clearly associated to a low supply of essential micronutrients, especially those preferentially provided by foods of animal origin. Furthermore, the data also reveals a very worrisome finding and is the tendency of the children to consume snacks that are high in energy and very poor in nutritional density (sweets and potato chips), which may later cause serious problems of chronic diseases, and the establishment of bad nutritional habits.

Table 13 summarizes the main sources of protein for the two communities. In the case of the protein intake, it seems that it is fine, although sources of protein of good quality (meat, eggs, and milk and derivatives) are low for the children. The foods of animal origin are not only source of protein, but also of basic micronutrients whose intakes can be predicted as low for the populations of Hebron and Gaza City.

Table 13. Main food sources of protein for children and women of Hebron and Gaza City in 2005

Food Group	Children (3-7 years old)	Women (18-50 years old)
Wheat flour and bread	23 %	22 %
Chicken	16 %	17 %
Meat	7 %	16 %
Sugar and sweets	6 %	1 %
Sandwich falafel (chick-peas)	6 %	4 %
Milk and milk products	6 %	5 %
Rice	5 %	6 %
Eggs	5 %	6 %
Legumes, beans, nuts, seeds	4 %	4 %
Cooked vegetables	4 %	2 %
Fish	2 %	3 %
Stuffed Vegetables	1 %	3 %

As reference and for future use, the **Annex 6** presents the main food sources of the different macronutrients and micronutrients for children and women as found in this study.

Adequacy of Micronutrient Intakes and Potential Impact of Wheat Flour Fortification

We estimated usual nutrient intake distributions for most nutrients and for the two age groups of children and the women of reproductive age using the ISU method described in the section of Methods. **Tables 14, 15,** and **16** show the 5th, 10th, 25th, 50th, 75th, 90th, and 95th percentiles of usual intakes of the most common micronutrients for children aged 3-6 and 6-7 years of age, and women 18-50 years old, respectively. Annex 7 presents the same calculations for all the other nutrients that were computed. The same annex also shows the expected total intake values if wheat flour is fortifying accordingly to formula described in Table 8, and the estimated usual intakes of wheat flour from all foods that contain flour as an ingredient.

Table 14. Estimated percentiles of the usual nutrient intake distributions for children 3 to 6 years old of Hebron and Gaza City in 2005

Micronutrient	EAR[§]	5th	10th	25th	50th	75th	90th	95th
Vitamin A (RE) (μg)	321	127	158	224	337	522	791	1023
Vitamin E (mg)	4.0	5.2	5.8	6.8	8.2	9.8	11.3	12.3
Vit B-1 (Thiamin) (mg)	0.48	NA[¥]	NA	NA	NA	NA	NA	NA
Vit B-2 (Riboflavin) (mg)	0.48	0.45	0.50	0.60	0.74	0.92	1.11	1.24
Niacin (mg)	6	5	5	6	7	9	11	12
Vitamin B-6 (mg)	0.48	0.54	0.61	0.74	0.88	1.04	1.19	1.28
Folate (DFE) (μg)	160	105	116	138	167	201	238	263

Micronutrient	EAR§	5th	10th	25th	50th	75th	90th	95th
Vitamin B-12 (μg)	1.0	0.5	0.6	1.0	1.6	2.8	4.5	5.9
Vit C (mg)	25	28	34	46	61	79	98	111
Iron (mg)	5	5	5	6	7	9	10	11
Zinc (mg)	8	4	4	5	6	7	8	9
Calcium (mg)	500	169	194	243	307	382	459	511

§ EAR values as listed in Table 5.
¥ NA = not available; it was not possible to make the adjustment for calculating usual intakes due to the large intra-individual variation.

Table 15. Estimated percentiles of the usual nutrient intake distributions for children 6 to 7 years old of Hebron and Gaza City in 2005

Micronutrient	EAR§	5th	10th	25th	50th	75th	90th	95th
Vitamin A (RE) (μg)	357	105	129	186	285	455	716	952
Vitamin E (mg)	5.6	5.4	5.9	6.9	8.1	9.5	10.9	11.8
Vit B-1 (Thiamin) (mg)	0.72	NA¥	NA	NA	NA	NA	NA	NA
Vit B-2 (Riboflavin) (mg)	0.72	0.36	0.41	0.51	0.64	0.82	1.01	1.14
Niacin (mg)	9	4	5	6	7	9	11	12
Vitamin B-6 (mg)	0.80	0.50	0.56	0.66	0.80	0.96	1.11	1.20
Folate (DFE) (μg)	240	97	109	132	163	201	244	273
Vitamin B-12 (μg)	1.5	NA¥	NA	NA	NA	NA	NA	NA
Vit C (mg)	29	24	30	40	54	71	88	100
Iron (mg)	7	4	5	6	7	9	11	12
Zinc (mg)	9	3	4	4	5	6	8	8
Calcium (mg)	583	151	173	217	276	349	427	481

§ EAR values as listed in Table 5.
¥ NA = not available; it was not possible to make the adjustment for calculating usual intakes due to the large intra-individual variation.

Table 16. Estimated percentiles of the usual nutrient intake distributions for women of reproductive age (18-50 years old) of Hebron and Gaza City in 2005

Micronutrient	EAR§	5th	10th	25th	50th	75th	90th	95th
Vitamin A (RAE) (μg)	357	165	199	270	383	554	788	981
Vitamin E (mg)	6.3	5.5	6.3	7.9	10.0	12.4	15.0	16.8
Vit B-1 (Thiamin) (mg)	0.92	0.39	0.43	0.50	0.59	0.70	0.80	0.86
Vit B-2 (Riboflavin) (mg)	0.92	0.49	0.55	0.66	0.81	0.98	1.16	1.28
Niacin (mg)	11	6	6	8	9	11	14	15

Micronutrient	EAR§	5th	10th	25th	50th	75th	90th	95th
Vitamin B-6 (mg)	1.08	0.61	0.69	0.83	1.01	1.20	1.39	1.51
Folate (DFE) (μg)	320	118	133	163	202	249	300	335
Vitamin B-12 (μg)	2.0	NA¥	NA	NA	NA	NA	NA	NA
Vit C (mg)	35	33	39	51	66	83	101	113
Iron (mg)	26	5	6	7	9	11	14	15
Zinc (mg)	8	4	5	6	7	8	10	11
Calcium (mg)	833	204	231	283	354	439	528	588

§ EAR values as listed in Table 5.
¥ NA = not available; it was not possible to calculate usual intakes due to the large intra-individual variation.

As expected, the analysis of the tables reveals that the nutritional adequacies vary from micronutrient to micronutrient and from group to group. Micronutrients that appear to be of little concern were vitamin E and vitamin C for the three age groups, and vitamin B-2 and iron for children 3-6 years old. This situation can be explained in part because the different biological needs similar intakes might be sufficient for one group and not for another. For example, intakes of folate, iron and calcium are less deficient for children 6-7 years old than they are for women of reproductive age. Thus, for comparison purposes, it is preferable to express the micronutrient intake values in terms of proportion of the corresponding EAR values as it is done **Table 17.** This table shows the proportion of the population of each age group with intakes below the corresponding EAR values, both in the absence as well as in the presence of wheat flour fortification following the formulation presented in **Table 8.**

Table 17. Proportion of the population with estimated intakes below the EAR values of Hebron and Gaza city in 2005, in the absence and in the presence of wheat flour fortified with several micronutrients

Micronutrient	Absence of Fortification			Presence of Fortification		
	3-6 y.o.	6-7 y.o.	Women	3-6 y.o.	6-7 y.o.	Women
Vitamin A	47 %	63 %	45 %	29 %	47 %	10 %
Vit B-1	NA¥	NA	97 %	17 %	81 %	77 %
Vit B-2	8 %	62 %	67 %	2 %	35 %	27 %
Niacin	21 %	77 %	70 %	5 %	48 %	32 %
Vitamin B-6	3 %	50 %	61 %	0 %	22 %	23 %
Folate	44 %	89 %	93 %	7 %	41 %	34 %
Vitamin B-12	27 %	NA	NA	20 %	49 %	30 %
Iron	9 %	42 %	100 %	1 %	15 %	98 %
Zinc	91 %	97 %	71 %	72 %	85 %	36 %
Calcium	49 %	58 %	62 %	49 %	58 %	62 %

¥ NA = not available; it was not possible to calculate usual intakes due to the large intra-individual variation.

Although the analysis of the proportion of the population below the corresponding EAR values provides the estimation of the proportion of the affected population, it is also necessary to have an idea of the nutritional gap. The magnitude of the nutritional gap denotes the additional amount of micronutrients that are needed to supply to correct the inadequate intake of the individuals of the population. **Table 18** presents the micronutrient gaps (in terms of % EAR) at percentile 5 in the absence or in the presence of fortified wheat flour for each one of the three groups that were studied.

Table 18. Magnitude of the nutrient gaps (in terms of % EAR) at percentile 5 of intake of the populations of Hebron and Gaza city in 2005, in the absence and in the presence of whet flour fortified with several micronutrients

Micronutrient	Absence of Fortification			Presence of Fortification		
	3-6 y.o.	6-7 y.o.	Women	3-6 y.o.	6-7 y.o.	Women
Vitamin A	60 %	71 %	54 %	54 %	53 %	15 %
Vit B-1	NA¥	NA	58 %	17 %	51 %	39 %
Vit B-2	6 %	50 %	47 %	0 %	36 %	28 %
Niacin	17 %	56 %	45 %	0 %	40 %	29 %
Vitamin B-6	0 %	37 %	44 %	0 %	25 %	22 %
Folate	34 %	59 %	63 %	7 %	42 %	39 %
Vitamin B-12	50 %	NA	NA	37 %	68 %	56 %
Iron	0 %	43 %	81 %	0 %	17 %	71 %
Zinc	50 %	67 %	50 %	42 %	55 %	29 %
Calcium	66 %	74 %	76 %	66 %	74 %	76 %

NA ¥ = not available; it was not possible to calculate usual intakes due to the large intra-individual variation.

Intakes at percentile 5 are the worst. If the micronutrient gap at this percentile of intake continue being too large (e.g. above 20% of EAR) after the implementation of an intervention, it would be an indication that other measures should be introduced to supply the additional intake that are needed to correct the nutrient inadequacy. The new and complementary strategies should be extensive (i.e. with large population coverage) if simultaneously a large proportion of the population continue being affected (i.e. 30%), or targeted if only a small proportion of the population. In other words, both variables are important for designing predicting the potential benefit of a nutritional intervention.

Data of **Tables 17** and **18** suggest that it was a good strategy to include 8 vitamins (the formulation also contains vitamin D, which does not appear in the table) and 2 minerals in the fortification formulation of wheat flour. All the micronutrients are needed for the populations that were studied in Hebron and Gaza City. It is predicted that the population with the largest benefit would be women of reproductive age, because their needs are larger and most of them consume reasonable high amounts of wheat flour. Nevertheless, also children of the two age groups would improve the nutritional status of several of the micronutrients. The largest changes would be for vitamin B-2, niacin, folate, and vitamin B-6. Nevertheless, the nutritional status of vitamin A would have a large improvement in women, although not in children. The opposite is true for iron, because the very large need of this mineral by women of reproductive age. Therefore, complementary intervention would be needed to assure positive changes of vitamin A in children, and in iron in women. This condition justifies the permanence of the preventive supplementation programs of vitamin A for children and iron for women.

The results also suggest that school-age children would still require the supply of micronutrients by other means beyond fortified wheat flour. Products of the school canteens should be fortified, but the nutrient contents are going to be much lower than in the absence of the wheat flour fortification program. Here it is important to emphasize that the formulation of the foods aimed to school children must be done taking in consideration the usual diet and the improvements introduced with the use of fortified wheat flour.

The consumption of fortified wheat flour is also going to have some impact in the nutritional status of vitamin B-1, vitamin B-12, and zinc. However, because the unpredicted large inadequacies of these micronutrients, the increase in the content of these micronutrients in wheat flour may be considered. The two vitamins doe not have UL values, and therefore safety concerns are small. In the case of zinc, although has an UL value especially for the small children, the very low intake of zinc justifies an increase in the level of this mineral.

Calcium is a nutrient that appears has a large nutrient gap and that affects large sectors of the population. Addition of calcium to wheat flour is difficult because the large weights of this mineral that are needed to be incorporated. Therefore, it is important to identify other strategies to supply calcium to the population, either promoting the production and consumption of milk and its derivatives, or the production of beverages and other foods enriched with this nutrient.

In order to interpret the results in an easier and comprehensive manner, both for predicting benefits as well as to ensure safe intakes, we propose the use of cumulative figures **Figure 1**. The **Annex 8** describes several figures for presenting nutrient intake data. Perhaps the reading of it would make easier the understanding and interpretation of **Figure 1.**

On **Figure 1**, the percentiles of the intake distribution are presented in the X-axis and the corresponding intake values for each percentile in the Y-axis. The blue line shows the distribution of values in the absence of wheat flour fortification, and the pink line in its presence. In the latter case the intakes are larger, and therefore all the values of the pink line are above the blue line; and this is the reason the words “additional intake” with an up-arrow appears in the right side of the figure. The horizontal and green line represents the EAR value of this nutrient for women of reproductive age (the group illustrated in the figure). The proportion of values below that line expresses the probable proportion of this population with insufficient intakes of vitamin A (the nutrient illustrated in the figure). Therefore in this case, it is easy to calculate that around 45% of the population of women of reproductive age in Hebron and Gaza in 2005 had a low and inadequate intake of vitamin A in the absence of fortification, but only 10% in its presence.

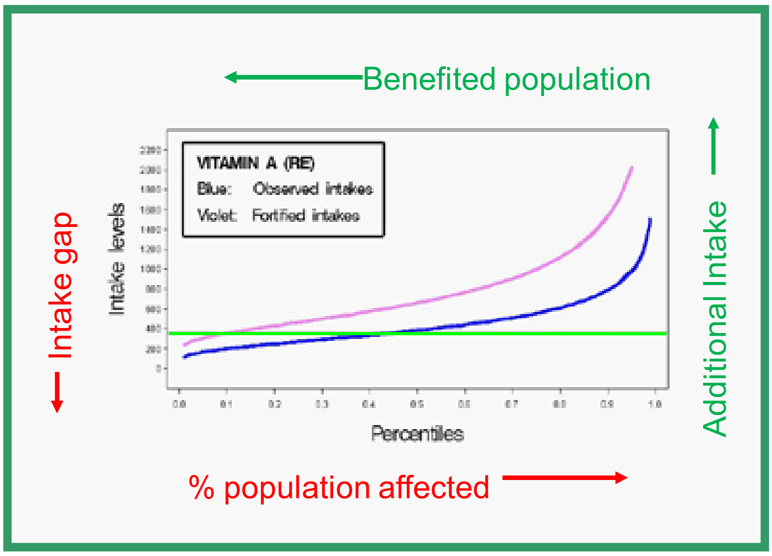
At the bottom of the figure, the words “% population affected” with an arrow toward the right symbolizes that the intersection point over the X-axis between the EAR line (green) and the line of the baseline of intakes (blue) is the percent of the population that has a low inadequate intake of the nutrient that is being analyzed. Once fortification is taken in consideration, the intersection points shift to the left, and that is the reason why at the top of the figure with an arrow toward the left, the words “benefited population” appears. In this cases, wheat flour fortification would benefit 35% of the originally deficient population; i.e. 45-10 = 35%. This is a very large change, and it is predicted that the biomarkers associated to vitamin

A nutritional status (serum retinol, and breast milk retinol –in the case of lactating women-) would have very large probabilities of improving.

At the left side of the figure, the words "intake gap" with a bottom-arrow represents the magnitude of the intake gap for those percentiles of the intake distribution that are below the EAR line (green). Thus, in the absence of fortification, five percent (percentile 5) of the women of reproductive age in Hebron and Gaza City in 2005 had a vitamin A intake of around 175 μg/day (165 exactly), but which would change to around 300 μg/day (304 exactly) in the presence of fortification. In other words, the consumption of fortified wheat flour is going to provide around 125 μg/day (175-300) of vitamin A to the women with the lowest vitamin A intake of the studied population. It also means that fortified wheat flour would supply 42% (125/300) of the whole new intake of vitamin A to the women with the lowest intake of this vitamin. The new vitamin A intake is much better than at the baseline, although some women still have intakes below the EAR. However, the estimated inadequacy is only 100 μg/day and not 225 μg/day as in the baseline; and the inadequacy would affect now to less than 10% of the population.

Here, it is important to point out that for all the added nutrients with UL values, except vitamin A and lesser degree folic acid, the intakes with and without fortification are low enough, even at percentile 95 of intake (see **Tables A7-5** of the **Annex 7**). Therefore, the practice of fortification of wheat flour could be considered safe. The case of vitamin A and folic acid deserves special consideration, because once the wheat flour fortification is working well, the supply of those micronutrients by other strategies may need regulation, as for example limiting the use of supplements with high amounts of vitamin A (e.g. 200,000 IU) only for children younger than 36 months of age. However, any decision in these matters requires the existence of a monitoring and evaluation system using biomarkers, and which would be treated in the next section.

Figure 1. Cumulative distribution of vitamin A intakes (μg/day) by women of reproductive age in Hebron and Gaza City in 2005.



*Line blue represent the intakes in the absence of wheat flour fortification, and the violet-pink line in the presence of wheat flour fortification. The green line is the estimated WHO/FAO EAR of vitamin A for women of reproductive age. The UL value of vitamin A for this group is 3,000 μg/day, and it is not included in the figure; in should appear as a red horizontal line in the figure.

In summary, it is possible to predict that, by the use of fortified wheat flour, the vitamin A inadequacy in women of reproductive age of Hebron and Gaza City is going almost to disappear. On the other hand, the same figure shows that the introduction of wheat flour fortified with vitamin A is very safe for women of reproductive age; even at the largest new intake of vitamin A as retinol (even when including the portion that derives from β-carotene) is far from the UL value. The percentile 95 in the presence of fortified wheat flour, would have a predicted total vitamin A intake of around 2,000 μg/day (exactly 2,025), which is only 67% of the UL value (2000/3000).

Annex 9 presents the same type of figure with results of the entire list of nutrient that were analyzed in this study.

Analysis of Biomarkers Associated to Status of Micronutrients

Figures 2 and **3** show the results of the biomarkers obtained in children (3-7 years old) and women of reproductive age, respectively. It is clear that the nutritional deficiencies were different between the two groups. In general, women had a worse nutritional status than children. This was especially true for vitamin D, which revealed that almost all women had an insufficient status (levels below 50 μmol/L), but that condition affected only around 10% of children. This contrasting situation also evidences that the serum samples were well conserved during the period of storage, because using the same indicator and the cut-off reference value, samples from children had good levels of vitamin D while those for women do not, and it happened both in Hebron and Gaza City.

The situation of vitamin D is too frankly deficient in women, that more than half of women had serum vitamin D levels that are associated to risk of rickets and osteomalacia (less than 27.5 μmol/L). Since the vitamin D status of their children is reasonably good, and sunlight is the usual main source of the vitamin, this situation is likely to be caused by the design of the women's clothing preventing exposure of their skin to ultraviolet light. A high prevalence of vitamin D deficiency in women has also been described in other middle-Eastern countries including Egypt, Saudi Arabia and Iran, but this information appeared to be new for the Palestinian territories.

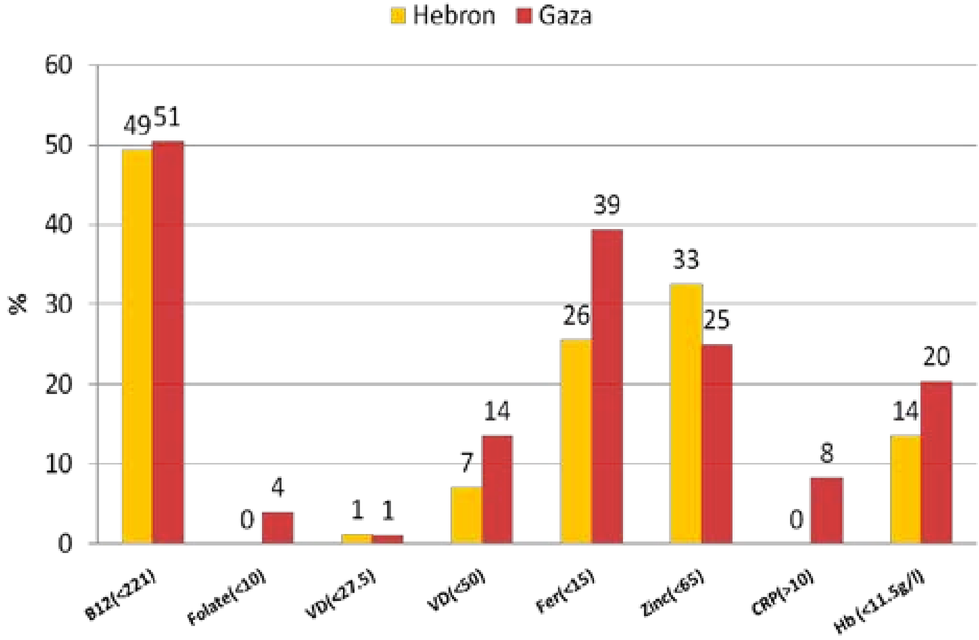
Both age groups were highly deficient for vitamin B-12 but not for folate (serum folate levels were higher than 10 nmol/L), although 44% of the women of Hebron, and 24% in Gaza City, presented serum folate levels below 16 nmol/L that, although are not indicative of nutritional deficient, may place genetically-susceptible women to have pregnancies affected with neural tube defects. Deficiency of vitamin B-12 was expected because the low intake of foods from animal origin, especially milk, eggs and liver. The adequate serum folate levels did not correlate with the estimated low intake of folate from the diet. The little association between the estimate values of folate intake and the levels of serum folate may be due that the food composition tables are underestimating the true content of folate in the foods; chickpeas, peas, beans and other legume grains are rich in folate, and they are common in the traditional Palestinian diet. This is a situation that has been found in other places, and it is explained because most of the folate content of foods were calculated many years ago when the analytical assays were neither accurate nor extracted well the folate compounds from foods. This assumption should be confirmed by means of measuring the folate content of commonly consumed foods in Hebron and Gaza City, as well as other regions of the Palestinian territories.
Children status of iron and zinc were also low; nearly one third of children showed low serum levels of the associated indicators, ferritin and serum zinc, respectively. This finding is also explained by the low consumption of meat, fish and poultry, combined with the high intake of unleavened bread, which has a high phytate content and therefore low bioavailability of iron and zinc. Although the

same indicators were not measured in women, the situation should be similar or worse, especially when anemia prevalence was larger in women (29-36%) than in children (14-20%). The data from serum zinc deserves an especial analysis, because blood samples were not collected in trace-mineral free tubes, but despite of this, the serum zinc values were low. Zinc is a mineral, and hence it would not decay during sample storage.

In 2004, the MARAM Project, which carried out a vitamin A and anemia survey for children 1-5 years old of the different Palestinian provinces. In that survey 1,127 children were selected from regions of the West Bank and Gaza Strip; both Hebron and Gaza City were studied as independent provinces. The 2004 study revealed that 14% children of Hebron and 31% children of Gaza City were anemic. The study of 2005, including older children and women of reproductive age, confirmed that anemia is a moderate public health problem in Hebron and Gaza City: 14% and 20% children 3-7 years old of Hebron and Gaza City, respectively, and 29% and 36% women of Hebron and Gaza City, respectively, were found anemic.

In the dietary survey of 2005, the proportion of individuals being affected with an infectious-inflammation status was low based on the levels of C-reactive protein (CRP); none of the children from Hebron, 8% children from Gaza City, and 13% and 12% of women from Hebron and Gaza City, respectively. This result differs from the findings of the vitamin A survey of 2004, which identified that 58% children 1-5 years old from Hebron and 54% from Gaza City were suffering from a form of infection or inflammation at the moment of the study. In 2004, alpha-acid glycoprotein (AGP $\geq$1 g/L) was used as the acute phase protein indicator. AGP remains high for a longer period than CRP. Furthermore, the study of 2004 included younger children, and they are generally more affected by infections and inflammation. Therefore, these two variables can explain the difference between the two studies. In any case, it is important to point out here that ferritin levels are usually interpreted using CRP; high values of CRP can increase the levels of ferritin, and hence underestimating iron deficiency.

Figure 2. Prevalence of abnormal biomarkers in children 3-7 years old, Hebron and Gaza City.

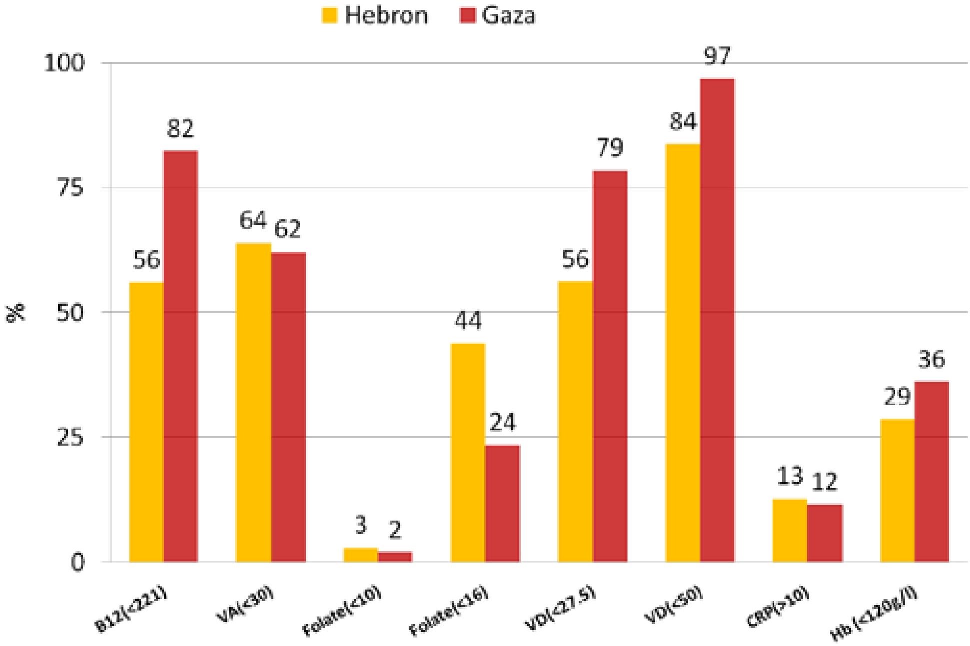


*Interpretation of the cut-off points for each variable appear in **Table 9.**

The dietary study of 2005 did not determine children's serum samples for vitamin A content, because these had already been analyzed by the MARAM Project (2004). Across all Palestinian regions the combined prevalence of low plasma vitamin A concentrations (<20 μg/dL) was 22%; this constitutes a severe vitamin A problem based on IVACG criteria (2002) that points out that prevalence above 15% is indicative of a public health problem . Seventy-six percent of children had levels <30 μg/dL. The problem was significantly worse in Gaza City, which shown a prevalence of low serum retinol levels (< 20 μg/dL) of 31.2%, which was the worst of all the studied regions. Hebron had a prevalence of 19.4%. Elevated AGP can explain lower values of serum vitamin levels because the Retinol Binding Protein (RBP) is an acute phase-responding protein whose amounts are decreased under that condition. Nevertheless, when only the data of the uninfected children was taken in consideration, the entire Gaza strip continued showing vitamin A deficiency as a public health problem (16%).

The dietary study of 2005 revealed that vitamin A deficiency is also a public health problem for women of reproductive age of Hebron and Gaza City; 64% in Hebron and 62% in Gaza City had serum retinol levels lower than 30 μg/dL, which is the cut-off point for diagnosis deficiency in women. This finding confirms the need to increase the supply of vitamin A to the entire population.

Figure 3. Prevalence of abnormal biomarkers in women of reproductive age (18-50 years old), Hebron and Gaza City.



*Interpretation of the cut-off points appear in **Table 9.**

Annex 10 presents the values of all the biomarkers that were determined in the 2005 study.

FINAL DISCUSSION AND INFERENCES

The combination of the dietary intake research and the nutritional status assessment analyses provides an excellent, and possibly the first example of the complimentary value of having data on both nutrient intakes and biochemical markers of status.The dietary data are important for estimating the prevalence of inadequate intakes of specific nutrients – for as many as there are data on their content in the diet. Dietary data are also required to identify the food sources of nutrients (and lack of them) and for determining the intakes of potential fortification vehicles (e.g. wheat flour), the amount of micronutrients that are needed to be added to such foods in order to correct the intake gaps, and the calculation of the impact of different levels of fortification on the prevalence of inadequate or excessive intakes of each nutrient. The biochemical data were necessary to detect the high prevalence of vitamin D deficiency in the mothers (because the main source of this nutrient is exposure to UV light and not diet), and to confirm the prevalence of most deficiencies predicted from the food intake data. However in the case of folate we found that intakes must be substantially higher than predicted from dietary assessment, most likely because of errors in the values available for the folate content of cooked legumes. This needs to be confirmed by analysis of food samples. The biochemical values also provide a baseline for monitoring changes in the biochemical data after fortification. A final important point is that potential users of such information are usually more readily convinced by biomarker values than by nutrient intake data.

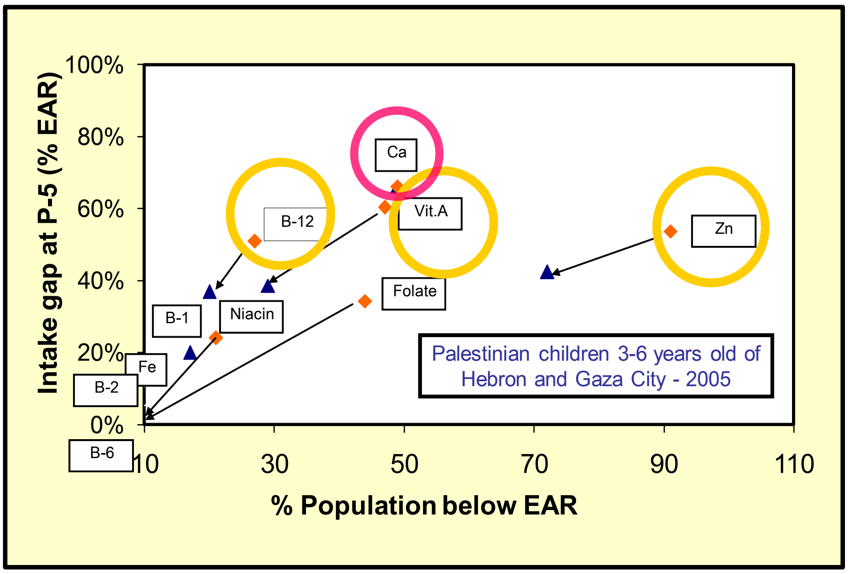
The nutrient intake analysis revealed that the intakes of a substantial number of other micronutrients were inadequate – including vitamins B-1, B-2, B-6 and niacin in children older than 6 years of age and women of reproductive age – but biochemical analyses were not performed for these nutrients. Future surveys should include assessment of biomarkers of these nutrients. There is no sensitive biomarker for calcium deficiency but dietary data also indicate that intakes of calcium are highly inadequate for the three groups studied, and probably for the entire population. Rising of calcium intakes would require the introduction of other strategies, such as promoting the production and consumption of milk and derivates, and supplementation and calcium fortification of food and beverages beyond wheat flour.

In summary, it can be say that for children and women of reproductive age in Hebron and Gaza City the largest nutritional inadequacies are for vitamin A, vitamin B-12, iron, zinc and calcium. Children older than 6 years of age and women might also be deficient for the vitamins B-1, B-2, B-6 and niacin, although biochemical confirmation is still pending. Women were more affected than children and they deserve especial attention for additional supply of vitamin D and iron. Although folate status was found good, some women may still require additional intakes of folic acid to prevent occurrence of pregnancies affected with neural tube defects; assessment of serum folate levels after the introduction of fortified wheat flour is necessary to define if another source of folic acid would be required for this purpose. Based on the estimated intake data, it appears that supply of vitamin E and vitamin C are adequate for the Palestinian population.

In most populations, children aged 6 months to about 36 months are the most nutritionally vulnerable. The nutrient intakes and biomarkers in this group need to be assessed. Flour fortification is unlikely to be very effective for improving the nutritional status of children during the complementary feeding period as their intakes of flour are low. Special measures to increase the micronutrient density of foods of this age group are needed.

The **Figures 4** and **5** illustrate the current intake situation and the potential improvement due to the use of fortified wheat flour for children 3-6 years old and women of reproductive age, respectively, from Hebron and Gaza City. These figures correlate the data presented in **Tables 17** and **18.** The horizontal axis (X-axis) shows the proportion of the population with estimated intakes below the corresponding EAR values. The vertical axis (Y-axis) shows the magnitude of the micronutrient gaps, in terms of the percent of the corresponding EAR values, for the individuals located at the percentile 5 of intake (i.e. the worst situation). The micronutrients with the worst situation are those whose baselines are located at the top and right section of the figures. The improvement in both variables due to the additional intake provided by the use of fortified wheat flour is shown by the arrows toward the bottom and left section of the figures. Ideally, the new situation should be that less that 20% of the population with intakes below the EAR values, and less than 20% of the EAR as the intake gap for the individuals located at percentile 5 of intake.

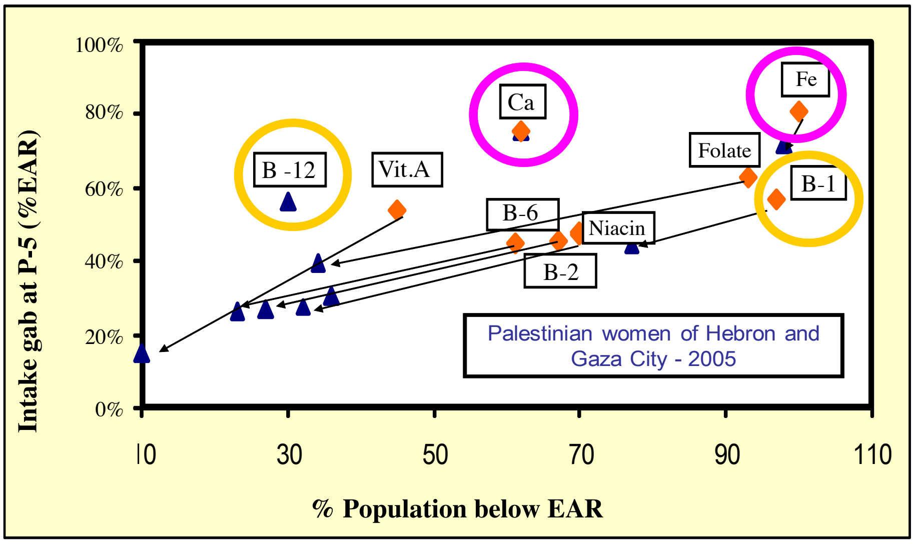
Figure 4. Potential benefit of the consumption of fortified wheat flour by children 3-6 years old from Hebron and Gaza City.



*The orange rhombs indicates the baseline intake, and the blue triangles the estimated final intake after adding the supply provided by wheat flour fortified as described in **Table 8.**

The **Figure 4** suggest that once wheat flour is fortified, children 3-6 years old would reach the EAR values for most micronutrients, excepting vitamin A, vitamin B-12, zinc and calcium. The content of vitamin B-12 and zinc can be increased from the current fortification formulation. However, supply of additional vitamin A and calcium would require of the combined use of other strategies, as for example the provision of supplements with vitamin A and D during infancy, and then vitamin A supplements thereafter. However, the dose of vitamin A to be given through supplements should be reviewed based on the new estimated nutritional gap for this nutrient; in other words, probably supplements with content lower than 200,000 IU would be needed for children older than 3 years. Furthermore, the situation may vary from province to province. Both Hebron and Gaza City have the most nutritionally affected population, conditions of other provinces may be much better, and perhaps the presence of the program of vitamin A supplementation beyond 36 months of age may be unnecessary in some of the Palestinian provinces if wheat flour is well fortified. Calcium deserves further studies in order to determine the magnitude of its deficiency and to propose suitable interventions to correct the nutritional gap.

Figure 5. Potential benefit of the consumption of fortified wheat flour by women of reproductive age from Hebron and Gaza City.



*The orange rhombs indicates the baseline intake, and the blue triangles the estimated final intake after adding the supply provided by wheat flour fortified as described in **Table 8.**

The **Figure 5** makes a similar analysis as done in **Figure 4** but applied to women of reproductive age. In this case, the deficiencies are larger and despite that population changes associated to the additional intakes through the consumption of fortified wheat flour are larger too, there are some micronutrient inadequacies than remain important for a proportion of the women of Hebron and Gaza City. Thus, like in the case of children, additional amounts of vitamins B-1 and B-12 in the fortification formulation of wheat flour might be useful. Improvements of the intakes of iron and calcium require the simultaneous presence of other interventions, as for example supplements or beverages containing these two minerals would be necessary.

The **Figure 5** implies that vitamin A deficiency would be corrected in the whole group of women by the use of fortified wheat flour, and therefore use of supplements of vitamin A after delivery would be unnecessary. If the estimations are correct, the biomarkers associated to the nutritional status of this vitamin in women would have a large positive change. Therefore, it would be interesting to monitor the changes of retinol not only in serum but also in breast milk. The assessment of the nutritional content of breast milk would also be important for other vitamins and minerals, because they may become of the strongest biomarkers to follow the impact of wheat flour in the population. Assessing the nutritional value of breast milk would also useful for estimating the nutritional status of the breast-fed infants. Given the poor nutritional status of the mothers, is whether the micronutrient content of their breast milk is compromised by their poor nutritional status, whether this can be improved sufficiently by the flour fortification program, and whether these women need multiple micronutrient supplements during lactation as well as pregnancy.

The highest intake of vitamin A in the presence of fortified wheat flour was below the UL values for the studied groups of Hebron and Gaza City. However, it is important to check that after the use of fortified wheat flour the intake of vitamin A, specifically as retinol, is not higher than the corresponding UL values. Thus, it is important to determine whole retinol intakes in the populations of other districts that are not as nutritional-at risk as in Hebron and Gaza City. In the event that it were the case, then it would be necessary to decrease in some amounts the content of vitamin A in fortified wheat flour, it probably that may be done without jeopardizing the good impact in the vitamin A-deficient individuals. In any case, it is necessary that vitamin A is not allowed to be incorporated into other fortified foods, except when added for restoration purpose (skimmed milk) or nutritional equivalence (margarine imitating the nutritional value of butter).

The case of folate is interesting, because the serum folate levels were relatively normal in the absence of fortified wheat flour. However, it is important to examine if after introduction of fortification the new serum folate levels for most women of reproductive age approaches 16 nmol/L. If it were not the case, then some complementary measures may be needed for this group for avoiding the risk of neural tube defects in future pregnancies. Use of supplements may be suitable, but providing around 100 μg/day, instead of the 400 μg/day that are recommended in the absence of food fortification (see Dary 2009).

The fortification level with vitamin D should also wait the evaluation of the impact of the use of fortified wheat flour in serum vitamin D; this is the only way to know if the current used amount is fine or it needs to be raised.

School-age children may still need to receive additional micronutrient intakes through foods available at schools. However, the fortification formulations of those products should take in consideration the additional intakes that are expected from fortified wheat flour. In other words, in the presence of fortified wheat flour the addition of vitamins and minerals in the school-feeding programs would be much lower than in its absence. Fortification formulation of other processed foods and that the industry would like to produce should also be regulated in such a way that they are not going to provide excessive amounts of micronutrients, which may not only be unnecessary but risky. In any case, analysis such as done in this study are needed for taking decisions in the fortification formulas of targeted- and market-driven fortifications (see Allen et al., 2006).

The current policy of the Palestinian Health Authority is to provide iron and folic acid supplements to women during pregnancy. Given the high prevalence of multiple micronutrient deficiencies in these women, changing to provide multiple micronutrients during pregnancy should be considered. UNICEF does have such supplements available (the UNIMAPP supplement).

The current policy of providing vitamin A and D supplements as drops to infants starting at 21 days postpartum, through 2 years of age, appears to be prudent based even in the presence of fortified wheat flour. Likewise, iron supplementation from 6 to 24 months, and extended to 36 months if child is found anemic, should continue.

CONCLUSIONS AND RECOMMENDATIONS

- Based on the reduction in the variety of the traditional Palestinian diet to mainly wheat flour, rice, chickpeas, and some vegetables and fruits, but scarce amounts of milk, eggs, and protein from animal origin, the Palestinian Authority decided in 2005 to proceed with the fortification of wheat flour with the vitamins A, D, B-1, B-2, niacin, B-6, folic acid, and B-12, and the minerals iron and zinc.

- Data of the usual micronutrient intakes by children 3-7 years old and women of reproductive age obtained in 2005, and analyzed in 2009, have confirmed that indeed all the above mentioned micronutrient are inadequate and therefore it is justified to incorporate them into wheat flour. Situation in 2009 might be similar or worse than that of 2005, and hence the decision of fortifying wheat flour continues being important.

- Amounts of vitamin B-1, vitamin B-12 and zinc might be raised in the current fortification formula because the grade of nutritional inadequacy of these micronutrients was larger than expected.

- Fortification contents of folic acid and vitamin D should be modulated after evaluation of the serum levels in the presence of fortified wheat flour. Vitamin A may also be incorporated to this group mainly for avoiding excessive intakes by some of the groups having good diets.

- Fortification formulations of school-feeding programs and products fortified by the industry using market-driven fortification should be done after taking in consideration the supply of micronutrients by the diet and by the programs of mass-fortification (salt and wheat flour). Incorporation of vitamin A and folic acid should have special attention during the preparation of standards and regulations because these two nutrients would be supplied in good amounts through fortified wheat flour.

- Despite wheat flour fortification, complementary measures to provide vitamin A and calcium are needed for the children 3-7 years old; and iron and calcium for women of reproductive age.

- Determination of the nutritional status of children 1-3 years old deserves a special consideration, because it is a group at high risk, and because fortified wheat flour would benefit them less because the low consumption of products containing this food. Therefore, continuation of the programs of supplementation with vitamin A and D, and iron during infancy should continue. Use of powder supplements for home-fortification to improve the micronutrient density of the foods used to complement breast-feeding should also be considered.

- Currently, wheat flour supply 23% and 24% of the total energy for children 3-7 years and women of reproductive age of Hebron and Gaza City, which are representative of the poor sectors of the Palestinian population. Furthermore, this food is consumed daily by more than 90% of this population. These facts support the selection of wheat flour as a micronutrient carrier in the Palestinian territories. Once the diet improves in quality and variety, fortified wheat flour would continue being useful to complement the delivery of essential micronutrients to the population; micronutrient supply would be lower but probably still important in the Palestinian diet. Adjustments in the fortification formulation should be based in future intake and biomarker studies.

- Both dietary and biomarker data reveal a very high prevalence of deficiency of most micronutrients assessed, in both children and in mothers. Folate status is, however, generally adequate presumably due to the consumption of legumes. Intakes of vitamin E and vitamin C appear to be adequate.

- Mothers have worse micronutrient status than their children, and their situation is worse in Gaza City than in Hebron. Vitamin D was highly deficient in women, and which is associated to the use of clothes that covers the body to sun exposure. Addition of this nutrient to wheat flour was an excellent idea, and its impact should be monitored through serum vitamin D levels.

- Intake of several other B vitamins is also likely to be inadequate although this has not yet been confirmed by biomarkers. In future studies assessment of biomarkers associated to vitamin B-1, B-2, niacin, and B-6 should be added.

- Based on the high prevalence and magnitude of micronutrient deficiencies in women of reproductive age of Hebron and Gaza City, the use of supplements with several micronutrients during pregnancy seems to be an adequate intervention of the poor segments of the Palestinian society.

- Interpretation of micronutrient intakes should be done as part of the overall analysis of the diet in order to avoid not only micronutrient deficiencies but also to prevent excessive intakes, as well as obesity and chronic diseases associate to unhealthy diets.

- The nutrition evaluation and monitoring capacity of the Palestinian Health Authority should be strengthened to better support the improvement of micronutrient status of the population, and monitor the impact of interventions.

- Evolution of the nutritional quality of breast-milk seems to be an appropriate way to monitor the impact of wheat flour fortification, as a way to determine the micronutrient adequacy of breast-fed children.

- Content of folate in foods should be checked; it appears that the current food composition table is underestimating the supply of this nutrient through the diet.

- Future dietary studies should include at least 20% repetitions in order to estimate intra-individual intake variations for the calculation of the usual intakes.

ANNEXES

Annex I:

Letter of approval of the study by the Internal Review Board of the Al-Quds University.

بسم الله الرحمن الرحيم

Al-Quds University
Jerusalem
Office of Research

جامعة القدس
القدس
عمادة البحث العلمي

Date: May 4, 2005

Dr Ziad Abdeen
Director,
The Al-Quds Nutrition and Health Research Institute
PI, Dietary and nutrient adequacy of Palestinians – ANAHRI / 9/05

Re: Proposal Number: ANAHRI / 9/05

Dear Dr. Abdeen,,

The University Institutional Board Review IRB has approved in its meeting # 4 - 05 the proposal entitled

"Approximation of dietary and nutrient adequacy of Palestinian communities residing in the West Bank and Gaza in support of the introduction of wheat flour fortification".

We request that we receive a progress report on quarterly basis.

Sincerely yours,,

Dr. Taisir Abdallah
Dean of Research
Al-Quds University

Tel: 2791293
Fax: 2796111
P. O Box 20002
Website: http://www.alquds.edu

تلفون: 2791293
فاكس: 2796111
ص.ب 20002
Email: Research@admin.alquds.edu

Annex 2:
Implementation of the field work of the dietary survey

Survey Design
An area based sampling frame was used with a three stage stratified design consisting of a selection of clusters/primary sampling units (PSUs), households within the selected clusters/PSU, and selecting the mother and youngest child as respondents within a household.

Development of 24-Hour Diet Recall Methodology
The first step in the development of this methodology was to review the use of methodologies in use in other large national surveys. The 24-hour diet recall methodology is widely regarded as the only suitable dietary survey methodology to be used in national surveys, which aim to determine the food and nutrient intake of the population. Following the decision to collect the data in the home, a decision was made to use methodology similar to that which the United States Department of Agriculture (USDA) used in their continuing Survey of Food Intakes of Individuals 1994-96 (CSFII). Permission was granted to use and adapt the instruments and associated booklets. This methodology was further developed and modified by the Al-Quds Nutrition and Health Research Institute for Health and Nutrition Project Team to Palestine conditions.

The multiple pass 24-hour diet recall interview was structured into three steps to maximize respondent recall of foods eaten. The first pass, the 'quick list', involved respondents supplying a broad description of all food and beverage items consumed in the previous day the 24 hours (from 4:00 am to 4:00 am).

In the second stage, a detailed description of each food or beverage item on the quick list was ascertained through a series of questions and prompts specific to each item. Questions for each item included: time of consumption (i.e. eaten in combination with other foods, for example, hummus and olive oil), the cooking method, fats used in preparation and recipe where appropriate. If the respondent did not know the recipe of a mixed item, probe questions about ingredients likely to influence the fat content of the food (for example type of fat, milk, yogurt and/or cheese used) were asked. If the respondent was able to supply some information about these ingredients it was used to modify a standard recipe.

Where the respondent had the package available from commercial foods, the product names were noted. The amount of food or beverages consumed was described by volume using cups, spoons, food photography and shape dimensions. Alternatively, a Food Intake Booklet (FIB) was available containing weights of common servings or measures of specified items (e.g. one slice of bread) and conversions from the raw to cooked form. When the respondent supplied a recipe the amount of each ingredient was obtained and the portion of the whole dish eaten was recorded.

The third and final pass was a review of the recall. The interviewer read aloud the foods eaten in chronological order and verified the descriptions and amounts consumed with the respondent. A final question checked whether anything had been omitted from the recall. Any information that was forgotten or incorrectly entered was added or edited at this step.

Training
A set of questionnaires (see **Annex 3**) and a training manual were specifically developed for the survey. These instruments covered all aspects of the survey, including the survey methodology.

Directors of the survey provided training to all coordinators in a four day workshop on the specific areas of the survey:
1. Design and sampling
2. Socio-demographic data
3. Dietary interviews
4. Food Intake Booklet
5. 24-H-RQ
6. Hematological assessment

The objective of the workshop was to address all aspects of the survey, including the training of fieldworkers. The workshop also included a number of exercises/tasks in order to ensure as comprehensive an understanding of the logistical and practical issues as well as expectations involved in the implementation of the survey as possible. Practical and appropriate suggestions for the improvement of the tools to be employed in the survey were incorporated in the finalization of the survey tools.

Fieldworkers, recruited locally from each region, according to the prevailing circumstances and needs of each region, implemented the fieldwork under the direct supervision of the coordinator/team leader. The fieldworkers had previous nutrition training. They underwent extensive (2 – 3 days) training regarding the survey methods and the survey tools. The pace of training was adapted according to the capabilities of the fieldworkers. The training, at region level, was conducted by an experienced dietitian/nutritionist (the coordinator), who had herself/himself been trained. In order to standardize the training as much as possible, practical exercises and tests were included. Each fieldworker evaluated the training they received by means of a questionnaire and additional training was given as necessary.

Training Instruments
The training manual was designed to provide each fieldworker with detailed instructions on the:

1. Selection of households
2. Selection of children within households
3. Self introduction at the household
4. Interviewing techniques
5. Filling in of the questionnaires.

A Food Intake Booklet (FIB) was prepared to be a complementary document to reduce the frustration of respondents who had formerly searched for words to describe volume, size and weight of food. This (FIB) was used during all 24-hour recall and food frequency interviews.

Pilot study
All regions in the first instance carried out a pilot in one urban and one non urban cluster. The pilot study also incorporated the exercise for the validation of the questionnaires. Once the pilot had been completed, the director, the coordinator, the team leader and the fieldworkers jointly addressed any points that needed to be attended to before the survey proper began. If no problem areas were identified during the pilot phase of the survey, then the survey proper could be started immediately.

Implementation of the Survey
The same procedure was followed at every household included in the survey by each fieldworker. Essentially, a fieldworker visited each randomly selected household and the mother or caregiver of the selected child was interviewed according to the following procedure:

- The fieldworker introduced herself/himself and explained the purpose of the survey
- The interviewee was reassured regarding the confidentiality of the data and requested to answer the questions truthfully
- An informed consent was obtained (see **Annex 3**)
- The socio-demographic questionnaire was completed (see **Annex 3**)
- The 24-HR questionnaire was completed

After completion of a cluster, the questionnaires were checked and signed by the fieldworker's team leaders and/or the coordinators and/or the director of the survey responsible for a particular Region, and dispatched to a central site for data entry. All questionnaires were sent to the data analyst.

Annex 3:
Examples of questionnaires used in the dietary survey

Nutritional Assessment Household Questionnaire

File No.
District: ________________________________ Locality: ________________________________
1. Urban 2. Non-Urban 3. Camp
Name of Head of Household: ______________________ Phone: _________________________
Name of Interviewee: ____________________ Sex of Interviewee: Male / Female
Interviewer _______________________ Code
GPS Data: Latitude: _ _ . _ _ _ _ _ Longitude: _ _ _ . _ _ _ _ _

Report of Interview
Date of Interview: _____ /_____ /_____ Day of Interview: 1 2 3 4 5 6 7
Time Started _____: _____ Time Finished _____:_____
Change of Address? 1.Yes 2.No
If yes, what is new address: ____

Table of Visits	Date
First visit	_________ /_________ /________
Second visit	_________ /_________ /________
Third visit	_________ /_________ /________

Pre-survey: Food Assistance

1. Does the household receive food assistance or food vouchers from any agencies?
   1. Yes
   2. No *(If no, skip to Informed Consent and continue survey)*

2. Which agency is your main source of food assistance (direct food, ration cards or vouchers?
   1.UNRWA
   2.WFP
   3.Others____

If household receives assistance from UNRWA or WFP exclude household.

3. This household has been excluded:
   1. YES
   2. NO

Informed Consent

Hello, my name is ____________________________ and I am working with Al Quds University. We would very much appreciate your participation in this survey. This survey will provide important information for the Ministry of Health and international agencies to plan for food assistance. I would like to ask you about nutrition, the nutrition of your children, and how well the family is able to access food for good nutrition. I would also like to collect a small amount of blood equivalent to 1-2 teaspoons. The survey usually takes 30-45 minutes to complete. Whatever information you provide will be kept strictly confidential and will not be shown to other persons.

Participation in this survey is voluntary and you can choose not to answer any individual question or all of the questions. However, we hope that you will participate in this survey since we believe your views are extremely important to assist your family and village/city.

At this time, do you want to ask me anything about the survey?	Y	N
May I begin the interview now?	Y	N

Signature of interviewee or parent of minors: ____
Date: __________________

Respondent(s) agree (s) to be interviewed:	Y	N

Household Demographics

1. Head of Household: Male Female If head of household is male go to question No. 3
2. If female head of household, what is marital status?

1. Single, not divorced	2. Divorced	3. Widowed	4. Married, husband not living with family

3. Refugee Status: Yes No
4. Level of education (highest level achieved):

- **Head of household**

1. Illiterate	2. Primary	3. Secondary
4. High School	5. Diploma	6. Bachelor
7. Post-graduate		

- **Mother**

1. Illiterate	2. Primary	3. Secondary
4. High School	5. Diploma	6. Bachelor
7. Post-graduate		

5. Who are the persons who reside permanently in this household?

Person Number	**Name**	**Relation to Head ****	**Sex 1.Male 2.Female**	**Date of Birth Day/Month/ Year**	**Subject Sampled**	**Survey Unique ID PCBS code number**
					Mark only for interviewed subject	
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						

** 1- Household Head ; 2- Spouse; 3- Son/Daughter ; 4- Parent ; 5- Sibling ;
6- Grandparent ; 7- Grandchild ; 8- Son/Daughter in law; 9- Other Relative; 10- Other
If there are more members please write on the back of the page

6. For women of childbearing age: Are you pregnant?
    1. Yes
    2. Uncertain
    3. No

If yes or uncertain, exclude from survey and replace where possible with other female household member of child bearing age (15-49)

7. Do you make your own bread or do you buy it?
Bought Yes No
If yes where ____(name and location of store)

Home made Yes No
If yes, where is flour bought_________________________________(name and location of store)

8. Do you make your own pita or do you buy it?
Bought Yes No
If yes where ____(name and location of store)

Home made Yes No
If yes, where is flour bought_________________________________(name and location of store)

24 hour recall questionnaire for Nutritional Status

A separate questionnaire is to be completed for interviewee from each age group

Interviewer read: "Now, I will ask some questions about your diet. We will ask about the food consumed **yesterday** by interviewee. "

Interviewer read: I will now ask you for details about everything you / your child ate and drank yesterday. (If asked why from 4:00 -read: "Previous studies show that at 4:00 it is possible to distinguish between one day (24 hours) to the next day (24 hours).

<table>
<tr><td></td><td>What did you eat from 4 a.m. yesterday _____until 4 a.m. today____? If asked "Why 4a.m.?" Read:
Previous studies have shown that at 4a.m. it is possible to distinguish between one day of 24 hours and the next,"

Specify everything you ate and drank in the house and out side of the house, including sweets and snacks, tea, soft drinks, etc.

Interviewer: Write each item in a separate row, and when the interviewee has finished, continue next question.</td><td></td><td>What time did you begin to eat /drink the ______?</td><td>Card no. 1
Where did you eat?

1. At home (home cooked food)
2. Home-(ready made /bought food)
3. At school-home-prepared food
4. At school-ready made/bought food
5. At school-cafeteria, dining room
6.restaurant
7. other(specify)</td></tr>
<tr><td></td><td>The quick list</td><td>√</td><td></td><td rowspan="13">Which meal?
1. Breakfast
2. Morning snack
3. Breakfast+Lunch (Brunch)
4. Lunch
5. Afternoon snack
6. Lunch/Dinner combined
7. Dinner
8. Late night snack
9. Other (specify)</td></tr>
<tr><td>A</td><td></td><td></td><td></td></tr>
<tr><td>B</td><td></td><td></td><td></td></tr>
<tr><td>C</td><td></td><td></td><td></td></tr>
<tr><td>D</td><td></td><td></td><td></td></tr>
<tr><td>E</td><td></td><td></td><td></td></tr>
<tr><td>F</td><td></td><td></td><td></td></tr>
<tr><td>G</td><td></td><td></td><td></td></tr>
<tr><td>H</td><td></td><td></td><td></td></tr>
<tr><td>I</td><td></td><td></td><td></td></tr>
<tr><td>J</td><td></td><td></td><td></td></tr>
<tr><td>K</td><td></td><td></td><td></td></tr>
<tr><td>L</td><td></td><td></td><td></td></tr>
</table>

Interviewer read: There are foods and drinks which people may forget they ate or drank. Try to remember if you forgot to mention any of these foods: hot drinks, cold drinks, sweets, salty snacks, fruits, vegetables, bread, water, small foods given to the child outside of regular mealtimes by others.

Interviewer read: I would now like to ask you for additional details regarding the food and drinks that you mentioned. I will ask "where did you/the child eat" and "which meal was it?" If you remember other foods, tell me. When I ask you about the quantity the child ate or drank, you can use the examples I suggest, the dishes in your house or the information on the wrapper/packet.

Food/Drink description.

To the interviewer: Transfer from the Quick List the item letter to column 1, the hour to column 2, and name to column 5. Mark (√) on the Quick list in the column near the item you've copied and move to columns 3 and 4 using card 2. Complete columns 6 and 7 using the Food Guide.

		Where did you eat/drink this item?	**What meal was it?**	**Item name**	**Food/drink description**	**What quantity did you eat/drink?**
1	**2**	**2**	**3**	**4**	**5**	**6**
					1	
					2	
					3	
					4	
					5	
					6	
					7	
					8	
					9	
					10	
					11	
					12	
					13	
					14	
					15	
					16	

1. Was the amount (NAME ________________) ate yesterday similar to the amount he/she usually eats?
   1. Yes, the same
   2. No, yesterday he/she ate less than usual
   3. No, yesterday he/she ate more than usual
   4. Don't know

2. What is the main reason (NAME ______________) ate a different amount to that he/she usually eats?
   1. Illness
   2. Vacation, trip, travel
   3. Lack of time
   4. Religious holiday
   5. Family celebration, social occasion
   6. Stress, boredom, depression
   7. Didn't feed child for health reasons
   8. Other, specify: _____________

3. Do you (or the child) use vitamin pills:
1. Yes
2. No

If yes then ask to see label and complete questions 4 and 5

4. Vitamin Commercial Name: ___________________________

5. Record amount of nutrients:

#	**Nutrient**	**Amount**
1.	Iron	
2.	Zinc	
3.	Folic acid	
4.	B12 (cobalamin)	
5.	Vitamin A	
6.	Vitamin D	
7.	Vitamin B6	
8.	Vitamin B1	
9.	Vitamin B2	

<u>Coordinator Summary</u>

The questionnaire arrived at the Operational Research Laboratory (ORL) on ___ / ___ / ___
Entered by: _________________ at: _____: ______
Checked: Needs correction? Yes No
Interviewer's corrections returned on date: ______ / ______ / ______
Other corrections needed: Yes No
Final questionnaire entry date: _______by: ________________
Entry completed: Yes No

Annex 4:

Procedure for the Elimination of Outliers for Calculating Usual Intakes

In order to identify noticeable outliers, and if there were differences between refugee and non-refugee children and women, the data was analyzed by exploring the intake patterns.

Figures below show the bivariate distributions of mineral and vitamin two-day mean intakes of all children and women. The observed distributions of two-day mean intakes are shown along the main diagonal of the scatterplot matrix. Red crosses correspond to children who do not have refugee status whereas blue circles correspond to children who are classified as refugees. Note that the distributions of observed intakes appear to be similar for refugees and for non-refugees.

From the scatter plot matrices we observed that a few of the children have atypical estimated mean intakes. For example, two children have iron intakes and one child has copper intake that can be considered to be outliers. We removed those clear outliers from the dataset before we carried out any analysis.

From the scatter plot matrices of women, we identified results of some women exhibited intakes that can be considered atypical and were thus excluded from the analysis.

Figure A4-1. Observed two-day mean intakes of minerals for children aged 3 to 7 years. Red crosses correspond to non-refugees and blue circles correspond to refugees.

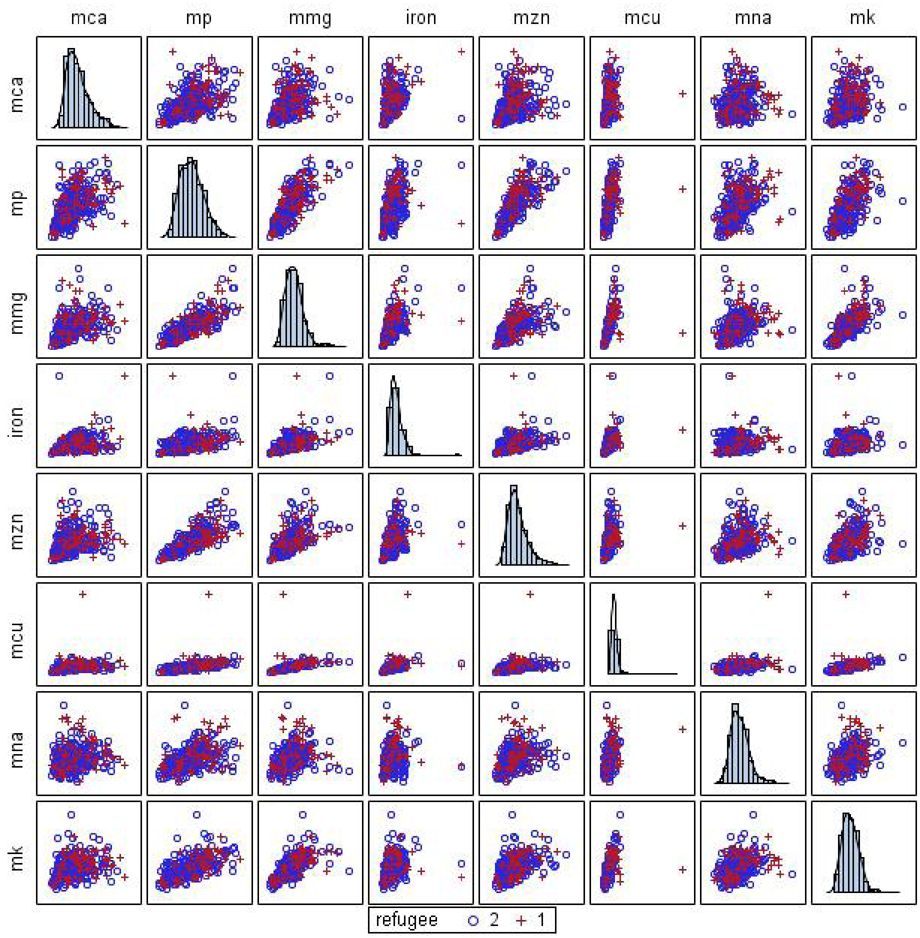


Figure A4-2. Observed two-day mean intakes of vitamin E, vitamin A (IU), vitamin A (RE), carotene, thiamin and riboflavin for children aged 3 to 7 years. Red crosses correspond to non-refugees and blue circles correspond to refugees.

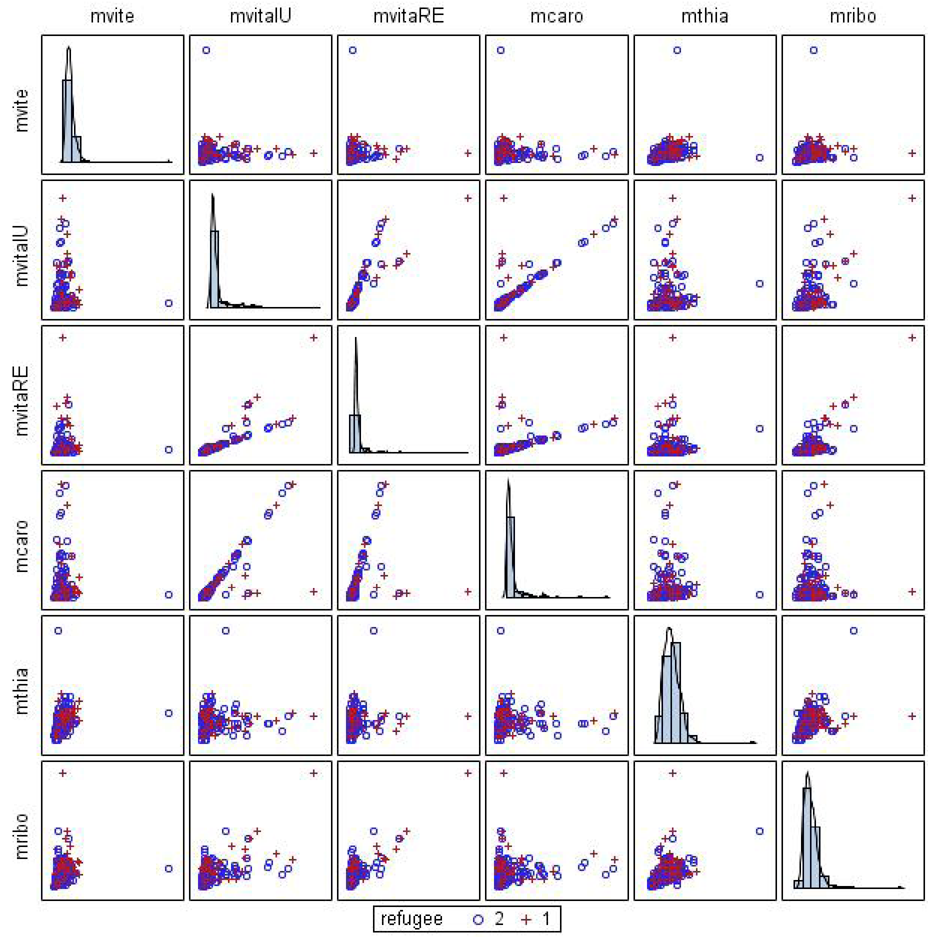


Figure A4-3. Observed two-day mean intakes of niacin, vitamin B 6, folate, vitamin B12 and vitamin C for children aged 3 to 7 years. Red crosses correspond to non-refugees and blue circles correspond to refugees.

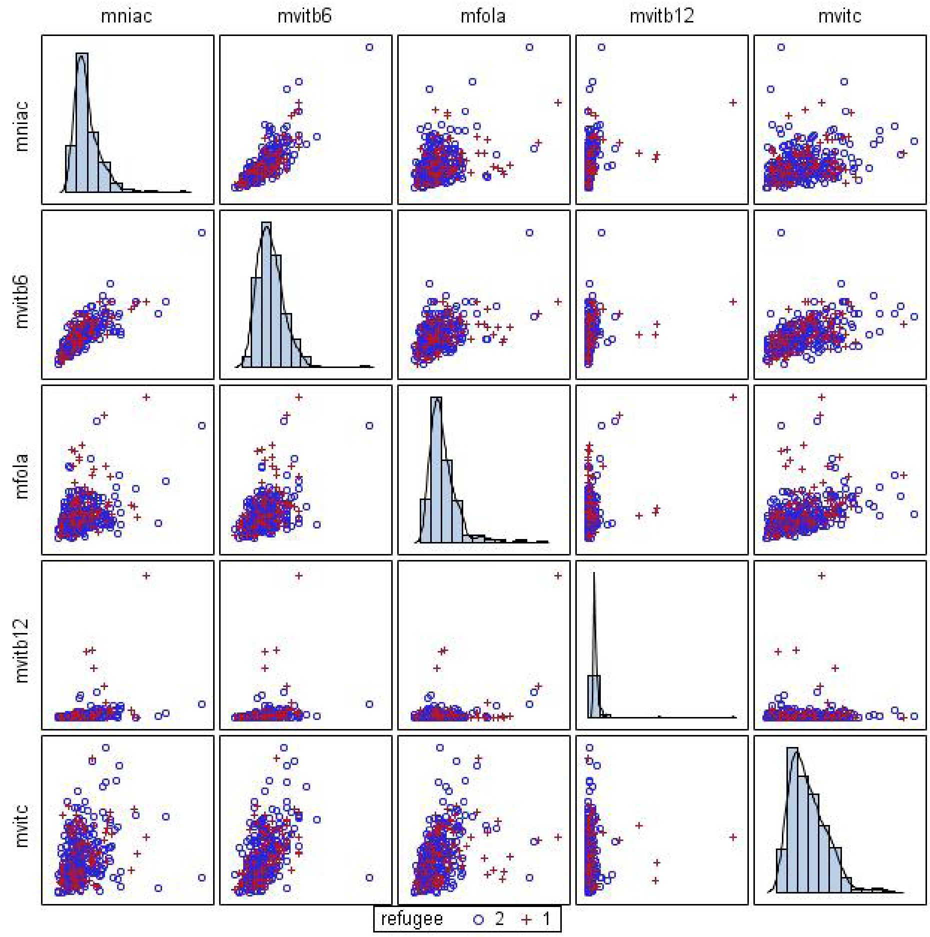


Figure A4-4. Observed two-day mean intakes of minerals for women aged 18 to 49 years. Red crosses correspond to non-refugees and blue circles correspond to refugees.

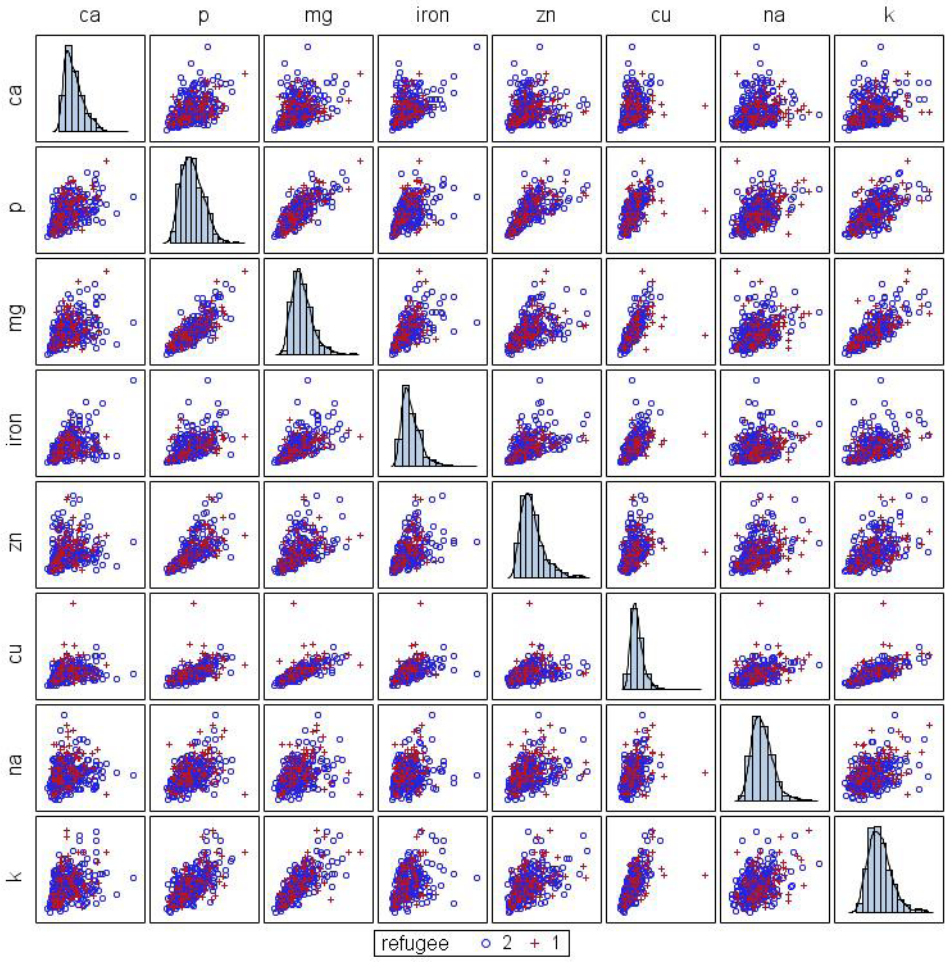


Figure A4-5. Observed two-day mean intakes of vitamin E, vitamin A (IU), vitamin A (RE), carotene, thiamin and riboflavin for women aged 18 to 49 years. Red crosses correspond to non-refugees and blue circles correspond to refugees.

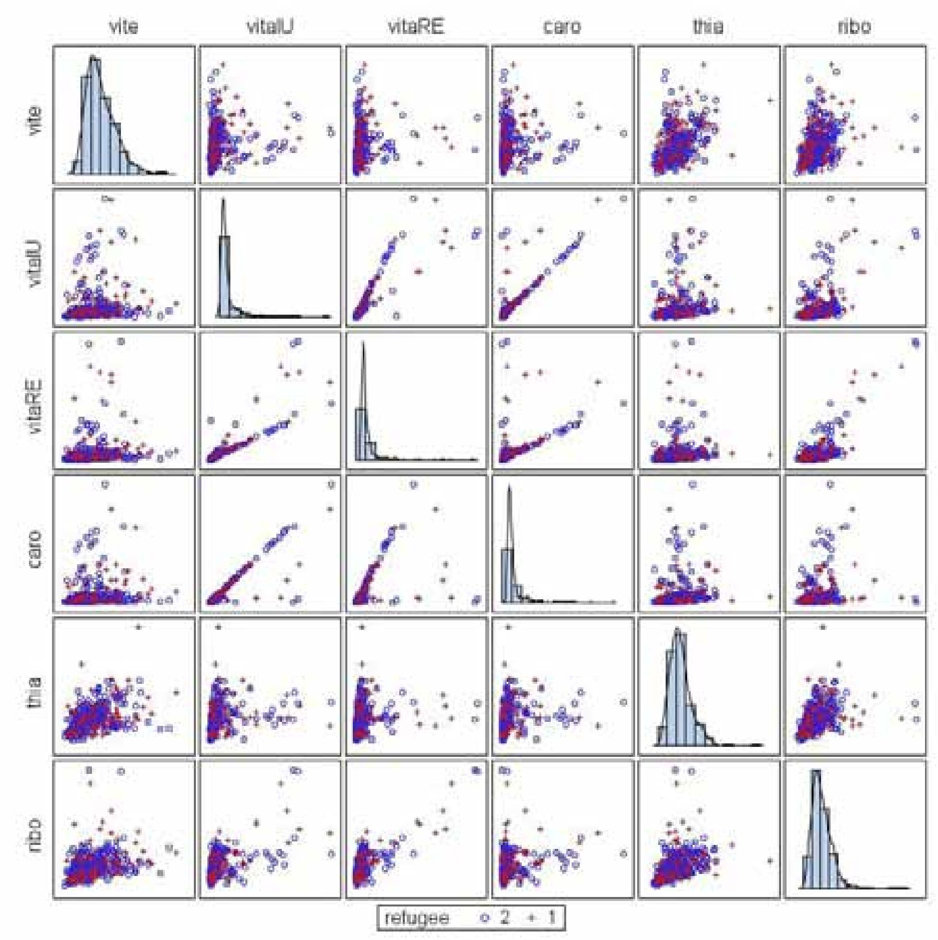
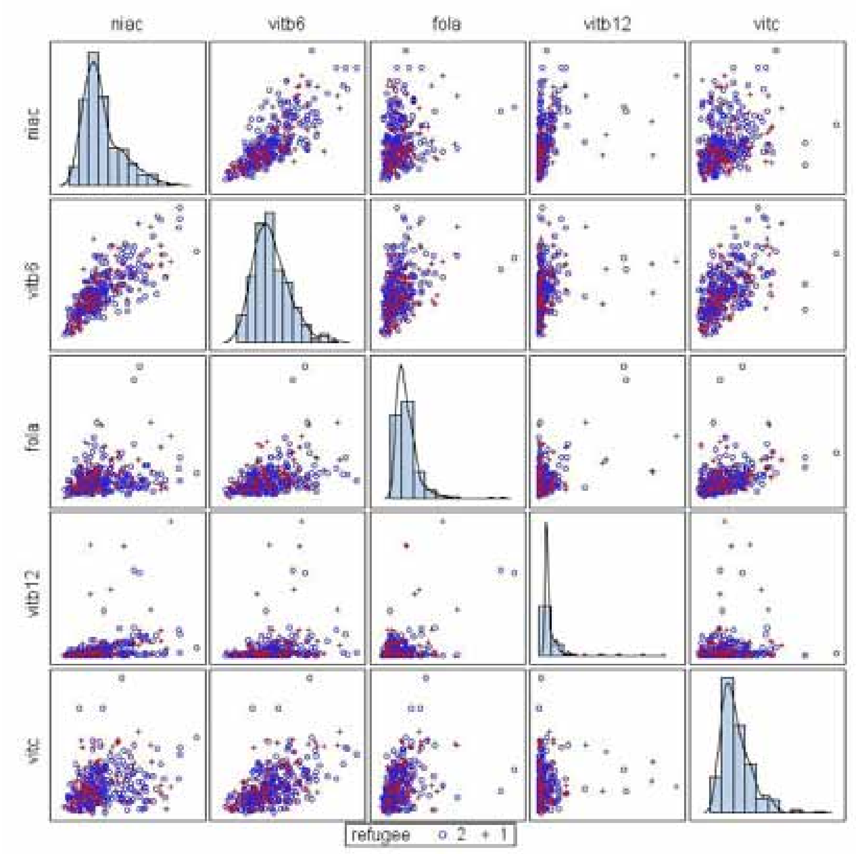


Figure A4-6. Observed two-day mean intakes of niacin, vitamin B 6, folate, vitamin B12 and vitamin C for women aged 18 to 49 years. Red crosses correspond to non-refugees and blue circles correspond to refugees.



Annex 5:

Letter from the MOH of the Palestinian Authority Authorizing Transference of Samples to the USDA, ARS Western Human Nutrition Research Center, in Davis, California.

Palestinian National Authority
Ministry of Health
Primary Health Care & Public Health Directorate

PHCGD

السلطة الوطنية الفلسطينية
وزارة الصحة
الإدارة العامة للرعاية الصحية الأولية والصحة العامة

Ref.:
PG0250477.doc

التاريخ:٢٠٠٨/٧/١٦

Dear Dr. Rand
A2Z Project Director

Greetings,

Subject: Authotorization letter

Following our discussion concerning the analysis of the serum samples collected in 2005 .

Kindly note that MOH has no objection concerning the parameters suggested , the place for analysis (laboratory in Human Nutrition in the University of California)

Sincerely yours

Dr. Assad Ramlawi

Director General Primary Health Care
And Public Health Directorate

1051-188-878
17-7-2008

Tel.: 00970 2 2988055
Fax: 00970 2 2988033

هاتف: ٠٠٩٧٠ ٢٩٨٨٠٥٥
فاكس: ٠٠٩٧٠ ٢٩٨٨٠٣٣

Annex 6:
Main food sources of micronutrients for children and women of Hebron and Gaza City in 2005.

Table A6-1. Supply of macronutrients (%) through food groups for children of Hebron and Gaza City in 2005

Food Group	Energy	Protein	Carbohydrate	Total Fat
Wheat Flour and Bread	22.7	23.0	33.8	3.6
Rice	9.0	4.7	10.9	7.0
Sweet and Sugar	7.8	5.6	8.6	7.6
Fruits	6.6	2.0	11.9	1.8
Sandwich Falafel	6.5	6.2	5.4	8.5
Cooked vegetables	6.2	4.1	5.7	7.9
White potato, chips	5.7	2.2	4.4	9.1
Chicken	4.9	15.8	0.4	7.3
Egg	4.4	4.9	0.4	10.3
Milk & Milk Product	4.3	6.2	1.8	7.4
Vegetables Soup	3.5	6.5	1.9	4.7
Beverages	3.3	0.4	6.3	0.1
Olive Oil	2.8	0.0	0.0	8.2
Meat	2.8	6.7	0.4	4.6
Legume, beans, peas	2.7	3.6	2.7	2.7
Stuffed Vegetables	1.7	1.4	1.6	2.2
Nuts and seeds	1.2	1.2	0.9	1.9
Fish	1.1	2.5	0.4	1.6
Raw Vegetables	0.8	0.7	1.1	0.7
Za'ater	0.8	0.7	0.6	1.4
Vegetables Salad	0.6	0.6	0.6	0.9
Liver and Kidney	0.4	0.9	0.1	0.6
Water	0.0	0.0	0.0	0.0

Table A6-2. Supply of vitamins (%) through food groups for children of Hebron and Gaza City in 2005

Food Group	Vit. E	Vit. A	Vit- B1	Vit-B2	Niacin	Vit- B6	Folate	Vit-B12
W. Flour and Bread	5.2	0.7	16.2	11.7	15.1	6.0	17.0	0.4
Rice	10.0	0.4	3.7	1.6	3.8	7.9	3.6	0.0
Sweet and Sugar	3.7	3.0	5.1	7.0	4.3	3.4	4.4	8.1
Fruits	10.0	9.9	15.5	7.8	5.7	13.8	3.5	0.0
Sandwich Falafel	8.3	2.6	5.4	3.8	2.2	4.0	7.6	0.4
Cooked vegetables	12.5	3.0	9.0	4.1	9.5	13.1	5.2	2.0
White potato, chips	6.4	0.5	3.8	3.2	5.5	8.3	3.1	0.1
Chicken	4.2	2.3	3.1	6.1	19.1	8.6	1.2	3.1
Egg	11.2	8.3	2.1	10.7	0.6	3.0	3.4	6.3
Milk & Milk Product	1.4	8.2	4.2	14.4	1.6	3.5	2.4	9.9
Vegetables Soup	3.0	3.8	3.8	4.4	7.6	5.4	7.8	8.6
Beverages	0.6	3.5	4.2	2.6	1.1	1.8	10.1	0.0
Olive Oil	5.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Meat	1.0	5.7	2.1	5.1	8.3	3.3	1.7	22.3
Legumes, beans, peas	2.3	3.9	6.7	2.8	2.9	3.5	12.1	0.3
Stuffed Vegetables	2.6	16.2	1.1	2.0	2.3	2.5	1.7	1.2
Nuts and seeds	4.7	1.5	4.0	2.2	2.2	2.1	2.7	1.1
Fish	2.6	0.8	1.2	1.1	2.0	1.0	0.5	5.7
Raw Vegetables	1.6	3.3	3.3	1.5	1.8	2.8	3.7	0.0
Za'ater	0.5	1.1	2.9	1.0	1.4	2.7	2.4	0.0
Vegetables Salad	1.5	2.7	2.4	1.2	1.5	2.1	1.7	0.3
Liver and Kidney	0.7	18.7	0.4	5.9	1.7	1.2	4.1	30.1
Water	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table A6-3. Supply of vitamin C and minerals (%) through food groups for children of Hebron and Gaza City in 2005

Food Group	Vit. C	Calcium	Iron	Zinc
Wheat Flour and Bread	0.5	6.9	15.3	15.1
Rice	1.2	2.7	3.0	6.2
Sweet and Sugar	7.9	6.8	4.2	8.0
Fruits	19.3	4.7	4.0	1.9
Sandwich Falafel	2.8	6.3	7.8	6.2
Cooked vegetables	12.2	3.5	5.3	5.6
White potato, chips	5.1	2.0	2.7	2.6
Chicken	0.5	1.4	4.5	10.0
Egg	1.2	2.7	3.4	3.3
Milk & Milk Product	0.8	24.6	1.7	5.8
Vegetables Soup	1.6	10.2	5.6	7.9
Beverages	16.7	1.3	0.9	0.9
Olive Oil	0.0	0.0	0.2	0.0
Meat	0.8	0.9	3.5	8.6
Legumes, beans, peas	6.6	3.4	5.5	4.7
Stuffed Vegetables	1.5	3.8	1.7	1.9
Nuts and seeds	1.9	0.6	3.8	1.9
Fish	1.3	1.1	0.8	0.7
Raw Vegetables	10.2	1.4	1.9	0.7
Za'ater	0.9	10.7	20.3	2.8
Vegetables Salad	6.4	0.9	1.3	0.8
Liver and Kidney	0.7	0.2	1.6	1.1
Water	0.0	4.0	0.8	3.3

Table A6-4. Supply of macronutrients (%) through food groups for women of Hebron and Gaza City in 2005

Food Group	Energy	Protein	Carbohydrates	Total Fat
Wheat Flour and Bread	23.7	22.0	35.8	3.5
Rice	10.8	5.6	13.3	8.5
Fruits	6.8	1.9	12.9	1.3
Meat	6.8	15.6	0.9	11.6
Chicken	5.8	17.0	0.6	8.6
Eggs	4.9	6.0	0.4	11.1
Sandwich falafel	4.6	4.1	3.6	6.6
Beverages	4.5	0.4	8.7	0.1
Milk and Milk products	4.2	5.5	1.6	7.8
Stuffed Vegetables	4.0	3.3	3.7	4.7
Sweet and Sugar	3.8	1.2	5.0	3.3
Olive Oil	3.1	0.1	0.1	9.0
Cooked Vegetables	3.0	2.4	2.4	4.9
White Potato and chips	3.0	1.2	2.9	4.1
Legumes, beans, peas	2.8	3.6	2.8	2.7
Nuts and seeds	1.9	2.0	1.1	3.4
Vegetables Soup	1.9	2.7	1.6	2.0
Fish	1.9	3.5	0.7	2.9
Vegetables Salad	0.8	0.5	0.6	1.5
Raw Vegetables	0.8	0.6	0.8	1.1
Za'ater	0.7	0.7	0.6	1.3
Pickles	0.1	0.0	0.1	0.1
Water	0.0	0.0	0.0	0.0

Table A6-5. Supply of vitamins (%) through food groups for women of Hebron and Gaza City in 2005

Food Group	Vit. E	Vit. A	Vit- B1	Vit-B2	Niacin	Vit- B6	Folate	Vit-B12
Wheat Flour and Bread	5.2	0.4	15.4	11.0	14.2	5.9	16.0	0.3
Rice	10.0	0.7	5.3	2.3	4.3	9.3	5.4	0.0
Fruits	3.7	9.7	15.4	7.4	5.9	14.2	3.6	0.0
Meat	10.0	19.3	4.2	12.9	17.5	9.4	3.4	58.7
Chicken	8.3	15.0	3.3	9.3	22.4	10.5	6.1	12.6
Eggs	12.5	7.5	2.5	13.7	0.5	3.6	4.4	7.3
Sandwich falafel	6.4	0.9	3.8	2.4	1.3	2.9	7.0	0.1
beverages	4.2	1.7	3.7	3.2	1.1	1.5	10.5	0.0
Milk and Milk products	11.2	6.6	3.5	12.6	1.6	3.4	2.1	6.3
Stuffed Vegetables	1.4	15.7	2.0	3.3	4.6	4.2	2.3	3.0
Sweet and Sugar	3.0	2.1	1.1	2.1	0.8	0.4	0.7	0.3
Olive oil	0.6	0.2	0.1	0.2	0.0	0.0	0.0	0.1
Cooked Vegetables	5.9	4.7	8.8	4.2	5.4	7.7	6.1	0.8
White potato, chips	1.0	0.0	3.6	1.1	4.3	7.3	1.4	0.0
Legumes, beans, peas	2.3	2.0	6.3	2.3	2.4	3.3	12.2	0.2
Nuts and seeds	2.6	3.7	7.9	4.2	4.4	4.7	5.4	2.9
Vegetables Soup	4.7	2.7	2.5	2.3	2.6	2.9	6.3	0.2
Fish	2.6	1.1	3.1	1.7	2.9	1.6	0.8	7.1
Vegetables Salad	1.6	1.8	2.4	1.2	1.2	1.9	1.9	0.1
Raw Vegetables	0.5	3.0	2.4	1.3	1.6	2.8	2.1	0.0
Za'ater	1.5	0.8	2.7	0.9	1.2	2.4	2.2	0.0
Pickles	0.7	0.3	0.1	0.1	0.0	0.1	0.1	0.0
Water	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table A6-6. Supply of vitamin C and minerals (%) through food groups for women of Hebron and Gaza City in 2005

Food Group	Vit C	Calcium	Iron	Zinc
Wheat Flour and Bread	0.5	6.3	13.7	14.2
Rice	2.2	3.4	4.3	7.3
Fruits	22.8	5.1	3.9	1.9
Meat	1.6	1.8	9.0	23.1
Chicken	1.3	1.7	5.9	9.7
Eggs	0.3	3.5	3.8	3.9
Sandwich falafel	1.7	3.8	5.5	4.3
Beverages	17.1	1.6	1.3	1.2
Milk and Milk products	0.7	22.4	1.7	5.1
Stuffed Vegetables	2.1	5.3	3.0	4.5
Sweet and Sugar	0.8	2.7	1.1	0.8
Olive Oil	0.0	0.4	0.2	0.1
Cooked Vegetables	13.3	4.3	4.2	3.4
Fried Potato	6.9	0.7	2.3	1.7
Legumes, beans, peas	7.5	3.2	5.1	4.6
nuts and Seeds	0.1	1.0	8.3	3.5
Vegetables Soup	1.1	12.5	2.9	1.7
Fish	2.4	2.2	1.3	1.1
Vegetables Salad	7.0	1.3	1.2	0.8
Raw Vegetables	9.2	1.6	2.1	0.7
Za'ater	0.9	10.3	18.1	2.5
Pickles	0.5	0.0	0.2	0.0
Water	0.0	4.9	0.9	3.7

Table A6-7. Supply of vitamins (%) through food groups for children of Hebron and Gaza City in 2005, considering that wheat flour is fortified with micronutrients[6]

Food Group	Vit. E	Vit. A	Vit- B1	Vit-B2	Niacin	Vit- B6	Folate	Vit-B12
W. Flour and Bread	7.6	15.4	32.1	32.0	32.4	24.1	48.2	9.3
Rice	10.1	1.9	3.3	1.5	3.2	6.5	2.4	1.4
Fried Potato	13.0	0.1	5.2	3.1	7.7	12.4	2.5	0.1
Sweet and Sugar	4.1	2.9	4.3	0.0	1.9	1.7	2.8	1.8
Sandwich falafel	8.0	2.0	4.3	2.9	1.7	3.2	4.6	0.3
Fruits	8.8	7.5	12.5	5.8	4.1	11.0	2.0	0.0
Meat	1.9	10.9	3.3	9.0	13.0	6.6	2.1	48.9
Egg	11.8	9.2	2.3	13.4	0.4	3.2	3.4	9.7
Chicken	4.6	11.1	2.6	6.7	16.1	7.4	2.9	10.2
Milk and Milk products	1.4	6.4	3.4	11.3	1.2	2.8	1.5	8.5
beverages	0.7	2.8	4.1	2.2	1.0	1.7	7.0	0.0
Stuffed Vegetables	2.9	12.4	1.3	2.1	3.1	2.7	1.1	2.4
Olive Oil	5.7	0.0	0.1	0.0	0.0	0.0	0.0	0.0
Cooked/raw vegetables	6.4	7.0	6.1	2.8	4.3	6.2	3.7	0.5
Legumes, beans, peas	2.0	2.7	4.9	2.0	2.2	2.7	7.2	0.3
Vegetables Soup	2.4	3.6	2.2	2.0	2.3	2.4	4.3	0.4
Seeds and Nuts	5.4	1.2	3.5	1.9	2.1	1.7	1.8	1.0
Fish	2.5	0.9	0.9	0.8	1.6	0.8	0.3	5.0
Za'ater	0.5	0.8	2.4	0.8	1.1	2.1	1.5	0.0
Vegetables Salad	0.5	1.3	1.2	0.5	0.6	0.9	0.8	0.0
Water	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

6 Based on fortification formula of Table 8 of the text.

Table A6-8. Supply of vitamin C and minerals (%) through food groups for children of Hebron and Gaza City in 2005, considering that wheat flour is fortified with micronutrients[7]

Food Group	Vit C	Calcium	Iron	Zinc
Wheat Flour and Bread	0.5	6.8	35.5	31.8
Rice	1.2	2.8	2.5	5.2
White potato, chips	11.4	2.0	3.7	3.2
Sweet and Sugar	8.2	7.2	2.3	2.4
Sandwich falafel	2.8	6.2	5.8	4.8
Fruits	19.3	4.4	2.8	1.2
Meat	1.5	1.6	6.1	16.0
Egg	0.2	4.0	3.4	3.8
Chicken	1.0	1.5	4.2	8.4
Milk and Milk products	0.8	24.2	1.3	4.5
beverages	21.3	1.5	0.7	0.8
Stuffed Vegetables	1.3	4.0	1.9	2.9
Olive Oil	0.0	0.0	0.2	0.1
Cooked/raw vegetables	15.5	3.8	3.2	2.4
Legumes, beans, peas	6.5	3.2	3.9	3.3
Vegetables Soup	1.2	9.6	2.5	1.6
Seeds and Nuts	1.2	0.8	3.0	1.7
Fish	1.3	1.1	0.6	0.5
Za'ater	0.9	10.6	15.2	2.2
Vegetables Salad	4.0	0.6	0.6	0.4
Water	0.0	3.8	0.6	2.5

7 Based on fortification formula of Table 8 of the text.

Table A6-9. Supply of vitamins (%) through food groups for women of Hebron and Gaza City in 2005, considering that wheat flour is fortified with micronutrients[8]

Food Group	Vit. E	Vit. A	Vit- B1	Vit-B2	Niacin	Vit- B6	Folate	Vit-B12
Wheat Flour and Bread	2.5	0.9	17.1	12.2	14.9	7.1	17.1	0.4
Rice	9.4	0.7	4.3	1.7	3.9	8.7	4.8	0.0
Meat	1.9	19.3	4.3	13.0	17.6	9.4	3.5	58.6
Fruits	7.8	9.7	15.4	7.4	5.9	14.2	3.6	0.0
Chicken	4.7	15.0	3.4	9.3	22.3	10.5	6.1	12.6
Egg	10.1	7.5	2.5	13.7	0.5	3.5	4.4	7.2
Beverages	0.8	1.5	3.7	3.2	1.1	1.5	10.5	0.0
Milk and Milk products	1.1	6.6	3.5	12.6	1.6	3.4	2.1	6.3
Sweet and Sugar	19.1	2.3	1.4	2.2	0.9	0.5	0.8	0.3
Stuffed vegetables	3.3	15.7	2.0	3.3	4.6	4.2	2.3	2.9
Cooked/raw vegetables	7.7	6.9	10.1	4.5	5.9	10.0	6.9	0.3
Sandwich falafel	4.4	0.4	2.9	1.7	0.9	2.2	6.5	0.0
Olive Oil	5.4	0.2	0.1	0.2	0.0	0.0	0.0	0.1
Fried Potato	5.7	0.0	3.2	1.1	3.9	6.6	1.2	0.0
Legumes, beans, peas	1.4	2.0	6.0	2.3	2.3	3.2	12.1	0.2
Vegetables Soup	3.0	3.7	4.0	3.4	3.7	4.1	7.8	0.5
Fish	3.1	1.1	3.1	1.7	3.0	1.7	0.8	7.3
Nuts and seeds	7.4	3.7	7.8	4.2	4.3	4.7	5.3	2.9
Za'ater	0.4	0.8	2.7	0.9	1.2	2.4	2.2	0.0
Vegetables Salad	0.9	1.9	2.5	1.2	1.6	1.9	1.9	0.4
Water	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

8 Based on fortification formula of Table 8 of the text.

Table A6-10. Supply of vitamin C and minerals (%) through food groups for women of Hebron and Gaza City in 2005, considering that wheat flour is fortified with micronutrients[9]

Food Group	Vit C	Calcium	Iron	Zinc
Wheat Flour and Bread	1.2	7.9	15.4	15.9
Rice	2.2	3.1	3.6	6.5
Meat	1.6	1.8	9.0	23.2
Fruits	22.8	5.1	3.8	1.9
Chicken	1.3	1.7	5.9	9.7
Egg	0.3	3.5	3.8	3.9
Beverages	16.9	1.6	1.3	1.2
Milk and Milk products	0.7	22.4	1.7	5.1
Sweet and Sugar	1.0	2.8	1.4	1.1
Stuffed vegetables	2.1	5.3	3.0	4.5
Cooked/raw vegetables	20.9	5.3	5.2	3.2
Sandwich falafel	0.9	2.4	4.4	3.4
Olive Oil	0.0	0.4	0.2	0.1
Fried Potato	6.5	0.6	2.2	1.6
Legumes(beans, chickpeas..)	7.5	3.1	4.9	4.3
Vegetables Soup	3.2	13.5	4.2	2.5
Fish	2.5	2.2	1.3	1.2
NUTS, AND SEEDS	0.1	1.0	8.2	3.4
Za'ater	0.9	10.3	18.1	2.5
Vegetables Salad	7.4	1.0	1.4	1.1
Water	0.0	4.9	0.9	3.7

9 Based on fortification formula of Table 8 of the text.

Annex 7:
Usual nutrient intake distributions for children and women of Hebron and Gaza City in 2005.

Table A7-1. Scales to express the amounts of the different nutrients presented in the following tables.

Nutrient	Scale of amounts
β-Carotene[§]	μg
Calcium	mg
Carbohydrates	g
Cholesterol	mg
Copper	mg
Energy	kcal
Fiber	g
Folate (DFE[ω]) (Vit. B-9)	μg
Iron	mg
Magnesium	mg
Monounsaturated fats	g
Niacin (Vit. B-3)	mg
Polyunsaturated fats	g
Phosphorous	mg
Potassium	mg
Protein	g
Riboflavin	mg
Saturated fats	g
Sodium	mg
Total fats	g
Thiamin (Vit. B-1)	mg
Vitamin A (RE[¥])	μg
Vitamin B-6	mg
Vitamin B-12	μg
Vitamin C	mg
Vitamin E	mg
Zinc	mg

§ Following tables say Alpha-carotene, but it is beta-carotene.
ω DFE = Dietary Folate Equivalents.
¥ RE = Retinol equivalents.

Table A7-2. Estimated percentiles of the usual nutrient intake distributions for children 4 to 6 years old. The last column shows the estimated prevalence of inadequate intakes of each nutrient for which a value of EAR§ was available and for calcium (by probability analysis based on the Adequate Intake value).

Nutrient	5th	10th	25th	50th	75th	90th	95th	Prevalence
Alpha Carotene	56.32	74.23	117.15	196.28	335.52	550.59	743.06	
Calcium	168.93	194.49	243.21	306.93	381.72	459.37	510.88	49%
Carbohydrate	127.08	135.59	150.17	166.85	184.00	199.83	209.47	
Cholesterol	60.22	77.85	115.18	169.50	237.21	307.53	352.50	
Copper	0.66	0.72	0.83	0.96	1.11	1.26	1.36	
Energy	919.64	994.41	1122.47	1268.71	1418.44	1555.91	1639.39	
Fiber	7.57	8.50	10.26	12.55	15.25	18.07	19.95	
Folate	104.71	116.07	137.77	166.52	201.06	237.99	263.10	44.30%
Iron	4.55	5.06	6.01	7.24	8.69	10.20	11.21	9.30%
Magnesium	107.95	117.78	136.26	160.23	188.46	218.12	238.07	
Monounsaturated fat	10.48	11.81	14.22	17.17	20.40	23.55	25.54	
Niacin	4.73	5.25	6.23	7.50	8.99	10.55	11.60	21.00%
Polyunsaturated fat	8.76	9.97	12.22	15.03	18.17	21.29	23.29	
Phosphorous	377.71	420.28	497.41	592.02	696.18	798.27	863.24	
Potassium	1006.32	1122.44	1328.23	1574.05	1837.78	2090.08	2247.64	
Protein	27.14	30.21	35.67	42.20	49.19	55.86	60.02	
Riboflavin	0.45	0.50	0.60	0.74	0.92	1.11	1.24	7.90%
Saturated fat	7.58	8.58	10.43	12.75	15.35	17.93	19.60	
Sodium	1905.66	2126.61	2526.64	3017.63	3558.93	4089.90	4427.70	
Total fat	32.15	35.78	42.16	49.69	57.63	65.12	69.76	
Thiamin	na	na	na	na	na	na	na	
Vitamin A (RE)	127.40	157.65	224.31	337.14	521.78	791.10	1023.11	46.90%
Vitamin B6	0.54	0.61	0.74	0.88	1.04	1.19	1.28	2.60%
Vitamin B12	0.49	0.63	0.96	1.60	2.76	4.46	5.89	26.80%
Vitamin C	28.01	34.02	45.71	61.20	79.42	98.24	110.62	3.30%
Vitamin E	5.19	5.77	6.85	8.21	9.76	11.32	12.34	0.60%
Zinc	3.72	4.08	4.77	5.68	6.75	7.88	8.65	91.00%

§ EAR values presented in Table 5 of the main text of this document.

Table A7-3. Estimated percentiles of the usual nutrient intake distributions for children 6 to 7 years old. The last column shows the estimated prevalence of inadequate intakes of each nutrient for which a value of EAR§ was available and for calcium (by probability analysis based on the Adequate Intake value).

Nutrient	5th	10th	25th	50th	75th	90th	95th	Prevalence
Alpha Carotene	51.96	65.85	97.58	151.47	236.70	355.57	454.45	
Calcium	150.57	173.06	216.96	276.37	348.89	427.27	480.93	58.0%
Carbohydrate	122.62	130.94	145.67	163.31	182.35	200.72	212.29	
Cholesterol	52.06	67.75	101.49	151.54	216.60	289.39	339.92	
Copper	0.63	0.68	0.78	0.91	1.05	1.18	1.27	
Energy	850.81	922.90	1058.24	1226.32	1404.01	1562.16	1652.29	
Fiber	7.46	8.33	9.94	12.00	14.37	16.79	18.38	
Folate	97.28	109.07	132.00	163.10	201.45	243.55	272.82	89.2%
Iron	4.64	5.15	6.12	7.40	8.93	10.57	11.68	42.2%
Magnesium	103.07	112.89	130.91	153.51	179.04	204.76	221.49	
Monounsaturated fat	10.49	11.77	14.08	16.93	20.07	23.15	25.11	
Niacin	4.43	4.94	5.92	7.23	8.83	10.57	11.77	77.0%
Polyunsaturated fat	8.97	10.04	11.99	14.40	17.06	19.68	21.35	
Phosphorous	339.48	380.69	456.64	551.88	659.15	766.49	835.86	
Potassium	878.49	984.69	1180.03	1424.35	1698.64	1972.32	2148.78	
Protein	23.91	26.98	32.75	40.19	48.83	57.71	63.58	
Riboflavin	0.36	0.41	0.51	0.64	0.82	1.01	1.14	62.4%
Saturated fat	6.31	7.23	8.94	11.14	13.66	16.24	17.93	
Sodium	1913.96	2140.92	2556.91	3075.42	3655.99	4233.82	4605.52	
Total fat	30.96	34.26	40.09	46.98	54.30	61.25	65.56	
Thiamin	na	na	na	na	na	na	na	
Vitamin A (RE)	104.97	129.49	185.76	285.15	454.93	715.91	951.71	63.1%
Vitamin B6	0.50	0.56	0.66	0.80	0.96	1.11	1.20	50.6%
Vitamin B12	na	na	na	na	na	na	na	
Vitamin C	24.48	29.75	40.13	54.13	70.89	88.48	100.19	9.2%
Vitamin E	5.38	5.90	6.87	8.09	9.48	10.89	11.80	7.9%
Zinc	3.26	3.61	4.30	5.22	6.33	7.55	8.39	97.3%

§ EAR values presented in Table 5 of the main text of this document.

Table A7-4. Estimated percentiles of the usual nutrient intake distributions for women of reproductive age (18-50 years old). The last column shows the estimated prevalence of inadequate intakes of each nutrient for which a value of EAR§ was available and for calcium (by probability analysis based on the Adequate Intake value).

Nutrient	5th	10th	25th	50th	75th	90th	95th	Prevalence
Alpha Carotene	91.93	112.37	157.34	231.28	346.05	504.75	635.78	
Calcium	204.48	230.92	283.03	353.78	439.05	528.42	587.55	62.30%
Carbohydrate	126.23	140.54	166.19	197.22	230.92	263.51	284.05	
Cholesterol	78.47	98.06	136.39	194.15	268.89	341.17	386.95	
Copper	0.75	0.83	0.98	1.17	1.37	1.59	1.72	
Energy	967.51	1078.89	1272.05	1495.27	1725.80	1938.68	2068.40	
Fiber	8.42	9.68	12.07	15.20	18.87	22.66	25.18	
Folate	117.76	133.01	162.39	201.66	249.10	299.98	334.65	93.30%
Iron	5.14	5.84	7.20	9.02	11.23	13.61	15.24	100.00%
Magnesium	116.56	130.37	156.37	190.11	229.68	270.74	297.93	
Monounsaturated fat	10.21	12.02	15.46	19.97	25.23	30.64	34.20	
Niacin	5.62	6.32	7.63	9.37	11.50	13.75	15.23	70.10%
Polyunsaturated fat	10.16	11.53	14.07	17.27	20.89	24.52	26.87	
Phosphorous	423.53	474.60	569.11	688.43	823.88	960.47	1049.22	
Potassium	1058.23	1190.37	1431.71	1731.32	2065.53	2396.71	2608.86	
Protein	33.37	37.31	44.36	52.85	62.04	70.90	76.47	
Riboflavin	0.49	0.55	0.66	0.81	0.98	1.16	1.28	66.60%
Saturated fat	6.71	7.88	10.13	13.13	16.70	20.44	22.94	
Sodium	2468.00	2808.75	3434.87	4216.03	5089.69	5956.59	6512.37	
Total fat	32.48	37.11	45.59	56.04	67.58	78.89	86.07	
Thiamin	0.39	0.43	0.50	0.59	0.70	0.80	0.86	97.20%
Vitamin A (RE)	164.96	198.55	269.83	382.79	554.17	788.46	980.88	44.80%
Vitamin B6	0.61	0.69	0.83	1.01	1.20	1.39	1.51	61.00%
Vitamin B12	na	na	na	na	na	na	na	
Vitamin C	32.94	39.06	50.73	65.90	83.43	101.26	112.87	6.40%
Vitamin E	5.49	6.31	7.89	9.98	12.45	15.03	16.76	9.90%
Zinc	4.33	4.80	5.70	6.88	8.30	9.82	10.86	70.50%

§ EAR values presented in Table 5 of the main text of this document.

Table A7-5 a to c. Estimated percentiles of the usual nutrient intake distributions for nutrients added to wheat flour, for children 3 to 6 years old (**a**), 6 to 7 years old (**b**), and women of reproductive age (18-50 years old)(**c**). The last two columns show the prevalence of inadequate nutrient intakes estimated from the observed intake data before fortification (next to last column) and from the data including fortification of wheat flour (last column). Inadequacy analysis was done based on the reference EAR§ and using probability analysis based on the Adequate Intake value for calcium.

a. Children 3 to 6 years old.

Nutrient	5th	10th	25th	50th	75th	90th	95th	Prevalence	Prevalence (Fort)
Folate	149.00	170.80	212.03	265.45	327.62	391.63	433.83	44.30%	7.30%
Iron	6.01	6.69	7.94	9.51	11.31	13.12	14.30	9.30%	1.20%
Niacin	5.98	6.60	7.77	9.24	10.93	12.64	13.77	21.00%	5.20%
Riboflavin	0.55	0.62	0.75	0.92	1.12	1.33	1.47	7.90%	1.90%
Thiamin	0.40	0.44	0.51	0.61	0.71	0.81	0.88	na	17.20%
Vitamin A (RE)	196.81	231.04	302.95	419.05	606.96	887.91	1138.02	46.90%	29.20%
Vitamin B6	0.68	0.75	0.89	1.04	1.21	1.38	1.48	2.60%	0.40%
Vitamin B12	0.63	0.78	1.11	1.67	2.51	3.64	4.56	26.80%	19.70%
Zinc	4.61	5.07	5.92	6.98	8.18	9.38	10.17	91.00%	71.90%

b. Children 6 to 7 years old.

Nutrient	5th	10th	25th	50th	75th	90th	95th	Prevalence	Prevalence (Fort)
Folate	139.14	160.36	202.44	260.72	333.81	414.94	471.66	89.2%	41.2%
Iron	5.83	6.50	7.79	9.51	11.59	13.83	15.37	42.2%	15.0%
Niacin	5.37	6.04	7.35	9.11	11.28	13.64	15.28	77.0%	48.4%
Riboflavin	0.46	0.52	0.65	0.83	1.05	1.30	1.47	62.4%	34.6%
Thiamin	0.35	0.39	0.47	0.57	0.68	0.79	0.86	na	81.4%
Vitamin A (RE)	169.13	199.06	263.24	372.76	565.65	880.07	1177.93	63.1%	46.9%
Vitamin B6	0.60	0.68	0.82	0.99	1.18	1.36	1.48	50.6%	22.3%
Vitamin B12	0.48	0.61	0.94	1.53	2.55	4.08	5.44	na	49.0%
Zinc	4.02	4.47	5.34	6.52	7.98	9.58	10.70	97.3%	85.4%

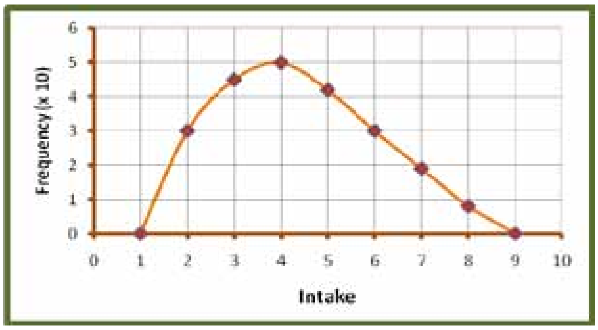
c. Women 18-50 years old.

Nutrient	5th	10th	25th	50th	75th	90th	95th	Prevalence	Prevalence (Fort)
Folate	193.81	222.96	279.28	354.38	444.52	540.18	604.73	93.30%	34.50%
Iron	7.44	8.43	10.28	12.73	15.81	19.37	22.00	100%	98.20%
Niacin	7.81	8.72	10.38	12.50	14.99	17.63	19.44	70.10%	32.20%
Riboflavin	0.66	0.74	0.90	1.11	1.38	1.69	1.92	66.60%	26.70%
Thiamin	0.50	0.55	0.64	0.76	0.90	1.06	1.17	97.20%	76.70%
Vitamin A (RE)	304.04	353.13	463.62	658.76	998.36	1533.77	2025.25	44.80%	10.50%
Vitamin B6	0.84	0.93	1.10	1.30	1.53	1.77	1.95	61.00%	23.20%
Vitamin B12	0.88	1.13	1.78	3.06	5.52	9.74	13.85	na	30.00%
Zinc	5.68	6.27	7.37	8.80	10.46	12.19	13.35	70.50%	35.80%

Annex 8:
Figures to present the results of nutrient intake distributions.

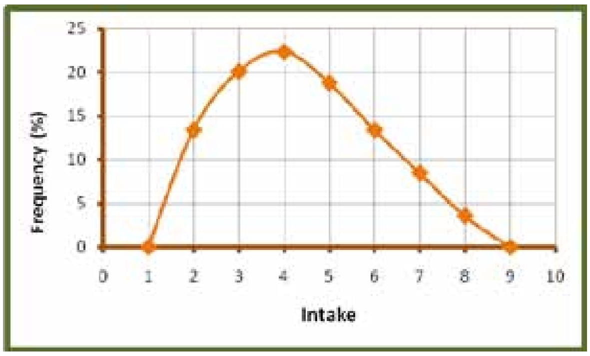
Distribution of food and nutrient intakes is asymmetric, with values skewed to the right, i.e. a lower portion of the population with high intake values. This condition is important for the formulation of fortified foods because the micronutrient content is limited by those individuals with high consumption of the fortification vehicle. **Fig. A8-1** shows a typical asymmetric distribution of intakes.

Figure A8-1. Intake distribution of a nutrient for any population (X-axis shows the usual intakes, and the Y-axis shows the number of individuals within each category of intake).



The number of individuals can be expressed in relative terms, i.e. as percent of the total population. **Figure A8-2** presents the figure, which is similar to Figure A8-1.

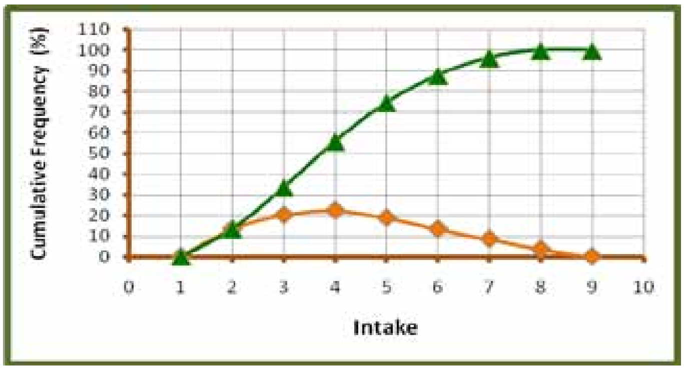
Fig. A8-2. Intake distribution of a nutrient for any population (X-axis shows the usual intakes, and the Y-axis shows the proportion of the population within each category of intake).



The proportion of the population between two different values of intake in **Fig. A8-2** can be computed from the area below the curve and with inferior and superior limit for the specific values of intake. For example, if one would like to know the proportion of the population with intakes larger than 4 but equal or lower than 7 unit of intake, using Fig. A8-2, it would be: 19 + 13 + 8 = 40 %.

However, a graphical manner to make this estimation easier is to present cumulatively the increasing intakes at increasing values of intake. **Fig. A8-3** presents the data arranged in that form.

Fig. A8-3. Cumulative intake distribution of a nutrient for any population (X-axis the usual intakes, and the Y-axis the cumulative proportion of the population within each category of intake). The lower figure represents the data as done in Fig. A8-2.



The same question asked above is easily responded by observing the Y-values between 4 and 7 units of intake. The calculation is: 95 – 55 = 40%. Thus, Fig. A8-3 is very easy to understand and it is very practical for making estimations.

The limitation of Fig. A8-3, when used for different nutrients, is that the X-axis varies depending on the nutrient, not only because the dimensions are different (micrograms, milligrams and grams), but also because the usual intakes also change. This could be cumbersome when one would try to compare among different nutrients. A way to overcome this situation is to switch the axis: i.e. placing the cumulative frequencies (which are indeed the percentiles of intake) in the X-axis, and the values of intake in the Y-axis. Although the Y-axis would change from nutrient to nutrient, it is advantageous to have the X-axis with fix dimensions. A graph of this type makes easier the visual estimation of the cumulative frequencies between two intake points. Furthermore, any additional intake would be observed as moving up, which is **Fig. A8-4** shows that figure.

Fig. A8-4. Cumulative intake distribution of a nutrient for any population (X-axis the cumulative proportion of the population within each category of intake, or percentiles, and the Y-axis the usual intakes).

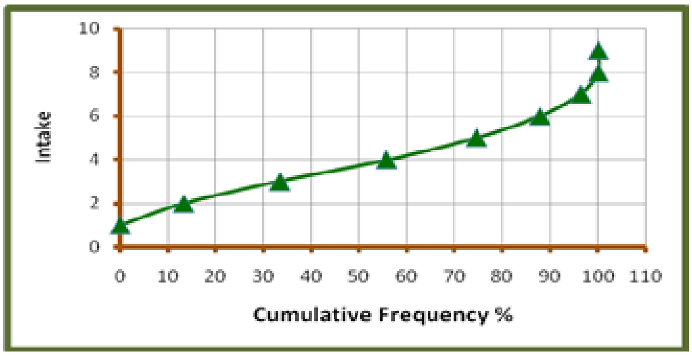
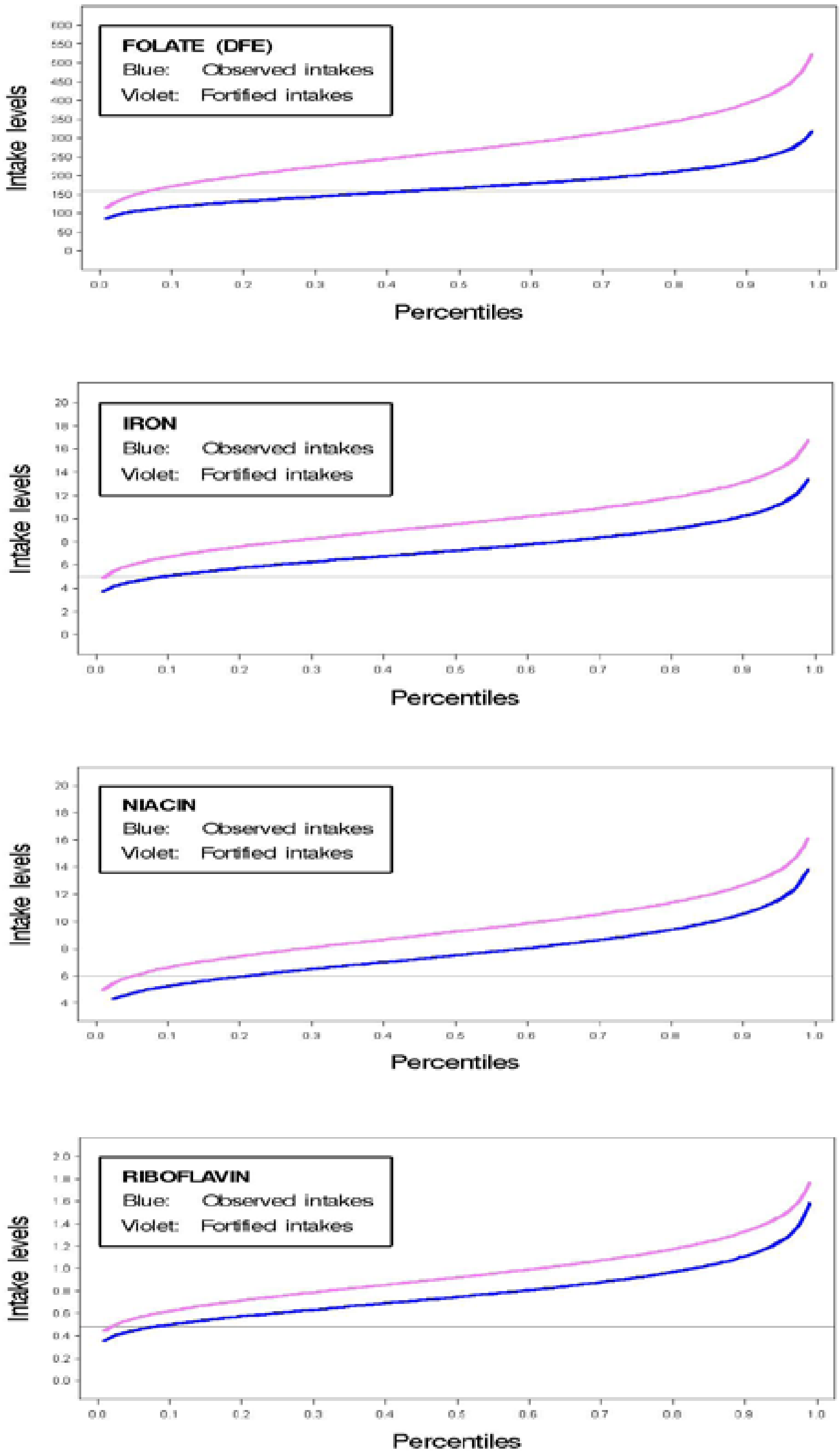
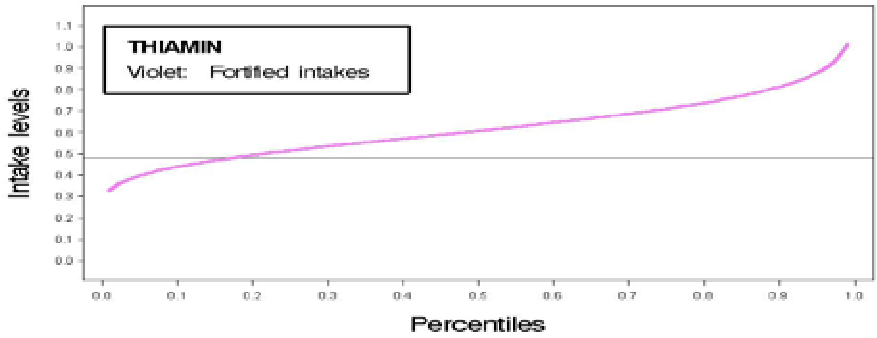


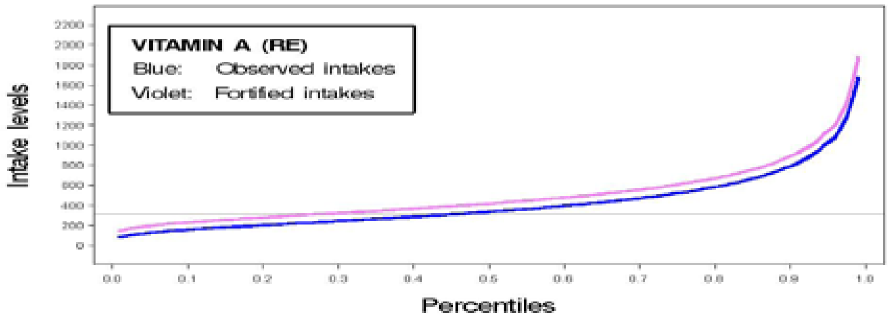
Fig. A8-4 is the model that was used for making the Fig. 1 in the text, and the figures of the Annex 9.

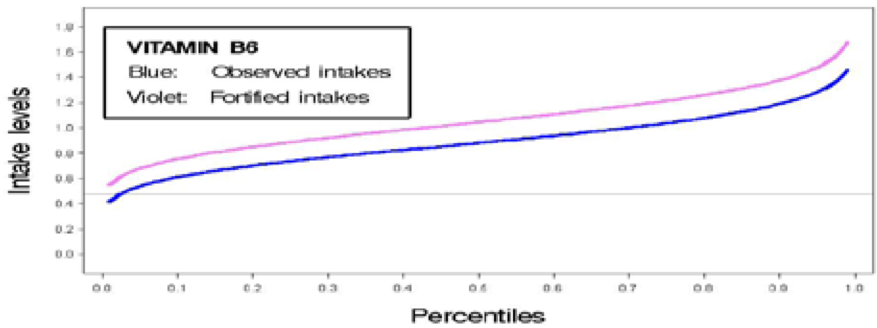
Annex 9:
Cumulative figures of the distribution intakes of basic nutrients in Hebron and Gaza City in 2005.

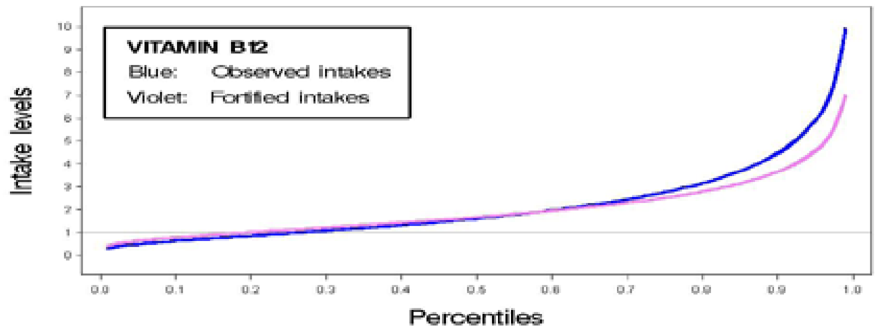
Figures A9-1. Cumulative distributions of usual intakes of nutrients by children 3-6 years old. The blue line corresponds to baseline usual intakes. The violet-pink line corresponds to usual intakes computed from a simulated food intake data set where wheat flour was fortified. The horizontal line displays the location of the corresponding EAR value.

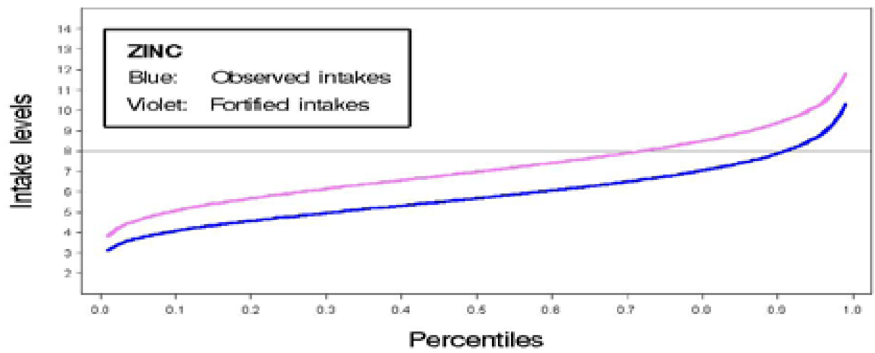



THIAMIN
Violet: Fortified intakes
Intake levels
Percentiles

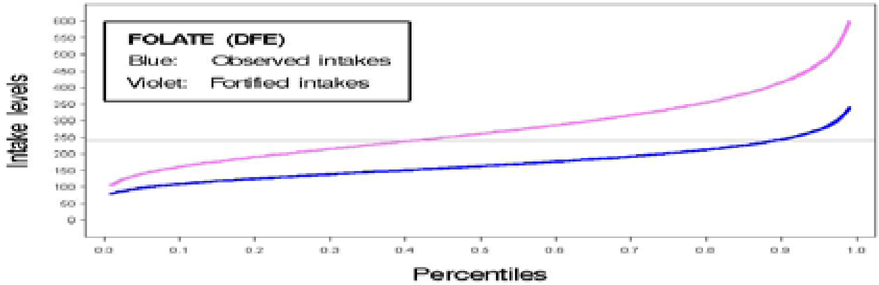

VITAMIN A (RE)
Blue: Observed intakes
Violet: Fortified intakes
Intake levels
Percentiles

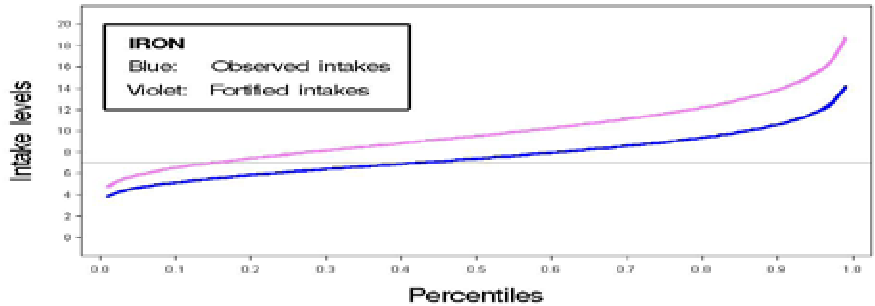

VITAMIN B6
Blue: Observed intakes
Violet: Fortified intakes
Intake levels
Percentiles

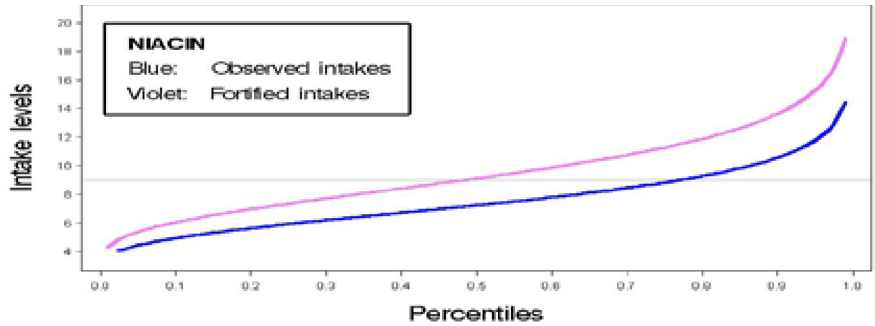

VITAMIN B12
Blue: Observed intakes
Violet: Fortified intakes
Intake levels
Percentiles

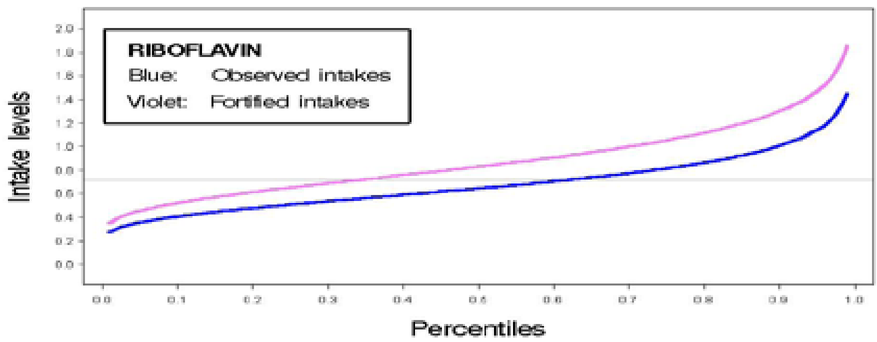

ZINC
Blue: Observed intakes
Violet: Fortified intakes
Intake levels
Percentiles

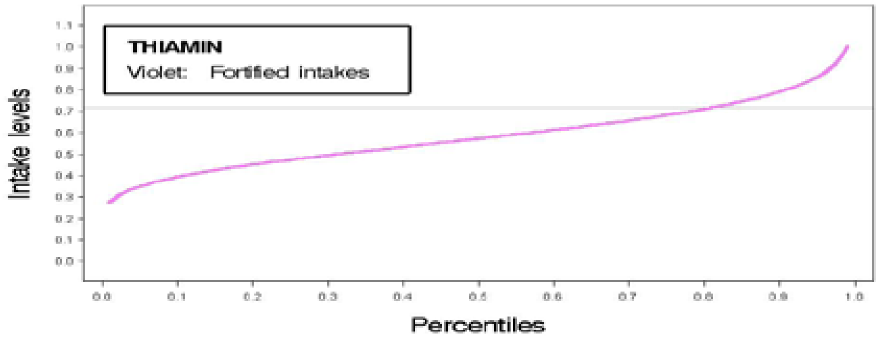
Figures A9-2. Cumulative distributions of usual intakes of nutrients by children 6-7 years old. The blue line corresponds to baseline usual intakes. The violet-pink line corresponds to usual intakes computed from a simulated food intake data set where wheat flour was fortified. The horizontal line displays the location of the corresponding EAR value.

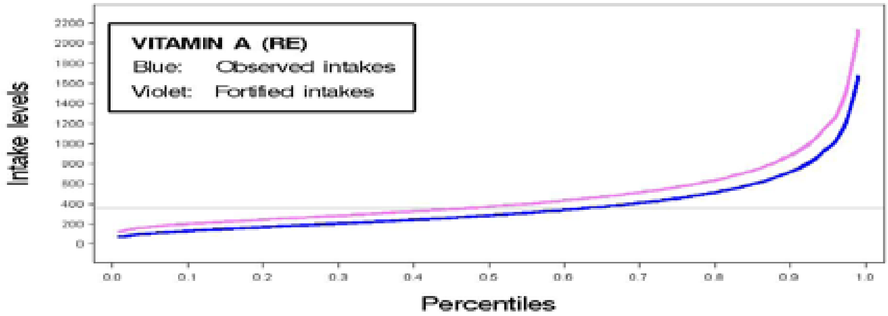


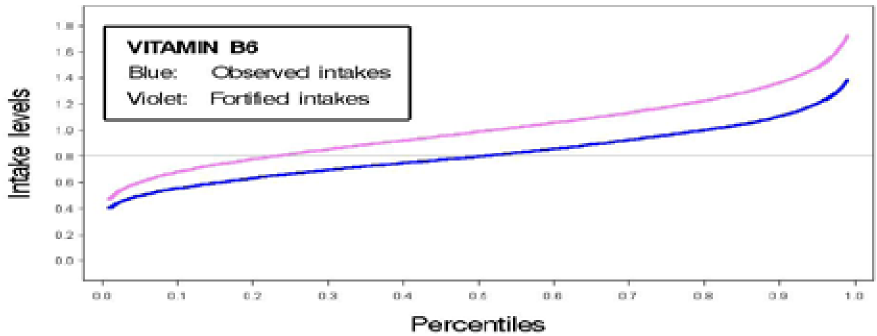


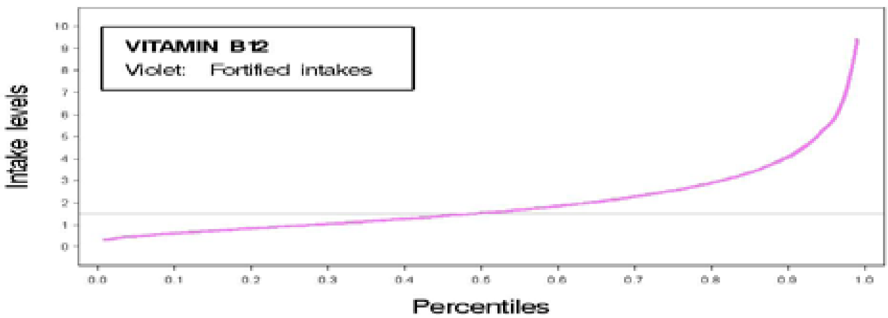


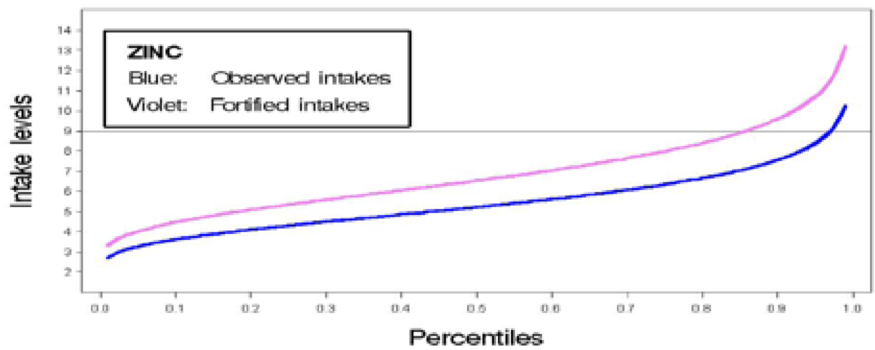



THIAMIN
Violet: Fortified intakes
Intake levels
Percentiles

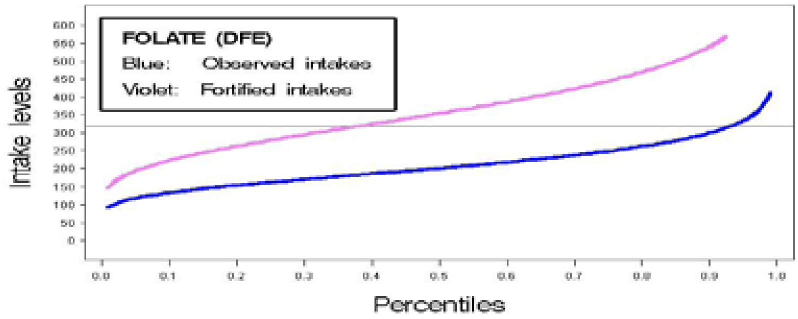

VITAMIN A (RE)
Blue: Observed intakes
Violet: Fortified intakes
Intake levels
Percentiles

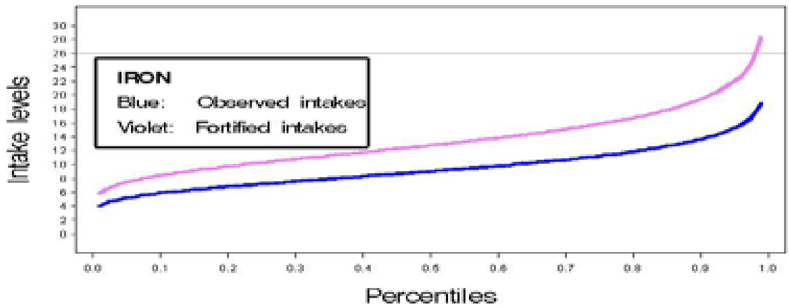

VITAMIN B6
Blue: Observed intakes
Violet: Fortified intakes
Intake levels
Percentiles

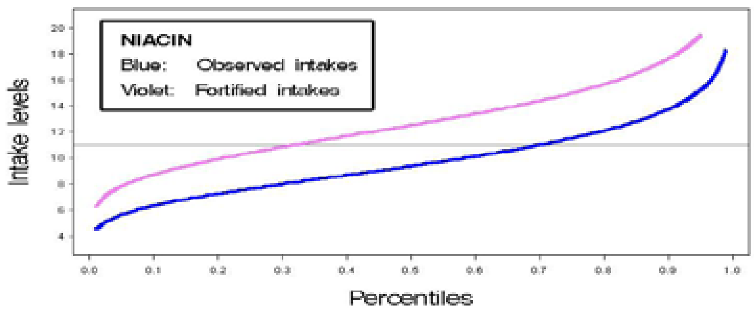

VITAMIN B12
Violet: Fortified intakes
Intake levels
Percentiles

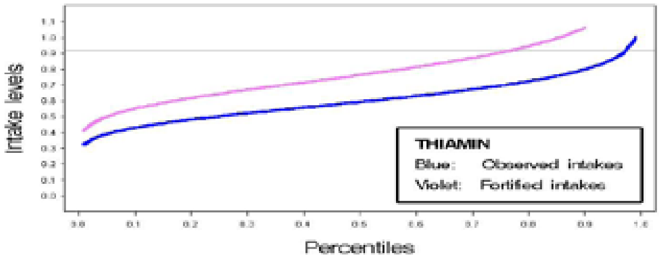

ZINC
Blue: Observed intakes
Violet: Fortified intakes
Intake levels
Percentiles

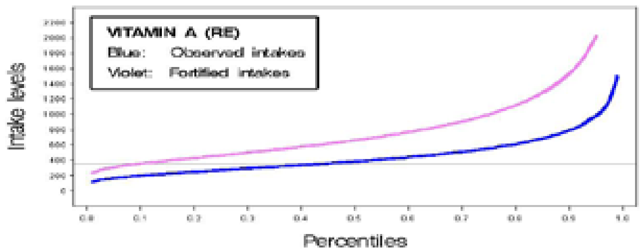
Figures A9-3. Cumulative distributions of usual intakes of nutrients by women of reproductive age. The blue line corresponds to baseline usual intakes. The violet-pink line corresponds to usual intakes computed from a simulated food intake data set where wheat flour was fortified. The horizontal line displays the location of the corresponding EAR value.

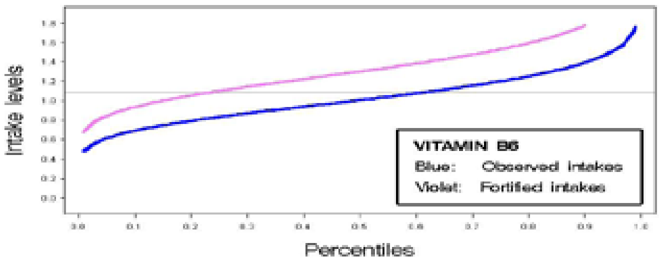


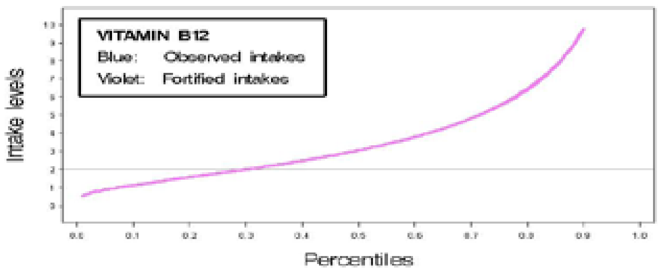


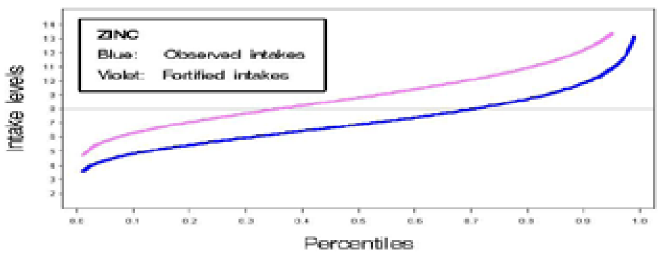



THIAMIN
Blue: Observed intakes
Violet: Fortified intakes
Intake levels
Percentiles

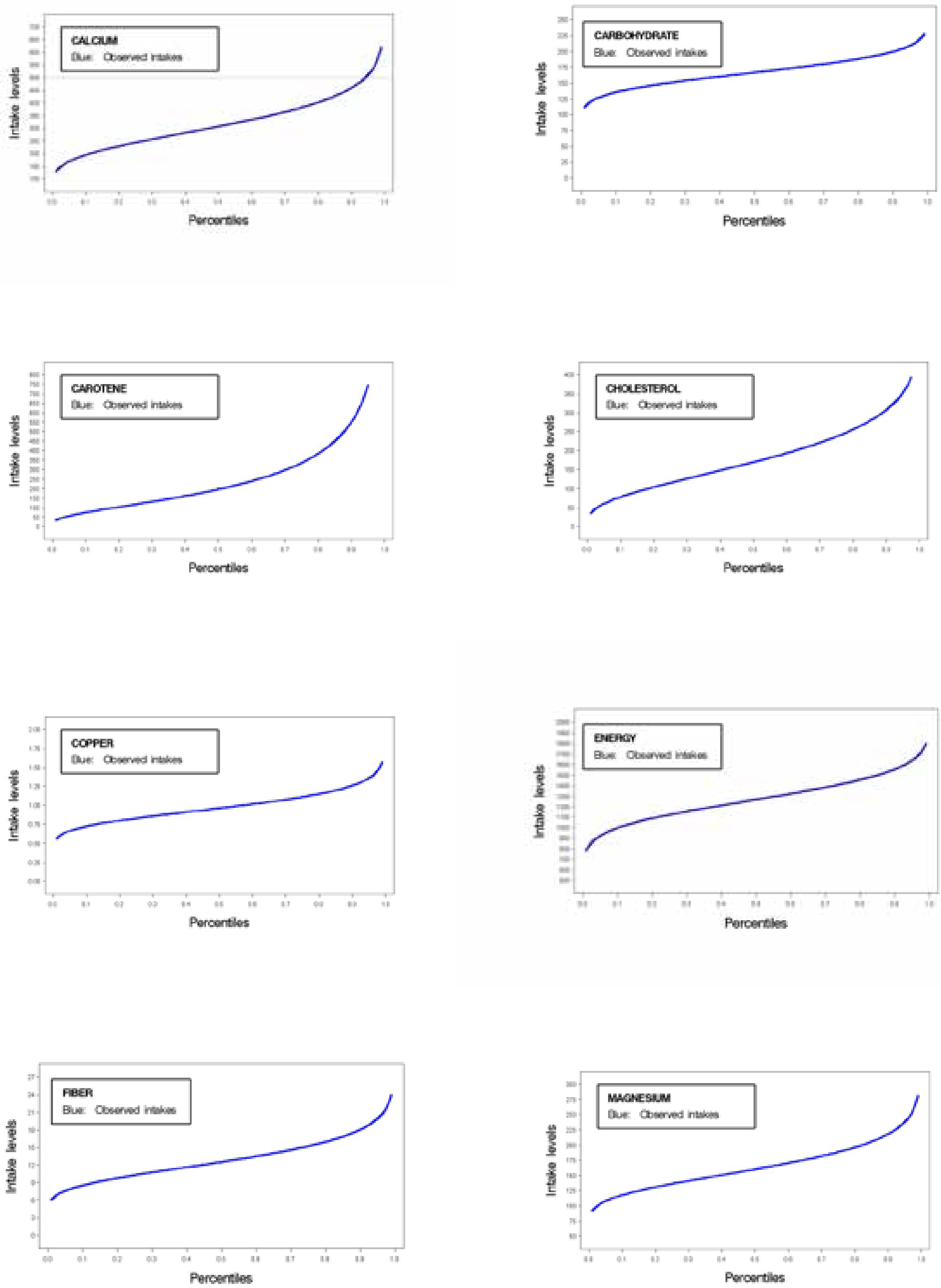

VITAMIN A (RE)
Blue: Observed intakes
Violet: Fortified intakes
Intake levels
Percentiles

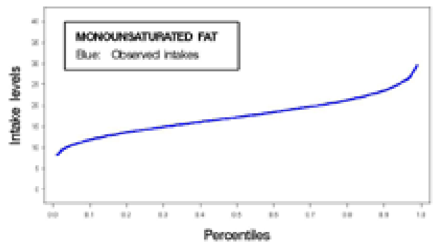

VITAMIN B6
Blue: Observed intakes
Violet: Fortified intakes
Intake levels
Percentiles

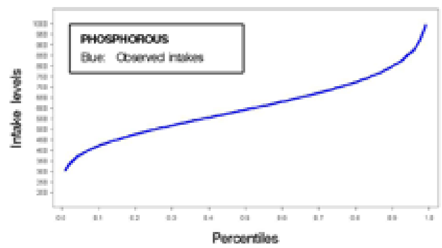

VITAMIN B12
Blue: Observed intakes
Violet: Fortified intakes
Intake levels
Percentiles

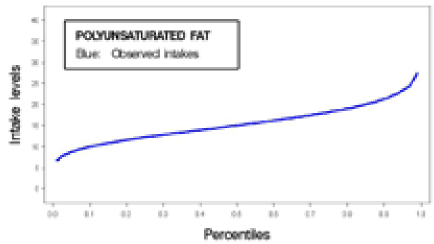

ZINC
Blue: Observed intakes
Violet: Fortified intakes
Intake levels
Percentiles

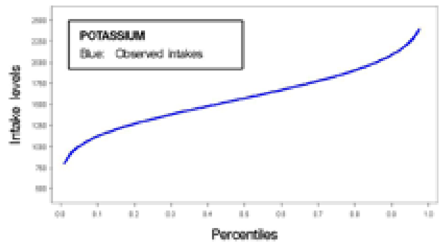
Figures A9-4. Cumulative distributions of usual intakes of nutrients by children 3-6 years old. The blue line corresponds to baseline usual intakes. The horizontal line displays the location of the corresponding EAR value, and AI for calcium.

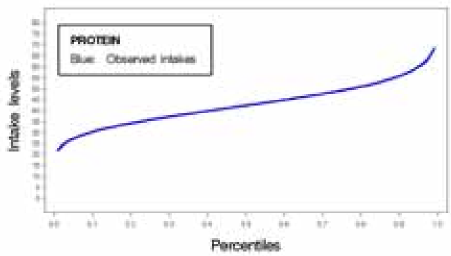


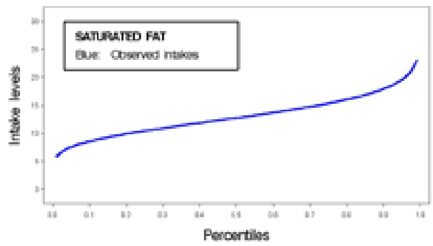

MONOUNSATURATED FAT
Blue: Observed intakes
Intake levels
Percentiles

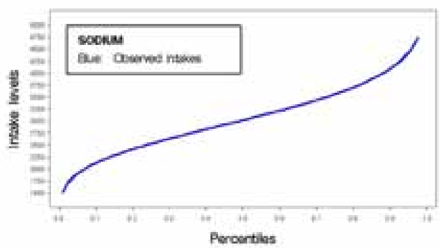

PHOSPHOROUS
Blue: Observed intakes
Intake levels
Percentiles

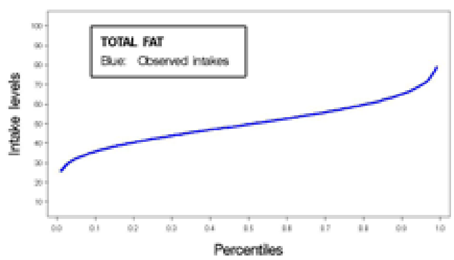

POLYUNSATURATED FAT
Blue: Observed intakes
Intake levels
Percentiles

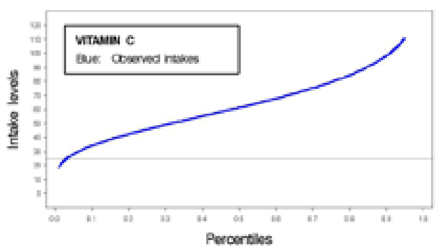

POTASSIUM
Blue: Observed intakes
Intake levels
Percentiles

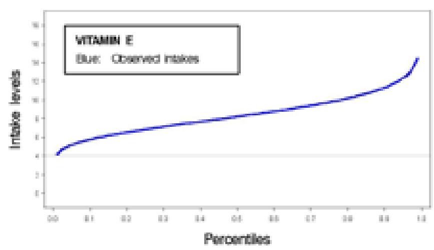

PROTEIN
Blue: Observed intakes
Intake levels
Percentiles


SATURATED FAT
Blue: Observed intakes
Intake levels
Percentiles

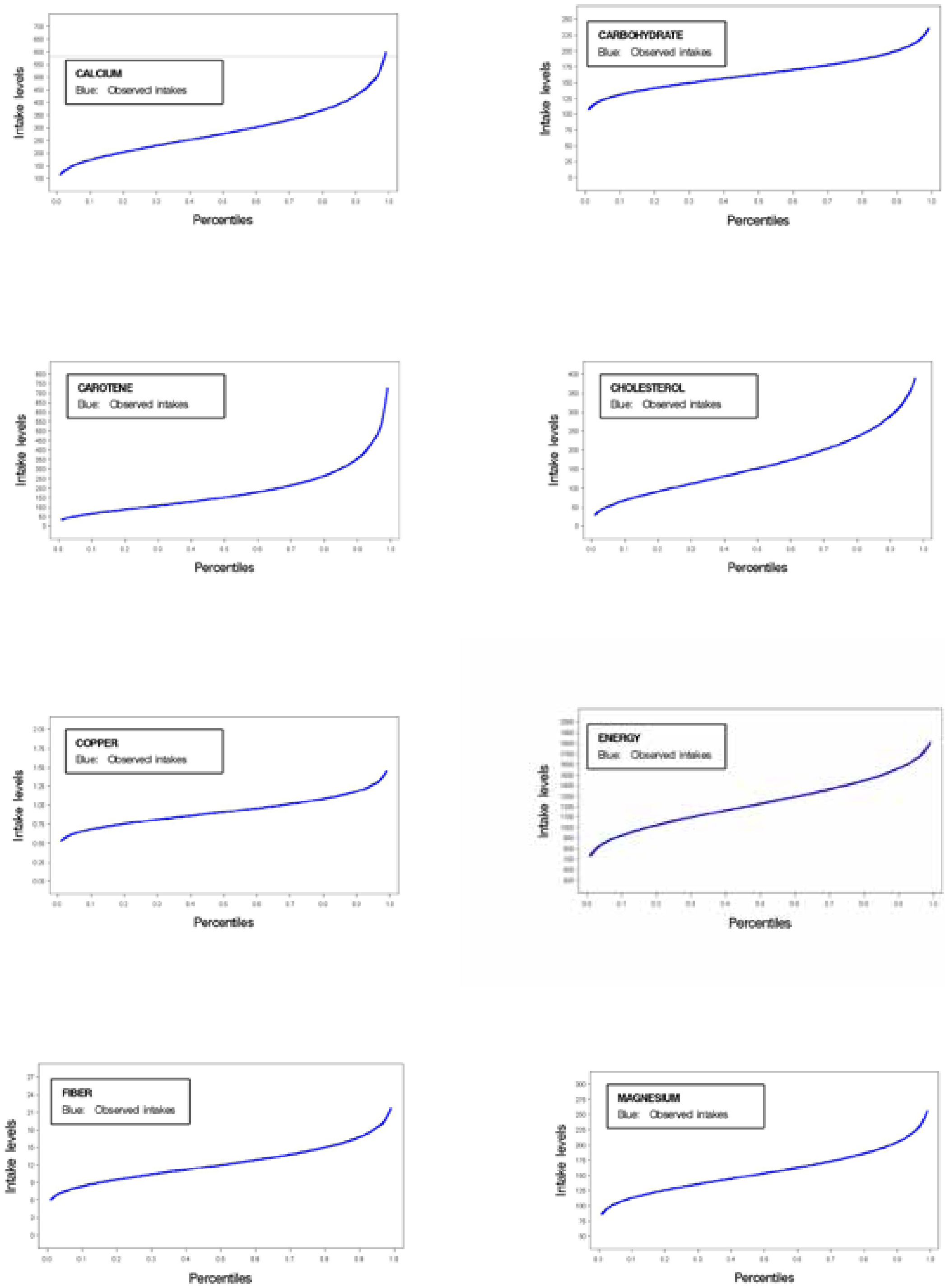

SODIUM
Blue: Observed intakes
Intake levels
Percentiles

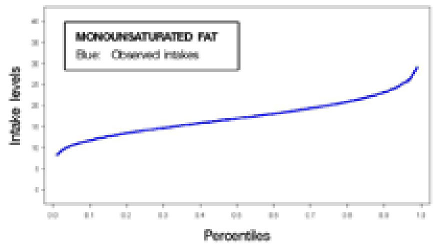

TOTAL FAT
Blue: Observed intakes
Intake levels
Percentiles

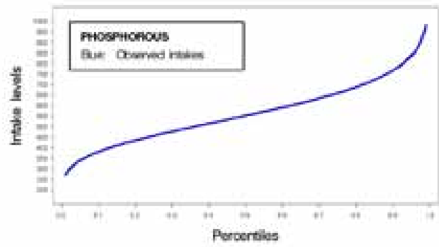

VITAMIN C
Blue: Observed intakes
Intake levels
Percentiles

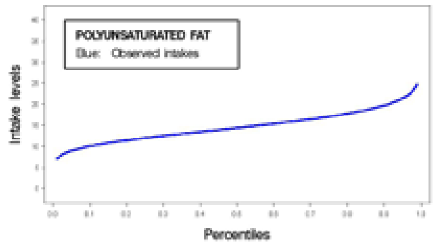

VITAMIN E
Blue: Observed intakes
Intake levels
Percentiles

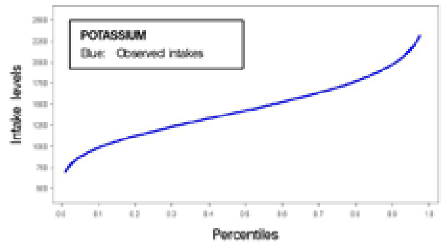
Figures A9-5. Cumulative distributions of usual intakes of nutrients by children 6-7 years old. The blue line corresponds to baseline usual intakes. The horizontal line displays the location of the corresponding EAR value, and AI for calcium.

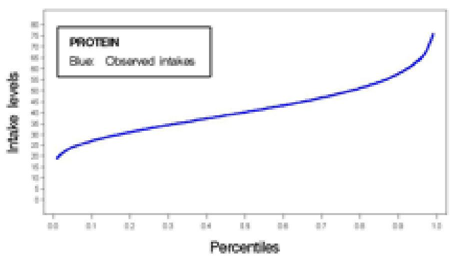


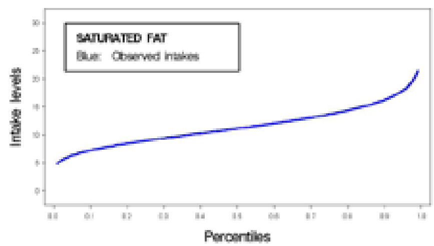

MONOUNSATURATED FAT
Blue: Observed intakes
Intake levels
Percentiles

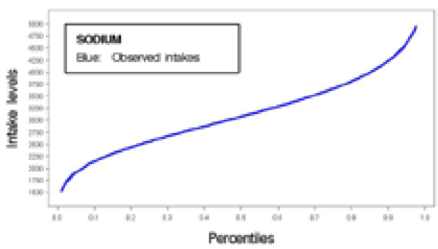

PHOSPHOROUS
Blue: Observed intakes
Intake levels
Percentiles

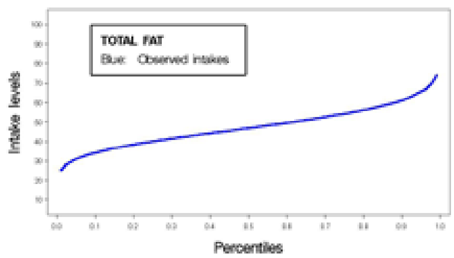

POLYUNSATURATED FAT
Blue: Observed intakes
Intake levels
Percentiles

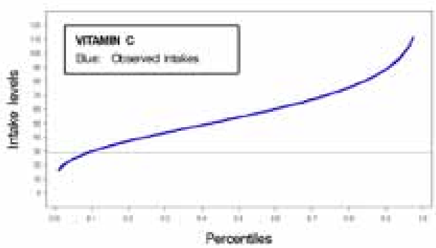

POTASSIUM
Blue: Observed intakes
Intake levels
Percentiles

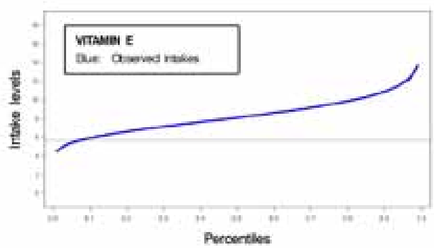

PROTEIN
Blue: Observed intakes
Intake levels
Percentiles


SATURATED FAT
Blue: Observed intakes
Intake levels
Percentiles

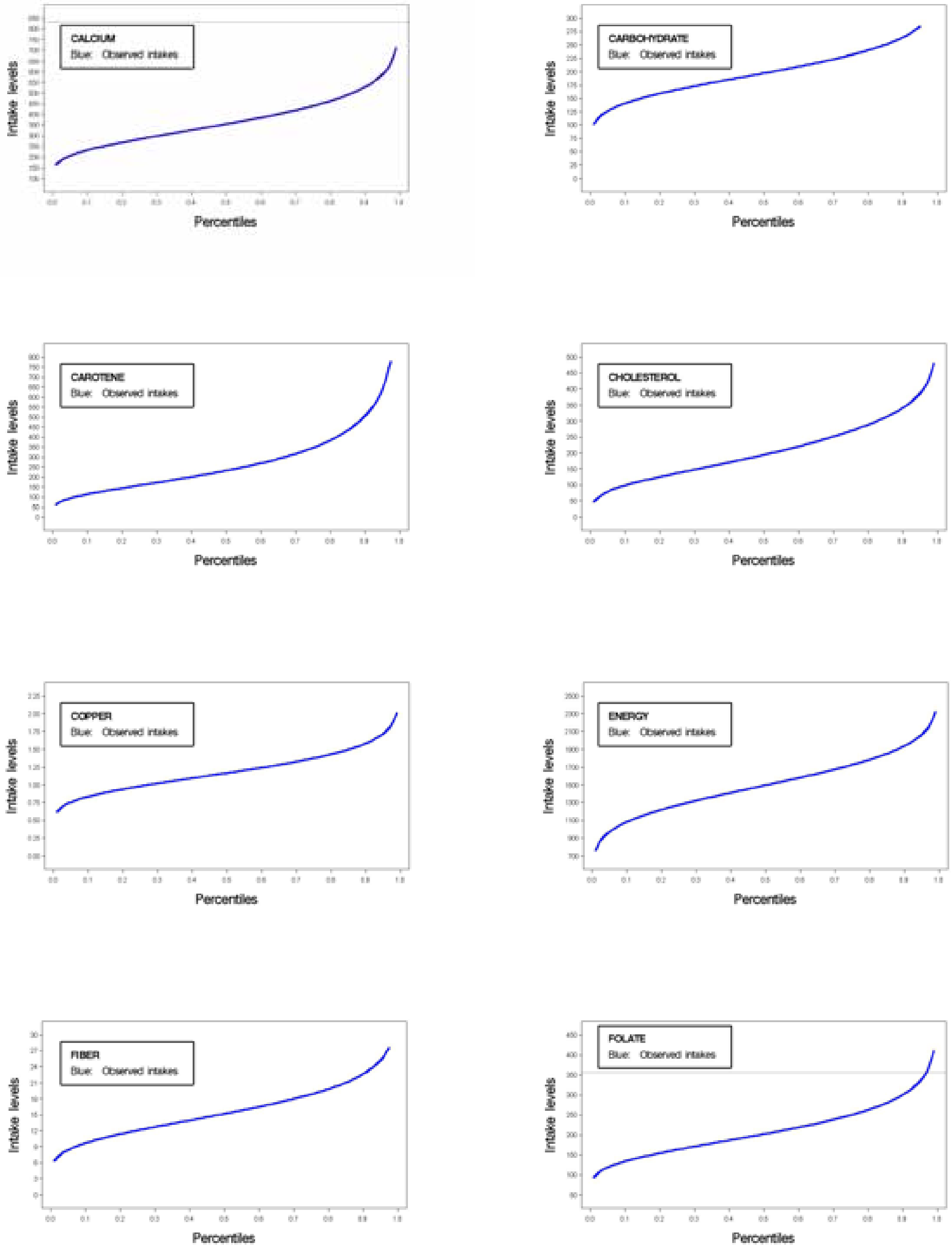

SODIUM
Blue: Observed intakes
Intake levels
Percentiles

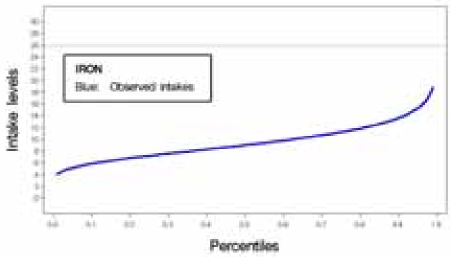

TOTAL FAT
Blue: Observed intakes
Intake levels
Percentiles

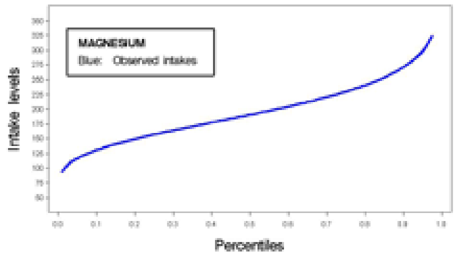

VITAMIN C
Blue: Observed intakes
Intake levels
Percentiles

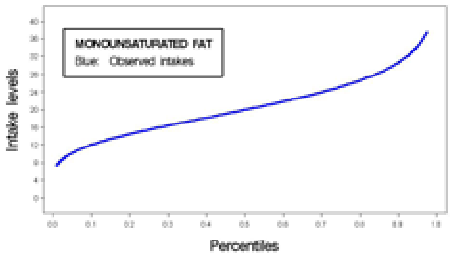

VITAMIN E
Blue: Observed intakes
Intake levels
Percentiles

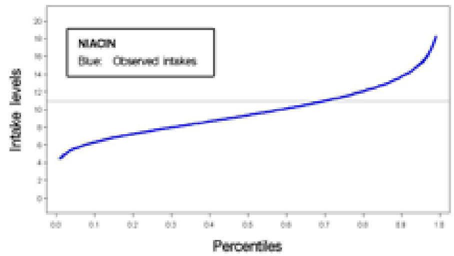
Figures A9-6. Cumulative distributions of usual intakes of nutrients by women of reproductive age. The blue line corresponds to baseline usual intakes. When used, the horizontal line displays the location of the corresponding EAR value, and AI for calcium.

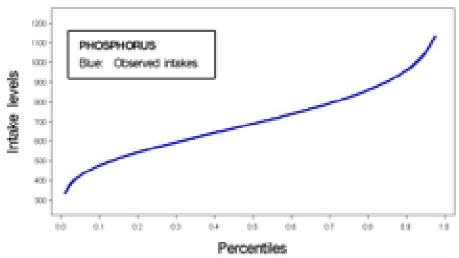


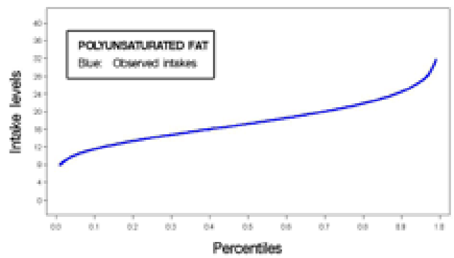

IRON
Blue: Observed intakes
Intake levels
Percentiles

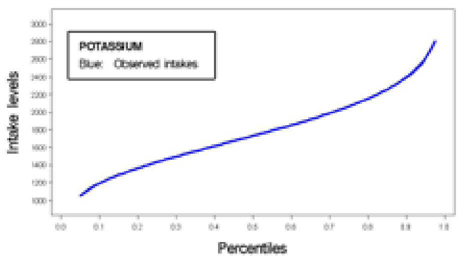

MAGNESIUM
Blue: Observed intakes
Intake levels
Percentiles

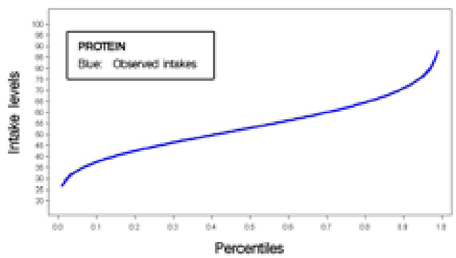

MONOUNSATURATED FAT
Blue: Observed intakes
Intake levels
Percentiles

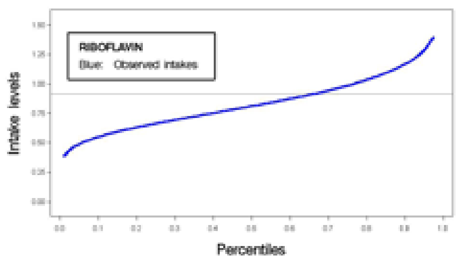

NIACIN
Blue: Observed intakes
Intake levels
Percentiles

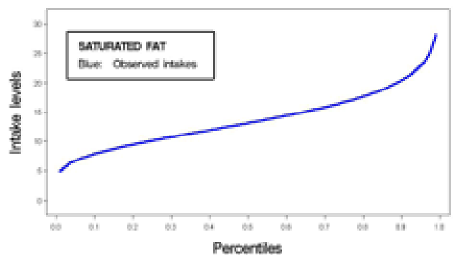

PHOSPHORUS
Blue: Observed intakes
Intake levels
Percentiles

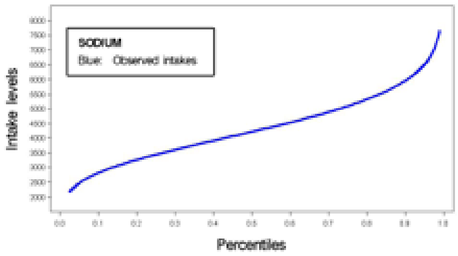

POLYUNSATURATED FAT
Blue: Observed intakes
Intake levels
Percentiles

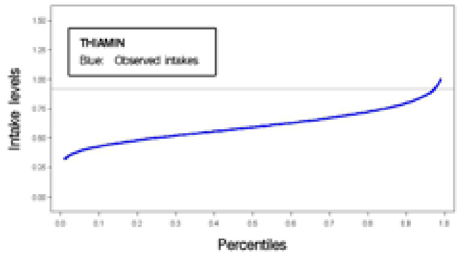

POTASSIUM
Blue: Observed intakes
Intake levels
Percentiles

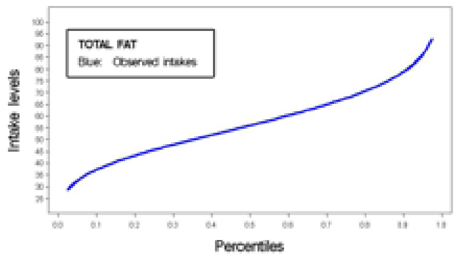

PROTEIN
Blue: Observed intakes
Intake levels
Percentiles

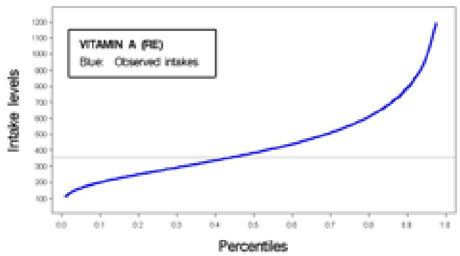

RIBOFLAVIN
Blue: Observed intakes
Intake levels
Percentiles

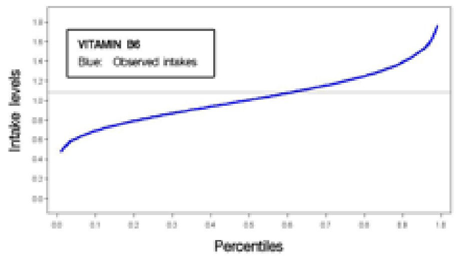

SATURATED FAT
Blue: Observed intakes
Intake levels
Percentiles

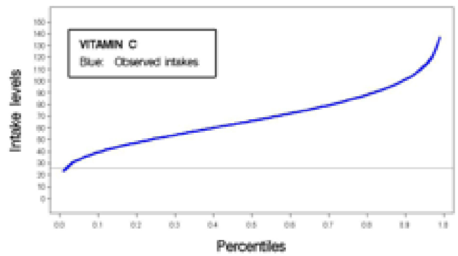

SODIUM
Blue: Observed intakes
Intake levels
Percentiles

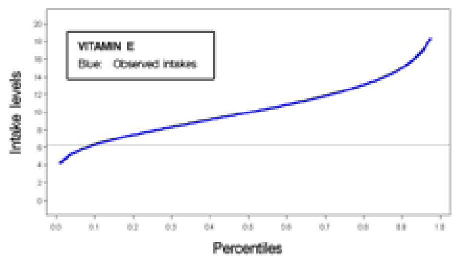

THIAMIN
Blue: Observed intakes
Intake levels
Percentiles

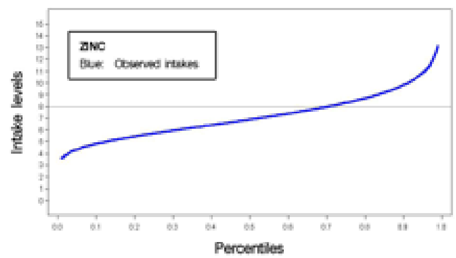

TOTAL FAT
Blue: Observed intakes
Intake levels
Percentiles


VITAMIN A (RE)
Blue: Observed intakes
Intake levels
Percentiles


VITAMIN B6
Blue: Observed intakes
Intake levels
Percentiles


VITAMIN C
Blue: Observed intakes
Intake levels
Percentiles


VITAMIN E
Blue: Observed intakes
Intake levels
Percentiles


ZINC
Blue: Observed intakes
Intake levels
Percentiles

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