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# Dietary intake in pregnant women in a Spanish Mediterranean area: as good as it is supposed to be?

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## Abstract

*Objective:* To assess food and nutrient intakes and compliance with nutritional recommendations in pregnant women according to selected sociodemographic characteristics.

*Design:* Cross-sectional study based on data from the INMA-Valencia cohort (Spain), which recruited pregnant women between 2004 and 2005. Information on maternal sociodemographics and anthropometry was collected. Dietary intake was assessed through an FFQ. Intakes of foods were compared with Spanish food-based dietary guidelines. Intake inadequacy for nutrients was assessed using the Dietary Reference Intakes of the US Institute of Medicine.

*Setting:* Valencia, Spain.

*Subjects:* We studied 822 pregnant women who had information on dietary intake during their first trimester of pregnancy.

*Results:* More than 50 % of pregnant women did not meet the guidelines for cereals and legumes; reported intakes of carbohydrates, *n*-3 and *n*-6 fatty acids were below recommendations and exceeded the total fat intake according to dietary references. Dietary inadequacy for folate, Fe and vitamin E ranged from 99 % to 68 %. Vegetable intake was related to age only. Younger and less educated women showed lower intakes of protein and *n*-3 fatty acids and higher intakes of *trans*-fatty acids as well as greater inadequacy for micronutrients. Spanish women reported lower intakes of fruit and carbohydrates and higher intakes of protein, total fat, SFA, MUFA and *n*-3 fatty acids compared with their foreign-born counterparts.

*Conclusions:* Women in the studied area have inadequate intakes of several nutrients relevant during pregnancy. Age, education and country of origin are factors significantly related to dietary intake and adequacy.

**Keywords**
Diet
Pregnancy
Adequacy
Nutritional guidelines
Sociodemographic characteristics

Maternal diet during the periconceptional and pregnancy period has been shown to be an important determinant of birth outcomes, such as birth defects, preterm delivery and fetal growth(1–4), and of maternal health problems such as pre-eclampsia(5) and gestational diabetes(6). Moreover, nutrient intake during pregnancy has been related to cognitive development and allergic disorders in childhood(7,8).

Nutritional requirements increase during pregnancy in order to support fetal growth and the development of maternal tissue specific to reproduction(9). This may lead to deep deficiencies of micronutrients such as Fe and folate, the recommended daily intakes of which are not usually achieved from food sources even in populations assumed to be well nourished(10–12). As a result, recommendations on specific supplementation during pregnancy for these micronutrients have been formulated(13,14). On the other hand, it has been shown that recommended levels of other micronutrients are met by dietary intake from food in developed countries(12,15,16), making supplementation unnecessary in some cases.

Neither the dietary intake of pregnant women in Mediterranean areas(17–19) (where diet is considered to be healthier than in other Western societies) nor their compliance with food-based dietary guidelines for pregnancy has been examined extensively(20). Furthermore,

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from a global perspective, few studies have estimated total nutrient intakes in pregnant women taking into account food and supplements jointly[15,19,21]. Evaluating nutrient intakes from both food and supplements would reflect in a more realistic way the adequacy with respect to recommendations[22].

We assessed intakes from foods and supplements during the first trimester of pregnancy in a cohort of women in a Spanish Mediterranean area, and estimated the compliance with pregnancy-specific recommendations for food groups and nutrients.

## Materials and methods

### *Population and study design*

INMA (Spanish acronym for Childhood and Environment) is a network of research groups in Spain that set up a collaborative mother and child cohort study in 2003[23].

The present study was based on data from the INMA-Valencia birth cohort. The mother's recruitment and follow-up procedures have been described in detail elsewhere[23]. In brief, pregnant women from a well-defined geographic area in the Valencia province, who attended their first prenatal visit at La Fe Hospital between February 2004 and June 2005, were eligible if they fulfilled the inclusion criteria[23]. Pregnant women were identified at the hospital admission desk and were invited to participate by the team staff if they were at least 16 years old, had a singleton pregnancy, were between 10 and 13 weeks of gestation at enrolment, did not follow any programme of assisted reproduction for the current pregnancy, had no previous history of hypertension, had no communication handicap and planned to deliver at the reference hospital.

Eligible women who agreed to participate signed an informed consent form; 855 out of 1563 eligible women were included in the study (55 % participation rate). Participants were similar in educational level to non-participants but the former were slightly older and more likely to work at the time of the participation request.

Of the 855 included women, twenty-three had an abortion before their first appointment, four were lost to follow-up, one abandoned the study and five were excluded because their dietary information from food sources was missing. Finally, 822 women were included in the present analysis. The study protocol was approved by the Ethics Committee of La Fe Hospital.

### *Data collection and processing*

Information on sociodemographic and lifestyle factors and maternal anthropometric variables was obtained from a questionnaire, administered by trained interviewers, in the first trimester of pregnancy (week 12 approximately) and from maternal medical records. The variables were: age at recruitment; country of origin; educational level (primary, 6–9 years of schooling; secondary, 10–14 years of schooling; university, ≥15 years of schooling); social class following a widespread Spanish classification[24]; working status during the first trimester; smoking during the first trimester; pre-pregnancy BMI; parity; planned pregnancy; drug use; and self-reported vomiting during the first trimester.

Information on usual daily food and nutrient intakes during the first trimester of pregnancy was collected using an FFQ with 101 food items. The FFQ was an adapted version of Willett's questionnaire[25] developed and validated for use among adults living in Spain[26], with satisfactory coefficients for validity and reproducibility[26,27].

In our population of pregnant women we asked how often, on average, participants had consumed a particular amount of a specific type of food from the last menstrual period until the time of the interview (10–13 weeks). Standard units and serving sizes were specified for each food item. The questionnaire included nine possible answers to determine frequency of intake, ranging from 'never or less than once per month' to 'six or more times per day'. The response to each food item was converted to average daily intake for each participant. Nutrient values and total energy intake were obtained from the US Department of Agriculture food composition tables and other published sources[28,29]. We calculated nutrient intakes by multiplying the frequency of consumption for each food item by the nutrient composition of the portion size specified on the FFQ and by addition across all foods to obtain total intake of each nutrient for each individual. Nutrient intakes were adjusted for total energy intake by calculating the residuals from a linear regression with the natural logarithm of the nutrient modelled as the dependent variable and the natural logarithm of total energy intake as the independent variable[25].

Information on supplement use was collected by asking women at their first visit (weeks 10–13) the question: 'In three months before becoming pregnant and until now, have you ever taken specific supplements or multivitamins?' Monthly intake of nutrients from supplements was estimated based on supplement brand name, composition, daily dose and timing of consumption.

From food sources, intakes of protein, carbohydrates, total fat, SFA, MUFA, PUFA, *n*-3 fatty acids, *n*-6 fatty acids, dietary fibre, vitamins A, D, E, C, $B_{12}$, folic acid, Ca, Fe, iodine, Zn, Mg and energy were calculated. Dietary iodine intake was assessed taking into account iodized salt consumption.

From supplements, intakes of vitamins A, D, E, C, $B_{12}$, folic acid, Ca, Fe, iodine and Zn were calculated using the mean intake of the first, second and third months to obtain the intake of the first trimester of pregnancy. In the case of folic acid, its intake was calculated in folate equivalents (1 μg dietary folate = 0·6 μg of folic acid from supplements). Supplementary iodine intake in our cohort was mainly from multivitamins, so we decided to consider 'iodine users' those women who took at least 100 μg of iodine from multivitamins. Then, we added the nutrient intake from supplements to that previously obtained from diet alone, to obtain the intake 'from food and supplements'.

Lack of compliance with food-based dietary guidelines was assessed by calculating the proportion of women not reaching the minimum recommended daily number of servings of each food group according to the Spanish recommendations – those specific for pregnancy[30]. The cut-off values for the food groups assessed were the lowest values of the following ranges: farinaceous foods (cereals and legumes), 4–5 servings/d; vegetables, 2–4 servings/d; fruits, 2–3 servings/d; dairy, 3–4 servings/d; protein-rich foods (meat, poultry, fish, eggs, nuts), 2 servings/d; drinks (water, herbal teas, low-sugar, non-alcoholic drinks), 4–8 glasses/d. Inadequate intake of macronutrients was calculated by taking as cut-off points the Acceptable Macronutrient Distribution Range[31] and that of micronutrients using the Estimated Average Requirement[32–36]. We then estimated the percentage of the population whose intake was below the recommended values for micronutrients or outside the range established for macronutrients. These values correspond to the Dietary Reference Intakes established by the Institute of Medicine for the US population and assessment methods used in the present study were made following recommendations for evaluation of dietary adequacy in population groups[22,37].

### *Statistical analysis*

Descriptive statistics of maternal characteristics and dietary variables are shown by means of percentages, means and standard deviations and percentiles. Differences in the intake of food groups according to sociodemographic characteristics were contrasted using the non-parametric Kruskal–Wallis test. Since the distribution of some macronutrients was right skewed, they were transformed by the natural logarithm in order to approximate normality. Subsequently, their intake according to sociodemographic characteristics was compared using ANOVA. When significant differences were found, Tukey's *post hoc* test was performed in order to detect paired differences between groups. Homogeneity of variances was assessed with Levene's test. Heteroscedasticity ($P < 0{\cdot}05$ in Levene's test) was treated using the robust Welch statistic and Dunnett's D3 *post hoc* test. We verified the robustness of ANOVA to small deviations from normality: additional analysis with the Kruskal–Wallis test led to equivalent conclusions. Differences in intake inadequacy of food groups, macro- and micronutrients according to maternal characteristics were assessed using the $\chi^2$ test. Statistical differences were determined by a level of significance $P < 0{\cdot}05$ in all tests. Statistical analysis was carried out using the statistical software package SPSS version 15·0.

## Results

The mean age of our study population was 29·8 years, with 53 % of the sample being ≥30 years of age (Table 1).

**Table 1** Sociodemographic and lifestyle characteristics among pregnant women of the INMA-Valencia cohort (*n* 822), 2004–2005

| Characteristic | *n* | % |
|---|---|---|
| Age (years) | | |
| <25 | 99 | 12·0 |
| 25–29 | 290 | 35·3 |
| ≥30 | 433 | 52·7 |
| Educational level | | |
| Primary school | 286 | 34·8 |
| Secondary school | 348 | 42·3 |
| University studies | 188 | 22·9 |
| Country of origin | | |
| Spain | 723 | 88·0 |
| Latin America | 64 | 7·8 |
| Others | 35 | 4·3 |
| Socio-economic status | | |
| I+II (highest) | 127 | 15·5 |
| III | 194 | 23·6 |
| IV+V (lowest) | 501 | 60·9 |
| Number of previous pregnancies | | |
| 0 | 374 | 45·5 |
| ≥1 | 448 | 54·5 |
| Smoking* | 194 | 24·8 |
| Alcohol consumption* | 251 | 30·5 |
| Drugs use* | 10 | 1·3 |
| Pre-pregnancy BMI (kg/m$^2$) | | |
| <18·5 | 41 | 5·0 |
| 18·5–25·0 | 549 | 67·0 |
| >25·0 | 230 | 28·0 |
| Self-reported vomiting* | | |
| No | 474 | 42·3 |
| Yes | 348 | 57·7 |
| Planned pregnancy | | |
| No | 198 | 24·4 |
| Yes | 615 | 75·6 |
| Multivitamin supplements use | 459 | 55·8 |
| Folic acid supplements use* | 785 | 95·5 |
| Fe supplements use* | 88 | 10·7 |
| Iodine from supplements*,† | 407 | 49·6 |
| Iodized salt consumption* | 502 | 61·1 |

*During first trimester.
†From multivitamins (at least 100 μg).

Concerning educational level, 65 % of women completed at least secondary studies. Eighty-eight per cent of the women were born in Spain. About 95 % and 11 % of the mothers took folic acid and Fe supplements, respectively. At least 50 % of women consumed iodine through multivitamin supplements or ioidized salt in early pregnancy (Table 1).

### *Food groups*

For the whole population, median intakes (in servings/d) were within the range of recommendations for all food groups except for cereals and legumes, which was below the minimum recommended (Table 2). Older women consumed a greater amount of vegetables ($P < 0{\cdot}001$); more educated women had a lower intake from the meat group ($P = 0{\cdot}016$); and women of foreign origin had a higher intake of fruits compared with Spanish women ($P = 0{\cdot}001$).

When frequency of compliance with recommendations was assessed (Table 3), overall, lack of compliance was very high for cereals (77 %), followed by dairy (52 %) and fruit and vegetables (about 47 %). Equal proportions of

**Table 2** Intake of food groups (servings/d) during the first trimester of pregnancy according to age, educational level and country of origin among women of the INMA-Valencia cohort (*n* 822), 2004–2005

| | | | | Age (years) | | | | | | | Education | | | | | | | Country origin | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | All women | | <25 | | 25–29 | | ≥30 | | | Primary | | Secondary | | University | | | Spain | | Latin America | | Others | | |
| Food group | Recommended (servings/d) | Median | IQR | Median | IQR | Median | IQR | Median | IQR | *P* | Median | IQR | Median | IQR | Median | IQR | *P* | Median | IQR | Median | IQR | Median | IQR | *P* |
| Cereals and legumes | 4–5 | 3·1 | 1·9 | 3·2 | 2·2 | 3·1 | 1·8 | 3·0 | 1·9 | 0·600 | 3·2 | 1·9 | 3·1 | 1·8 | 2·9 | 2·1 | 0·255 | 3·1 | 1·8 | 2·4 | 2·1 | 3·5 | 3·1 | 0·095 |
| Vegetables | 2–4 | 2·1 | 1·5 | 1·6 | 1·6 | 2·1 | 1·6 | 2·3 | 1·5 | <0·001 | 2·0 | 1·6 | 2·2 | 1·6 | 2·2 | 1·3 | 0·437 | 2·1 | 1·6 | 2·2 | 1·3 | 2·4 | 1·8 | 0·378 |
| Fruits | 2–3 | 2·0 | 1·8 | 2·0 | 1·9 | 2·0 | 1·8 | 2·1 | 1·9 | 0·306 | 2·1 | 2·1 | 2·1 | 1·8 | 2·0 | 1·5 | 0·857 | 2·0 | 1·8 | 2·6 | 2·2 | 2·7 | 2·3 | 0·001 |
| Milk and dairy | 3–4 | 2·9 | 2·0 | 2·8 | 2·1 | 2·9 | 2·0 | 3·0 | 2·0 | 0·897 | 3·1 | 2·1 | 2·9 | 1·9 | 2·7 | 2·2 | 0·187 | 2·9 | 2·0 | 3·2 | 2·3 | 3·1 | 2·0 | 0·618 |
| Meat, poultry, fish and eggs | 2 | 2·3 | 0·9 | 2·4 | 0·8 | 2·3 | 0·9 | 2·3 | 0·9 | 0·789 | 2·4 | 0·9 | 2·3 | 0·8 | 2·2 | 0·9 | 0·016 | 2·3 | 0·9 | 2·2 | 0·8 | 2·4 | 0·9 | 0·119 |
| Non-alcoholic low-sugar drinks | 4–8 | 6·5 | 2·3 | 6·5 | 2·1 | 6·6 | 2·6 | 6·5 | 2·3 | 0·712 | 6·5 | 2·1 | 6·5 | 2·4 | 6·5 | 2·6 | 0·813 | 6·5 | 2·4 | 6·5 | 2·4 | 6·6 | 2·5 | 0·179 |

IQR, interquartile range (25th–75th percentile).
*P* values obtained using the Kruskal–Wallis test.

**Table 3** Percentage not meeting recommendations* for food intake during the first trimester of pregnancy according to age, educational level and country of origin among women of the INMA-Valencia cohort (*n* 822), 2004–2006

| | | | Age (years) | | | | Education | | | | Country of origin | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | All women | <25 | 25–29 | ≥30 | | Primary | Secondary | University | | Spain | Latin America | Others | |
| Food group | Recommended (servings/d) | % | % | % | % | *P* | % | % | % | *P* | % | % | % | *P* |
| Cereals and legumes | 4–5 | 76·6 | 69·7 | 77·9 | 77·4 | 0·216 | 75·9 | 77·9 | 75·5 | 0·771 | 77·6 | 76·6 | 57·1 | 0·020 |
| Vegetables | 2–4 | 46·2 | 62·6 | 48·3 | 41·1 | 0·000 | 49·0 | 44·5 | 45·2 | 0·514 | 47·6 | 35·9 | 37·1 | 0·110 |
| Fruits | 2–3 | 47·9 | 50·5 | 50·3 | 45·7 | 0·410 | 47·9 | 46·6 | 50·5 | 0·679 | 49·8 | 34·4 | 34·3 | 0·016 |
| Milk and dairy | 3–4 | 52·3 | 56·6 | 53·8 | 50·3 | 0·440 | 49·0 | 53·4 | 55·3 | 0·340 | 53·1 | 45·3 | 48·6 | 0·441 |
| Meat, poultry, fish and eggs | 2 | 30·2 | 25·3 | 29·0 | 32·1 | 0·349 | 29·0 | 26·1 | 39·4 | 0·006 | 29·7 | 39·1 | 22·9 | 0·187 |
| Non-alcoholic low-sugar drinks | 4–8 | 11·6 | 7·1 | 13·1 | 11·5 | 0·269 | 13·3 | 8·9 | 13·8 | 0·124 | 11·2 | 17·2 | 8·6 | 0·304 |

*P* values obtained using the $\chi^2$ test.
*Food-based dietary guidelines of the Spanish Society of Community Nutrition.

Spanish and Latin-American women did not meet guidelines for cereals intake (about 77 %); regarding vegetable consumption, significant differences were found by age only, with the highest percentage of women not meeting dietary guidelines being observed among those under 25 years ($P<0·001$); approximately 50 % of Spanish women had a fruit intake below the minimum recommended and inadequacy was lower (about 34 %) for foreign-born women ($P=0·016$; Table 3).

### *Macronutrients*

The distribution of macronutrient intakes for the whole sample is presented in Appendix 1.

Regarding differences in mean intakes by selected maternal characteristics (Table 4), it was found that the intakes of protein and *n*-3 fatty acids increased, whereas intake of *trans*-fatty acids decreased, with older age ($P<0·001$). Women with the lowest educational level had the lowest intakes of protein ($P=0·002$) and *n*-3 fatty acids ($P=0·012$) and the highest intake of *trans*-fatty acids ($P=0·003$) but also the highest consumption of fibre ($P=0·048$). Women of Spanish origin had the highest intakes of protein ($P<0·001$), total fat ($P<0·001$), SFA ($P=0·008$), MUFA ($P<0·001$) and *n*-3 fatty acids ($P<0·001$); Latin-American women had higher intake of carbohydrates ($P<0·001$) and women from other origins, higher intake of *trans*-fatty acids ($P=0·050$; Table 4).

When the adequacy with respect to the Institute of Medicine's recommendations was assessed (Table 5), it was found that about 57 % of women had an intake of carbohydrates under the recommended range. Virtually all women had protein intake which fell within recommendations. Total fat intake was too high (almost 71 % of women exceeded the recommendation). More than 50 % of women had deficient intakes of *n*-3 and *n*-6 fatty acids (Table 5). Spanish women had the highest percentage of inadequacy for carbohydrates (61 % had low intakes, $P<0·001$) and total fat (74 % exceeded the recommended consumption, $P<0·001$). Latin-American women showed the highest percentages of inadequacy for *n*-3 fatty acids (almost 77 % of them were below the recommendation, $P<0·001$). Additionally, younger ($P<0·001$) and less educated women ($P=0·048$) showed the highest percentages of inadequacy for *n*-3 fatty acids because of low intake (Table 5).

### *Micronutrients*

The distribution of micronutrient intakes (from food only and total intake – food plus supplements) for the whole sample is presented in Appendix 2. It is worthy to highlight a very high – sevenfold – increase in folate intake after including intake from supplements: 298 μg/d from food only *v.* 2112 μg/d from food plus supplements.

Regarding inadequacy, data obtained from food intake only, showed that the greatest percentages of inadequacy for the whole study population were observed – in

**Table 4** Intake of macronutrients (g/d) during the first trimester of pregnancy according to age, educational level and country of origin among women of the INMA-Valencia cohort (*n* 822), 2004–2005

| | All women | | Age (years) | | | | | | | | | Education | | | | | | | Country of origin | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | <25 | | 25–29 | | ≥30 | | | Primary | | Secondary | | University | | | Spain | | Latin America | | Others | | |
| Macronutrient | Mean | SD | Mean | SD | Mean | SD | Mean | SD | *P* | Mean | SD | Mean | SD | Mean | SD | *P* | Mean | SD | Mean | SD | Mean | SD | *P* |
| Protein | 100·5 | 14·5 | 95·4[a] | 12·3 | 98·9[a] | 14·4 | 102·6[b] | 14·6 | <0·001 | 98·0[a] | 14·4 | 101·7[b] | 14·8 | 101·8[b] | 13·6 | 0·002 | 101·2[a] | 14·4 | 93·5[b] | 14·4 | 98·1[a,b] | 13·9 | <0·001 |
| Carbohydrates* | 249·5 | 1·2 | 256·0 | 1·2 | 250·6 | 1·2 | 247·3 | 1·2 | 0·079 | 250·4 | 1·2 | 249·3 | 1·2 | 248·5 | 1·2 | 0·846 | 246·4[a] | 1·1 | 274·5[b] | 1·2 | 270·7[b] | 1·2 | <0·001 |
| Total fat | 96·1 | 14 | 95·3 | 15·2 | 96·1 | 13·6 | 96·2 | 14·1 | 0·843 | 96·6 | 14·6 | 95·6 | 13·7 | 96·3 | 13·8 | 0·634 | 97·1[a] | 13·4 | 88·5[b] | 16 | 88·2[b] | 16·3 | <0·001 |
| SFA | 29·9 | 5·9 | 29·9 | 6·1 | 30·3 | 5·8 | 29·8 | 5·9 | 0·53 | 30·1 | 5·4 | 29·8 | 6·3 | 30·1 | 5·8 | 0·789 | 30·3[a]‡ | 5·7 | 27·8[b]‡ | 6·6 | 28·2[a,b]‡ | 7·4 | 0·008† |
| *Trans*-fatty acids* | 1·49 | 1·5 | 1·80[a] | 1·5 | 1·60[b] | 1·5 | 1·36[c] | 1·5 | <0·001 | 1·59[a]‡ | 1·5 | 1·46[b]‡ | 1·6 | 1·40[b]‡ | 1·5 | 0·003† | 1·47[a] | 1·5 | 1·52[a,b] | 1·5 | 1·76[b] | 1·5 | 0·050 |
| MUFA | 44·8 | 8·8 | 43·8 | 8·9 | 44·7 | 8·8 | 45·2 | 8·8 | 0·338 | 45 | 9·2 | 44·6 | 8·6 | 44·9 | 8·8 | 0·852 | 45·6[a] | 8·5 | 39·5[b] | 8·9 | 39·1[b] | 9·3 | <0·001 |
| PUFA* | 13·9 | 1·3 | 14·1 | 1·3 | 13·9 | 1·2 | 13·9 | 1·3 | 0·903† | 14·0 | 1·3 | 13·8 | 1·2 | 13·9 | 1·3 | 0·731 | 13·9 | 1·3 | 13·8 | 1·4 | 13·8 | 1·3 | 0·941† |
| *n*-3 fatty acids* | 1·51 | 1·3 | 1·36[a] | 1·2 | 1·49[b] | 1·3 | 1·56[c] | 1·2 | <0·001 | 1·47[a] | 1·2 | 1·55[b] | 1·3 | 1·52[a,b] | 1·2 | 0·012 | 1·54[a] | 1·2 | 1·31[b] | 1·2 | 1·39[b] | 1·2 | <0·001 |
| *n*-6 fatty acids* | 12·2 | 1·3 | 12·5 | 1·3 | 12·2 | 1·3 | 12·1 | 1·3 | 0·601† | 12·3 | 1·3 | 12·0 | 1·3 | 12·2 | 1·3 | 0·508 | 12·2 | 1·3 | 12·3 | 1·4 | 12·2 | 1·3 | 0·972† |
| Dietary fibre* | 22·3 | 1·4 | 23·1 | 1·4 | 21·8 | 1·5 | 22·5 | 1·4 | 0·293 | 23·2[a] | 1·4 | 22·1[a,b] | 1·4 | 21·4[b] | 1·4 | 0·048 | 22·2 | 1·4 | 21·9 | 1·4 | 24·8 | 1·6 | 0·181 |

*P* values obtained using ANOVA, unless otherwise stated.
[a,b,c]Mean values within a row with unlike superscript letters were significantly different using Tukey's *post hoc* test or ‡Dunnett's T3 *post hoc* test ($P<0·05$).
*Variables were transformed by the natural logarithm before analysis. Geometric means and geometric standard deviations are presented.
†*P* value obtained using Welch's test.

**Table 5** Intake inadequacy* of selected macronutrients during the first trimester of pregnancy according to age, educational level and country of origin among women of the INMA-Valencia cohort (*n* 822), 2004–2005

| | | | Age (years) | | | | Education | | | | Country of origin | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Type of | All women | <25 | 25–29 | ≥30 | | Primary | Secondary | University | | Spain | Latin America | Others | |
| Macronutrient | inadequacy | % | % | % | % | *P* | % | % | % | *P* | % | % | % | *P* |
| Protein | Deficit | 0·2 | 1·0 | 0·3 | 0·0 | 0·167 | 0·3 | 0·3 | 0·0 | 0·734 | 0·0 | 3·1 | 0·0 | <0·001 |
| | Excess | 0·0 | 0·0 | 0·0 | 0·0 | | 0·0 | 0·0 | 0·0 | | 0·0 | 0·0 | 0·0 | |
| Carbohydrates | Deficit | 57·4 | 51·5 | 58·3 | 58·2 | 0·291 | 57·7 | 56·0 | 59·6 | 0·350 | 61·1 | 29·7 | 31·4 | <0·001 |
| | Excess | 0·2 | 1·0 | 0·3 | 0·0 | | 0·7 | 0·0 | 0·0 | | 0·0 | 1·6 | 2·9 | |
| Total fat | Deficit | 0·2 | 0·0 | 0·3 | 0·2 | 0·799 | 0·3 | 0·0 | 0·5 | 0·732 | 0·1 | 0·0 | 2·9 | <0·001 |
| | Excess | 70·8 | 68·7 | 73·1 | 69·7 | | 71·7 | 69·8 | 71·3 | | 74·0 | 42·2 | 57·1 | |
| *n*-3 fatty acids | Deficit | 54·1 | 72·7 | 56·2 | 48·5 | <0·001 | 59·1 | 49·4 | 55·3 | 0·048 | 51·5 | 76·6 | 68·6 | <0·001 |
| | Excess | 0·4 | 0·0 | 0·7 | 0·2 | | 0·0 | 0·9 | 0·0 | | 0·4 | 0·0 | 0·0 | |
| *n*-6 fatty acids | Deficit | 62·9 | 55·6 | 62·1 | 65·1 | 0·288 | 58·4 | 66·4 | 63·3 | 0·284 | 63·2 | 60·9 | 60·0 | 0·621 |
| | Excess | 2·1 | 2·0 | 1·4 | 2·5 | | 2·4 | 1·4 | 2·7 | | 1·8 | 4·7 | 2·9 | |

*P* values obtained using the $\chi^2$ test.
*Values of intake inadequacy are expressed as the percentage of women whose intake is below (deficit) or above (excess) the Acceptable Macronutrient Distribution Range established for each macronutrient by the US Institute of Medicine.

**Table 6** Intake inadequacy* for selected micronutrients from food and food plus supplements during the first trimester of pregnancy according to age, educational level and country of origin among women of the INMA-Valencia cohort (*n* 822), 2004–2005

| | | Age (years) | | | | Education | | | | Country of origin | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | All women | <25 | 25–29 | ≥30 | | Primary | Secondary | University | | Spain | Latin America | Others | |
| Nutrient | % | % | % | % | *P* | % | % | % | *P* | % | % | % | *P* |
| From food | | | | | | | | | | | | | |
| Vitamin A (μg/d) | 4·6 | 12·1 | 5·5 | 2·3 | <0·001 | 8·0 | 3·2 | 2·1 | 0·003 | 4·8 | 1·6 | 5·7 | 0·465 |
| Vitamin C (mg/d) | 14·4 | 22·2 | 15·5 | 11·8 | 0·022 | 16·1 | 14·9 | 10·6 | 0·234 | 14·8 | 9·4 | 14·3 | 0·495 |
| Vitamin D (μg/d) | 99·8 | 100·0 | 99·8 | 99·7 | 0·832 | 100·0 | 99·7 | 99·5 | 0·504 | 99·7 | 100·0 | 100·0 | 0·872 |
| Vitamin E (mg/d) | 67·8 | 77·8 | 69·0 | 64·7 | 0·036 | 71·0 | 67·5 | 63·3 | 0·215 | 67·8 | 65·6 | 71·4 | 0·840 |
| Folate (μg/d) | 99·6 | 99·0 | 99·3 | 100·0 | 0·169 | 99·7 | 99·4 | 100·0 | 0·574 | 99·6 | 100·0 | 100·0 | 0·814 |
| Fe (mg/d) | 67·9 | 71·7 | 72·4 | 64·0 | 0·040 | 77·6 | 65·2 | 58·0 | <0·001 | 68·2 | 71·9 | 54·3 | 0·177 |
| Iodine (μg/d) | 24·3 | 31·3 | 24·8 | 22·4 | 0·171 | 28·3 | 22·1 | 22·3 | 0·150 | 24·1 | 21·9 | 34·3 | 0·346 |
| Ca (mg/d) | 5·5 | 11·1 | 4·8 | 4·6 | 0·031 | 6·3 | 6·0 | 3·2 | 0·290 | 5·1 | 6·2 | 11·4 | 0·266 |
| From food & supplements | | | | | | | | | | | | | |
| Vitamin A (μg/d) | 3·0 | 8·1 | 3·4 | 1·6 | 0·003 | 5·2 | 1·7 | 2·1 | 0·026 | 3·0 | 1·6 | 5·7 | 0·516 |
| Vitamin C (mg/d) | 8·9 | 15·2 | 9·7 | 6·9 | 0·029 | 10·5 | 8·6 | 6·9 | 0·398 | 9·0 | 6·3 | 11·4 | 0·657 |
| Vitamin D (μg/d) | 88·1 | 91·9 | 87·9 | 87·3 | 0·439 | 88·1 | 89·1 | 86·2 | 0·611 | 87·7 | 85·9 | 100·0 | 0·077 |
| Folate (μg/d) | 40·8 | 51·5 | 42·8 | 37·0 | 0·020 | 42·7 | 42·0 | 35·6 | 0·263 | 39·7 | 43·8 | 57·1 | 0·107 |
| Fe (mg/d) | 13·4 | 29·3 | 15·5 | 8·3 | <0·001 | 16·4 | 14·9 | 5·9 | 0·002 | 11·6 | 26·6 | 25·7 | <0·001 |
| Iodine (μg/d) | 50·9 | 57·6 | 54·3 | 47·1 | 0·061 | 59·8 | 49·3 | 40·4 | <0·001 | 51·3 | 52·4 | 40·0 | 0·413 |
| Ca (mg/d) | 14·2 | 21·2 | 14·1 | 12·7 | 0·091 | 15·7 | 13·8 | 12·8 | 0·633 | 13·6 | 18·8 | 20·0 | 0·317 |
| Vitamin A (μg/d) | 4·1 | 7·1 | 3·8 | 3·7 | 0·294 | 4·2 | 4·9 | 2·7 | 0·466 | 3·7 | 4·7 | 11·4 | 0·081 |

*P* values obtained using the $\chi^2$ test.
*Values of intake inadequacy are expressed as the percentage of women whose intake is below (deficit) or above (excess) the Dietary Reference Intake established for each micronutrient by the US Institute of Medicine.

descending order – for vitamin D, folate, Fe and vitamin E (Table 6). Virtually none of the women of our study reached the recommended intake for folate or vitamin D (under deficient sun exposure) and nearly 68 % of them did not comply with recommendations for Fe or vitamin E either. Intake inadequacy was significantly higher in younger women for vitamins A, C, E and Fe and Ca ($P<0·001$, $P=0·022$, $P=0·036$, $P=0·040$ and $P=0·031$, respectively). With regard to educational level, the overall pattern was a decrease in inadequacy as level of studies increased. Nevertheless, this relationship was significant for vitamin A ($P=0·003$) and Fe ($P<0·001$) only (Table 6). Although Latin-American women had a lowest proportion of inadequacy for all nutrients except for Fe and folate, the differences found according to women's country of origin were not statistically significant.

When the addition of supplements to dietary consumption was assessed (Table 6), an important reduction in inappropriate intake was observed for all the nutrients examined, especially for folate. None the less, inadequacy remained high for vitamin E, Fe and vitamin D (40·8 %, 50·9 % and 88·1 %, respectively). Differences regarding maternal characteristics followed a similar pattern to that found for intake from food only, except that according to women's country of origin, foreign-born women showed higher inadequacy for folic acid than Spain-born women (about 26 % *v.* 12 %; $P<0·001$). Regarding vitamin D and Ca intakes, there was a trend showing that inadequacy did not change in non-Latin-American foreign women after intake from supplements was considered.

## Discussion

Pregnant women in our study did not reach the recommendations established for this life stage for some food groups, macro- and micronutrients. A very high percentage of women were found to have an intake of cereals and legumes, and to a lesser extent, of fruit and vegetables, below the recommendations. Composition of the diet regarding macronutrients was not adequate, according to recommendations. More than 50 % of women had insufficient intakes of carbohydrates, *n*-3 and *n*-6 fatty acids and about 70 % exceeded the recommendations for total fat. The greatest deficiencies in micronutrient intakes were found for vitamin D, folate and Fe. Supplementation reduced the frequency of intake inadequacy, but not in a substantial way for vitamin D, Fe and vitamin E. It was also found that dietary intake varied significantly according to sociodemographic characteristics such as age, education and country of origin.

### *Intakes by food group*

Ferrer *et al.* performed a cross-sectional study in pregnant women in a Spanish Mediterranean island[20], finding intakes of cereals, legumes and vegetables below the recommendations, which coincides with our results. Nevertheless, the consumption of fruit and vegetables found in our study is more adequate than that seen in non-Mediterranean settings[15].

Taking into account sociodemographic characteristics, we found that older women consumed a greater amount of vegetables. Studies in other industrialized settings[15,38,39] have found the same association. Nevertheless, no differences according to educational level were found for fruit and vegetable intakes in our study. This evidence differs from studies in non-Mediterranean settings in which higher education was related to higher vegetable intake[15,38,40]. In agreement with our findings, Ferrer *et al.* did not find significant differences in fruit or vegetable intake by educational level[20]. Furthermore, there is evidence that in Southern European countries, fruit and vegetable consumption is common due to cultural and economic reasons and not determined by occupation or education[40–42].

Country of origin was found to be related to fruit intake. In Spain only one study, to our knowledge, has included foreign-born pregnant women when examining dietary intake and found no differences in food consumption[20]. One study in the USA comparing the diet of Mexican immigrants with that of Mexican-Americans found that Mexico-born women consumed significantly more fruits, grains and dairy products than US-born women[43], partially coinciding with our results.

### *Macronutrient intakes*

Other studies set in Spain and in Portugal also revealed a diet with an excessive content of total fat and a poor intake of carbohydrates[17,44,45]. None of these studies assessed macronutrient intake by sociodemographic characteristics. Seventy-four per cent of Spanish women in the present study had an excessive total fat intake; it is important to note, however, that it came mainly from MUFA. Nevertheless, SFA intake was also high. Latin-American, younger and less educated women were found to have the highest percentages of inadequacy for *n*-3 fatty acids because of low intake. Regarding carbohydrates, Spanish women showed the highest percentage of inadequacy because of low intake. Evidence suggests that the quality of lipids and carbohydrates during pregnancy is important. Excessive consumption of saturated fat and low *n*-3 fatty acid intake, as well as high intakes of sugar and lower intakes of starchy food, have been related to adverse maternal and infant health outcomes[46–49]. Thus, pregnant women in the studied area should be advised to reduce their fat intake, especially from saturated fats (reducing the consumption of foods such as red and processed meats), and increase their consumption of *n*-3 fatty acids (raise their consumption of fish other than red tuna or swordfish, and also that of walnuts and leafy vegetables) as well as their intake of starchy carbohydrates from sources such as cereals and legumes.

### *Micronutrient intakes*

The mean vitamin D intake from food found in the present study was lower than that reported in other studies including Nordic or Mediterranean pregnant women[15,17,19,21]. In our population, virtually all women had inadequate intakes of vitamin D according to the Institute of Medicine reference values. When taking into account total intake (food plus supplements), the percentage of inadequacy observed was still elevated, and higher than that reported in studies among Nordic pregnant women[15,21]. None the less, it is important to consider that the Estimated Average Requirement established for vitamin D is based on an assumption of minimal or no sun exposure. In the Valencia region, sun exposure might be relatively high all year round, so it is likely that the inadequacy is lower than that estimated in the present study. Yet, women should be encouraged to consume foods rich in vitamin D such as dairy products, enriched breakfast cereals and types of fish recommended for pregnancy. Dietary deficiencies of other important nutrients such as folate, Fe and vitamin E, as found in the present study, are not uncommon in industrialized countries[12,16,17,36,41,50]. The fact that a high percentage of women consumed low amounts of folate sources such as cereals, vegetables and fruit partly explains our results. Supplementation greatly reduced deficient intakes for folic acid; however, it increased mean intake in a disproportionate way, which might lead to an important proportion of women taking daily doses exceeding the safety limits as shown in a previous study within this cohort[51]. Considering sociodemographic characteristics, younger, less educated and foreign-born women showed the greatest percentage of inadequacy for folate after intake from supplements was considered. As fruit and vegetables are widely available in Mediterranean settings and not related to socio-economic status, strategies at the population level should be established to promote a higher consumption. Besides, the appropriateness in the use of folic acid supplements in the periconceptional period and during pregnancy as well as the causes of differences found by maternal characteristics should be assessed as part of public health policies.

The small reduction in inadequacy for Fe found after considering supplements consumption is likely to be due to the current recommendations in Spain of starting supplementation in the second half of pregnancy[50]. Nevertheless, it is important to consider that, even in developed countries, some women might start pregnancy with deficient Fe status[52], which is a strong predictor of maternal and infant adverse outcomes[53,54].

Other studies in Mediterranean areas have found mean intakes and/or percentages of inadequacy for vitamin E from food similar to those shown here[17–19], which makes evident the need to promote a higher consumption of vitamin-E-rich foods other than olive oil, of which intake is already high. Such foods include nuts and seeds. Vitamin E might protect against maternal and childhood illnesses such as pre-eclampsia or asthma[8,55].

Iodine intake from different sources (foods, iodized salt and supplements) has already been described in our pregnant population[56], as has its effect on maternal thyroid function[57] and infant neurodevelopment[58]. In summary, inadequate intake of iodine was very low in women who consumed either iodized salt or iodine supplements; however, a high iodine intake from supplements was associated with both maternal thyroid dysfunction and decreased psychomotor scores in infants at the age of 1 year. These findings suggest the need to further evaluate the safety and effectiveness of iodine supplementation during pregnancy in iodine-sufficient or mildly deficient populations.

The differences in dietary intake and adequacy found according to the maternal characteristics studied reveal the influence of socio-economic and cultural factors. There is evidence that populations are less likely to meet dietary guidelines if food plans are not socially or culturally accepted[59]. Consumption at population level depends also on food supply and availability[60]. Therefore, public policies aiming to reduce food-related diseases should take into account these issues.

The present study has some limitations such as the moderate participation rate, which could make the generalization of our results difficult; however, when sociodemographic characteristics of participants and non-participants were assessed, no significant differences were found, except for the fact that participants were slightly older and more likely to work at the time of enrolment. As older age was related to better adequacy with respect to recommendations, one could expect that in the general population the inadequacy will, if anything, be slightly higher than that found here. Regarding the validity of dietary intake estimates, the validity and reproducibility of a similar version of the FFQ were satisfactory when comparing the FFQ with four 1-week dietary records in an adult population of the same region.

## Conclusions and implications for public health

An important percentage of women in the studied area did not meet the guidelines for certain food groups and were also found to have inadequate intakes of several nutrients which are relevant during pregnancy. Age, education and country of origin seem to be variables strongly related to dietary intake and adequacy.

A nutrient-rich and balanced diet is necessary and must be promoted in women of childbearing age before pregnancy, to avoid the risk of deficient intake until women know they are pregnant or their first antenatal visit takes place. In the light of the situation observed in the present study, policies to improve supplementation schemes based on the nutritional status of pregnant women are needed in order to reduce the likelihood of both deficient and excessive intakes and the resulting potential risks for health. Monitoring the nutritional status of pregnant women is important and a good start point. However, based on these findings, and acknowledging that people's food consumption is conditioned to a certain extent by factors different from individual choices, it would be also necessary to implement intervention programmes that take into account social and cultural contexts and guarantee a healthier food environment.

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## Appendix 1

***Daily intake of selected macronutrients during the first trimester of pregnancy among women of the INMA-Valencia cohort (n 822), 2004–2005***

| | Mean | SD | P5 | P25 | P50 | P75 | P95 |
|---|---|---|---|---|---|---|---|
| Energy (kJ) | 9680·5 | 88·3 | 6118·3 | 7941·6 | 9296·8 | 11 024·4 | 14 538·1 |
| Energy (kcal) | 2313·7 | 21·1 | 1462·3 | 1898·1 | 2222·0 | 2634·9 | 3474·7 |
| Protein (g) | 102·5 | 25·6 | 62·7 | 84·9 | 100·3 | 119·5 | 149·1 |
| Carbohydrates (g) | 261·8 | 83·7 | 143·9 | 206·1 | 249·3 | 305·7 | 423·9 |
| Total fat (g) | 99·2 | 30·1 | 59·8 | 78·4 | 95·6 | 114·9 | 156·4 |
| SFA (g) | 31·1 | 10·9 | 16·9 | 23·8 | 29·6 | 36·7 | 50·6 |
| *Trans*-fatty acids (g) | 1·7 | 0·9 | 0·6 | 1·0 | 1·4 | 2·1 | 3·5 |
| MUFA (g) | 46·1 | 14·3 | 26·2 | 35·5 | 44·9 | 53·7 | 71·0 |
| PUFA (g) | 14·9 | 6·3 | 8·3 | 11·1 | 13·3 | 17·1 | 27·3 |
| *n*-3 fatty acids (g) | 1·6 | 0·5 | 0·9 | 1·2 | 1·5 | 1·8 | 2·6 |
| *n*-6 fatty acids (g) | 13·2 | 5·9 | 7·1 | 9·5 | 11·6 | 15·1 | 24·8 |
| Dietary fibre (g) | 23·7 | 8·1 | 11·9 | 18·0 | 22·8 | 28·6 | 39·0 |

P, percentile.

## Appendix 2

***Daily intake of selected micronutrients during the first trimester of pregnancy among women from the INMA-Valencia cohort (n 822), 2004–2005***

| | Nutrient intakes | | | | | | | Reference values | |
|---|---|---|---|---|---|---|---|---|---|
| | Mean | SD | P5 | P25 | P50 | P75 | P95 | EAR | UL |
| From food | | | | | | | | | |
| Vitamin A (μg/d)* | 1395·6 | 821·8 | 557·3 | 864·6 | 1217·1 | 1656·3 | 2813·4 | 550 | 3000‖ |
| Vitamin D (μg/d) | 3·0 | 1·7 | 1·0 | 1·8 | 2·6 | 3·8 | 6·6 | 10 | 100 |
| Vitamin C (mg/d) | 140·9 | 76·1 | 52·4 | 86·0 | 123·6 | 176·9 | 278·5 | 70 | 2000 |
| Vitamin E (mg/d)† | 11·1 | 3·0 | 7·2 | 9·1 | 10·8 | 12·6 | 16·3 | 12 | 1000¶ |
| Vitamin $B_{12}$ (μg/d) | 9·7 | 4·9 | 4·6 | 6·6 | 8·6 | 11·2 | 18·8 | 2·2 | ND |
| Folate (μg/d) | 298·1 | 75·3 | 192·6 | 240·3 | 289·3 | 346·7 | 440·7 | 520 | 1000¶ |
| Fe (mg/d) | 20·7 | 3·4 | 15·6 | 18·3 | 20·4 | 22·8 | 27·0 | 22 | 45 |
| Ca (mg/d) | 1275·9 | 342·3 | 788·4 | 1025·3 | 1253·1 | 1467·9 | 1891·2 | 800 | 2500 |
| Iodine (μg/d)‡ | 218·1 | 76·5 | 98·7 | 162·3 | 214·8 | 269·8 | 341·9 | 160 | 1100 |
| Zn (mg/d) | 27·2 | 4·8 | 19·8 | 23·9 | 26·6 | 30·0 | 35·9 | 9·5 | 40 |
| From food & supplements | | | | | | | | | |
| Vitamin A (μg/d) | 1474·8 | 825·4 | 623·9 | 963·3 | 1289·1 | 1730·4 | 2926·6 | 550 | 3000‖ |
| Vitamin D (μg/d) | 5·3 | 3·8 | 1·3 | 2·5 | 4·3 | 7·0 | 13·3 | 10 | 100 |
| Vitamin C (mg/d) | 158·9 | 79·7 | 59·9 | 100·9 | 143·2 | 198·3 | 298·9 | 70 | 2000 |
| Vitamin E (mg/d) | 14·0 | 5·0 | 7·9 | 10·4 | 12·9 | 16·7 | 23·1 | 12 | 1000¶ |
| Vitamin $B_{12}$ (μg/d) | 12·1 | 13·2 | 5·8 | 8·1 | 10·4 | 13·8 | 23·0 | 2·2 | ND |
| Folate (μg/d)§ | 2111·6 | 2995·4 | 406·0 | 644·5 | 880·1 | 1214·7 | 8775·1 | 520 | 1000¶ |
| Fe (mg/d) | 26·8 | 18·3 | 16·3 | 19·2 | 21·9 | 26·1 | 60·7 | 22 | 45 |
| Ca (mg/d) | 1309·2 | 345·0 | 823·3 | 1057·4 | 1285·6 | 1512·3 | 1912·9 | 800 | 2500 |
| Iodine (μg/d) | 262·9 | 96·9 | 116·2 | 192·5 | 258·2 | 322·7 | 435·0 | 160 | 1100 |
| Zn (mg/d) | 28·1 | 5·1 | 20·2 | 24·6 | 27·6 | 31·1 | 37·9 | 9·5 | 40 |

P, percentile; EAR, Estimated Average Requirement; UL, Upper Limit; ND, not determined.
*Calculated as retinol activity equivalents.
†Calculated as α-tocopherol equivalents.
‡Calculated taking into account iodized salt consumption.
§Calculated as folate equivalents.
‖As preformed vitamin A only.
¶Applies to synthetic forms only.