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**Performance of a short dietary questionnaire to assess nutrient intake using regression-based weights**

Short title: Evaluation of a short dietary questionnaire

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**Keywords:** nutrient; dietary questionnaire; evaluation study; epidemiological method; prevention

## **Abstract:**

*Objectives:* To evaluate the performance of a short dietary questionnaire, using weights to estimate nutrient intake.

*Design:* Using dietary data collected in 1993-1995 from a large cohort of French women, stepwise regression was used to identify the food-groups that best predicted nutrient intakes, resulting in a short list of 23-foods. This list was used to design a 23-item dietary questionnaire. Nutrient intake was estimated from the answers to the 23 questions, applying weights to each response. Weights were calculated from the large database as regression coefficients of the nutrient intake against the 23 food-groups. In 2005-2006, 103 women responded (at a one-year interval) to both the short questionnaire and a previously validated dietary history questionnaire. Intakes of 20 nutrients and energy estimated from these two questionnaires were compared.

*Setting:* French adult female population.

*Subjects:* For developing the instrument, 73,034 women aged 41-72 years. For testing, 103 women aged 55-80 years in 2005.

*Results:* Mean nutrient intakes generally differed by less than 10% between the two methods. Correlation coefficients of nutrient intakes ranged from 0.23 for vitamin D to more than 0.65 for magnesium, vitamin B3 and alcohol. For most nutrients, at least 70% of subjects fell into the same or an adjacent quintile when classified by either of the two questionnaires.

*Conclusions:* In light of both its strengths and limitations, this short questionnaire could be used in French adult women to obtain some general nutritional information, notably for adjustment purposes when response to an extensive questionnaire cannot be obtained.

## Introduction

Currently, the leading causes of death in developed countries are chronic diseases such as cancer, cardiovascular disease and dementia. Diet appears to play a major role in their aetiology (1-3). Therefore, reliable assessment of nutritional intake is needed for epidemiological studies but also for screening of potentially inappropriate diet. Several tools are available, including 24 h recall and food frequency questionnaires, but they require time for completion and are often difficult to interpret. Other instruments are more simple, but were designed to assess intake only of specific nutrients (4-7).

We sought to estimate a wide range of nutritional intakes and thus developed an original dietary assessment method based on responses to a 23-item dietary questionnaire. We performed an evaluation study of this method in a sample of 103 French women. We report here its capacity to estimate 20 nutrient and energy intakes, taking as the reference a previously validated dietary history questionnaire.

## Methods

### *Development of the instrument*

#### Selection of food items that predict nutrient intake

In developing the short questionnaire, we concentrated our efforts on dietary intake assessment of five nutrients often known to be in deficit in the French female population: calcium, iron, magnesium, vitamin B6 and omega3 fatty acids (8).

To identify food items which best predicted intakes of these five nutrients, we analyzed dietary data collected in 1993-1995 from a cohort of French women from the National Education System, the E3N study (9). This ongoing prospective cohort was initiated in 1990. It represents the French part of the European Prospective Investigation into Cancer and Nutrition (EPIC) study (10). Available dietary data included average daily individual intakes

of 208 food and beverage items, as well as energy and various macro- and micronutrient intakes. For simplification, we first reduced the number of available food groups from 208 to 121 by summing up items of similar nutritional content and pertaining to the same dietary pattern. For example, white bread and white sandwich loaf were grouped into a single “white bread” item; fresh fish and canned fish were grouped into a single “fish” item.

We then implemented ascending stepwise regression analyses in the E3N population (n=73,034 ) to identify, among the 121 food groups, those that best predicted nutrient intakes of interest. For each of the five nutrients selected to develop the questionnaire, we retained the set of food-groups that enabled to model intake with an  $R^2$  of at least 75%, so as to maximize precision on the nutrients while minimizing the number of retained foods or food groups. This first step led to a short list of foods.

In a second step, another set of regression models was implemented (still among the 73,034 women) for a wider range of nutrients (20 in total + energy) than the 5 initially used to implement the short list. Each nutrient to be estimated was modeled as the dependent variable against the short list of foods as independent variables; the coefficient thus obtained were the weights to be subsequently used to estimate the nutrient intake from the short questionnaire.

#### Building up the short questionnaire

The short questionnaire was then built up by formulating specific questions for each retained food in the above-described short list. Responses were closed-ended with discrete modalities representing possible and meaningful amounts of consumption. It is noteworthy that since nutrient intake is calculated using the linear combination of mean food intake reported in the short questionnaire with their corresponding weight, the estimation no longer requests the use of a food composition table. .

#### *Evaluation study*

##### Subjects and study design

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In the evaluation study, 150 women who responded to the seventh questionnaire of the E3N cohort were randomly selected and in April 2005 were requested to complete an extensive two-part dietary history questionnaire. The first part contained questions on the quantity and frequency of consumption of food groups, while the second consisted of qualitative questions. A booklet of photographs accompanied the questionnaire in order to facilitate estimation of portion sizes. Both the questionnaire and the illustrated booklet had been validated previously (11;12), taking as reference the average of twelve 24 h dietary recalls obtained at monthly intervals over a 1-year period. Approximately one year later (May 2006), the short dietary questionnaire was sent to the 119 women who had satisfactorily completed the extensive dietary history questionnaire. Among them, 16 were excluded because of non-response to the short questionnaire. Finally, 103 women were included in the evaluation study. As compared to the 47 women excluded, these 103 women were younger (mean age=65.3 vs. 65.9 years), more educated (83.5% vs. 78.7% with at least 12 years of education) and leaner (mean body mass index =22.4kg/m<sup>2</sup> vs. 23.1), but none of these associations reached significance level. Reference values of average daily dietary intakes of energy and nutrient were computed on the basis of responses to the extensive dietary questionnaire using a food composition table derived from the French national database (13). We also estimated intakes of the same nutrients on the basis of the short questionnaire, using the regression-based method exposed above.

### Statistical analysis

Means and standard deviations (SD) of nutritional intakes in the 103 women sampled were estimated by the two methods. Relative over- or underestimation was expressed as percentage of the ratio (intake estimated from the short dietary questionnaire)/(intake calculated from the extensive questionnaire). Spearman correlations were then used to compare individual intakes between the two methods. Since the capacity of a questionnaire to classify or rank individuals

by level of nutrient intake is usually greater than the ability to measure group means, cross-classification between the short questionnaire and the extensive one was also examined: data were grouped into tertiles and quintiles, and percentages of individuals with concordant classification (respectively, same tertile/ same or adjacent quintile) were computed.

## Results

Of the initial 121 food-groups, 23 were finally retained in the short list. The number of food items required to reach  $R^2=0.75$  in modeling each nutrient intake through ascending stepwise regression ranged from 3 for calcium or omega3 fatty acids, up to 10 food-groups for iron. The 23-item questionnaire is provided in appendix.

Absolute mean nutritional intake levels produced from the short dietary questionnaire compared favorably with those based on the extensive questionnaire (Table 1). Overall, the short questionnaire tended to slightly underestimate mean nutrient intakes compared to the extensive one. Most mean estimated intakes were within 90-100% of intake levels based on the extensive questionnaire (reference intakes), and all intakes were within 83-106% of reference intakes with the notable exception of alcohol (underestimation by 56%).

Spearman correlation coefficients between nutritional intake values from the two questionnaires were lowest ( $<0.3$ ) for vitamin D and retinol and highest ( $>0.65$ ) for magnesium, vitamin B3 and alcohol (Table 2). Overall, correlations were found to be equal to or higher than 0.50 for half the tested nutritional intakes.

Comparison of tertile and quintile cross-classification of subjects from both questionnaires (Table 3) showed that for 12 of the 20 nutrients analyzed, at least 70 % of subjects, when classified with either method, fell into the same or an adjacent quintile.

## Discussion

Our weighted 23-item dietary questionnaire proved successful in estimating mean intakes of energy and most nutrients. In addition, correlation coefficients observed in the present study (mostly between 0.4 and 0.7) were comparable to those observed in other validation studies of dietary questionnaires, which mainly chose diet records as the reference for dietary assessment (14-25). Because of the method used to develop the short questionnaire, the two sets of nutrient intakes we used in our evaluation study may be considered as dependant on one another. However, it must be emphasized that the weights were calculated on a very large data set of 73,034 women, thus making them quite “robust” and rather independent of the 103-women evaluation sub-sample. In addition, the “long” questionnaire used for obtaining these weights was answered to in 1993-1995, while the evaluation study took place more than 10 years later. Finally, the structure of the short and the long questionnaire in the evaluation study are quite different thus limiting recall of the previous answers: the long questionnaire considered each daily meal separately and asked for extensive information (frequency and portion size) on food items potentially consumed during the considered meal, whereas the short questionnaire asked for mean consumption during a day, or a week, or a month depending of the investigated food.

To the best of our knowledge, no published questionnaire considered less than 30 food items except for the 17-item screener developed by Thompson et al. (23) and the 8-item food frequency questionnaire validated by Bogers et al (22). However, these two instruments were specifically developed to estimate fruit and vegetable intake, and relative validity indices were not available for a wide range of nutrients.

In general, a short questionnaire may not be adequate for accurately assessing consumption of certain specific nutrients (when not expressly designed for that purpose). The problem may



arise when some rare foods have a very high concentration of a specific nutrient (e.g. liver for retinol); it also arises for lipid-soluble vitamins, specifically for vitamin E, and most fatty acids, which would request addition of several questions on intake of vegetable fats. Indeed our questionnaire was not designed to assess such nutrients, and results confirmed mediocre estimates (data not tabulated). Although it is possible to increase the number of considered food groups or gather more detailed information (open-ended questions on portion size and frequency of use), the more complex the dietary questionnaire, the lower the compliance. Since diet history questionnaires may be lengthy and end up with a non-negligible rate of non-response, an easy-to-fill dietary questionnaire may well be the only solution for obtaining some general nutritional information from non-respondents.

Finally, the purpose of the dietary survey will guide the choice of the dietary questionnaire. The absolute individual intake level may not be required; ranking of subjects can be sufficiently informative, notably in the case of adjustment for nutritional intake in epidemiological studies, and our short questionnaire proved satisfactory to rank individuals for most nutrients. For example, while absolute individual alcohol intake was clearly underestimated in the short questionnaire, categorization of the subjects according to alcohol proved satisfactory. In the opposite, mean population estimates of vitamin D and beta-carotene intakes were close to those from the extensive questionnaire, and sufficient for surveillance purposes at the public health level; however ranking of individuals for these nutrients was mediocre, which was not unexpected for lipid-soluble vitamins as discussed above. Indeed, correct classification by chance alone to within the same or adjacent quintile is expected in 52% of subjects(16), and it has been suggested that ranking was not satisfactory when less than 70% (which corresponds to a Kappa value for cross-classification of quintiles around 0.40).

It must also be stressed that the validity of the new tool could be influenced by different sources of error involved in the method. First, the validity of the short questionnaire depends on the ability of respondents to report their usual pattern of intake (evaluation of consumed quantities/ adequacy between reality and available modalities in the answer). Second, it is possible that the regression-based method gives a less satisfactory performance if weights used to compute intakes do not suit the population responding to the short questionnaire. In the present case, the short questionnaire was developed from data only from women; moreover, their education level was particularly high compared to that of the general population (most of them were teachers). However, the weights appeared relatively stable towards sample modification. Further analyses in subgroups of the initial dataset (for example, among women with less than 12 years of education) showed weights of a similar magnitude as those computed in the whole sample, allowing to argue that our instrument can be used in other French female populations, and possibly in other female European populations.

In any case, the general methodology exposed in the present article could be used to adapt the short questionnaire to other populations. In designing a new version, it will be interesting to customize the food-items list for the specific country or region, to adapt the length and format of the answers, and to evaluate the performance of the method through an evaluation study in a sample from the target population. It would also be necessary to compute weights adapted from an adequate database.

In conclusion, the performance of this new instrument, as compared to an extensive validated dietary questionnaire, appears satisfactory for most examined nutrients. The originality of our study relies mostly on the regression-based approach used to develop the short dietary assessment tool. The main strength of this short questionnaire is that it is easy to respond and

not time-consuming. Therefore and given its rather good performance in ranking individuals, the present short questionnaire seems appropriate as dietary assessment tool in studies in which nutrition is not central but nevertheless required for adjustment purposes. Its use as a screening method for detecting low-adherence to nutritional advice, especially when a longer questionnaire cannot be obtained warrants further investigation.

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## Appendix: Dietary questionnaire

Please tick the box corresponding to your usual dietary consumption. One box per question.

### Per day...

1/ How much white bread do you consume per day?

(1 “baguette”= 250g ; 1 “ficelle”= 120g ; 1 loaf of French bread= 400g)

☐ 0g ☐ 30g ☐ 60g ☐ 90g ☐ 120g ☐ 150g ☐ 200g ☐ 250g and +

2/ How much whole-meal bread do you consume per day?

☐ 0g ☐ 15g ☐ 30g ☐ 45g ☐ 60g ☐ 75g ☐ 90g ☐ 120g ☐ 150g and +

3/ How many cups of milk do you drink per day? (1 small cup= 70 ml ; 1 bowl = 4 cups)

☐ 0 ☐ 1/2 ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 and +

4/ How many cups of coffee do you drink per day? (1 small cup= 70 ml ; 1 bowl = 4 cups)

☐ 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 and +

5/ How many portions of cheese do you consume per day? (1 portion = 30g)

☐ 0 ☐ 1/4 ☐ 1/2 ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 and +

6/ How much fruit do you consume per day? (1 apple= 1 pear= 1 banana= 200g)

☐ 0g ☐ 50g ☐ 100g ☐ 150g ☐ 200g ☐ 250g ☐ 300g ☐ 350g ☐ 400g ☐ 500g  
☐ 600g and +

7/ How many tablespoons of oil do you consume per day? (for cooking, seasoning, etc.

☐ 0 ☐ 1/4 ☐ 1/2 ☐ 1 ☐ 1,5 ☐ 2 ☐ 3 ☐ 4 ☐ 5 and +

8/ How many portions of butter do you consume per day?

(on slices of bread, for cooking, seasoning, etc. 1 individual portion= 10g)

☐ 0 ☐ 1/4 ☐ 1/2 ☐ 1 ☐ 1,5 ☐ 2 ☐ 3 ☐ 4 ☐ 5 and +

### Per week...

9a/ How many times do you eat lettuce per week?

☐ 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 and +

9b/ How many portions each time? (1 portion = 60g)

☐ 0 ☐ 1/2 ☐ 1 ☐ 1,5 ☐ 2

10/ How many portions of French beans do you consume per week? (1 portion = 100g)

☐ 0 ☐ 1/2 ☐ 1 ☐ 1,5 ☐ 2 ☐ 2,5 ☐ 3 and +

11/ How many portions of cooked carrots do you consume per week? (1 portion = 100g)

☐ 0 ☐ 1/2 ☐ 1 ☐ 1,5 ☐ 2 ☐ 2,5 ☐ 3 and +

12/ How many portions of legumes (whole lentils, beans, etc. do you consume per week?

(1 portion = 100g)



☐ 0 ☐ 1/2 ☐ 1 ☐ 1,5 ☐ 2 ☐ 2,5 ☐ 3 ☐ 3,5 and +

13/ How many portions of chips or fried potatoes do you consume per week?

(1 portion = 100g)

☐ 0 ☐ 1/4 ☐ 1/2 ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 and +

14/ How many eggs do you consume per week?

☐ 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 and +

15/ How many portions of fish do you consume per week? (1 breaded fish= 50g)

☐ 0g ☐ 50g ☐ 100g ☐ 150g ☐ 200g ☐ 300g ☐ 400g ☐ 500g and +

16/ How much poultry (chicken, turkey, rabbit.) do you consume per week?

( 1 leg = 100g)

☐ 0g ☐ 50g ☐ 100g ☐ 150g ☐ 200g ☐ 300g ☐ 400g ☐ 500g and +

17/ How much pork (chop, ham, sausage.) do you consume per week?

( 1 chop= 2 slices of ham= 2 sausages = 100g)

☐ 0g ☐ 50g ☐ 100g ☐ 150g ☐ 200g ☐ 300g ☐ 400g ☐ 500g and +

18/ How much beef do you consume per week? (1 steak of medium size = 100g)

☐ 0g ☐ 50g ☐ 100g ☐ 150g ☐ 200g ☐ 300g ☐ 400g ☐ 500g and +

19/ How much wine do you drink per week?

☐ 0 ☐ 1 glass ☐ 2 glasses ☐ 3 glasses ☐ 1 bottle ☐ 2 bottles ☐ 3 bottles ☐ 4 bottles and +

20/ How many yogurts do you consume per week?

☐ 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10 ☐ 11 and +

21/ How much chocolate or how many chocolate bars do you consume per week?

☐ 0 ☐ 2 squares ☐ 1 bar ☐ 2 bars ☐ 3 bars ☐ 1 block ☐ 2 blocks and +

### **Per month...**

22/ How many bags of breakfast cereal do you consume per month? (1 bag = 375g)

☐ 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 and +

23/ How many portions of nuts (walnuts, peanuts, almonds, etc.) do you consume per month?

(1 portion = 60g)

☐ 0 ☐ 1/2 ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 and +

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### *Author contributions:*

F. Clavel-Chapelon had full access to all data in the study and takes responsibility for the integrity of the data. MN. Vercambre takes responsibility for the accuracy of data analysis. Study concept and design: Ragusa, Vercambre. Acquisition of data and statistical analysis: Clavel-Chapelon, Vercambre. Drafting of the manuscript: Vercambre. Critical revision of the manuscript for important intellectual content: Vercambre, Boutron-Ruault, Clavel-Chapelon, Berr, Ragusa. Study supervision: Clavel-Chapelon, Ragusa.



Table 1. Basic statistics for average daily intakes of energy and 20 macro- and micronutrients as estimated by an extensive or a 23-item dietary questionnaire in 103 women from the E3N cohort, France, 2005-2006

<b>Daily nutrient intake</b>	<b>Extensive dietary questionnaire mean (SD)</b>	<b>Short dietary questionnaire mean (SD)</b>	<b>Ratio of short to extensive questionnaire %</b>
Energy (kcal)	2085.64 (617.03)	2055.81 (381.81)	99
Alcohol (g)	14.31 (14.61)	8.01 (7.52)	56
Total carbohydrates (g)	242.45 (75.07)	229.16 (40.92)	95
Proteins (g)	94.1 (28.05)	87.5 (17.97)	93
Total lipids (g)	71.03 (31.71)	81.46 (21.13)	115
Beta-carotene (mg)	4032.44 (1565.58)	4146.93 (1254.93)	103
Retinol (mg)	931.59 (1010.82)	983.19 (248.48)	106
Vitamin B1 (mg)	1.31 (0.41)	1.21 (0.25)	92
Vitamin B2 (mg)	2.2 (0.73)	2.07 (0.43)	94
Vitamin B3 (mg)	23.85 (9.4)	20.61 (5.85)	86
Vitamin B5 (mg)	5.57 (1.52)	5.39 (1.01)	97
Vitamin B6 (mg)	1.86 (0.53)	1.76 (0.36)	94
Vitamin B9 (mg)	405.47 (115.32)	394.27 (81.58)	97
Vitamin B12 (mg)	7.5 (4.41)	7.31 (1.87)	98
Vitamin C (mg)	139.21 (62.03)	146.93 (43.92)	106
Vitamin D (mg)	2.67 (1.34)	2.23 (0.68)	83
Calcium (mg)	1039.34 (450.46)	993.45 (278.23)	96
Iron (mg)	14.23 (3.69)	12.98 (2.47)	91
Magnesium (mg)	426.25 (147.85)	366.93 (80.74)	86
Omega3 fatty-acids (g)	1.43 (0.54)	1.3 (0.32)	91
Dietary fiber (g)	26.19 (9.47)	24.64 (5.63)	94

Table 2. Spearman correlation coefficients for comparison between an extensive and a 23-item dietary questionnaire in 103 women from the E3N cohort, France, 2005-2006

<b>Nutrient</b>	<b>Spearman correlation</b>
Energy (kcal)	0.46
Alcohol (g)	0.86 (0.81 among consumers*)
Total carbohydrates (g)	0.45
Proteins (g)	0.53
Total lipids (g)	0.49
Beta-carotene (mg)	0.33
Retinol (mg)	0.28
Vitamin B1 (mg)	0.45
Vitamin B2 (mg)	0.54
Vitamin B3 (mg)	0.69
Vitamin B5 (mg)	0.53
Vitamin B6 (mg)	0.53
Vitamin B9 (mg)	0.47
Vitamin B12 (mg)	0.36
Vitamin C (mg)	0.50
Vitamin D (mg)	0.23
Calcium (mg)	0.53
Iron (mg)	0.56
Magnesium (mg)	0.66
Omega3 fatty-acids (g)	0.48
Dietary fiber (g)	0.48

\* Alcohol consumers = women whose alcohol intake was non-null from one or the other dietary questionnaire. Consumer frequency: n =85

Table 3. Agreement between classification by intake level using the extensive dietary questionnaire and the 23-item questionnaire in 103 women from the E3N cohort, France, 2005-2006

<b>Nutrient</b>	<b>% Of study subjects classified into the same tertile</b>	<b>% Of study subjects classified into the same or an adjacent quintile</b>
Energy (kcal)	49	68
Alcohol (g)	77	92
Total carbohydrates (g)	50	75
Proteins (g)	48	73
Total lipids (g)	55	78
Beta-carotene (mg)	45	60
Retinol (mg)	38	62
Vitamin B1 (mg)	52	68
Vitamin B2 (mg)	52	77
Vitamin B3 (mg)	58	81
Vitamin B5 (mg)	51	73
Vitamin B6 (mg)	55	70
Vitamin B9 (mg)	48	69
Vitamin B12 (mg)	43	65
Vitamin C (mg)	47	68
Vitamin D (mg)	42	58
Calcium (mg)	49	73
Iron (mg)	60	77
Magnesium (mg)	57	83
Omega3 fatty acids (g)	53	69
Dietary fiber (g)	48	70