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

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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 analysis was used to identify the food groups that best predicted nutrient intakes, resulting in a short list of twenty-three foods. This list was used to design a twenty-three-item dietary questionnaire. Nutrient intake was estimated from the answers to the twenty-three questions, applying weights to each response. Weights were calculated from the large database as regression coefficients of the nutrient intake against the twenty-three food groups. In 2005–2006, 103 women responded (at a 1-year interval) to both the short questionnaire and a previously validated dietary history questionnaire. Intakes of twenty 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 >0·65 for Mg, vitamin B_3 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.

Keywords
Nutrient
Dietary questionnaire
Evaluation study
Epidemiological method
Prevention

Currently, the leading causes of death in developed countries are chronic diseases such as cancer, CVD 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 diets. Several tools are available, including 24 h recall and FFQ, but they require time for completion and are often difficult to interpret. Other instruments are simpler, 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 twenty-three-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 twenty 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: Ca, Fe, Mg, vitamin B_6 and *n*-3 fatty acids[8].

To identify food items which best predicted intakes of these five nutrients, we analysed dietary data collected in 1993–1995 from a cohort of French women from the National Education System, the E3N study[9]. This ongoing

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prospective cohort was initiated in 1990. It represents the French part of the EPIC (European Prospective Investigation into Cancer and Nutrition) 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 (twenty in total plus energy) than the five initially used to implement the short list. Each nutrient to be estimated was modelled as the dependent variable against the short list of foods as independent variables; the coefficients 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 short list described earlier. 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 intakes reported in the short questionnaire with their corresponding weight, the estimation no longer requires the use of a food composition table.

Evaluation study

Subjects and study design

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, sixteen were excluded because of non-response to the short questionnaire. Finally, 103 women were included in the evaluation study. Compared with the forty-seven women excluded, these 103 women were younger (mean age 65·3 *v.* 65·9 years), more educated (83·5 % *v.* 78·7 % with at least 12 years of education) and leaner (mean BMI 22·4 *v.* 23·1 kg/m^2), but none of these associations reached significance level.

Reference values of average daily dietary intakes of energy and nutrients 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 described earlier.

Statistical analyses

Means and standard deviations of nutritional intakes in the 103 women sampled were estimated by the two methods. Relative over- or underestimation was expressed as a 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 (same tertile or same/adjacent quintile) were computed.

Results

Of the initial 121 food groups, twenty-three were finally retained in the short list. The number of food items required to reach $R^2 = 0{\cdot}75$ in modelling each nutrient intake through ascending stepwise regression analysis ranged from three for Ca and n-3 fatty acids up to ten food groups for Fe.

The twenty-three-item questionnaire is provided in the Appendix.

Absolute mean nutritional intake levels produced from the short dietary questionnaire compared favourably with those based on the extensive questionnaire (Table 1). Overall, the short questionnaire tended to underestimate mean nutrient intakes slightly compared with 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 %).

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Table 1 Average daily intakes of energy and twenty macro- and micronutrients as estimated by an extensive or a twenty-three-item dietary questionnaire in 103 women from the E3N cohort, France, 2005–2006

	Extensive dietary questionnaire		Short dietary questionnaire		Ratio of short to extensive questionnaire (%)
Daily nutrient intake	Mean	SD	Mean	SD	
Energy (kJ)	8732·16	2583·38	8607·27	1598·56	99
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)	94·10	28·05	87·50	17·97	93
Total lipids (g)	71·03	31·71	81·46	21·13	115
β-Carotene (mg)	4032·44	1565·58	4146·93	1254·93	103
Retinol (mg)	931·59	1010·82	983·19	248·48	106
Vitamin B_1 (mg)	1·31	0·41	1·21	0·25	92
Vitamin B_2 (mg)	2·20	0·73	2·07	0·43	94
Vitamin B_3 (mg)	23·85	9·40	20·61	5·85	86
Vitamin B_5 (mg)	5·57	1·52	5·39	1·01	97
Vitamin B_6 (mg)	1·86	0·53	1·76	0·36	94
Vitamin B_9 (mg)	405.47	115·32	394·27	81·58	97
Vitamin B_{12} (mg)	7·50	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
Ca (mg)	1039·34	450·46	993·45	278·23	96
Fe (mg)	14·23	3·69	12·98	2·47	91
Mg (mg)	426·25	147·85	366·93	80·74	86
n-3 fatty-acids (g)	1·43	0·54	1·30	0·32	91
Dietary fibre (g)	26·19	9·47	24·64	5·63	94

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

Nutrient	Spearman correlation
Energy (kJ/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
β-Carotene (mg)	0·33
Retinol (mg)	0·28
Vitamin B_1 (mg)	0·45
Vitamin B_2 (mg)	0·54
Vitamin B_3 (mg)	0·69
Vitamin B_5 (mg)	0·53
Vitamin B_6 (mg)	0·53
Vitamin B_9 (mg)	0·47
Vitamin B_{12} (mg)	0·36
Vitamin C (mg)	0·50
Vitamin D (mg)	0·23
Ca (mg)	0·53
Fe (mg)	0·56
Mg (mg)	0·66
n-3 fatty-acids (g)	0·48
Dietary fibre (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 an extensive dietary questionnaire or a twenty-three-item questionnaire in 103 women from the E3N cohort, France, 2005–2006

Nutrient	% of study subjects classified into the same tertile	% of study subjects classified into the same or an adjacent quintile
Energy (kJ/kcal)	49	68
Alcohol (g)	77	92
Total carbohydrates (g)	50	75
Proteins (g)	48	73
Total lipids (g)	55	78
β-Carotene (mg)	45	60
Retinol (mg)	38	62
Vitamin B_1 (mg)	52	68
Vitamin B_2 (mg)	52	77
Vitamin B_3 (mg)	58	81
Vitamin B_5 (mg)	51	73
Vitamin B_6 (mg)	55	70
Vitamin B_9 (mg)	48	69
Vitamin B_{12} (mg)	43	65
Vitamin C (mg)	47	68
Vitamin D (mg)	42	58
Ca (mg)	49	73
Fe (mg)	60	77
Mg (mg)	57	83
n-3 fatty acids (g)	53	69
Dietary fibre (g)	48	70

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 Mg, vitamin B_3 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 twelve of the twenty nutrients analysed, at least 70 % of subjects when classified with either method fell into the same or an adjacent quintile.

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Discussion

Our weighted twenty-three-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 dependent 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 in 1993–1995, while the evaluation study took place more than 10 years later. Finally, the structures 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, a week or a month depending on the investigated food.

To the best of our knowledge, no published questionnaire considers less than thirty food items except for the seventeen-item screener developed by Thompson *et al.*[23] and the eight-item FFQ 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 require addition of several questions on intake of vegetable fats. Our questionnaire was not designed to assess such nutrients and results indeed 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 contrast, mean population estimates of vitamin D and β-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 is not unexpected for lipid-soluble vitamins as discussed earlier. Indeed, correct classification by chance alone to within the same or an adjacent quintile is expected in 52 % of subjects[16], and it has been suggested that ranking is not satisfactory when less than 70 % (which corresponds to a κ value for cross-classification of quintiles of about 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 with 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 data set (for example, among women with less than 12 years of education) showed weights of a similar magnitude to those computed in the whole sample, allowing us 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 developed in the present paper 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 with 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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Author contributions: F.C.-C. had full access to all data in the study and takes responsibility for the integrity of the data. M.-N.V. takes responsibility for the accuracy of data analysis. Study concept and design: S.R., M.-N.V. Acquisition of data and statistical analysis: F.C.-C., M.N., M.-N.V. Drafting of the manuscript: M.-N.V. Critical revision of the manuscript for important intellectual content: M.-N.V., M.-C.B.-R., F.C.-C., C.B., S.R. Study supervision: F.C.-C., S.R.

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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' = 250 g; 1 'ficelle' = 120 g; 1 loaf of French bread = 400 g)
❑ 0 g ❑ 30 g ❑ 60 g ❑ 90 g ❑ 120 g ❑ 150 g ❑ 200 g ❑ 250 g and +

2. How much whole-meal bread do you consume per day?
❑ 0 g ❑ 15 g ❑ 30 g ❑ 45 g ❑ 60 g ❑ 75 g ❑ 90 g ❑ 120 g ❑ 150 g 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 = 30 g)
❑ 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 = 200 g)
❑ 0 g ❑ 50 g ❑ 100 g ❑ 150 g ❑ 200 g ❑ 250 g ❑ 300 g ❑ 350 g ❑ 400 g ❑ 500 g ❑ 600 g 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 = 10 g)
❑ 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 = 60 g)
❑ 0 ❑ 1/2 ❑ 1 ❑ 1·5 ❑ 2

10. How many portions of French beans do you consume per week? (1 portion = 100 g)
❑ 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 = 100 g)
❑ 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 = 100 g)
❑ 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 = 100 g)
❑ 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 = 50 g)
❑ 0 g ❑ 50 g ❑ 100 g ❑ 150 g ❑ 200 g ❑ 300 g ❑ 400 g ❑ 500 g and +

16. How much poultry (chicken, turkey, rabbit) do you consume per week? (1 leg = 100 g)
❑ 0 g ❑ 50 g ❑ 100 g ❑ 150 g ❑ 200 g ❑ 300 g ❑ 400 g ❑ 500 g and +

17. How much pork (chop, ham, sausage) do you consume per week? (1 chop = 2 slices of ham = 2 sausages = 100 g)
❑ 0 g ❑ 50 g ❑ 100 g ❑ 150 g ❑ 200 g ❑ 300 g ❑ 400 g ❑ 500 g and +

18. How much beef do you consume per week? (1 steak of medium size = 100 g)
❑ 0 g ❑ 50 g ❑ 100 g ❑ 150 g ❑ 200 g ❑ 300 g ❑ 400 g ❑ 500 g 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 yoghurts 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 = 375 g)
❑ 0 ❑ 1 ❑ 2 ❑ 3 ❑ 4 ❑ 5 and +

23. How many portions of nuts (walnuts, peanuts, almonds, etc.) do you consume per month? (1 portion = 60 g)
❑ 0 ❑ 1/2 ❑ 1 ❑ 2 ❑ 3 ❑ 4 ❑ 5 ❑ 6 and +

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