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Reproducibility of a short semi-quantitative food group questionnaire and its performance in estimating nutrient intake compared with a 7-day diet diary in the Million Women Study

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Abstract

Objectives: To assess the short- and long-term reproducibility of a short food group questionnaire, and to compare its performance for estimating nutrient intakes in comparison with a 7-day diet diary.

Design: Participants for the reproducibility study completed the food group questionnaire at two time points, up to 2 years apart. Participants for the performance study completed both the food group questionnaire and a 7-day diet diary a few months apart. Reproducibility was assessed by kappa statistics and percentage change between the two questionnaires; performance was assessed by kappa statistics, rank correlations and percentages of participants classified into the same and opposite thirds of intake.

Setting: A random sample of participants in the Million Women Study, a population-based prospective study in the UK.

Subjects: In total, 12 221 women aged 50–64 years.

Results: In the reproducibility study, 75% of the food group items showed at least moderate agreement for all four time-point comparisons. Items showing fair agreement or worse tended to be those where few respondents reported eating them more than once a week, those consumed in small amounts and those relating to types of fat consumed. Compared with the diet diary, the food group questionnaire showed consistently reasonable performance for the nutrients carbohydrate, saturated fat, cholesterol, total sugars, alcohol, fibre, calcium, riboflavin, folate and vitamin C.

Conclusions: The short food group questionnaire used in this study has been shown to be reproducible over time and to perform reasonably well for the assessment of a number of dietary nutrients.

Keywords
Diet
Dietary assessment
Food
Nutrition
Epidemiological method

The measurement of average long-term dietary intake in large epidemiological studies is difficult. A balance has to be achieved between methods that have high accuracy and those that are easy in terms of implementation and data capture. In the case of self-reported dietary intake, these two extremes are often characterised by a multi-day diet diary[1] and a machine-readable food-frequency questionnaire (FFQ)[2]. Numerous reproducibility and validation studies have been reported for these instruments[3] although it has long been recognised that there are considerable sources of error, both systematic and random, which can markedly affect the results of epidemiological analyses.

For the Million Women Study, which is a prospective cohort study of over one million females in the UK[4], a short semi-quantitative food group questionnaire was developed with the main aim of ranking individuals into categories according to intakes of foods and nutrients. This brief questionnaire was designed to capture the main sources of variability in the diets of the target population of UK women aged in their fifties and sixties. It differs from a traditional FFQ in that, instead of asking how often the respondent eats a specific food (e.g. lamb chops, carrots, fish fingers), the food group questionnaire first asks how often she typically eats any food within a particular food group (e.g. meat, fish) and then asks which foods within this group are usually eaten once a week or more often. For foods such as cooked vegetables, salad and fruit, participants were also asked about the quantity of the food group eaten per week (e.g. number of tablespoons of

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cooked vegetables, number of items of fresh fruit). The food group questionnaire asks respondents to write down the estimated number of times, or food items, eaten per week, rather than indicating consumption in pre-defined categories.

The food group questionnaire was designed to gather information on broad dietary groups and extremes of diet, including ascertaining which participants do not eat certain foods such as meat, dairy products or eggs. The questionnaire also asks about some dietary or culinary practices believed to relate to future health, such as use of saturated or unsaturated fats when cooking, addition of salt to food and removal of fat from meat.

The food group questionnaire was developed on the basis of the results from a pilot study of participants completing a 7-day diet diary that sought to establish the main sources of particular nutrients or food components and the sources of variation in intakes. For example, it was found that the main sources of dietary fibre and of variation in fibre intake were bread, breakfast cereals, fruit and vegetables. Questions about these items were therefore included on the food group questionnaire.

An inherent problem in assessing the reproducibility of dietary questionnaires over time is that differences between time points can reflect either real changes in dietary habits (long-term underlying changes or short-term seasonal changes) or poor repeatability. The aim of the present paper is to assess both the short- and long-term reproducibility of the semi-quantitative food group questionnaire, distinguishing those items which might reflect real dietary changes from those which have poor repeatability. Additionally, the performance of the food group questionnaire for estimating nutrient intakes, comparing results from the questionnaire with those obtained from a 7-day diet diary, was assessed.

Materials and methods

Study population

This study was carried out on a subset of women participating in the Million Women Study. The Million Women Study is a population-based, multi-centre prospective study in the UK aiming to investigate the association of hormone replacement therapy and other factors with health, and is described in detail elsewhere[4]. Briefly, recruitment of over one million women aged 50–64 years from the UK general population took place between May 1996 and March 2001. Participants joined by completing a self-administered questionnaire on lifestyle, sociodemographic factors, reproductive factors, past health and use of hormone replacement therapy, which they returned immediately prior to attendance at routine breast screening organised by the National Health Service. A Townsend deprivation score[5], which is an index of social class derived from each participant's area of residence, based on car and home ownership, overcrowding and employment levels, was allocated to each participant on the basis of their postcode of residence.

Approximately 2–3 years after recruitment into the Million Women Study all women were mailed a self-administered follow-up questionnaire that updated information on a range of measures, including new questions on diet. Recruitment and follow-up questionnaires can be viewed at http://www.millionwomenstudy.org.

The dietary study population for this analysis comprised a random sample of women recruited into the Million Women Study between January and March 1997. Of the 19 795 women sent a follow-up questionnaire, 12 221 (response rate 62%) were returned and these women were divided at random into five groups to be followed for further information on their diet. Four of the five groups (each with approximately 2000 participants) received a second copy of the follow-up questionnaire 3, 6, 12 or 24 months after the initial follow-up questionnaire was completed to assess short-term, seasonal (diets in opposite seasons of the year) and long-term trends in dietary consumption, respectively. Women in the fifth group (approximately 4000 participants) were mailed a 7-day diet diary approximately 3 months after completion of the follow-up questionnaire. In the four groups sent a repeat follow-up questionnaire 5063 questionnaires were returned (response rate 62%), whilst in the diet diary group 1785 diaries were returned (response rate 44%).

Food group questionnaire

The short food group questionnaire comprised 18 questions on the types and frequency of food intakes relating to a typical week; the questionnaire is reproduced in the Appendix.

Completed food group questionnaires were checked and data were entered using operator-verified data-capture software (Eyes & Hands®; ReadSoft Ltd, Milton Keynes, UK). Overall consumption for each food item in a food group was proportionately allocated, using standard portion sizes[6], according to the amount of each food group the participant reported eating each week. Daily nutrient intakes were calculated using data from *McCance & Widdowson's The Composition of Foods* and its supplements[7–16].

7-Day diet diary

The 7-day diet diary used was identical to the EPIC–Oxford diary[17] developed for use by the EPIC–Oxford and EPIC–Norfolk arms of the European Prospective Investigation into Cancer and Nutrition (EPIC) study. Participants reported either weighed portions or used photographs of portions provided in the diary when reporting portion sizes. A random sample of 202 of the available 1785 diaries, representative of each geographical recruitment region, was selected and coded using the food-coding program WISP version 2.0[18] to derive estimated daily nutrient intakes.

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Nutrient analysis

Nutrients included in this analysis were dietary energy, protein, total fat, saturated fat, monounsaturated fat, polyunsaturated fat, dietary cholesterol, carbohydrate, total sugars, alcohol, fibre (non-starch polysaccharides), calcium, retinol, carotene, thiamin, riboflavin, niacin, vitamin B_6, folate, vitamin B_{12}, vitamin C, vitamin D and vitamin E. Dietary supplement data from either the food group questionnaire or the 7-day diet diary were not included.

Nutrients were considered both unadjusted for energy and adjusted for energy using the residual method[2].

Unreliable intakes

Ratios of energy intake (EI) to estimated basal metabolic rate (BMR)[19] were calculated as a measure of the extent of unreliable reporting by both dietary methods. Participants in the top and bottom 2.5% of the distribution of the ratio EI/(BMR × 1.4) were classified as having unreliable reported intakes.

Statistical analysis

Before analyses, certain assumptions needed to be made regarding missing values in the food group questionnaire. For the food item (yes/no) questions, if there were no responses in a block of yes/no questions relating to a particular food group (indicating that items were either consumed at least once a week or never consumed), it was assumed that answers to the entire block of questions were missing. For the food intake questions, a blank response on a questionnaire was considered to be a missing value; the robustness of the results to this assumption was assessed by repeating the analysis, re-coding a blank on the questionnaire as a zero.

All comparisons were made separately between the baseline food group questionnaire and each of the repeat questionnaires.

For the food item (yes/no) questions, agreement between the baseline and repeat questionnaires was assessed by means of the kappa statistic[20]. Values of kappa over 0.80 indicate excellent agreement, between 0.61 and 0.80 very good agreement, between 0.41 and 0.60 moderate agreement, between 0.21 and 0.40 fair agreement and less than 0.20 poor agreement[20]. For food intake questions, the proportional change in average intake between the baseline and repeat dietary questionnaires was computed.

Nutrient intakes calculated from the 7-day diet diary, the food group questionnaire and percentage differences between the 7-day diet diary and the food group questionnaire were expressed as medians. Differences between absolute nutrient intakes from the 7-day diet diary and the food group questionnaire were assessed using the Kruskal–Wallis test. Pearson rank correlations were used to assess the relative degree of agreement between the 7-day diet diary and the food group questionnaire. Nutrient intakes from both the 7-day diet diary and the food group questionnaire were categorised into tertiles and a weighted kappa was calculated using Fleiss–Cohen weights[21] which attach greater importance to near disagreements.

All statistical analyses were performed in the data analysis language R[22].

Results

Description of study participants

Among the 12 221 women who were included in the detailed dietary follow-up study, the mean age at recruitment was 56.0 (standard error (SE) 0.03) years and mean body mass index (BMI) was 25.8 (SE 0.03) kg m^{-2}. There were no significant differences between age at recruitment, BMI or deprivation index in the five groups selected for further dietary follow-up. Those who did not respond to either the repeat food group questionnaire or the 7-day diet diary were on average slightly younger, had higher BMI and were from more deprived areas than those who either responded to both questionnaires or completed a 7-day diet diary (Table 1). The 202 women whose diaries were selected for analysis were on average 1 year older ($P < 0.01$) but had similar BMI and deprivation index compared with those women whose diaries were not selected.

Table 1 Characteristics of respondents in the repeatability and performance study

	n (%)	Age (years)*	Body mass index (kg m^{-2})*	Deprivation index*†
Overall sample (who returned a follow-up questionnaire)	12 221	56.0 (0.03)	25.8 (0.04)	−1.45 (0.03)
Returned repeat questionnaire	5063 (62)	56.1 (0.07)	25.6 (0.06)	−1.61 (0.04)
No reply to repeat questionnaire	3103 (38)	55.9 (0.08)	25.9 (0.08)	−1.21 (0.05)
P-value for difference		NS	<0.01	<0.001
Returned diet diary	1785 (44)	56.5 (0.11)	25.4 (0.10)	−1.77 (0.06)
No reply to diet diary	2270 (56)	55.8 (0.10)	26.4 (0.10)	−1.18 (0.06)
P-value for difference		<0.001	<0.001	<0.001

NS – not significant.
* Values are mean (standard error).
† Measured by Townsend score. A higher score corresponds to more deprivation.

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Reproducibility of food group questionnaire

Tables 2 and 3 show results for the reproducibility of the food group questionnaire. Table 2 shows percentage responding yes and kappa values for each of the dietary items for which the question was 'Which types of these items do you eat about once a week or more often?' Table 3 shows the mean reported intakes and the percentage change in reported intakes between baseline and each of the follow-up food group questionnaires.

Short-term comparison

Over the short term, 84 of the 87 (97%) yes/no items (Table 2) showed moderate agreement or above. Items for which agreement was only fair included kidney and corn oil or soya oil used in cooking or salads. These items were reported as eaten once a week or more by few women: 2% for kidney, 10–12% for corn oil and 1–2% for soya oil used in cooking or salads. Amounts of food eaten were reported with high consistency (Table 3), with 33 of the 35 items (94%) changing by less than 10%. Items for which there was a change of 10% or over were stewed/tinned fruit (−12%) and fizzy drinks (+13%), although this corresponds to less than 1 portion per day.

Seasonal comparison

For the seasonal, winter to summer comparison, 75 of the 87 (86%) items showed at least moderate agreement. Yes/no items (Table 2) showing only fair agreement included the meat products kidney, liver/pâté and beefburger/hamburger; these items were eaten by a low proportion of the study population, 2% or less for kidney and beefburger/hamburger and 7–8% for liver/pâté. The vegetable item Brussels sprouts was reported as eaten by 49% of women at the baseline food group questionnaire (during the winter season) and only 23% in the summer seasonal repeat food group questionnaire. In addition, a number of items relating to the types of fat eaten showed only fair repeatability, including soft cheese, mayonnaise or salad cream spread on bread, etc., soft margarine, corn oil, mayonnaise, soya oil used in cooking/salads, and the item never use milk/cream. Amounts of food consumed (Table 3) varied by less than 10% for 27 of the 35 items (77%). Those for which the amount reported varied by 10% or more were salad items/raw vegetables (+23%), dried fruit (+29%), cakes/buns/puddings/pies (−10%), gravy (−11%), glasses of milk/hot chocolate (+13%), fizzy drinks (+10%), water (+20%) and fruit squash (+21%).

Long-term comparisons

Over the long term, the patterns were very similar across 1- and 2-year comparisons. The vast majority of items were reported with at least moderate agreement (80% and 83% for 1- and 2-year comparisons, respectively). For the 1-year comparisons, yes/no items showing only fair agreement (Table 2) were the meat product kidney, the vegetable aubergine, and a number of items relating to types of fat spread on bread or in cooking or salads. Similarly, for the 2-year comparisons, the meat product kidney and the items relating to types of fat spread on bread or used in cooking or salads, along with the meat products liver/pâté and beefburger/hamburger, and cod/haddock/white fish showed only fair agreement. Also showing only fair agreement for both the 1-year and 2-year comparisons were the items soya milk and never use milk/cream. Amounts of food consumed differed by less than 10% for 89% and 86% for the 1- and 2-year comparisons, respectively (Table 3). Items for which there was a difference of 10% or over in the amount reported eaten for the 1-year comparison were dried fruit (+13%), fizzy drinks (−12%), water (+10%) and fruit squash (+15%). For the 2-year comparison, those items for which there was a difference of 10% or more were fish/seafood (+10%), nuts (+11%), fizzy drinks (−18%), water (+13%) and fruit squash (+11%).

Summary of reproducibility

Of the 87 items, 65 (75%) showed at least moderate agreement across all four time-point comparisons. Over half of the items showing only fair or poor agreement related to types of fat intake, either as spreads used on bread or used in cooking or salad dressing, and only three items (3%) showed consistently poor agreement for all four time-point comparisons. Virtually all of the vegetable items showed agreement that was moderate or better; two showed fair agreement but only for one time-point comparison. For the remainder of the items with at least one comparison showing fair agreement or worse, few respondents reported eating these items once a week or more often.

The percentage change was under 20% for all except four of the 140 comparisons; most notable was the intake of salad/raw vegetable items, consumption of which increased by 23% in the seasonal repeat compared with baseline. For the other three comparisons exceeding 20%, both intake and the number of responses were very low. Repeating the analysis assuming that a blank response represented a zero intake produced a very similar pattern of results.

Performance of food group questionnaire compared with 7-day diet diary for estimating nutrient intakes

Table 4 shows a comparison of the daily nutrient intake data estimated from the 7-day diet diary and the baseline food group questionnaire. There were a number of significant differences between the absolute median nutrient intakes estimated from the 7-day diet diary and the food group questionnaire. The largest disagreements were seen for total fat (+25%), monounsaturated fat (+46%), polyunsaturated fat (+59%), alcohol (−39%), carotene (−61%), vitamin D (+27%), and vitamin E (+36%). However,

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Table 2 Kappa values for agreement between responses at baseline and each of the repeat food group questionnaires to the question 'Which types of these items do you eat about once a week or more often?'

	Baseline $n = 12\,221$ Nov/Dec 1999	Short-term (3 months) $n = 1288$ Feb/March 2000		Seasonal (6 months) $n = 1217$ May/June 2000		Long-term (1 year) $n = 1287$ Nov/Dec 2000		Long-term (2 year) $n = 1271$ Nov/Dec 2001	
	% yes	% yes	Kappa	% yes	Kappa	% yes	Kappa	% yes	Kappa
Meat									
Beef	55	58	0.69	51	0.60	51	0.63	54	0.60
Bacon	39	42	0.62	39	0.55	39	0.53	41	0.54
Chicken/poultry	91	92	0.68	92	0.64	92	0.60	91	0.60
Lamb	41	41	0.61	39	0.60	41	0.59	40	0.59
Ham	37	39	0.52	41	0.45	37	0.40	40	0.45
Kidney	2	2	0.33	2	0.39	2	0.25	2	0.36
Pork	45	47	0.64	41	0.60	43	0.56	42	0.57
Sausages	24	25	0.61	22	0.52	26	0.51	24	0.53
Liver/pâté	8	8	0.49	7	0.35	8	0.40	7	0.32
Beefburger/hamburger	2	2	0.44	1	0.25	2	0.43	1	0.34
Never eat meat	3	3	0.92	4	0.83	3	0.87	4	0.81
Fish									
Tuna	43	44	0.70	49	0.63	44	0.54	46	0.56
Trout	8	9	0.58	8	0.49	8	0.54	7	0.47
Mackerel	11	11	0.60	13	0.53	13	0.51	15	0.45
Fish & chips	16	15	0.50	15	0.54	16	0.40	16	0.44
Salmon	39	39	0.62	41	0.58	38	0.58	43	0.52
Sardines	13	13	0.62	15	0.58	16	0.56	16	0.47
Other seafood	18	18	0.58	20	0.49	17	0.45	20	0.47
Cod/haddock/white fish	69	70	0.54	67	0.56	68	0.52	67	0.39
Never eat fish	3	3	0.72	3	0.81	3	0.80	2	0.77
Vegetables									
Green peas	70	70	0.64	72	0.55	71	0.53	74	0.51
Tomatoes	90	88	0.54	94	0.55	89	0.53	92	0.41
Green beans	59	54	0.54	58	0.45	59	0.48	65	0.46
Broccoli	75	77	0.68	77	0.63	75	0.58	75	0.51
Onions	79	80	0.60	78	0.56	78	0.53	78	0.53
Baked beans	52	50	0.67	52	0.62	51	0.54	51	0.55
Cabbage	55	53	0.65	51	0.57	57	0.58	55	0.53
Garlic	42	42	0.73	42	0.70	40	0.70	42	0.68
Soya meat/tofu	4	3	0.58	4	0.55	4	0.40	4	0.51
Carrots	89	90	0.59	88	0.49	89	0.52	90	0.48
Swede	32	36	0.60	21	0.50	32	0.59	28	0.54
Chick peas/lentils	10	8	0.55	9	0.62	8	0.50	11	0.48
Courgettes	29	27	0.61	31	0.63	26	0.63	30	0.59
Spinach	15	15	0.70	16	0.61	14	0.60	16	0.54
Cauliflower	63	59	0.54	57	0.57	61	0.52	61	0.51
Beetroot	25	25	0.61	31	0.45	25	0.49	27	0.46
Sweet corn	25	24	0.60	27	0.54	23	0.51	23	0.45
Green/red peppers	46	41	0.68	48	0.65	42	0.63	45	0.59
Leeks	35	39	0.66	26	0.49	34	0.56	31	0.55
Avocado	8	10	0.65	12	0.51	9	0.54	11	0.54
Brussels sprouts	49	53	0.57	23	0.36	48	0.54	39	0.54
Parsnip	39	42	0.53	24	0.44	38	0.56	32	0.49
Aubergine	8	6	0.49	5	0.44	4	0.35	6	0.55
Mushrooms	67	63	0.66	63	0.59	64	0.55	65	0.54
Lettuce	72	74	0.56	85	0.43	71	0.55	75	0.48
Celery	34	38	0.65	38	0.60	32	0.57	33	0.56
Cucumber	59	58	0.66	70	0.54	58	0.60	62	0.58
Fruit									
Apples	81	78	0.70	77	0.53	79	0.61	82	0.51
Bananas	86	84	0.74	87	0.65	85	0.61	86	0.61
Oranges, satsumas	64	71	0.56	62	0.56	64	0.52	61	0.51
Grapefruit	24	23	0.71	24	0.59	23	0.56	23	0.50
Pears	51	48	0.66	46	0.57	50	0.54	51	0.47
Stone fruit	58	51	0.51	67	0.45	55	0.44	61	0.46
Cereals									
Bran cereal	26	26	0.75	28	0.64	27	0.62	25	0.54
Muesli	26	24	0.70	30	0.61	24	0.56	25	0.53
Biscuit cereal	25	25	0.71	28	0.58	25	0.52	27	0.51
Other	29	30	0.61	29	0.55	29	0.51	32	0.44
Oat cereal	27	28	0.65	20	0.52	27	0.55	25	0.48

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Table 2 *Continued*

	Baseline $n = 12\,221$ Nov/Dec 1999	Short-term (3 months) $n = 1288$ Feb/March 2000		Seasonal (6 months) $n = 1217$ May/June 2000		Long-term (1 year) $n = 1287$ Nov/Dec 2000		Long-term (2 year) $n = 1271$ Nov/Dec 2001	
	% yes	% yes	Kappa	% yes	Kappa	% yes	Kappa	% yes	Kappa
Fats spread on bread, etc.									
Butter	36	37	0.77	33	0.73	34	0.68	36	0.61
Margarine	10	9	0.48	10	0.50	9	0.41	8	0.44
Soft cheese	14	14	0.45	13	0.40	13	0.25	11	0.31
Low-fat spread	49	50	0.67	47	0.66	47	0.59	43	0.51
Mayonnaise	10	11	0.43	13	0.40	10	0.38	10	0.44
Salad cream	7	8	0.43	10	0.32	8	0.29	7	0.28
Olive oil spread	19	18	0.75	20	0.70	23	0.58	24	0.58
Marmite	22	20	0.59	20	0.53	19	0.50	19	0.49
Rarely use spread	8	7	0.60	8	0.49	8	0.50	8	0.38
Fats used in cooking & salads									
Butter	13	16	0.51	12	0.53	13	0.47	14	0.44
Soft margarine	19	18	0.41	17	0.37	19	0.32	18	0.33
White Flora	8	8	0.58	8	0.65	7	0.61	7	0.57
Olive oil	54	56	0.76	57	0.71	56	0.70	60	0.68
Hard margarine	4	4	0.44	4	0.43	5	0.42	3	0.32
Lard/dripping	9	10	0.62	7	0.48	9	0.62	7	0.52
Corn oil	12	10	0.34	9	0.31	9	0.28	8	0.28
Sunflower oil	44	40	0.52	43	0.50	41	0.48	42	0.51
Mayonnaise	21	18	0.45	24	0.39	18	0.35	21	0.37
Soya oil	1	2	0.29	1	0.11	1	0.19	1	0.21
Other vegetable oil	20	19	0.47	19	0.46	20	0.39	18	0.43
Salad cream	15	14	0.51	19	0.45	16	0.38	15	0.42
Milk									
Full-cream milk	13	12	0.80	12	0.83	13	0.78	11	0.71
Single cream	13	12	0.53	14	0.51	13	0.51	12	0.49
Semi-skimmed milk	67	68	0.86	67	0.84	65	0.77	65	0.71
Double cream	9	11	0.53	7	0.52	10	0.49	9	0.43
Skimmed milk	27	26	0.88	26	0.82	26	0.79	28	0.79
Ice cream	17	15	0.45	21	0.43	15	0.43	17	0.35
Soya milk	6	5	0.42	4	0.51	4	0.38	5	0.38
Never have milk/cream	4	3	0.43	2	0.40	3	0.32	2	0.32

agreement in the relative ranking by the 7-day diet diary and the food group questionnaire was generally good, with rank correlations of 0.5 or over for nine of the 23 nutrients. Categorising the estimated nutrient intakes from the food group questionnaire and the 7-day diet diary into tertiles and assessing same classification (at least 45% classified into the same tertile by both methods) and extreme misclassification (e.g. lowest tertile using the food group questionnaire and highest tertile using the 7-day diet diary of at most 5% by both methods) showed consistently favourable performance for carbohydrate, saturated fat, cholesterol, total sugars, alcohol, fibre, calcium, riboflavin, folate, and vitamin C. These favourable ratings corresponded with weighted kappa values above 0.3.

Energy adjustment generally improved the measures of agreement considered in respect of the macronutrients, but the measures of agreement either declined or remained approximately the same for the micronutrients. Energy-adjusted nutrients that could be considered to have good agreement included all those for which unadjusted agreement was good, along with total fat.

Excluding those people who were classified as having an unreliable energy intake gave a similar pattern of results, with the same nutrients being consistently well estimated using both dietary assessment methods (results not shown).

Discussion

The data show excellent repeatability for the food group questionnaire over comparisons from 3 months to 2 years, giving confidence in the data collected using this questionnaire method. The small number of items that showed consistently poor repeatability were items relating to the types of fats eaten or used in cooking and items which were on average consumed in relatively small amounts, highlighting some of the aspects of diet about which it is difficult to capture information reliably. Using the diet diary as a reference, we showed that nutrient estimation using the food group questionnaire is reasonable for a selection of the nutrients studied. Recruitment into the Million Women Study and hence the follow-up, including the food group questionnaire,

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Table 3 Percentage change in reported intakes between baseline and each of the repeat food group questionnaires

Item	Portion size (per week)	Baseline $n = 12\,221$ Nov/Dec 1999	Short-term (3 months) $n = 1288$ Feb/March 2000		Seasonal (6 months) $n = 1217$ May/June 2000		Long-term (1 year) $n = 1287$ Nov/Dec 2000		Long-term (2 years) $n = 1271$ Nov/Dec 2001	
		Mean	Mean	% Change	Mean	% Change	Mean	% Change	Mean	% Change
Meat	portions	4.8	5.1	5	4.7	−3	4.9	2	4.7	−1
Fish/seafood	portions	2.1	2.1	1	2.3	7	2.2	3	2.3	10
Chips	portions	0.9	0.8	−2	0.9	1	0.9	2	0.9	3
Potatoes (not chips)	portions	4.2	4.4	4	4.0	−4	4.2	−1	4.1	−4
Pasta/spaghetti	portions	1.5	1.4	−4	1.5	5	1.5	3	1.4	−2
Rice	portions	1.2	1.2	2	1.2	1	1.2	−1	1.2	−1
Cheese	portions	3.0	3.1	1	3.0	−1	3.0	−1	3.0	−2
Eggs	number	2.4	2.4	1	2.5	4	2.6	7	2.4	−1
Cooked vegetables	tablespoons	13.1	13.0	−1	12.2	−7	13.3	2	13.3	2
Salad/raw vegetables	tablespoons	8.2	7.9	−4	10.1	23	8.5	3	8.9	8
Fresh fruit	pieces	11.5	11.2	−3	12.3	7	11.4	−1	11.9	3
Dried fruit	pieces	3.5	3.4	−2	4.5	29	3.9	13	3.5	2
Fruit juice	glasses	4.9	4.8	−3	5.4	9	5.2	5	4.8	−4
Stewed/tinned fruit	tablespoons	2.7	2.4	−12	2.7	−2	2.6	−4	2.6	−5
White bread	slices	7.9	7.4	−6	7.8	−1	7.9	0	7.4	−6
Brown/wholemeal bread	slices	9.8	9.7	−2	10.0	2	9.1	−7	9.2	−7
Crackers/crispbread	number	4.8	5.0	4	4.9	2	4.7	−3	4.8	0
Crisps	packets	1.3	1.3	2	1.2	−8	1.3	3	1.4	9
Sweet biscuits	number	6.1	5.7	−6	5.9	−3	6.0	−2	5.7	−7
Dairy desserts	number	3.9	3.7	−6	4.2	6	4.1	4	4.2	6
Cakes & puddings	number	3.1	3.0	−4	2.8	−10	3.2	2	2.9	−6
Chocolate	pieces	3.6	3.8	4	3.6	1	3.9	9	3.8	5
Boiled sweets	number	3.8	3.5	−8	3.6	−5	3.8	2	3.5	−7
Nuts	tablespoons	1.4	1.5	6	1.4	−4	1.4	−1	1.6	11
Gravy & cream sauces	tablespoons	5.4	5.1	−4	4.8	−1	5.6	4	5.2	−3
Jam/marmalade	tablespoons	2.2	2.1	−7	2.2	0	2.3	2	2.1	−5
Breakfast cereal	bowls	5.1	5.0	−2	5.1	1	5.1	1	5.1	0
Alcohol	drinks	4.6	4.6	1	4.3	−5	4.4	−4	4.9	6
Tea	cups/day	3.8	4.0	4	3.8	0	3.7	−3	3.8	−2
Milk/hot chocolate	cups/day	0.7	0.7	−5	0.8	13	0.7	−2	0.7	−5
Fizzy drinks	glasses/day	0.7	0.8	13	0.8	10	0.7	−12	0.6	−18
Coffee	cups/day	2.5	2.6	1	2.5	−3	2.5	−3	2.4	−6
Water	glasses/day	2.9	3.0	6	3.4	20	3.2	10	3.2	13
Fruit squash	glasses/day	0.8	0.9	9	1.0	21	0.9	15	0.9	11
Sugar	teaspoons/day	1.3	1.3	2	1.4	5	1.3	−4	1.2	−9

necessarily took place over a number of years. Hence the stability of responses to the food group questionnaire and the lack of any major time shift in reported dietary patterns, alongside the ability to estimate a range of nutrients, gives confidence that the dietary data collected can be utilised in future analyses of long-term consumption and disease.

While there were appreciable differences in certain vegetable items between the baseline (winter) questionnaire and the seasonal (summer) comparison questionnaire, these are likely to reflect true variation in the diet from winter to summer. The availability of the winter vegetable Brussels sprouts falls markedly throughout the summer, and the consumption of salad vegetables is likely to be higher during months of warmer weather. The long-term changes detected in the consumption of fluids are interesting; it is suggestive of an overall increase in consumption coupled with a switch from fizzy drinks to water and fruit squash. This pattern would be consistent with a trend towards a more health-conscious choice of drinks and may reflect a real change in behaviour.

The performance component of the current paper compared the nutrient intakes estimated using the 7-day diet diary with those from the food group questionnaire. We have assumed that the 7-day diaries represent the reference measurement, which is our most accurate estimate of nutrient intake. Ideally nutrient biomarkers should be the standard by which to judge the validity of any dietary assessment tool as has been shown in recent publications[23,24]; however, their use remains limited as adequate biomarkers do not exist for some key components of the diet such as total fat and fibre. Comparing nutrient intakes estimated from the food group questionnaire with those from the 7-day diet diaries has shown that carbohydrate, saturated fat, cholesterol, total sugars, alcohol, fibre, calcium, riboflavin, folate and vitamin C performed consistently well in terms of their rank correlations, percentage correct classification when the data were categorised into tertiles and weighted kappa statistics. However, since the reporting errors associated with the food group questionnaire and the 7-day diet diary are likely to be highly correlated, it is possible that the

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Table 4 Comparison of daily nutrient intakes estimated from the 7-day diet diaries and from the baseline food group questionnaire for the 202 women whose diet diaries were analysed

Nutrient	Diet diary median	Questionnaire median	Median difference (%) between diet diaries and questionnaire	*r*†		Lowest tertile diet diary, highest tertile questionnaire		Highest tertile diet diary, lowest tertile questionnaire		Same tertile classification using diet diary and questionnaire		Weighted kappa	
				Unadjusted	Energy-adjusted	Unadjusted	Energy-adjusted	Unadjusted	Energy-adjusted	Unadjusted	Energy-adjusted	Unadjusted	Energy-adjusted
Energy (kcal)	1746	1882*	9	0.29		7		8		46		0.22	
Protein (g)	70	69	−5	0.36	0.31	5	7	7	7	46	40	0.25	0.15
Total fat (g)	66	83*	25	0.34	0.48	6	5	7	4	47	55	0.24	0.39
Carbohydrate (g)	212	204	−4	0.49	0.64	4	2	5	2	48	54	0.31	0.44
Saturated fat (g)	23	23	2	0.50	0.56	3	2	5	2	47	51	0.31	0.39
Monounsaturated fat (g)	21	31*	46	0.31	0.34	7	6	7	7	44	44	0.20	0.21
Polyunsaturated fat (g)	10	15*	59	0.18	0.27	8	7	11	8	43	41	0.14	0.17
Cholesterol (mg)	224	214	−1	0.50	0.34	5	6	4	4	48	45	0.31	0.25
Total sugars (g)	99	96	−2	0.55	0.55	3	4	4	5	53	52	0.39	0.35
Alcohol (g)	5	3	−39	0.75	0.75	2	1	0	0	65	65	0.58	0.59
Fibre (g)	14	13	−7	0.56	0.62	4	3	3	1	50	58	0.35	0.48
Calcium (mg)	815	812	−3	0.58	0.62	4	3	4	4	56	54	0.41	0.41
Retinol (μg)	309	354	14	0.42	0.29	6	7	5	5	45	42	0.25	0.21
Carotene (μg)	1965	781*	−61	0.26	0.31	6	6	8	8	37	45	0.12	0.22
Thiamin (mg)	2	1*	−12	0.39	0.36	5	7	7	6	48	46	0.28	0.23
Riboflavin (mg)	2	2	3	0.60	0.58	2	3	3	3	59	55	0.49	0.43
Niacin (mg)	18	18	8	0.34	0.40	7	5	6	7	47	45	0.25	0.24
Vitamin B_6 (mg)	2	2	−3	0.37	0.43	6	6	7	4	49	48	0.27	0.29
Folate (μg)	253	232	−7	0.50	0.51	4	3	4	3	47	51	0.31	0.38
Vitamin B_{12} (μg)	4	5	12	0.34	0.24	7	10	6	8	44	43	0.22	0.15
Vitamin C (mg)	92	82*	−17	0.61	0.61	3	2	3	3	54	55	0.42	0.43
Vitamin D (μg)	3	3*	27	0.33	0.27	8	8	6	6	39	40	0.15	0.15
Vitamin E (mg)	6	9*	36	0.16	0.12	8	8	8	10	34	35	0.08	0.07

* $P < 0.001$.
† Rank correlation coefficient.

degree of agreement has been overstated[25]. While it is possible to estimate intakes of these nutrients, care is required in their use in future epidemiological studies of diet–disease relationships using the complete Million Women Study dataset.

Although it appears that the food group questionnaire was not able to reliably capture information relating to the consumption of rare or unpopular food items, it should be remembered that it was designed solely to capture information on major sources of variation in the diet, allowing classification of the women into appropriate groups. It was never expected that it would be suitable to capture entire diets, and as such was designed less like a classical FFQ and more like a shopping list. Additionally, it was kept brief to allow computerised data entry and to maximise compliance so as to gather information from as many study participants as possible. These results therefore give confidence in the future use of the food group questionnaire to allow categorisation of study participants in the Million Women Study according to a wide range of dietary exposures in disease-specific analyses.

Most FFQs are not designed to assess total energy intake accurately, and this also applies to the Million Women Study food group questionnaire. However, energy intake using the questionnaire was moderately well estimated, suggesting that the portion sizes allocated to food items in the questionnaire and the diet diary were reasonably accurate allowing participants to be similarly ranked according to energy intake by both methods. It can be hypothesised that energy-adjusted nutrients may be a better measure of relative intake as the adjustment may partially correct for measurement error. It is interesting to note that in the present analysis a beneficial effect of energy adjustment was mainly seen in terms of the macronutrients which could be considered as directly contributing to total energy, whereas energy-adjusted micronutrients had, on the whole, similar or worse agreement. Notably, energy adjustment did not improve the correlations for protein intake, which may indicate that there are differential reporting errors across the macronutrients. Energy adjustment yielded a considerable improvement in the measures of agreement of total fat intake between the food group questionnaire and the 7-day diet diary such that an energy-adjusted total fat intake could be used in future studies. The results suggest that energy-adjusted nutrient analyses should be considered on a case-by-case basis, as it may be the situation that absolute intakes of nutrients are important aetiologically.

Capturing information on habitual diet is potentially subject to much measurement error, and therefore selecting only those nutrients that not only have a high rank correlation but also a small misclassification rate will go some way to minimise the impact that measurement error may have on detecting diet–disease associations. A major feature of the Million Women Study is the size of the population for which exposure information is available. Based on current response rates, the Million Women Study is likely to have dietary information on over 800 000 participants. While it is well known that measurement error not only attenuates a diet–disease relationship[2] but also reduces the power to detect the association[26], such a large sample size should allow the detection of relatively modest diet–disease effects.

Three other studies have examined the reproducibility of food group data[27–29]. Pietinen *et al.*[29] examined the proportion of participants falling in the same frequency of intake category for various food groups in a Finnish study. When the food group consumption data were categorised into tertiles, exact agreement between the two questionnaires was 36% on average; agreement was better for foods eaten daily such as potatoes or for foods eaten rarely such as kidney and liver dishes, wheat bran and germ. Ocke *et al.*[28] showed correlations for women ranging from 0.61 for vegetables to 0.91 for alcoholic beverages over 6 months and from 0.63 for fish to 0.92 for alcoholic beverages over 12 months. Bohlscheid-Thomas *et al.*[27] reported that median differences in intake over a 6-month comparison were within ±10% for half the food groups and that correlation coefficients ranged from 0.49 for bread to 0.89 for alcoholic beverages. Dietary pattern differences between these study groups may account for specific differences, but overall the results we present here fall within the range of reproducibility previously reported.

Brunner *et al.*[3] compared nutrient intakes estimated from a 7-day diet diary with those from an FFQ. For the women in their study (low energy reporters excluded), Spearman's rank correlations ranged from 0.22 for energy to 0.86 for alcohol, median of 0.37, comparable with our range from 0.16 for vitamin E to 0.75 for alcohol with a median value of 0.41. Brunner's group also examined agreement across quartiles of intake: exact quartile agreement achieved ranged from 29% for carotenes to 65% for alcohol, with a median of 35%; in our study we found exact agreement into tertiles ranged from 34% for vitamin E to 65% for alcohol, median value 47%. Willett *et al.*[30] also reported a comparison of nutrient data from an FFQ versus a diet diary. Comparing the average of four 7-day dietary records with the initial administration of an FFQ, Pearson correlation coefficients ranged from 0.18 for protein to 0.52 for sucrose with a median of 0.32.

In summary, the short, simple and easy-to-administer, computerised questionnaire used in this study has been shown not only to be reproducible over time but also to be reasonably accurate for the assessment of a number of dietary nutrients in comparison with a 7-day diet diary. This may permit future analyses into relationships between diet and disease by allowing individuals to be categorised by either their reported eating habits or their estimated nutrient intakes.

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Appendix – Short food group questionnaire used in the Million Women Study

1. Which types of meat do you eat about once a week or more often?
(you can cross more than one box)

beef	bacon	chicken/poultry	lamb
ham	pork	sausages	liver/pâté
beefburger/hamburger	kidney	never eat meat	

2. Which types of fish do you eat about once a week or more often?
(you can cross more than one box)

tuna	sardines	trout	'fish & chips'	salmon
other seafood	cod/haddock	mackerel	never eat fish	

3. About how many times each week do you eat:
(please count all meals and snacks; put '0' if less than once a week)

meat? ____ number of times eaten each week *(remember meat in sandwiches)*

fish/seafood?____ number of times eaten each week

chips? ____ number of times eaten each week

potatoes? ____ number of times eaten each week

pasta? ____ number of times eaten each week

rice? ____ number of times eaten each week

cheese? ____ number of times eaten each week *(remember cheese in pizzas, quiches, cheese sauce, etc.)*

4. About how many eggs do you eat each week?
____ number of eggs eaten each week *(remember eggs in omelettes, quiches, cakes, etc.)*

5. Which types of vegetables/salads (fresh, frozen or tinned) do you eat once a week or more often?
(you can cross more than one box)

green peas	tomatoes	green beans	broccoli	onions
cabbage	garlic	soya meat/tofu	carrots	swede
courgettes	spinach	cauliflower	beetroot	sweet corn
leeks	avocado	Brussels sprouts	parsnip	aubergine
lettuce	celery	cucumber	baked beans	mushrooms
chick peas/lentils	green/red peppers			

6. About how much do you eat each week of:
(put '0' if less than one)

cooked vegetables? ____ number of heaped tablespoons each week

salad items/raw vegetables? ____ number of heaped tablespoons each week *(please count lettuce, tomato, etc. in sandwiches)*

7. Which types of fruit do you eat once a week or more often, when in season?
(you can cross more than one box)

apples	bananas	oranges, satsumas, etc.
grapefruit	pears	stone fruit *(peaches, plums, nectarines, etc.)*

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8. About how much fruit or fruit juice do you eat or drink each week?
(count 10 grapes, berries or raisins as one piece; put '0' if less than one a week)

____ number of pieces of fresh fruit eaten each week
____ number of pieces of dried fruit eaten each week
____ number of glasses of fruit juice each week
____ number of tablespoons of stewed or tinned fruit eaten each week

9. About how many of the following do you eat?
(put '0' if less than one)

____ number of slices/pieces of white bread each week
____ number of slices/pieces of brown/wholemeal bread each week
____ number of crackers, crispbread, etc. each week
____ number of sweet biscuits each week
____ number of dairy desserts (yoghurts, etc.) each week
____ number of cakes, puddings, pies, buns, etc. each week
____ approximate number of pieces of chocolate (in any food or drink) each week
____ number of boiled sweets/peppermints etc. each week
____ number of tablespoons of nuts (including peanut butter) each week
____ number of tablespoons of gravy, cream/cheese sauces, etc. each week
____ number of tablespoons of jam/marmalade each week
____ number of bowls of breakast-type cereal each week

If you eat breakfast cereal is it usually:

bran cereal? *(All-Bran, Bran Flakes, etc.)* muesli? biscuit cereal? *(Weetabix, Shreddies, etc.)*
oat cereal? *(porridge, Ready Brek, etc.)* other?

10. Which type of spread do you use on bread, crispbread, etc., once a week or more often?
(you can cross more than one box)

butter	margarine	soft cheese	low-fat spread	mayonnaise
salad cream	olive oil spread	Marmite, etc.	rarely use spread	

Do you spread it:
(please cross)

thick? medium? thin?

Do you add butter, etc. to:
potatoes? other vegetables?

11. Which types of fats or oils do you use for cooking or salad dressing once a week or more often?
(you can cross more than one box)

butter	soft (tub) margarine	White Flora	olive oil
hard (block) margarine	lard/dripping	corn oil	sunflower oil
mayonnaise	soya oil	other vegetable oil	salad cream

Please put a cross in the box if you RARELY OR NEVER:
use fats or oils for cooking use salad dressing/cream

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12. Please put a cross in the box if you NEVER eat:

beef	pork/ham	lamb	dairy products
kidney	liver/pâté	sugar	wheat products
salami	sausages	eggs	beefburgers

13. Which type of milk or cream do you drink or use once a week or more often?
(you can cross more than one box)

full-cream	semi-skimmed	skimmed/fat-free	soya milk
single cream	double cream	dairy ice cream	never have milk/cream

14. Do you never/sometimes/usually/always:

add milk to your tea?	milk to your coffee?	add salt to your food?
remove fat from meat?	eat breakfast?	eat an afternoon snack?
eat organic food?		

15. Have you made any major changes to your diet in the last 5 years?
No Yes – because of illness Yes – for some other reason

16. About how much alcohol do you drink each week?
(one drink = a glass of wine, half pint of lager or tot of spirits; put '0' if you drink less than one drink each week)

number of drinks of alcohol each week

If you have more than one drink of alcohol each week:

is it usually with meals?	no/yes/it varies
on how many days each week do you usually drink?	_____ days each week

17. About how much do you drink EACH DAY of:

cups of	_____tea?	_____ milk, hot chocolate, etc.?	_____ coffee?
glasses of	_____ fizzy/soft drink?	_____water?	_____ fruit squash?

18. How many teaspoons of sugar do you add to tea, coffee, cereal, fruit, etc. EACH DAY?

____ number of teaspoons of sugar each day

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