



Food Frequency Questionnaires

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Abstract

Food Frequency Questionnaires are dietary assessment tools widely used in epidemiological studies investigating the relationship between dietary intake and disease or risk factors since the early '90s. The three main components of these questionnaires are the list of foods, frequency of consumption and the portion size consumed. The food list should reflect the food habits of the study population at the time the data is collected. The frequency of consumption may be asked by open ended questions or by presenting frequency categories. Qualitative Food Frequency Questionnaires do not ask about the consumed portions; semi-quantitative include standard portions and quantitative questionnaires ask respondents to estimate the portion size consumed either in household measures or grams. The latter implies a greater participant burden. Some versions include only close-ended questions in a standardized format, while others add an open section with questions about some specific food habits and practices and admit additions to the food list for foods and beverages consumed which are not included. The method can be self-administered, on paper or web-based, or interview administered either face-to-face or by telephone. Due to the standard format, especially closed-ended versions, and method of administration, FFQs are highly cost-effective thus encouraging its widespread use in large scale epidemiological cohort studies and also in other study designs. Coding and processing data collected is also less costly and requires less nutrition expertise compared to other dietary intake assessment methods. However, the main limitations are systematic errors and biases in estimates. Important efforts are being developed to improve the quality of the information. It has been recommended the use of FFQs with other methods thus enabling the adjustments required.

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MÉTODOS DE FRECUENCIA DE CONSUMO ALIMENTARIO

Resumen

Los cuestionarios de frecuencia de consumo son herramientas ampliamente utilizadas en los estudios epidemiológicos que investigan la relación entre ingesta dietética y enfermedad o factores de riesgo desde comienzos de la década de los 90. Los tres componentes principales de estos cuestionarios son la lista de alimentos, la frecuencia de consumo y el tamaño de la ración consumida. La lista de alimentos debe reflejar los hábitos de consumo de la población de estudio en el momento en que se recogen los datos. La frecuencia de consumo puede preguntarse de forma abierta u ofreciendo categorías de frecuencia de consumo. Los cuestionarios cualitativos no preguntan por la ración consumida; los semi-cuantitativos presentan raciones estándar y los cuestionarios cuantitativos solicitan al encuestado que estime el tamaño de la ración consumida en medidas caseras o en gramos. Esta última opción supone un esfuerzo importante para el participante. Existen versiones exclusivamente cerradas en un formato estandarizado y otras que incorporan preguntas abiertas sobre algunos hábitos y prácticas alimentarias específicas y permiten añadir alimentos y bebidas consumidos que no están incluidos en la lista. Pueden ser auto-administrados, en papel o en soporte web, o bien mediante entrevista personal o telefónica. Por su formato estandarizado, especialmente los cerrados, y por la forma de administración, son un método con un alto rendimiento en términos de coste-efectividad que ha favorecido su extendido uso en grandes estudios epidemiológicos de cohortes y también con otros diseños. También el coste de codificación y proceso de la información recogida resulta menos costoso y requiere menos experiencia en temas nutricionales que otros métodos de evaluación de la ingesta. Sin embargo, presenta el inconveniente de incorporar errores sistemáticos y sesgos importantes, por lo que en la actualidad se buscan procedimientos para mejorar la calidad de la información y se recomienda utilizarlos junto a otros métodos que permitan realizar los ajustes necesarios.

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Palabras clave: *Hábitos alimentarios. Evaluación ingesta dietética. Error validez. Estudios poblacionales.*

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Abbreviations

FFQ: Food Frequency Questionnaire.

HDL: High Density Lipoprotein.

EPIC: European Prospective Investigation into Cancer and Nutrition.

NCI: National Cancer Institute.

DHQ: Diet History Questionnaire.

Introduction

Food Frequency Questionnaires (FFQ) are an advanced form of the diet history method aimed to assess habitual diet by asking how often and how much of selected food items or specific food groups included in a list are consumed over a reference period^{1,2}.

This method was originally designed to provide descriptive qualitative information about food-consumption patterns and later developed to provide nutrient information by specifying an average portion size. According to the interests of the researchers, FFQs may focus on the intake of specific nutrients, dietary exposures related to a certain disease, or comprehensively assess various nutrients¹⁻³.

Instruments including about 100 to 150 food items take 20-30 minutes to complete and can be completed during an interview or can be self-administered. Thus, this method enables the assessment of long term dietary intake in a relative simple, cost-effective and time-efficient manner²⁻⁴.

FFQs have been widely used in epidemiological studies investigating links between diet and disease. For this purpose it is more important to rank the intake of individuals in comparison to others in the population as high, medium, or low intake or as quantiles of the distribution of intake, than to determine the absolute intake^{3,5,6}. In large epidemiological studies, data on diet from FFQs are compared with specific disease outcomes like cancer diagnosis, or risk factors for disease such as total or HDL-cholesterol levels. FFQs may also be used to identify food patterns associated with inadequate intakes of specific nutrients³.

Components of FFQs

The main components of FFQs are the food list, the frequency of consumption in time units and the portion size consumed of each item.

The food list

The food list should be clear, concise, structured and organized in a systematic way^{2,3}. It can be newly designed specifically for the study or can be modified from an existing instrument, but in that case it must be adapted and validated for the study population. FFQs

may consist of an extensive or a relatively short list of food items. The foods included should be major sources of a group of nutrients of particular interest for the purpose of the study in which the instrument is to be used or foods which contribute to the variability in intake between individuals in the population. Additionally, should be foods commonly consumed in the study population^{2,3,7,8} and reflect the food habits and common practices in that particular group. The length of the food list can range from about 20 to 200 items.

FFQs should be developed specifically for each study group and research purposes because diet may be influenced by ethnicity, culture, an individual's preference, economic status, etc. and the appropriateness of the food list is essential in this method of diet assessment^{3,7-10}.

FFQs can ask the respondent to report either a combined frequency for a particular food eaten both alone and in mixtures or separate frequencies for each food use^{3,4,10}. However, people who is not used to cook or prepare meals may find it difficult to identify the ingredients involved in mixed dishes and it is likely to ignore how often consume certain food items.

Each quantitative FFQ must be associated with a food composition database to allow for the estimation of nutrient intakes for the either assumed or reported portion size of each food item included^{3,11,12}. Such a database is created using quantitative dietary intake information from the target population to estimate the typical nutrient density of a particular food group category. A mean or median nutrient composition is estimated based on the individual food codes reported in a population survey. In this case, dietary analyses software, specific to each FFQ, is used to compute nutrient intakes for individual respondents^{11,12}.

Comprehensive FFQ instruments designed to assess total diet generally list more than 100 food items, many with additional portion size questions, requiring 30 to 60 minutes to complete. This raises concern about length and its effect on response rates. Balance between length and specificity of the food list is required^{3,7-10,13}. Optically scanned instruments require the use of closed-ended response categories forcing a loss in specificity.

Frequency of consumption

Frequency of consumption is assessed by a multiple response grid or independent questions asking respondents to estimate how often a particular food or beverage is consumed^{2,3}. Frequency categories range from never or less than once per month up to 6 or more times per day and respondents have to choose one of these options. Most FFQs collect data using nine possible responses. Various answer choices have been used to improve data quality and reduce the burden on the subjects¹³.

The reference period for which the frequency of consumption is asked can be variable, but usually fo-

cuses over the past six months or the past year, but it is possible to ask about the past week or month depending on specific research situations. Even when respondents are asked about intake over the past year, some studies indicate that the season in which the questionnaire is administered influences reporting over the entire year^{3,14}.

The format of independent questions can be variable. Sometimes multiple choice questions are used, with an optimal number of 5 to 10 closed, exhaustive and mutually exclusive answer options (Fig. 1). In other cases, partly open answer formats are used, requesting for the frequency of consumption daily, weekly, monthly or yearly (Fig. 2). This allows for more flexibility and can contribute to reduce misclassification error^{14,15}.

For foods eaten seasonally, subjects are typically asked how frequently and over what duration they ate these seasonal foods. In some cases, the frequency of consumption is averaged for the whole length of the reference period. For frequently consumed foods such as coffee, answers are collected directly as an open-ended question in some FFQs.

Portion sizes commonly eaten

Qualitative FFQs do not ask respondents about portions commonly used. Conversely, quantitative FFQs try to estimate the portion size commonly used for each food item listed and then household measures, food models or other aids may be required for that purpose. Semi-quantitative FFQs include reference portion sizes and respondents are asked how often they consume the specified portion of a particular food or beverage or to assess their usual portion size based on a specified measure.

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Algunas preguntas sobre lo que su hijo/a suele comer habitualmente

(Marque solo 1 respuesta para cada pregunta)

F1 ¿Con qué frecuencia suele comer su hijo/a fruta?

Nunca

Menos de 1 vez a la semana

1 día a la semana

2-4 días a la semana

5-6 días a la semana

Todos los días, 1 vez al día

Todos los días, 2 veces al día

Todos los días, más de 2 veces al día

F2 ¿Con qué frecuencia suele comer su hijo/a ensalada, verduras crudas o ralladas (zanahora, remolacha, etc.)?

Nunca

Menos de 1 vez a la semana

1 día a la semana

2-4 días a la semana

5-6 días a la semana

Todos los días, 1 vez al día

Todos los días, 2 veces al día

Todos los días, más de 2 veces al día

F3 ¿Con qué frecuencia suele comer su hijo/a verduras cocidas?

Nunca

Menos de 1 vez a la semana

1 día a la semana

2-4 días a la semana

5-6 días a la semana

Todos los días, 1 vez al día

Todos los días, 2 veces al día

Todos los días, más de 2 veces al día

F5 ¿Con qué frecuencia suele comer su hijo/a patatas fritas?

Nunca

Menos de 1 vez a la semana

1 día a la semana

2-4 días a la semana

5-6 días a la semana

Todos los días, 1 vez al día

Todos los días, 2 veces al día

Todos los días, más de 2 veces al día

F6 ¿Con qué frecuencia suele comer su hijo/a legumbres, como lentejas, garbanzos, alubias?

Nunca

Menos de 1 vez a la semana

1 día a la semana

2-4 días a la semana

5-6 días a la semana

Todos los días, 1 vez al día

Todos los días, 2 veces al día

Todos los días, más de 2 veces al día

Fig. 1.—Sample of a Qualitative Food Frequency Questionnaire with close-ended frequency range answer options used in PERSEO Project to assess diet of school children. Parents or guardians were invited to fill in the form.

It is controversial whether FFQs should use portion size questions, since reporting portion sizes poses additional respondent burden³. Frequency has been reported to be a greater contributor than typical serving size to the variance in intake of most foods, but other authors cite small improvements in the performance of FFQs that ask the respondents to report a usual serving size for each food^{13,15}. Some research has been conducted to determine the best ways to ask about portion size on FFQs. Nevertheless the marginal benefit of such information in a particular study may depend on the objectives of the study and population characteristics¹³⁻¹⁷.

Some FFQs may include supplementary questions on cooking methods and specific types of fat, bread, milk and condiments or additions to foods such as salt. Brand name information may also be requested^{8,13,15}. Other FFQs may have an open-ended section where respondents may record consumption of other foods not included on the food list. This ensures that the total diet of the individual is captured and may also help to identify those whose diet is very unusual, for whom the FFQ may not be appropriate.

Processing of data from food frequency questionnaires require some analytical decisions, such as how to handle missing data, either to assign null values or to assign the median value from those who did provide valid answers. Both approaches have been found equivalent in terms of introducing bias into relative risk estimates^{3,18,19}.

Uses

FFQs can be self-administered using paper or web-based formats, or interviewer administered, either face-to-face or telephone interview. Many food

CB CUESTIONARIO FRECUENCIA DE CONSUMO

CB.1 Algunas preguntas sobre lo que suele comer Usted habitualmente. (Fíjese en los alimentos y bebidas que ha consumido de forma habitual, como promedio, en los últimos 12 meses. Para las frutas, verduras y otros productos de consumo estacional piense en su consumo en ese período del año. (Use alimentos que consume de cada uno de los grupos que mencionamos a continuación). ¿con qué frecuencia lo consume como promedio? ¿cuánto día que se lo saca más habitual? díjeme que es grande, mediano o pequeño y durante el último año, lo ha consumido con mayor frecuencia o cantidad, menos o igual que antes?

ALIMENTOS	¿COME?		SI LA RESPUESTA ES 'SI' ¿COME			TAMANO RACIÓN			Tendencia personal		
	SI	NO	VECES/DIA	VECES/SEMANA	VECES/MES	P	M	G			
A1 CARNES TOTAL	1	2				1	2	3	1	2	3
A.1 Pollo, pavo	1	2				1	2	3	1	2	3
A.2 Vacuno-tercera	1	2				1	2	3	1	2	3
A.3 Vacuno-buzy	1	2				1	2	3	1	2	3
A.4 Cerdo	1	2				1	2	3	1	2	3
A.5 Cordero, cabrito	1	2				1	2	3	1	2	3
A.6 Conejo	1	2				1	2	3	1	2	3
A.7 Caza (corzo, jabalí, faisán...)	1	2				1	2	3	1	2	3
A.8 Vísceras (hígado, corazón...)	1	2				1	2	3	1	2	3
A.9 Carne picada	1	2				1	2	3	1	2	3
A.10 Salchichas, hamburguesas	1	2				1	2	3	1	2	3
A.11 Mantequilla	1	2				1	2	3	1	2	3
A.12 Jamón York	1	2				1	2	3	1	2	3
A.13 Fiambre de pavo	1	2				1	2	3	1	2	3
A.14 Jamón serrano	1	2				1	2	3	1	2	3
A.15 Chistorra, salchichón, mortadela	1	2				1	2	3	1	2	3
A.16 Embutidos bajos en sal	1	2				1	2	3	1	2	3
A.17 Pato, filetes grasos	1	2				1	2	3	1	2	3
A.18 Otros tipos de productos cárnicos	1	2				1	2	3	1	2	3

Fig. 2.—Example of a semiquantitative Food Frequency and propensity Questionnaire with open-ended options to answer frequency used in ENPE study. Data collected in a face-to-face interview. P: pequeña (small); M: Media (medium); G: grande (large).

frequency instruments are designed to be self-administered and are either optically scanned paper version or web based. Require 30 to 60 minutes to complete depending on the instrument and the respondent and use a standard format, which reduces the time required for processing data.

For these reasons FFQs are one of the most commonly used retrospective methods in nutritional epidemiology, in a wide range of dietary study designs, as a research tool in examining the relationship between dietary intake and disease risk. Large-scale cohort studies²⁰⁻²² such as the European Prospective Investigation into Cancer and Nutrition (EPIC) have used the method²³. In the EPIC study, the FFQ instrument was specifically adapted to each country^{24,25}. However, large cohort studies can last for several decades and it is likely that food habits and practices change or new products enter within that period, and the food list may need to be revised and updated to be useful. These changes can make comparisons between observations at different time points in the study more difficult.

Despite FFQs can be designed to assess specific nutrients such as calcium or vitamin D, it is often required to assess the whole diet to obtain estimates of energy intake needed for adjustment and to estimate mis-reporting^{3,6,18,19}.

FFQs can also be used to identify food patterns associated with inadequate intakes of specific nutrients by using adequate statistical analysis.

Validity

FFQs should be evaluated for their accuracy before being used. Correlation coefficients ranging from 0.5 to 0.7 are considered moderate. Table I shows correlation coefficients ranges observed in a number of validation studies of FFQs since de '80s and the reference method used. Since FFQs are often designed to assess the ranking of intakes within a population, they cannot be relied on to produce reliable estimates of absolute intake. Over-estimation is common, particularly for

Table I
Selected validation studies of FFQs: population, items, procedure and reference method

<i>Authors</i>	<i>Population</i>	<i>Number of items</i>	<i>FFQ</i>	<i>Reference method</i>	<i>Number of days repetition</i>	<i>Correlations range</i>
Bohlscheid-Thomas, 1997	49 men, 55 women	104	Self	24-HR	12× in 1 y	
Boucher, 2006	166 women	126	Self	24-HR	2×	
Flagg, 2000	216 men, 223 women	114	Self	24-HR	4× in 1 y	
Jain, 2003	151 men, 159 women	166	Self	24-HR	3× in 1 y	
Johansson, 2002	96 men, 99 women	84	Interview	24-HR	10× in 1 y	
Katsouyanni, 1997	42 men, 38 women	190	Self	24-HR	12× in 1 y	
Kroke, 1999	75 men, 59 women	146	Self	DLW; 24-HR	14 d; 12× in 1 y	0,42 energy - 0,69 alcohol
Ocke, 1997	63 men, 58 women	178	Self	24-HR	12× in 1 y	
Pisani, 1997	47 men, 150 women	47	Self	24-HR	8–14× in 1 y	
Subar, 2001 (Block FFQ)	247 men, 267 women	106	Self	24-HR	4× in 1 y	
Subar, 2001 (DHQ)	501 men, 560 women	124	Self	24-HR	4× in 1 y	
Subar, 2001 (Willett FFQ)	254 men, 293 women	126	Self	24-HR	4× in 1 y	
Subar, 2003	261 men, 223 women	124	Self	DLW; 24-HR	14 d; 2× in 3 m	
van Liere, 1997	123 women	238	Self	24-HR	12× in 1 y	
Feunekes, 1993	95 men, 96 women	104	Interview	DH*	1 × 1 m	0,77 energy
Jain et al, 1982	50 women	69	Self	DH*	DH	0,50 cholesterol - 0,64 energy
Andersen, 2003	17 women	180	Self	DLW*	10 d	

Table I (cont.)
Selected validation studies of FFQs: population, items, procedure and reference method

Authors	Population	Number of items	FFQ	Reference method	Number of days repetition	Correlations range
Andersen, 1999	125 men	180	Self	FR*	14 d in 5 w	
Barasi et al 1983	103 women	27	Self	FR	4 d	
Bingham, 1997	156 women	130	Self	FR	4 × 4 d in 1 y	
Block, 1990	102 women	60	Self	FR	2 × 7 d	
Block, 1992	85 men and women	98	Interview	FR	4 × 3 d in 1 y	
Brunner, 2001	457 men, 403 women	127	Self	FR	7 d	
Callmer, 1993	57 men, 50 women	250	Self	FR	6 × 3 d in 1 y	
Engle, 1990	16 men, 34 women	120	Self	FR	7 d	
Fidanza, 1995	11 men, 35 women	93	Self	FR	7 d	
Goldbohm, 1994	59 men, 50 women	150	Self	FR	3 × 3 d in 1 y	
Hartwell, 2001	16 men, 9 women	162	Self	FR	2 × 4 d	
Larkin, 1989	228 men and women	116	Interview	FR	16 d in 1 y	
Longnecker, 1993	64 men, 74 women	116	Self	FR	3 × 2 d or 2 × 2 d	
Mannisto, 1996	152 women	110	Self	FR	2 × 7 d in 3 m	0,77 energy
Martin-Moreno, 1993	147 women	118	Self	FR	4 × 4 d in 1 y	0,50 cholesterol - 0,64 energy
McKeown, 2001	58 men, 88 women	130	Self	FR	2 × 7 d	
Munger, 1992	44 women	126	Self	FR	3 d	
Patterson, 1999	113 women	122	Self	FR	4 × 4 d	
Pietinen et al 1988	190 men	276	Self	FR	12 × 2 d in 6 m	
Pietinen et al 1988	190 men	44	Self	FR	12 × 2 d in 6 m	
Riboli, 1997	57 men, 50 women	350	Self	FR	6 × 3 d in 1 y	
Rimm, 1992	127 men and women	131	Self	FR	2 × 7 d in 6 m	
Schroder, 2001	44 men and women	157	Self	FR	3 d	
Stuff et al, 1983	40 pregnant women	105		FR	7 d	
Tjonneland, 1991	59 men, 85 women	92	Self	FR	2 × 7 d	
Willett, 1985	173 women	61	Self	FR	4 × 7 d in 1 y	
Willett, 1988	150 women	116	Self	FR	4 × 7 d, 3–4 y before	
Yarnell, 1983	119 men	54	Self	FR	7 d	

24HR: 24 Hour recall; FR: food record; DLW; Doubly labelled water; d: day; y: year. Modified from: Molag ML et al. 2007¹³.

foods eaten less often or for foods perceived as ‘healthy’ such as fruit and vegetables. There is some evidence that over-estimation increase with the length of the food list^{3,26-28}.

Validation studies of various FFQs using biomarkers have found large underestimates of self-reported energy intake and some underestimation of protein intake. Correlations of FFQs and the biomarkers ranged from 0.1 to 0.5 for energy and from 0.2 to 0.7 for protein^{26,28}. These results suggest that the measurement error associated with FFQs is larger than was previously estimated.

Various statistical methods employing measurement error models and energy adjustment are used to assess the validity of FFQs but also to adjust estimates of relative risks for disease outcomes^{6,19}. Analyses comparing relative risk estimation from FFQs to dietary records in prospective cohort studies indicate that observed relationships using an FFQ are severely attenuated, thereby obscuring associations that might exist²⁹. Controversy about error in FFQs has raised a debate considering alternative methods of collecting dietary data in large-scale prospective studies. In particular, the association between dietary fat consumption

and breast cancer is controversial and limitations of FFQs have been questioned³⁰⁻³².

For any study, the advantages and disadvantages of using FFQs compared to other dietary assessment methods should be carefully considered. It has been suggested that using a combination of methods, such as FFQ with dietary records or 24 hour recalls, or FFQ with biomarker levels provide more accurate estimates of dietary intakes than individual methods^{4,33}.

Several researchers have explored the use of cognitive interviewing techniques to increase the validity of self-reported data. Respondents are encouraged to verbalize their thought processes as they retrieve information from long-term memory to answer questions on the FFQ and then identify difficulties in formulating answers to specific questions, such as intake of seasonal foods or estimating portion sizes^{34,35}.

Qualitative study methods inform that several factors can influence individuals' perception of portion size, including; the type of food being considered, the role of a given food item in the meal (i.e. as a main or a side dish) and personal preference for the food. Cognitive research has also indicated that the level of grouping of foods can affect the recall of food intake and that respondents find it easier to respond to items when disaggregated, but this needs to be balanced with the disadvantages of longer food lists and the likelihood of over-estimation of intake and additional respondent burden^{34,35}.

Advantages and limitations of the method

Table II summarizes main pros and cons of Food Frequency Questionnaires. FFQs can be self-administered using paper or web-based formats thus reducing data collection costs. Paper forms are often designed to be optically scanned so that data can be entered and analyzed in a comparatively short period of time, often in an automated process, allowing dietary data on a large number of people to be collected relatively inexpensively. There is also less need for nutritional expertise in data entry.

Additional advantages of FFQs include low respondent burden compared to other methods. Frequency questionnaires assess habitual consumption over an extended period of time. More complete data may be collected if the FFQ is interviewer administered, but respondent bias may be less if self-administered. FFQs can be designed to focus on a particular group of foods or to assess the whole diet, including portion size estimates that can be used to obtain absolute nutrient intakes.

When an open section is included respondents can record consumption of foods which are not included on the food list. Sometimes include separate sections asking about consumption of seasonal foods, cooking procedures or additions to foods such as sauces and condiments.

The major limitation of the food frequency method is that it contains a substantial amount of measurement

Table II <i>Advantages and limitations of Food Frequency Methodology</i>	
<i>Advantages</i>	<i>Limitations</i>
Can be self-administered	Marked frequency of consumption and portion size may not represent usual intake of respondent Requires certain literacy and cognitive skills Often incomplete data is collected
Can be optically scanned	Effort and time consuming instrument design
Modest respondent burden	Depends on the respondents ability to describe diet
Relatively low cost for large scale studies	Relatively low cost for large scale studies
May be a better representation of usual dietary patterns than only a few days of observation	Particularly complex for children and elderly people
Instrument design can be based on population data	Memory of diet in the past may be biased by present diet
Does not influence dietary behaviour	Sometimes limited precision in estimates and quantifying food portion sizes
Classify individuals in food consumption categories	
Does not require deeply trained interviewers	
Easy to code and viable for automated processing if closed-ended	
Web-based administered improve the quality of collected data. Can add help aids, additional models and information.	Requires computer and internet access Requires web navigation skills Persist systematic errors inherent to the method Response bias Security risk for study data

error. Many details of dietary intake are not measured, and the quantification of intake is not as accurate as with recalls or records. Inaccuracies result from an incomplete listing of all possible foods and from errors in frequency and usual serving size estimations. A comprehensive list of all foods eaten cannot be included and reported intake is limited to the foods contained in the food list. Accurate reporting relies on respondent memory. Bias may be introduced with respondents reporting eating according to social desirability, thus resulting in over-estimation of certain foods and under-estimation of other items. A relatively high degree of literacy and numeracy skills are required if self-administered. Interviewers can help overcome this problem^{3,4}.

The serving size of foods consumed is difficult for respondents to evaluate in all assessment instruments, but attempting to estimate usual serving size in FFQs may be even more complex because a respondent is asked to estimate an average for foods that may have highly variable portion sizes depending on eating occasions. The use of small, medium and large to describe portion size may not have a commonly accepted meaning^{34,35}.

FFQs developed in one country or for a specific subpopulation are unlikely to be appropriate for use in another, since dietary habits differ. The same problem arises due to ethnical and cultural differences in a population.

Pre-prepared meals such as ready meals or take-away foods may not be easy for respondents to classify if the food list is based on more basic food categories, but grouping of foods into individual items may make answering some questions problematic. Validity can vary widely between foods and nutrients from the same FFQ

Recommendations and suggested improvements

Innovative FFQs are web-based. However, measurement errors in such instruments are most likely similar to those in conventional paper-based Food Frequency Questionnaires, suggesting that the underlying methodology is unchanged by the technology. New instruments such as the web-based version of the National Cancer Institute's (NCI) 124-item diet history questionnaire (Web-DHQ) include digital photographs to estimate portion sizes. Moderate-to-a-very good correlation has been assessed indicating reproducibility was observed between the NCI's Web-DHQ and its original paper version (Paper-DHQ)¹⁵.

The strengths of these innovative alternatives include data consistency and completeness through technical requisites, particularly in larger, geographically dispersed or multi-centric study populations. Innovative technological alternatives of the FFQs may have greater potential to overcome some of the completion difficulties that have been reported in the cognitive

research about conventional paper-based FFQs. Implementing digital pictures, for example, may improve the food identification. Also, certain technical functionalities can facilitate the skipping to more tailored questions at individual level or provide explanations on how to answer questions appropriately^{3,4,15}.

It has been suggested that in addition to focusing attention on trying to measure nutrients, also formulate hypotheses in terms of dietary behaviors including questions about usual dietary practices. Such questions may be more easily and accurately recalled than the frequencies and portion sizes of a long list of foods^{34,35}.

When FFQs are interviewer administered, interviewers should be properly trained to conduct the interview and to provide adequate information to participants either if the interviews are conducted face-to-face or by telephone. Appropriate ways of asking the questions and recording the answers need to be considered, particularly for telephone interviews that require full attention through the whole duration of the questionnaire. When the respondents are children, elder or handicapped people, parents, guardians or carers have to be present.

Standardised operating procedures are required for data checking, cleaning and analysis.

Some large epidemiological studies have implemented short-term dietary assessment methods, either as reference calibration method in a sub-sample or as main dietary assessment method for the entire population, given the debate about the accuracy of FFQs in ranking the individuals according to their usual dietary intake because methodological limitations. There is cumulated evidence that repeated open-ended quantitative 24-hour dietary recalls or food records may outperform the FFQ in assessing accurately individual usual intake. The complementation of the repeated short-term quantitative measures with the non-quantitative information on usual consumption (e.g. from non-quantitative FFQs, defined as Food Propensity Questionnaires or FPQs) and/or biomarkers and integrated with statistical modelling, may yield more accurate individual usual dietary intake estimates¹⁵. This may particularly provide less biased estimates for the intake of infrequently consumed foods that are often missed in the short-term dietary measures.

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