Development of the Melbourne FFQ: a food frequency questionnaire for use in an Australian prospective study involving an ethnically diverse cohort

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Objective. To develop an optically scannable food frequency questionnaire (FFQ), 'The Melbourne FFQ', suitable for classifying Australian-, Greek- and Italian-born individuals into quantiles of intake for a range of foods and nutrients. The FFQ would provide the primary measure of dietary exposure in a prospective cohort study.
Design. The FFQ was modelled on that used for the (US) Nurses' Health Study. Food items were chosen on the basis of their relative contribution to the intake of a range of nutrients computed from weighed food records.
Setting. Metropolitan Melbourne, Australia; a city of 3 million people, of whom 75.5% were born in Australia, 2.7% were born in Italy and 1.7% were born in Greece.
Participants. *Weighed Food Survey (1987–1989):* A volunteer sample of 810 healthy middle-aged (40–69 years) men and women of whom 35% were born in Greece, 33% were born in Italy, and 32% were born in Australia. *Melbourne Collaborative Cohort Study (1990–1993):* A volunteer sample of 17 949 healthy men and women aged between 40 and 69 years of whom 61% were born in Australia, 21% were born in Italy and 17% were born in Greece.
Results. A 121 item FFQ was developed, together with a customized nutrient database. The optical scanning format was generally well received with the majority of subjects requiring no assistance. The FFQ appeared to overestimate the consumption of fruit and vegetables.
Conclusions. The Melbourne FFQ provides a convenient method of measuring habitual dietary intake in a large population setting. A separate study is required to assess how well the instrument characterizes diet at the level of the individual.

Introduction

Large, longitudinal epidemiological studies of diet and health require accurate ordinal classification of individuals with respect to selected characteristics of their habitual diet. This can only be achieved economically by the use of a food frequency questionnaire (FFQ)[1] but at the time the Melbourne Collaborative Cohort Study (MCCS) was conceived[2], no Australian FFQ had been validated. Although one had been shown to have an acceptable degree of repeatability[3], it would have been improvident or venturesome to use that instrument in the MCCS which was designed to take advantage of the breadth of dietary exposures likely to be accomplished by the inclusion in the cohort of a large proportion of migrants from Greece and Italy[4].

The Weighed Food Survey (WFS) was thus undertaken with one aim being to develop an FFQ capable of correctly classifying men and women from Greek, Italian and Anglo-Celtic Australian backgrounds into quantiles of intake for a range of foods and nutrients suspected of having a role in the pathogenesis of cancer, heart disease, stroke, diabetes and premature death. Additional considerations were that the FFQ needed sufficient detail to allow quantitative assessment of dietary intake, yet be simple enough to enable self-administration in any of three languages in a format suitable for optical scanning[5]. Four other issues needed to be resolved in the development of the FFQ: the choice of frequency response options; whether questions were to be asked about portion sizes; which food items were to be included; and which nutrient database was to be used in the analysis. The first two points had straightforward solutions. The nine frequency response options used in the Nurses Cohort Study[5] were adopted. For simplicity, and because frequency was more discriminatory than portion size in the Nurses' Health Study[6], no information about usual portion size was sought.

Selection of the food list and the nutrient database were more complex matters. The inclusion of subjects

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from different ethnic backgrounds presented problems when formulating the list of food items required to classify subjects according to their usual diet. A fundamental tenet of the MCCS was that the cohort had to be considered as a single entity, rather than a collection of different ethnic sub-cohorts. Following this reasoning, an instrument was required that enabled the most accurate possible ranking of individuals by exposure irrespective of their ethnic background. Nonetheless, the food list could have become forbidding in length if it included every item that a proportion of subjects from each ethnic group might have been expected to eat. Additionally, the questionnaire could have lost face validity if subjects were asked how often they ate numerous items with which they were unfamiliar. Some information was available regarding the eating patterns of Italian- and Greek-born Australians[7,8]. As with the 1983 National Dietary Survey of Adults (NDSA)[9,10], these studies were useful for the purpose of identifying relevant foods but were unable to provide measures of individual variability (or dispersion) as they all relied on 24-hour recall data. In addition, the published analyses of the NDSA did not distinguish the specific country of birth of southern European-born migrants, presumably because the numbers were too small. It was therefore considered necessary to obtain records of weighed food intake from a sample of Italian-, Greek- and Australian-born men and women to use in the formulation of the Melbourne FFQ food list.

Methods

Study population and recruitment

As there is only limited geographic clustering of Melbourne residents by birthplace, and as there is no population register of residents by place of birth, it was considered impossible to recruit random samples. It was also deemed desirable to obtain samples of persons likely to want to participate in a long-term study of health. The WFS population, therefore, consisted of a volunteer sample of 810 healthy men and women aged between 40 and 69 years who were living within the Melbourne Statistical Division and were born in Australia or had entered Australia on an Italian or Greek passport – referred to throughout as Australian-, Italian-, and Greek-born. (The latter included some ethnic Greeks born in Egypt and Cyprus.) The same eligibility criteria applied to subjects enrolled in the MCCS.

Assistance with recruitment was provided by established network within the local Italian and Greek communities. Talks were given to church congregations, regional clubs and people attending centres providing assistance to migrants. Articles were written in the ethnic and commercial radio programmes and awareness was spread further by word of mouth. Most of the Australian-born subjects in the WFS responded to an advertisement in a major metropolitan daily newspaper whereas most of the participants in the MCCS responded to personally addressed invitation letters produced from the rolls of the Australian Electoral Commission.

Weighed food records

Upon enrolment into the WFS, subjects were visited at home by a bilingual research assistant who demonstrated the food weighing technique and explained how the diet record booklets were to be complete. Subjects were asked to weigh individual food items separately and record the weight of foods in the form that they were eaten. Serve size was recorded each time a particular food or drink was consumed. Subjects were also asked to provide recipes for cooked dishes.

Weighed food records (WFRs) were kept on two occasions, each of four days duration, at least six weeks apart. To ensure that each day of the week was covered, subjects were randomized to begin their first 4-day WFR on either a Sunday or a Wednesday. Subjects who completed the first WFR from Sunday to Wednesday, completed the second from Wednesday to Saturday and vice versa. The completed WFRs were returned by mail in pre-paid envelopes. The WFRs of the Greek-born subjects were conducted between November 1987 and July 1988, those of the Italian-born subjects were conducted between May and December 1988 and the Australian-born subjects completed their WFRs between October 1988 and March 1989.

Most of the WFRs of the Italian- and Greek-born subjects required translation prior to coding, as did the recipes which were used to estimate the nutrient content of items not already available on the nutrient database. The WFRs were coded as precisely as the information provided would allow, but a standard item was coded in cases where the description was not specific. For example, if the description was simply 'roast chicken', the standard item 'roast chicken, meat and skin' was assumed.

At the time the WFRs were coded (December 1989 to February 1990) the Australian Food Composition Tables (NUTTAB) had only just been released[11]. The list of foods for which complete data was available was inadequate so we used the British nutrient database McCance and Widdowson's The Composition of Foods[12], which we supplemented with certain local foods[11]. The nutrient content of some further items was estimated from recipes provided by the Italian- and Greek-born subjects. These values were added to the database together with the nutrient content of some Greek composite dishes supplied by the author of the Greek Food Composition Table[13].

Selecting items for inclusion on the FFQ

When compiling the list of food items for inclusion on the FFQ, it was necessary to combine similar foods and drinks. Decisions regarding food combinations were largely based on those used in previous US[14,15] and UK[16] studies. Additionally, a cluster analysis was performed on the nutrient database to provide a further objective means of collapsing nutritionally comparable items into a smaller number of common groupings. We refer to the abridged food classifications as categories, rather than groups, because some comprise a single food. Altogether 911 unique food items were coded in the WFRs. Each item was assigned to one of 168 discrete WFR categories. These WFR categories were then ranked, separately for each nutrient, according to their contribution to the overall intake within each of the six sex-ethnicity strata (Tables 1 and 2). In principle, a WFR category was included on the FFQ if it contributed to the first 80% of the cumulative intake for at least one nutrient for at least

Table 1. Percentage of energy intake from major* food sources: Weighed Food Survey, 1987–1989.

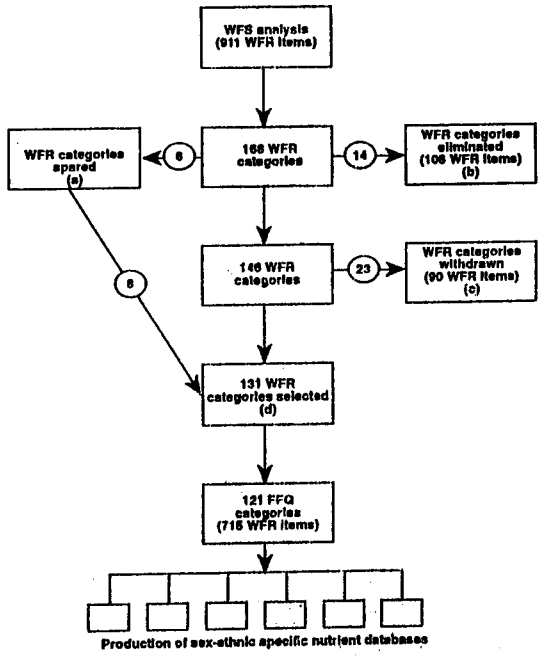
	Australian-born		Greek-born		Italian-born	
	females	males	females	males	females	males
Number of subjects	163	99	151	130	147	120
WFR category						
white bread	4.7	4.9	8.9	11.0	10.5	13.5
pasta or noodles	1.4	1.3	3.1	3.5	7.4	8.1
wholewheat or rye bread	5.6	6.3	3.2	4.1	2.6	2.5
cheeses *(excluding fetta)*	2.5	2.6	1.9	2.3	4.1	3.7
cakes	4.0	3.9	2.3	2.0	2.5	1.8
beef or veal, grilled or fried	1.6	2.2	2.0	3.4	3.5	3.3
milk, full cream	3.3	2.9	3.0	2.9	1.7	1.6
chicken, roast or fried	2.3	2.0	3.1	3.0	2.6	1.9
lentil or bean soup			2.6	2.9	3.9	4.0
olive oil *(as a seasoning)*			2.8	2.5	4.5	3.5
lamb, chops or roast	2.4	2.1	2.7	4.0	0.7	0.9
biscuits, plain	1.3	1.5	2.0	1.2	3.0	2.3
sugar	1.7	2.0	1.3	1.4	2.1	2.1
margarine, polyunsaturated	3.7	3.8	0.7		1.3	1.0
potatoes, fried	1.5	1.8	1.9	2.3	0.8	0.9
potatoes, not fried	1.9	2.0	1.1	1.1	1.3	1.1
apples *(fresh, stewed or juice)*	1.1	1.0	1.6	1.2	2.2	1.4
savoury pastries	1.3	1.8	2.6	2.7		
wine, red				1.6	1.2	5.4
salad vegetables with dressing		0.6	2.5	2.7	0.9	0.8
breakfast cereals *(sweetened)*	1.2	1.0	0.7	0.9	1.6	1.9
beer		3.7		2.1		0.7
fish, steamed, grilled or baked	0.8		1.9	1.5	1.1	1.2
coffee *(including espresso and Greek style)*			2.3	1.9	1.3	0.9
spinach or other leafy greens			1.9	1.8	1.6	1.1
rissoles or meatloaf	1.0	1.2	1.2	1.3	0.9	0.9
butter	2.1	1.6	0.7		0.8	0.9
biscuits, sweet	1.2	1.1	1.4	1.2		0.8
muesli	2.4	2.5		0.7		
crackers or crispbreads	1.7	1.1	1.2		1.4	
fish, fried	1.1	0.7	1.8	1.5		
milk, reduced fat (1.5%)	2.1	1.3			1.0	0.7
desserts or puddings	1.9	1.8	0.7		0.7	
wine, white	1.4	1.1			0.9	1.1
vegetable oils *(as a seasoning)*					2.6	2.0
pizza		0.6			2.0	1.9
bananas	1.5	1.4		0.6		0.7
cola or other soft drink	0.7	1.1	0.9	0.9	0.7	
milk, skimmed	2.3	1.8				
mixed dishes with rice			1.7	1.1	0.7	0.7
soups or broths *(without beans or lentils)*			1.2	1.0	1.0	0.8
fetta cheese			2.1	1.9		
mixed vegetable dishes			2.2	1.5		
oranges or mandarins			0.9	0.7	1.2	1.0
mixed dishes with beef	0.9	1.3	0.6			0.7
salami				0.7	0.9	1.5
frankfurters or sausages	1.1	1.9				
bran-based breakfast cereal	1.3	0.9			0.7	
orange juice	1.0	1.0	0.8			
ice cream	1.3	1.2				
smoked or canned fish	0.8	0.6			0.7	
chocolate	1.2	1.0				
breakfast cereals *(unsweetened)*	0.8	1.3				
grapes			1.1	1.0		
buns or doughnuts	0.9	1.2				
pears			0.6		0.7	0.7
peanuts or peanut butter	0.9	1.0				
cabbage rolls or stuffed vine leaves			1.0	0.7		
cocoa or coffee substitutes	0.9	0.7				
oatmeal porridge	0.8	0.7				
liqueurs or fortified wines	0.6	0.8				
marmalade or other jams	0.6	0.8				
rice, boiled	0.7				0.7	
honey or syrups			0.6	0.7		
nuts, other than peanuts	0.6		0.7			
peaches or nectarines	0.6			0.6		
sweet pastries			0.8			
mixed dishes with lamb			0.7			
capsicum *(including stuffed peppers)*			0.7			
tomato			0.7			
mixed dishes with egg	0.7					
eggs, boiled or poached	0.7					
yoghurt	0.7					
mayonnaise	0.7					
pork, chops or roast				0.7		
Other	13.4	12.2	10.8	7.5	9.5	8.8
Total	100	100	100	100	100	100

*The food categories for which values are indicated provide 80% of the cumulative intake within each sex-ethnicity stratum.

Table 2. Percentage of beta-carotene intake from major* food sources: Weighed Food Survey, 1987–1989.

	Australian-born		Greek-born		Italian-born	
	females	males	females	males	females	males
Number of subjects	163	99	151	130	147	120
WFR category						
carrots	43.6	46.1	28.5	18.4	24.6	20.7
spinach or other leafy greens	4.8	4.9	28.6	37.0	31.1	24.0
broccoli or cauliflower	4.4	3.7	4.1	3.8	17.5	19.9
lettuce or other salad greens	6.8	6.1	4.8	5.4	7.8	9.7
tomato	5.1	5.4	5.9	6.4		2.1
cantaloupe or honeydew	5.0	3.7	6.6	5.1		
mixed dishes with beef	4.3	4.4				5.2
pumpkin	5.2	4.9				
figs			3.0	2.9		
lentil or bean soup *(including minestrone)*		2.9				
apricots	2.8					
peaches or nectarines						
Other	16.1	10.3	11.9	12.9	10.1	14.7
Total	100	100	100	100	100	100

*The food categories for which values are indicated provide 80% of the cumulative intake within each sex-ethnicity stratum.



a WFR categories that did not satisfy the criteria for inclusion in the FFQ (ie not among the first 80% cumulative intake for any nutrient for any sex-ethnicity stratum) but were able to be reassigned appropriately to another category.

b WFR categories that made a negligible contribution to nutrient intake and which comprised items that could not readily be reassigned to other categories.

c In the MCCS, questions regarding the use of these important sources of nutrients were asked separately from the FFQ. This includes alcoholic drinks, sugar, oils, nutrient supplements and milk added to hot drinks and cereal.

d Post-analysis collapsing and splitting of selected WFR categories to achieve greater specificity and clarity on the FFQ.

Figure 1. Flow chart outlining the process of selecting categories for inclusion in the Melbourne FFQ and producing the sex-ethnic-specific nutrient databases used in its analysis.

one sex-ethnicity stratum[17,18]. The nutrients of interest were: energy; fat; saturated fat; monounsaturated fat; polyunsaturated fat; carbohydrate; sugars; starch; dietary fibre; protein; cholesterol; sodium; potassium; calcium; iron; zinc; retinol; carotene; vitamin C; vitamin E; and folic acid. The process of selecting the 121 FFQ food categories is outlined in Figure 1.

Creation of sex-ethnic specific FFQ nutrient databases

Once the 121 FFQ food categories were determined, a method was required for assigning nutrient values to a serve (or portion) of each category. We chose to customize the nutrient database to take account of sex and ethnic variations in food intake. We were interested in two sources of inter-stratum variation, which were the differences in portion size and the differences in the relative contribution made by various items within a category. The imputed nutrient values per portion were obtained from the WFR data as outlined below.

Of the 911 food items coded in the WFR analysis, 715 were assigned to the 121 FFQ food categories. Ninety of the remaining items related to alcoholic drinks, sugar, oils and condiments. These items were excluded because questions were to be asked about their use separately from the FFQ. The remaining food items did not correspond to any of the FFQ food categories. Collectively they made a negligible contribution to nutrient intake with most having had fewer than 10 serves in total over the 6480 person days of diet recording.

For each FFQ food category, the nutrient content per portion was averaged for each ethnic group (by sex). Within food categories, a proportion of food items had zero content for one or more nutrients. Geometric means across non-zero entries were used due to the naturally skewed distributions, but numbers of zero nutrient values were also recorded. Ethnic group and sex strata were combined in cases which showed little heterogeneity or for which there were fewer than 50 serves in total. Arithmetic mean nutrient content was computed after weighting for the number of portions with zero nutrient content.

FFQ administration and analysis

The FFQ was completed by 17 949 subjects attending the MCCS between November 1990 and April 1993. The English version is illustrated in the appendix. All language versions align identically so that only one optical scanning program was required for data entry. Although the FFQ was designed to be self-administered, approxi-

mately 25% of subjects required at least some assistance. The FFQs were scanned while the subjects were in attendance so that gross errors, such as the omission or duplication of frequency responses, were rectified immediately.

Average daily nutrient intake for each FFQ response was calculated by matrix multiplication with the nutrient table appropriate for the respondent's ethnicity and sex. The nine frequency response options were converted to daily equivalents as follows:

Frequency response label	Daily equivalent
never or less than once per month	0
1–3 per month	0.067
1 per week	0.15
2–4 per week	0.43
5–6 per week	0.80
1 per day	1
2–3 per day	2.5
4–5 per day	4.5
6+ per day	8

The cut-off points for improbable energy intake were those used in the Health Professionals Follow-up Study[19] and the Nurses' Health Study[20]. This involved excluding values for women with intake below 2100kJ/day, men below 3360kJ/day, and men and women with intake above 16 800kJ/day.

Energy adjustment

Energy-adjusted nutrient intakes for both the WFRs and the FFQs were computed as the residuals from the regression model on a log scale plus the expected nutrient intake for the mean energy intake of the study population[21]. The regression analyses were specific for each of the six sex-ethnicity sub-populations. This method of energy adjustment alters the distribution of nutrient intake values within the population but does not substantially change median values. The other purpose for adjusting energy intake is to facilitate comparison of nutrient intakes in situations where there are differences in total consumption between groups, so median nutrient intakes were expressed per MJ of energy derived from protein, carbohydrate and fat. This enabled a standardized comparison between the FFQs and the WFRs, which also included alcohol.

Results

The criteria for selecting categories for listing on the FFQ were chosen to capture the breadth of dietary exposure likely to be experienced in a cohort of men and women from diverse culinary backgrounds. Cross-cultural dietary heterogeneity was evident when ranking food sources to the intake of particular nutrients calculated from the WFRs. The proportion of energy intake contributed by major food sources for each of the sex-ethnicity strata is presented in Table 1. A blank value indicates that the category was not among those that contributed to the first 80% of the cumulative energy intake for that particular stratum; it does not necessarily indicate that the food source made no contribution to energy intake, indeed in each stratum the sum of the 'other' categories was less than 20%. On the basis of energy alone, 75 categories satisfied the criterion for inclusion on the FFQ. As with the other ubiquitous nutrients, eg protein, fat and carbohydrate, many categories each contributed a relatively small proportion (0.5–1.0%) to total energy intake. In contrast, more than 80% of the beta-carotene intake was derived from only 12 categories (Table 2).

Twenty-two WFR categories did not satisfy the criteria for inclusion on the Melbourne FFQ (Figure 1). Of these, 14 were eliminated because they could not be reassigned sensibly to another category. These rejected categories were: poultry other than chicken; mixed dishes with pork;mixed dishes with fish or seafood; turnips or swedes; globe artichoke; asparagus; okra; radishes; sweet potato; cherries; yeast; seeds; bean sprouts; and polenta. The Melbourne FFQ does not include 19 WFR categories relating to alcoholic drinks, dietary supplements, oils, sugar, milk added to breakfast cereal, tea and coffee because questions concerning their use were asked separately. For the purposes of clarity and greater specificity, some modifications were made to the list of chosen categories. A net reduction of 10 was achieved by the post-analysis collapsing of 29 WFR categories (including eight that did not satisfy the model) into nine FFQ categories and the splitting of 10 WFR categories into 20 FFQ categories. For example, the category 'broccoli and cauliflower' was split into separate categories on the FFQ because these two vegetables differ substantially in their beta-carotene content. The combined category was quantitatively the third most important source of beta-carotene in the analysis of the WFRs (Table 2).

Median daily intake data for a range of nutrients in the WFS and the MCCS are presented in Table 3. The energy values calculated from the FFQs in the MCCS do not include energy derived from alcoholic drinks. Energy-adjusted nutrient intake values were therefore calculated to facilitate a standardized comparison between the two dietary intake methods (Table 4). The FFQ energy values were not identical in Table 3 and 4. Table 3 presents median values for energy as a nutrient in its own right, whereas in Table 4 energy values were computed as the sum of energy derived from the population median intake of carbohydrate (16 kJ/g), fat (37 kJ/g) and protein (17 kJ/g). The energy-adjusted intakes of dietary fibre, beta-carotene and vitamin C in the MCCS were consistently higher than those in the WFS. On the other hand, energy-adjusted calcium intakes were consistently lower in the MCCS.

Discussion

Not surprisingly, the WFRs indicated differences between the ethnic groups in the proportion of nutrients derived from different food sources (Tables 1 and 2). In particular, men and women born in Australia reported eating more carrots, wholegrain bread, breakfast cereals, butter and margarine and less legumes and leafy green vegetables than did their Italian- and Greek-born counterparts. Those born in Greece ate more savoury pastries, salads, fish and fetta cheese, whereas the Italian-born ate more pasta and pizza and less lamb. Within each of the ethnic groups, the most notable difference between the sexes involved alcoholic drinks, particularly beer and red wine.

Table 3. Median daily nutrient intake in the Melbourne Collaborative Cohort Study (FFQ, 1990–1993) and the Weighed Food Survey (WFR, 1987–1989).

	Greek-born				Italian-born				Australian-born			
	females		males		females		males		females		males	
	WFR	FFQ	WFR	FFQ	WFR	FFQ	WFR	FFQ	WFR	FFQ	WFR	FFQ
Number of subjects	**151**	**1620**	**130**	**1273**	**147**	**2057**	**120**	**1613**	**163**	**6522**	**99**	**4202**
Subjects excluded[a] (n)		**95**		**141**		**55**		**92**		**92**		**187**
Total energy (kJ)[b]	6680	8300	8790	9370	6910	7160	7470	7800	7400	7100	10 500	8320
Protein (g)	71	105	98	121	74	79	100	91	76	71	97	84
Carbohydrate (g)	177	226	228	263	174	222	236	241	207	204	291	238
Fibre (g)	17	30	21	33	18	26	24	26	20	23	26	23
Fat (g)	70	78	91	85	65	54	84	58	72	66	91	80
Retinol (μg)	135	176	158	174	184	165	215	157	302	313	346	322
Beta-carotene (μg)	2470	6360	2590	5930	2670	5000	2840	4180	2940	5190	3510	4280
Vitamin C (mg)	68	139	64	129	53	98	65	93	81	103	102	92
Calcium (mg)	578	673	726	708	636	604	820	609	771	583	951	616
Iron (mg)	9	15	12	17	11	13	16	14	12	13	17	15

[a] subjects were excluded from the analysis if their estimated energy intake computed from the FFQ was above 16 800 kJ/day or below 2100 kJ/day (women) or 3360 kJ/day (men).

[b] FFQ does not include sugar and alcoholic drinks.

Table 4. Median daily energy-adjusted[a] nutrient intake in the Melbourne Collaborative Cohort Study (FFQ, 1990–1993) and the Weighed Food Survey (WFR, 1987–1989).

	Greek-born				Italian-born				Australian-born			
	females		males		females		males		females		males	
	WFR	FFQ	WFR	FFQ	WFR	FFQ	WFR	FFQ	WFR	FFQ	WFR	FFQ
Number of subjects	**151**	**1620**	**130**	**1273**	**147**	**2057**	**120**	**1613**	**163**	**6522**	**99**	**4202**
Subjects excluded[c] (n)		**95**		**141**		**55**		**92**		**92**		**187**
Non-alcohol energy[b] (kJ)	6631	8283	8694	9410	6456	6908	8591	7566	7258	6921	9656	8199
Protein (g/MJ)	10.7	12.7	11.3	12.9	11.4	11.5	11.6	12.0	10.5	10.2	10.0	10.3
Carbohydrate (g/MJ)	26.7	27.3	26.2	27.9	27.0	32.1	27.5	31.9	28.5	29.5	30.1	29.0
Fibre (g/MJ)	2.6	3.6	2.4	3.5	2.8	3.8	2.7	3.4	2.7	3.3	2.7	2.8
Fat (g/MJ)	10.6	9.4	10.5	9.0	10.1	7.9	9.8	7.7	9.9	9.6	9.4	9.7
Retinol (μg/MJ)	20.4	21.2	18.2	18.5	28.5	23.9	25.0	20.8	41.6	45.2	35.8	39.3
Beta-carotene (μg/MJ)	372.5	767.8	297.9	630.2	413.6	723.8	330.6	552.5	405.1	749.9	363.5	522.0
Vitamin C (mg/MJ)	10.2	16.8	7.3	13.7	8.1	14.1	7.6	12.2	11.1	14.9	10.6	11.3
Calcium (mg/MJ)	87.2	81.3	83.5	75.2	98.5	87.4	95.4	80.5	106.2	84.2	98.5	75.1
Iron (mg/MJ)	1.4	1.9	1.4	1.8	1.7	1.8	1.8	1.8	1.7	1.9	1.7	1.8

[a] nutrient values are expressed per MJ non-alcohol energy intake.

[b] computed as the sum of energy derived from the population median intake of carbohydrate, fat and protein.

[c] subjects were excluded from the analysis if their estimated energy intake computed from the FFQ was above 16 800 kJ/day or below 2100 kJ/day (women) or 3360 kJ/day (men).

While it is crucial to the performance of an FFQ, the procedure used for attributing nutrient values to the food items as listed on the FFQ is often obscure. We used a 'weighted average' method whereby nutrient values derived from the analysis of WFRs were assigned to each FFQ food category. The nutrient values assigned to each category were stratified by the sex and ethnicity of individual respondents. The 'weighted-average' nutrient values incorporated the differences in composition among the foods and drinks that constituted particular aggregate items as well as differences in portion size. Ethnic differences in food patterns notwithstanding, median-computed nutrient intakes showed relatively little variation by ethnic group (Tables 3 and 4). Protein and retinol were the only exceptions. Relative to the Italian- and Greek-born subjects, the Australian-born men and women had a lower protein and higher retinol intake per MJ of energy consumed.

Judging the performance of the FFQ in relation to the WFRs is an imperfect exercise, especially as the two methods refer to different groups of subjects. Even when the distributions for a nutrient are identical, there can be no certainty that the two methods rank individuals similarly. However, widely discrepant distribution profiles would most likely indicate that the derivative method, in this case the FFQ, is defective. It seems that our FFQ has overestimated the intake of some micronutrients. Taking beta-carotene as an example, the values calculated from the FFQ were between 50 and 100% higher than those reported on the WFRs. To some extent, this can be explained by the fact that all FFQ respondents were asked to indicate how often they ate vegetables and fruit 'when in season'.

Serum levels of beta-carotene and alpha-tocopherol were significantly correlated with their respective dietary intake values in the WFS (unpublished data). We are currently conducting a validation study to assess the ranking ability of the FFQ. If it is found that the FFQ ranks correspondingly to biochemistry, the limitations for determination of absolute intakes by the FFQ do not alter its other values. The problem of everestimating the intake of some micronutrients is not peculiar to our FFQ; it applies to most methods that attempt to characterize an individual's usual eating habits. Two other large studies conducted in Victoria within the past decade have reported higher median beta-carotene intakes than those

calculated from our FFQ. One involved a dietitian-administered diet history[22] and the other used a self-administered FFQ[23,24]. In each case, the level of beta-carotene substantially exceeds estimates derived from food balance sheets[25]. The 1983 NDSA[10] used the 24-hour recall method of dietary assessment. Although beta-carotene intakes were not reported separately, values extrapolated from total vitamin A were more in line with our WFR data and the national apparent consumption data[25].

The energy exclusion criteria successfully identified aberrant data. Some subjects obviously failed to understand how to complete the FFQ (eg marking 'never or less than once per month' for every item). Additional reference range checks could be employed to identify other implausible responses. It would be preferable if these were based on the primary food frequency data rather than estimates of nutrient intake because apparent under- or overestimation of nutrients could result from the use of standard imputed portion sizes.

As a method of assessing the genuineness of estimated energy intake, the cutpoints are likely to be too conservative[19,20]. Nevertheless, 3.8% of the overall study population was excluded, including 10% of the Greek male stratum. A comparison with individual energy requirement calculated from basal metabolic rate (BMR) would be a more appropriate method of establishing the accuracy of energy intake. If an arbitrary range of acceptable intakes was chosen (eg 1.4 to 2.0 times BMR) a far higher proportion of subjects would be excluded. The median energy intake to BMR ratio in our study was 1.25, which is below the operational maintenance requirement[26], and almost 60% of subjects had energy values below the cutoff limits recently suggested for identifying under-reporting in diet surveys[27]. Notwithstanding, it would be the view of the investigators that the ranking ability of the FFQ remains of value in its own right. Therefore, whilst retaining the Willett[19,20] approach for energy cutoff, which basically deals with erratic questionnaire completion facility of individuals, we have retained data which otherwise would have been excluded by the Goldberg criterion[27].

Total intake at the group level may have been underestimated by the use of portion size values imputed from the WFS. We chose to focus our FFQ solely on frequency described at the initial contact. Information regarding usual portion size is difficult to estimate outside of the home environment and the possibility remains open of asking about the usual portion size of common foods in a follow-up questionnaire. The effect of variation in usual portion size within sex and ethnicity strata for various classes of foods will be tested in a separate validation study which is currently being conducted.

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Appendix

HEALTH 2000 ANSWER SHEET

1	2	3	4	5

EATING HABITS

FIRST SOME QUESTIONS RELATING TO YOUR DIETARY HABITS

1. Have you been on a special diet in the last 12 months?

- ○ No
- ○ Yes, Weight loss
- ○ Yes, Vegetarian
- ○ Yes, Low fat, low cholesterol
- ○ Yes, High fibre
- ○ Yes, Other, please specify

_____

2. How much oil is used per month in your household?

Pure olive oil	Other vegetable oils/blends
○ none	○ none
○ less than 1 litre	○ less than 1 litre
○ 1 to 3 litres	○ 1 to 3 litres
○ 3 to 5 litres	○ 3 to 5 litres
○ 5 to 7 litres	○ 5 to 7 litres
○ 7 to 9 litres	○ 7 to 9 litres
○ more than 9 litres	○ more than 9 litres
○ don't know	○ don't know

3. Which of the following do you most often have on or with bread/toast?

- ○ butter
- ○ margarine
- ○ sometimes butter, sometimes margarine
- ○ olive oil
- ○ I don't use anything

4. When FRYING meat, fish, poultry or vegetables, which do you (or the person who cooks your food) use most often?

- ○ butter
- ○ margarine
- ○ dripping or lard
- ○ olive oil
- ○ vegetable oil
- ○ I never eat fried food
- ○ don't know

5. What dressing do you usually add to salad vegetables?

- ○ no dressing
- ○ oil and vinegar
- ○ mayonnaise
- ○ lemon juice or other fat free dressing
- ○ Other, please specify

_____

6. What dressing do you usually add to cooked vegetables?

- ○ no dressing (or fat free dressing)
- ○ butter
- ○ margarine
- ○ olive oil
- ○ vegetable oil

7. What kind of fat do you (or the person who cooks your food) most often use for BAKING cakes, biscuits, pies, etc?

- ○ butter
- ○ margarine
- ○ dripping or lard
- ○ olive oil
- ○ vegetable oil
- ○ I never eat baked foods
- ○ don't know

8. When you add milk to cereal or tea/coffee etc. which do you most often use?

- ○ full cream milk
- ○ reduced fat milk eg. PhysiCAL, REV
- ○ skim milk
- ○ soya milk
- ○ I don't use milk

9. Do you usually take milk in:

Tea	Coffee	Coffee Substitute (e.g. Caro)
○ Yes	○ Yes	○ Yes
○ No	○ No	○ No
○ Don't drink tea	○ Don't drink coffee	○ Don't drink coffee substitutes

10. How many teaspoons of sugar on average do you add to your food and drink each day?
(Do not consider sugar used in cooking)

⓪ ① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨ ⑩
⑪ ⑫ ⑬ ⑭ ⑮ ⑯ ⑰ ⑱ ⑲ ⑳

11. How often do you eat garlic or foods cooked with garlic?

- ○ every day
- ○ 4 to 6 times a week
- ○ 2 to 3 times a week
- ○ once a week
- ○ 2 to 3 times a month
- ○ once a month
- ○ less than once a month
- ○ never

12. Did you take any of the following diet supplements at least once a week over the last 12 months?

Multivitamins	○ No	○ Yes
Vitamin A	○ No	○ Yes
Vitamin C	○ No	○ Yes
Vitamin E	○ No	○ Yes
Calcium	○ No	○ Yes

	No Yes	capsules or teaspoons per	day/week
Fish oils	Ⓝ Ⓨ	⓪ ① ② ③ ④ ⑤ ⑥	Ⓓ Ⓦ
Cod Liver oil	Ⓝ Ⓨ	⓪ ① ② ③ ④ ⑤ ⑥	Ⓓ Ⓦ
Wheat bran	Ⓝ Ⓨ	⓪ ① ② ③ ④ ⑤ ⑥	Ⓓ Ⓦ
Oat bran	Ⓝ Ⓨ	⓪ ① ② ③ ④ ⑤ ⑥	Ⓓ Ⓦ
Fibre supplements (e.g. Fybogel, metamucil)	Ⓝ Ⓨ	⓪ ① ② ③ ④ ⑤ ⑥	Ⓓ Ⓦ

13. Which best describes what happens to your skin when, or if, you are exposed to strong sunshine?

- ○ I usually burn and rarely tan
- ○ I burn first, then tan
- ○ I usually tan and rarely burn

STICK BARCODE LABEL HERE

SCANFORM REF No. 9011 6301 PRINTED BY BARRADENE PRESS

COMPLETE AS IF FOODS ARE IN SEASON

FOODS — Number of times you have eaten these foods over the last year;	Never or less than once per month	1–3 per month	1 per week	2–4 per week	5–6 per week	1 per day	2–3 per day	4–5 per day	6+ per day
CEREAL FOODS, CAKES & BISCUITS									
Wheatgerm	○	○	Ⓦ	○	○	Ⓓ	○	○	○
Muesli	○	○	Ⓦ	○	○	Ⓓ	○	○	○
Other Breakfast cereals	○	○	Ⓦ	○	○	Ⓓ	○	○	○
Rice boiled (incl. brown rice)	○	○	Ⓦ	○	○	Ⓓ	○	○	○
Fried rice	○	○	Ⓦ	○	○	Ⓓ	○	○	○
Mixed dishes with rice	○	○	Ⓦ	○	○	Ⓓ	○	○	○
White bread, rolls or toast	○	○	Ⓦ	○	○	Ⓓ	○	○	○
Wholewheat or rye bread, rolls or toast	○	○	Ⓦ	○	○	Ⓓ	○	○	○
Fruit bread	○	○	Ⓦ	○	○	Ⓓ	○	○	○
Crackers or crispbreads	○	○	Ⓦ	○	○	Ⓓ	○	○	○
Sweet biscuits	○	○	Ⓦ	○	○	Ⓓ	○	○	○
Cakes or sweet pastries	○	○	Ⓦ	○	○	Ⓓ	○	○	○
Puddings	○	○	Ⓦ	○	○	Ⓓ	○	○	○
Pasta or noodles	○	○	Ⓦ	○	○	Ⓓ	○	○	○
Pizza	○	○	Ⓦ	○	○	Ⓓ	○	○	○
Dim sims or spring rolls	○	○	Ⓦ	○	○	Ⓓ	○	○	○
Pies or savoury pastries	○	○	Ⓦ	○	○	Ⓓ	○	○	○
DAIRY FOODS & EGGS									
Cottage cheese	○	○	Ⓦ	○	○	Ⓓ	○	○	○
Ricotta cheese	○	○	Ⓦ	○	○	Ⓓ	○	○	○
Fetta cheese	○	○	Ⓦ	○	○	Ⓓ	○	○	○
Low fat, low cholesterol cheese	○	○	Ⓦ	○	○	Ⓓ	○	○	○
Hard grating cheeses eg. parmesan	○	○	Ⓦ	○	○	Ⓓ	○	○	○
Cream cheese	○	○	Ⓦ	○	○	Ⓓ	○	○	○
Cheddar or similar cheeses	○	○	Ⓦ	○	○	Ⓓ	○	○	○
Ice cream	○	○	Ⓦ	○	○	Ⓓ	○	○	○
Custard	○	○	Ⓦ	○	○	Ⓓ	○	○	○
Cream or sour cream	○	○	Ⓦ	○	○	Ⓓ	○	○	○
Yoghurt (incl. low fat varieties)	○	○	Ⓦ	○	○	Ⓓ	○	○	○
Eggs, boiled or poached	○	○	Ⓦ	○	○	Ⓓ	○	○	○
Eggs, fried or scrambled	○	○	Ⓦ	○	○	Ⓓ	○	○	○
Mixed dishes with egg	○	○	Ⓦ	○	○	Ⓓ	○	○	○
Butter	○	○	Ⓦ	○	○	Ⓓ	○	○	○
Margarine	○	○	Ⓦ	○	○	Ⓓ	○	○	○
MEAT, POULTRY, SEAFOOD & MIXED DISHES									
Veal or beef schnitzel	○	○	Ⓦ	○	○	Ⓓ	○	○	○
Beef or veal, roast	○	○	Ⓦ	○	○	Ⓓ	○	○	○
Beef steak	○	○	Ⓦ	○	○	Ⓓ	○	○	○
Rissoles or meatloaf	○	○	Ⓦ	○	○	Ⓓ	○	○	○
Mixed dishes with beef (inc. stews, curry & meat sauce)	○	○	Ⓦ	○	○	Ⓓ	○	○	○
Chicken, roast or fried (incl. schnitzel)	○	○	Ⓦ	○	○	Ⓓ	○	○	○

FOODS Number of times you have eaten these foods over the last year	Never or less than once per month	1 – 3 per month	1 per week	2 – 4 per week	5 – 6 per week	1 per day	2 – 3 per day	4 – 5 per day	6+ per day
Chicken, boiled or steamed	○	○	Ⓦ	○	○	Ⓓ	○	○	○
Mixed dishes with chicken (e.g. casseroles, stir fry)	○	○	Ⓦ	○	○	Ⓓ	○	○	○
Lamb, chops or roast	○	○	Ⓦ	○	○	Ⓓ	○	○	○
Mixed dishes with lamb	○	○	Ⓦ	○	○	Ⓓ	○	○	○
Pork, chops or roast	○	○	Ⓦ	○	○	Ⓓ	○	○	○
Rabbit, or other game	○	○	Ⓦ	○	○	Ⓓ	○	○	○
Liver (incl. Liverwurst & paté)	○	○	Ⓦ	○	○	Ⓓ	○	○	○
Other offal meats	○	○	Ⓦ	○	○	Ⓓ	○	○	○
Salami or continental sausages	○	○	Ⓦ	○	○	Ⓓ	○	○	○
Sausages or frankfurters	○	○	Ⓦ	○	○	Ⓓ	○	○	○
Bacon	○	○	Ⓦ	○	○	Ⓓ	○	○	○
Ham (incl. prosciutto)	○	○	Ⓦ	○	○	Ⓓ	○	○	○
Corned beef (silverside)	○	○	Ⓦ	○	○	Ⓓ	○	○	○
Manufactured luncheon meats (incl. mortadella)	○	○	Ⓦ	○	○	Ⓓ	○	○	○
Fish, steamed, grilled or baked	○	○	Ⓦ	○	○	Ⓓ	○	○	○
Fish, fried (incl. takeaway)	○	○	Ⓦ	○	○	Ⓓ	○	○	○
Fish, smoked	○	○	Ⓦ	○	○	Ⓓ	○	○	○
Canned fish (incl. tuna, salmon & sardines)	○	○	Ⓦ	○	○	Ⓓ	○	○	○
Seafood (other than fish)	○	○	Ⓦ	○	○	Ⓓ	○	○	○
SOUPS, SALADS & COOKED VEGETABLES									
Creamed soup	○	○	Ⓦ	○	○	Ⓓ	○	○	○
Bean, pea or lentil soup	○	○	Ⓦ	○	○	Ⓓ	○	○	○
Other soup or broth	○	○	Ⓦ	○	○	Ⓓ	○	○	○
Pickled vegetables	○	○	Ⓦ	○	○	Ⓓ	○	○	○
Tomato	○	○	Ⓦ	○	○	Ⓓ	○	○	○
Capscium	○	○	Ⓦ	○	○	Ⓓ	○	○	○
Lettuce, endive or other salad greens	○	○	Ⓦ	○	○	Ⓓ	○	○	○
Cucumber	○	○	Ⓦ	○	○	Ⓓ	○	○	○
Celery or fennel	○	○	Ⓦ	○	○	Ⓓ	○	○	○
Beetroot	○	○	Ⓦ	○	○	Ⓓ	○	○	○
Coleslaw	○	○	Ⓦ	○	○	Ⓓ	○	○	○
Potato fried or roasted	○	○	Ⓦ	○	○	Ⓓ	○	○	○
Potato cooked without fat	○	○	Ⓦ	○	○	Ⓓ	○	○	○
Carrot	○	○	Ⓦ	○	○	Ⓓ	○	○	○
Cabbage or Brussels sprouts	○	○	Ⓦ	○	○	Ⓓ	○	○	○
Cauliflower	○	○	Ⓦ	○	○	Ⓓ	○	○	○
Broccoli	○	○	Ⓦ	○	○	Ⓓ	○	○	○
Silverbeet, spinach or other leafy greens	○	○	Ⓦ	○	○	Ⓓ	○	○	○
Green beans or peas	○	○	Ⓦ	○	○	Ⓓ	○	○	○
Cooked dried bean, chick pea or lentil dish (inc. baked beans)	○	○	Ⓦ	○	○	Ⓓ	○	○	○
Pumpkin	○	○	Ⓦ	○	○	Ⓓ	○	○	○
Onion or leeks	○	○	Ⓦ	○	○	Ⓓ	○	○	○

FOODS Number of times you have eaten these foods over the last year	Never or less than once per month	1 – 3 per month	1 per week	2 – 4 per week	5 – 6 per week	1 per day	2 – 3 per day	4 – 5 per day	6+ per day
Mushrooms	○	○	Ⓦ	○	○	Ⓓ	○	○	○
Sweet corn	○	○	Ⓦ	○	○	Ⓓ	○	○	○
Zucchini, squash or eggplant	○	○	Ⓦ	○	○	Ⓓ	○	○	○
Cooked mixed vegetable dish	○	○	Ⓦ	○	○	Ⓓ	○	○	○
DRIED, FRESH, STEWED AND CANNED FRUIT									
Dried apricots or peaches	○	○	Ⓦ	○	○	Ⓓ	○	○	○
Other dried fruit	○	○	Ⓦ	○	○	Ⓓ	○	○	○
Fruit salad	○	○	Ⓦ	○	○	Ⓓ	○	○	○
Oranges or mandarins	○	○	Ⓦ	○	○	Ⓓ	○	○	○
Apples	○	○	Ⓦ	○	○	Ⓓ	○	○	○
Bananas	○	○	Ⓦ	○	○	Ⓓ	○	○	○
Peaches or nectarines	○	○	Ⓦ	○	○	Ⓓ	○	○	○
Pears	○	○	Ⓦ	○	○	Ⓓ	○	○	○
Cantaloupe or honeydew melon	○	○	Ⓦ	○	○	Ⓓ	○	○	○
Watermelon	○	○	Ⓦ	○	○	Ⓓ	○	○	○
Strawberries	○	○	Ⓦ	○	○	Ⓓ	○	○	○
Plums	○	○	Ⓦ	○	○	Ⓓ	○	○	○
Apricots	○	○	Ⓦ	○	○	Ⓓ	○	○	○
Grapefruit	○	○	Ⓦ	○	○	Ⓓ	○	○	○
Pineapple	○	○	Ⓦ	○	○	Ⓓ	○	○	○
Avocados	○	○	Ⓦ	○	○	Ⓓ	○	○	○
Olives	○	○	Ⓦ	○	○	Ⓓ	○	○	○
Figs	○	○	Ⓦ	○	○	Ⓓ	○	○	○
Grapes	○	○	Ⓦ	○	○	Ⓓ	○	○	○
BEVERAGES & MISCELLANEOUS									
A milk drink (inc. milk shakes, hot chocolate etc.)	○	○	Ⓦ	○	○	Ⓓ	○	○	○
Orange juice or lemon juice	○	○	Ⓦ	○	○	Ⓓ	○	○	○
Other fruit juice	○	○	Ⓦ	○	○	Ⓓ	○	○	○
Tea	○	○	Ⓦ	○	○	Ⓓ	○	○	○
Herbal or mountain tea	○	○	Ⓦ	○	○	Ⓓ	○	○	○
Coffee	○	○	Ⓦ	○	○	Ⓓ	○	○	○
Coffee substitute	○	○	Ⓦ	○	○	Ⓓ	○	○	○
Water (inc. soda & plain mineral water)	○	○	Ⓦ	○	○	Ⓓ	○	○	○
Diet (Lo-cal) soft drink	○	○	Ⓦ	○	○	Ⓓ	○	○	○
Soft drink (inc. flav. mineral water)	○	○	Ⓦ	○	○	Ⓓ	○	○	○
Chocolate or confectionery containing chocolate	○	○	Ⓦ	○	○	Ⓓ	○	○	○
Other confectionery	○	○	Ⓦ	○	○	Ⓓ	○	○	○
Peanuts or peanut butter	○	○	Ⓦ	○	○	Ⓓ	○	○	○
Other nuts	○	○	Ⓦ	○	○	Ⓓ	○	○	○
Dips	○	○	Ⓦ	○	○	Ⓓ	○	○	○
Corn chips, potato chips or similar snacks	○	○	Ⓦ	○	○	Ⓓ	○	○	○
Jam, honey or syrups	○	○	Ⓦ	○	○	Ⓓ	○	○	○
Vegemite, marmite or promite	○	○	Ⓦ	○	○	Ⓓ	○	○	○

Development of the Melbourne FFQ: a food frequency questionnaire for use in an Australian prospective study involving an ethnically diverse cohort

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墨爾本食物次數調查表 (FFQ) 的研製：一種用於研究澳洲人和不同種族的食物次數調查表

摘要

目的：建立一種可用光學掃描的食物次數調查表 (FFQ) ，墨爾本 FFQ 適合於澳洲、希臘和意大利出生的人，並可用四分位數的方法對進食一系列食物和營養素分析。FFQ 在未來人群的研究中將提供基本的膳食估量。

設計：該 FFQ 是模仿美國護士健康的研究。食物項目的選擇是基於一系列營養素進食的相對貢獻，這從食物稱重記錄估計的。

背景：在澳洲一個有三百萬人口的墨爾本市進行，該市有 75.5% 的人在澳洲出生；2.7% 的人在意大利出生；和 1.7% 的人在希臘出生。

參加者：食物稱重調查 (1987—1989) ，包括 810 位健康、中年 (40—69 歲) 男人和婦女志願者。他們有 35% 在希臘出生；33% 在意大利出生；和 32% 在澳洲出生。墨爾本人群研究 (1990—1993) ，包括 17,949 位健康男人和婦女，年齡在 40—69 歲。他們有 61% 在澳洲出生；21% 在意大利出生；和 17% 在希臘出生。

結果：一個包括 121 項的 FFQ，連同按規格改製的營養素數據基礎已被制定。這種光學掃描格式一般地被普遍接受。該 FFQ 似高估水果和蔬菜的消耗。

結論：該墨爾本 FFQ 提供了測定大人群慣常膳食的簡便方法。但在個體的水平，去評估該法究竟有多大的好處，仍需進一步的研究。