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Comparison of two frequency questionnaires for quantifying fruit and vegetable intake

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Abstract

Objective: The effect on individual rankings and total intakes of nutrients of correcting total fruit and vegetable frequencies from a long food frequency questionnaire (FFQ) using the responses to two summary questions was examined in a group of women.

Methods: The performance of a self-administered FFQ in ranking individual levels of intake and estimating absolute levels of nutrient and energy intake was compared with the performance of the questionnaire when it was corrected for fruit and vegetable intake reported using the Block summary questions.

Subjects: The study population included 123 women, aged between 18 and 54 years, who were recruited from the Family Planning Association Colposcopy Clinic in Sydney.

Results: Substantial and significant differences ($P < 0.001$) were found in fruit and vegetable intakes between the FFQ and the summary questions. Intake frequency by the FFQ was more than double that by the summary questions. When the FFQ was corrected for fruit and vegetable intakes using the summary questions, the intakes of beta-carotene, vitamins A and C, and dietary fibre were more than 20% lower ($P < 0.001$) than the uncorrected results. However, this had little effect on ranking individuals. This study also examined seasonal differences in vegetable intakes and differences in nutrient intakes when either summer or winter vegetable consumption was substituted for seasonal vegetable intake in the FFQ. Although there were seasonal differences for some foods, the substitution had little effect on intake of nutrients.

Conclusion: These results indicate that important differences in intakes are observed when two methods, which appear to yield the same results, are used. Further work is needed to determine which, if either, of the two methods yields intakes that can be compared quantitatively with national references for assessing the adequacy of population intakes.

Keywords
Questionnaires
Validity
Fruit
Vegetables

Food frequency questionnaires (FFQs) are designed to assess usual food intake and are commonly used in case–control and cohort studies to examine the relationship between diet and disease. In this context, they are used to rank individuals, often into quantiles, according to nutrient and energy intake. More recently, FFQs have been used in cross-sectional surveys to estimate the means and standard deviations of population intakes, and in randomized controlled trials to measure change in intake.

Studies have shown that detailed FFQs tend to produce higher estimates of food intake than do food records or recalls[1,2]. Questionnaires with more items yield a higher frequency of food intake and total energy intake[3] than shorter lists. Overestimation may be especially magnified for fruit and vegetables, which are perceived as healthy and socially acceptable foods[4]. This, in turn, may lead to overestimation of the intakes of beta-carotene, vitamins A and C and dietary fibre, which is a problem if the goal of the study is to determine absolute intakes rather than to rank people.

In Australia, different versions of an FFQ developed at the Commonwealth Scientific and Industrial Research Organisation (CSIRO) Division of Human Nutrition in Adelaide[5] have been used in case–control studies[6–8] and randomized controlled trials to measure outcomes[9]. It has

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also been used in state-wide cross-sectional surveys[10,11] with the results presented as mean nutrient intakes, which are compared with Recommended Dietary Intakes (RDIs), and mean intakes of groups of foods such as fruits and vegetables, which are compared with the Dietary Goals.

The total frequency of consumption of a class of foods may be related to the number of items on the list[3]. Block *et al.*[12] introduced two summary questions as part of the National Cancer Institute's Health Habits and History Questionnaire to correct for overestimation of nutrients found in fruits and vegetables. These questions are 'Not counting juices, about how many servings of fruit do you eat per day or per week?' and 'Not counting salad or potatoes, about how many vegetables do you eat per day or per week?'. The responses to these questions are used to correct the total frequency of consumption of the longer list, with the final nutrient profile reflecting the relative frequency of the various fruits and vegetables on the longer list. This correction improves the correlation between multiple days of food records and the FFQ for beta-carotene, vitamins A and C and dietary fibre[12].

In this paper, we compare the total frequency of consumption of fruits and vegetables reported on a CSIRO-style FFQ and the Block summary questions. We examine the impact of correcting the total frequency using the Block approach on the assessed intakes of beta-carotene, vitamins A and C and dietary fibre, and also on the ranking of study participants. As the questionnaire ascertains the intakes of vegetables and some fruits separately for summer and winter, we also examine the seasonal differences to determine whether the questionnaire could be shortened.

Methods

Study population

Women with minor atypia or cervical intraepithelial neoplasial were recruited from the Family Planning Association of NSW Colposcopy Clinic between July 1991 and November 1993 to participate in a randomized trial testing the effect of high doses of beta-carotene and/or vitamin C on the progression and regression rates of the condition[13]. On recruitment, a face-to-face questionnaire was administered which included the Block summary questions, self-reported height and weight, and various other demographic and lifestyle questions relevant to the trial. They were also given a copy of the FFQ and a stamped addressed envelope, and shown how to fill it out. Participants were phoned every month to encourage compliance with capsule taking and return of the questionnaire. Additional copies were sent if requested.

Dietary assessment

A food frequency approach was chosen as usual intake was desired, and the trial required comparison of groups at baseline, and possibly cohort-type analyses based on ranking by nutrient intake. The FFQ developed by CSIRO was modified by adding some foods high in beta-carotene or by dividing some foods, e.g. capsicum was separated into red and green varieties (Table 1). This was done because of the trial's focus on carotenoids. In a pilot study also conducted at the Colposcopy Clinic, this modified version had a correlation of 0.44 with serum beta-carotene[14].

Coding and calculation of variables

Our FFQ contained 175 items, each with a serving size, arranged in groups of similar composition (cereals, vegetables, beverages, etc.). Participants reported open-ended frequencies (never, rarely, *n* times per month/week/day), could add other commonly eaten foods at the end of each group or alter the serving sizes. Twenty-six additional questions assessed various habits, such as the type of fat normally used in cooking, or use of milk in tea. 'Rarely' was entered as once per year. A weekly frequency of each item was calculated, setting 1 month to equal 4 weeks, and 12 months in the year. Table 1 shows the list of vegetables for which summer and winter consumption frequencies were ascertained separately. Annual frequencies were based on the assumption that each season was 6 months long.

As the list had been altered, the original analysis package could not be used. Instead, a template was set up in Diet/1 (Xyris Software, 1991) using the NUTTAB95 database[15] and information from the 1983 Dietary Survey of Adults[16]. For example, the question about apple intake included 'fresh, canned or stewed?'. In the 1983 survey, 90% of apple eaten was fresh. Therefore, the nutrient composition for this item was derived as 90% fresh (which was an average of the four varieties in the database) and 10% canned (average of the two canned varieties in the database). A small number of additional foods were added to the database using manufacturers' information.

To examine the impact of seasonal differences, mean nutrient and energy intakes from the FFQ were calculated assuming that either the summer or winter vegetable frequencies applied throughout the year. These were compared with the intakes calculated from the annualized data.

Given the wording of the summary questions, it would not be correct to compare them to the annualized total frequency of all possible fruit and vegetable items on the FFQ. Some items had to be excluded from the FFQ totals, based on whether it was reasonable to expect the respondents to have thought of them when answering the summary questions. Table 1 shows which of the vegetables frequently eaten fresh were included. Capsicum, celery, canned beetroot and canned sweetcorn are frequently eaten as salads in Australia. Including or excluding these items made little substantial difference to the results and so they have been excluded from the

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Table 1 Medians and interquartile ranges of total monthly intake of vegetables for summer and winter†

		Summer consumption			Winter consumption		
		Interquartile range			Interquartile range		
	Vegetable	25%	50%	75%	25%	50%	75%
	Potato, mashed	0.08	1.0	4.0	0.08	3.0***	8.0
	Potato, boiled	0.08	3.0	8.0	0.8	4.0*	8.0
	Potato, roasted	0.08	1.0	3.0	0.08	2.0***	4.0
	Hot chips	0.08	1.0	3.0	0.08	2.0***	4.0
x	Yellow sweet potato	0.0	0.08	0.08	0.0	0.08*	1.0
x	Carrots, fresh/frozen	4.0	8.0	12.0	4.0	8.0	12.0
x	Turnip, swede/yam	0.0	0.0	0.08	0.0	0.0	0.08
x	Broad beans, fresh/frozen	0.0	0.0	0.08	0.0	0.0	0.08
x	Green beans, fresh/frozen	0.08	3.0	6.0	1.0	4.0***	8.0
x	Haricot, lima beans	0.0	0.0	0.08	0.0	0.0	0.08
x	Green peas, fresh/frozen	0.08	2.7	4.0	0.08	3.0**	8.0
x	Cabbage	0.08	1.0	4.0	0.08	1.0	4.0
x	Brussel sprouts	0.0	0.08	0.2	0.0	0.08**	1.5
x	Silver beet/spinach	0.0	0.1	3.0	0.08	1.0*	4.0
x	Broccoli, fresh/frozen	1.5	4.0	12.0	3.0	7.0**	12.0
x	Cauliflower, fresh/frozen	0.08	2.0	4.0	1.0	3.0**	5.4
x	Egg plant	0.0	0.08	1.0	0.0	0.08*	2.0
x	Pumpkin	0.08	1.0	4.0	1.0	4.0***	6.0
x	Sweetcorn, fresh/frozen	0.08	2.0	4.0	0.08	2.0	4.0
x	Zucchini, fresh/frozen	0.08	2.0	4.0	0.3	2.0	4.0
x	Onion, fried	0.08	1.0	4.0	0.0	2.0**	8.0
x	Onion, raw/baked/boiled	0.02	1.0	4.0	0.0	0.5	4.0
	Tomato	8.0	12.0	20.0	3.0	8.0***	16.0
	Tabouli salad	0.0	0.08	2.0	0.0	0.08	1.0
	Lettuce, white	0.08	8.0	16.0	0.0	2.0***	8.0
	Lettuce, green	0.08	8.0	16.0	0.08	3.0***	8.0
	Cucumber	4.0	12.0	21.2	0.08	2.0***	8.0
	Coleslaw	0.08	1.0	4.0	0.0	0.08***	1.0
	Celery	0.08	4.0	8.0	0.08	1.0***	4.0
	Green capsicum	1.0	6.0	16.0	0.08	4.0***	8.0
	Red capsicum	0.08	3.0	12.0	0.08	2.0***	8.0
x	Mushrooms, fresh	1.0	3.0	8.0	1.0	2.6**	4.0
	Bean shoots	0.08	0.08	3.0	0.0	0.08*	1.0
x	Fried mixed vegetable (e.g. stir fry)	0.08	1.0	4.0	0.08	2.0*	6.0

† Units are servings per month.
*** $P < 0.0001$, ** $P < 0.001$ and * $P < 0.01$ for summer versus winter frequency of consumption.
x, Vegetables included when comparing the frequency reported on the long FFQ to the frequency reported on the summary question. Other vegetables included for this comparison were some canned items (tomatoes, carrots, broad and green beans, peas, zucchini and mushrooms) and dried green peas.

definition of vegetables in this paper. Vegetables such as canned tomatoes were also included but canned or dried beans and lentils and condiments such as olives, gherkins and pickles were excluded. After discussion with colleagues, we decided to exclude fruit fritters, fruit pastries and dried fruit, in addition to juice, from the definition of fruit as it was thought that people would only think of fresh fruit when answering the summary question.

The corrected nutrient data for the FFQ were calculated using the summary questions. For example, if the response to the summary fruit question was half the summed frequency of all fruit (except juices, dried fruit, fruit pastries) then the frequency of each fruit in the FFQ was halved. The extent to which this would alter total nutrient intake would depend on the consumption of other items rich in various nutrients, such as fruit juice, which did not have their frequencies corrected. As there will always be some variability in reporting, these corrections were only done if there was greater than a 20% difference between the two reports. In a small number of cases, the approach of Subar *et al.*[17] was used for the recalculation. When participants reported eating one or more items on the FFQ, but said zero servings to the summary question, no recalculation was done if the total frequency of all individual servings was 2.5 servings per week or less ($n = 3$); if the sum was greater than 2.5 servings per week, the zero was replaced by the median value for the summary question and the recalculation performed as above ($n = 5$).

Statistical analysis

As a check on under-reporting, the ratio of energy intake to basal metabolic rate (EI/BMR) was calculated for the group and for each individual. BMR was calculated using the Schofield equation based on age, gender and self-reported weight[18]. The ratios were compared with a series of cut-off limits derived by Goldberg *et al.*[19]

The difference between summer and winter frequency

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Table 2 Geometric means of total daily nutrient and energy intakes calculated from the FFQ by annualizing the season-specific vegetable frequency intakes and when the season-specific frequency of vegetable intake was assumed to apply to the whole year

Nutrient	Annualized frequencies	Summer frequencies	Winter frequencies
Energy (kJ)	8185	8160*	8200*
Carbohydrate (g)	245	244	246
Fibre (g)	28.4	28.5	28.2
Beta-carotene (μg)	4180	4130**	4159**
Vitamin A (μg) RE	1062	1056	1061
Vitamin C (mg)	188	190	185*
Zinc (mg)	11.4	11.4	11.3
Iron (mg)	13.2	13.3	13.1
Magnesium (mg)	347	347	346
Potassium (mg)	3667	3667	3660

** $P < 0.001$; * $P < 0.05$ for summer versus annualized consumption, or winter versus annualized consumption using $\log_e$ transformation to improve normality.
RE, Retinol Equivalents.

was tested for each vegetable using Wilcoxon's signed-rank test as the data were highly skewed with many null frequencies. The energy and nutrient intakes were $\log_e$-transformed and compared using a paired *t*-test.

The median total weekly fruit and vegetable intake frequencies were also positively skewed, so the responses from the two sources were compared using Wilcoxon's signed-rank test. After natural log transformation, paired *t*-tests were used to compare corrected and uncorrected nutrient intakes. Agreement between the corrected and uncorrected intakes was examined by ranking individuals into quartiles according to each definition. Energy-adjusted intakes[20] were used to assess agreement to highlight variations due to food intake profile rather than overall quantity.

Using the RDIs for women aged 18–54 years[21], the proportion of participants not meeting the RDI was determined for each method of calculating nutrient intake. When the RDI specified a range rather than a single figure, the lower end of the range was used. Dietary fibre intake was compared with the target for the year 2000[22].

Results

Of the 147 women who were recruited to the trial, 123 returned the FFQ. These women had an average age of 30.6 (SD = 8.7) years, a mean body mass index of 22.4 (SD = 3.8) kg m^{-2} and 28.5% were smokers. The mean EI/BMR was 1.49 (95% CI: 1.41–1.57), which suggests that there is some under-reporting of total energy intake on the FFQ.

Overall, the median total monthly intake of fresh and frozen vegetables was 35.2 servings in summer and 31.0 servings in winter ($P < 0.001$). Monthly frequencies are presented for individual vegetables as some were very low (Table 1). Tomato, green and white lettuce, cucumber, coleslaw, celery and red and green capsicum were consumed significantly more often in summer, while potatoes, green beans, broccoli, cauliflower and pumpkin were consumed more often in winter ($P < 0.001$). Even so, apart from some of the salad items, broccoli and pumpkin, there was not a large difference in some of the statistically significant frequencies. Although some of the seasonal differences in nutrient intakes are statistically significant, these differences are trivial from a nutritional point of view (Table 2).

The fruit summary question gave approximately half the weekly fruit intake of the FFQ (Table 3). Hence, when corrected for this, the median frequency assessed by the FFQ of all fruit and juice fell from 20.9 servings per week to 12 servings per week. Similarly, correcting vegetable intake for the summary question responses reduced median total frequency from 36.2 servings per week to 26.6 servings per week. These corrections decreased the fruit frequency of 75% of subjects and increased it for 8%. The corresponding figures for vegetable intake were 65% and 15%, respectively.

As expected, the energy and nutrient intakes decreased when the FFQ responses were corrected (Table 4). This difference ranged from 4.4% for zinc to nearly 30% for beta-carotene. There was a corresponding increase in the proportion of women whose intakes fell below the recommended intakes or targets. Overall, the mean percentage classified into the same quartiles was 72% with a range from 58% for beta-carotene to 90% for zinc (Table 5). The mean percentage grossly misclassified (individuals who had moved more than two quartiles) was 2.4% and ranged from 0% to 7%. Energy adjustment did not make a large difference and did not always improve classification.

Discussion

Major differences in frequency of fruit and vegetable intakes were found between the summary questions and the FFQ, the difference in estimates from the FFQ being more than double those from the summary questions for

Table 3 Mean and median total weekly fruit and vegetable intake estimated from the FFQ before and after corrections were performed using information from the summary questions

	Servings per week		
	Mean	95% CI	Median
Fruit summary question	10.2	8.6–11.6	7.0
FFQ: total fruit	19.3	17.1–21.5	16.8
FFQ: total fruit + fruit juice	23.3	20.6–26.0	20.9
FFQ: corrected total fruit + fruit juice†	13.1	11.2–15.0	12.0
Vegetable summary question	13.5	11.9–15.1	14.0
FFQ: vegetables	21.3	19.0–23.6	18.4
FFQ: total vegetables, salads and potatoes and legumes	42.6	34.2–50.9	36.2
FFQ: corrected total vegetables, salads, potatoes and legumes‡	28.1	24.6–31.6	26.6

† Corrected using the summary question for fruit.
‡ Corrected using the summary question for vegetables.
Correction of the long FFQ for the summary questions led to significant differences ($P < 0.001$) for both fruit and vegetable intakes.

Table 4 Relationships between raw and corrected daily nutrient and energy intakes calculated from the FFQ†

	Geometric means				Difference %	% below RDI‡	
	Uncorrected	95% CI	Corrected	95% CI		Uncorrected	Corrected
Energy (kJ)	8185	7778–8604	7770	7398–8160	5.2	–	–
Carbohydrate (g)	245	232–259	227	215–241	7.4	–	–
Fibre (g)	28.4	26.5–30.4	24.3	22.8–26.0	15.4	47	70
Beta-carotene (mcg)§	4180	3748–4656	3168	2867–3498	29.7	–	–
Vitamin A (mcg) RE§¶	1062	974–1160	886	818–959	18.1	20	38
Vitamin C (mg)	188	170–208	153	139–169	20.8	0	0
Zinc (mg)	11.4	10.7–12.1	10.9	10.2–11.5	4.4	48	50
Iron (mg)	13.2	12.4–14.1	12.3	11.6–13.1	6.7	28	37
Magnesium (mg)	347	323–372	318	300–337	8.7	22	26
Potassium (mg)	3667	3436–3909	3288	3096–3495	10.9	–	–

† For all nutrients, intakes were statistically significantly different ($P < 0.001$) between the uncorrected and corrected data. A $\log_e$ transformation was used.
‡ Target for fibre, 30 mg; RDIs for vitamin A, 750 mcg; vitamin C, 30 mg; zinc, 12 mg; iron, 12 mg; magnesium, 270 mg.
§ Includes some other provitamin A carotenoids expressed as beta-carotene equivalents.
¶ RE, Retinol Equivalents.

Table 5 Percentage of agreement within quartiles between the uncorrected and corrected values

	Similarly classified		Grossly misclassified†	
	Unadjusted (%)	Energy adjusted‡ (%)	Unadjusted (%)	Energy adjusted‡ (%)
Carbohydrate	74	82	2	0
Fibre	69	74	3	2
Beta-carotene	58	55	7	8
Vitamin A	68	60	4	6
Vitamin C	62	73	2	2
Zinc	90	94	0	0
Iron	75	87	0	0
Magnesium	80	85	2	0
Potassium	74	76	2	1

† Grossly misclassified is defined as individuals who have moved two or more quartiles.
‡ Intakes were adjusted for energy using the residual from regressions with energy intake as the independent variable and each nutrient intake as the dependent variable.

fruit. This discrepancy had a substantial effect on the estimate of absolute nutrient intakes when the summary questions were used to correct for fruit and vegetable intakes from the FFQ. Despite this, the effect on ranking of individuals was not particularly marked. These results indicate different impacts for two types of studies that might use this questionnaire.

As regards the total frequency of intake, these results are consistent with those of Subar *et al.*[17], who found that the summary question reduced the frequency of fruit and vegetable consumption by 29% compared with a list of 33 items. The reduction in our study was larger, which may indicate that the longer list of 73 items leads to greater overestimation, as has been found by others[1,23]. State-wide surveys using the CSIRO questionnaire have yielded intakes that are higher than the apparent consumption

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and sales data for fruit and vegetables in Australia (R. Stanton, personal communication, May 1997).

The energy intake calculated using the uncorrected method indicated that about 20% of women had under-reported their total energy intake, which is similar to findings of the recent national survey[24]. As the fruits and vegetables involved in the corrections were mainly low in energy density, a large correction to the intake frequency had a relatively small effect on the energy intake. From these data, it is not possible to identify the source of the misreporting. It may be that either the lengthy list of items on the FFQ or the response to health promotion information has led to relative over-reporting of fruit and vegetable intakes. Alternatively, health promotion information may have led to under-reporting of high-fat or other high-energy foods which are seen as less acceptable. All of these effects may be operating. As the women in the current study are not a representative sample, comparisons with intake patterns in the national survey provide little helpful information about which effect may be occurring. Compared with the mean intakes for women aged 25–44 years in the national survey[24], the corrected geometric mean intakes using the FFQ were more than 10% higher in our subjects for fibre, vitamin C, magnesium and potassium but more than 10% lower for total vitamin A, but these may reflect real differences due to socio-economic differences rather than methodological differences.

The CSIRO questionnaire has been used in state surveys[10,11]. Several states have also done surveys using different sets of summary questions to estimate usual fruit and vegetable intake and these do not yield the same results[25]. It is clear that trends must be assessed using the same instrument on all occasions or that the various tools must be calibrated to each other. These data indicate that it is not valid to use a long FFQ in some surveys and summary questions in others, and to make judgements about trends, unless the results of one instrument are corrected to the scale of the other. As it is not known which of the two instruments yields the 'correct' result it is only possible to monitor the direction of trends. It is not possible, at this stage, to predict when a target such as 'two pieces of fruit daily' will be reached, or to make statements about the proportion of the population currently not meeting this target. Clearly, the targets will appear to be reached more quickly if the longer FFQ is used than if the summary questions are used. These data also suggest that summary questions for potato and salad consumption might be needed.

Compared with the results for absolute intake, the results for ranking are robust, with less than 5% changing to the opposite quartile of classification. Hence, when no statements about total intake are planned, as may be the situation in case–control or cohort studies, it would not be necessary to use the summary questions with the FFQ.

Although there were differences in intake between the seasons for some foods, this made no important difference to the nutrient intakes of women living in Sydney. Hence, it would seem that retaining separate questions about summer and winter consumption would be necessary for an analysis focused on foods, but not for one focused on nutrients. Ideally, this finding would be further tested by asking a similar group to fill in questionnaires with and without seasonal separation of the vegetables, and in other areas of Australia.

In summary, this study has revealed that two different, commonly used questionnaire styles lead to very discrepant estimates of fruit and vegetable intakes. Although it is not possible to say which, if either, of the results is 'correct', these results warn against comparing the results of either questionnaire with national recommended intakes and targets. If precise estimates of nutrients need to be generated then summary questions and/or other correction factors may need to be employed. As ranking was barely affected, the two methods would be essentially interchangeable for research where subjects will only be ranked. This study provides a reminder that a questionnaire which is valid for one use may be invalid for other uses.

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References

1 Pietinen P, Hartman AM, Haapa E, *et al*. Reproducibility and validity of dietary assessment instruments: I. A self-administered food use questionnaire with a portion size picture booklet. *Am. J. Epidemiol.* 1988; **28**: 655–66.
2 Salvini S, Hunter DJ, Sampson L, *et al*. Food-based validation of dietary questionnaire: the effects of week-to-week variation in food consumption. *Int. J. Epidemiol.* 1989; **18**: 858–67.
3 Serdula M, Coates R, Byers T, *et al*. Evaluation of a brief telephone questionnaire to estimate fruit and vegetable consumption in diverse populations. *Epidemiology* 1993; **4**: 455–63.
4 Hebert JR, Clemow L, Pbert L, Ockene IS, Ockene JK. Social desirability bias in dietary self-report may compromise the validity of dietary intake measures. *Int. J. Epidemiol.* 1995; **24**: 389–98.
5 Baghurst KI, Baghurst PA. The measurement of usual dietary intake in individuals and groups. *Trans. Menzies Found.* 1981; **3**: 139–60.
6 Potter JD, McMichael AJ. Diet and cancer of the colon and rectum: a case–control study. *J. Natl. Cancer Inst.* 1986; **76**: 557–69.
7 Rohan TE, McMichael AJ, Baghurst PA. A population-based case–control study of diet and breast cancer in Australia. *Am. J. Epidemiol.* 1988; **128**: 478–89.
8 Baghurst PA, McMichael AJ, Slavotinek AH, Baghurst KI,

https://doi.org/10.1079/PHN200094 Published online by Cambridge University Press

Boyle P, Walker AM. A case–control study of diet and cancer of the pancreas. *Am. J. Epidemiol.* 1991; **134**: 167–79.
9 Barratt A, Reznik R, Irwig L, *et al.* Worksite cholesterol screening and dietary intervention: the Staff Healthy Heart Project. *Am. J. Public Health* 1994; **84**: 779–82.
10 Baghurst KI, Record SJ, Baghurst PA, Syrette JA, Crawford D, Worsley A. Sociodemographic determinants in Australia of the intake of food and nutrients implicated in cancer aetiology. *Med. J. Aust.* 1990; **153**: 444–52.
11 CSIRO Division of Human Nutrition. *What are Australians Eating?: Results from the 1985 and 1990 Victorian Nutrition Surveys.* Adelaide: CSIRO, 1993.
12 Block G, Woods M, Potosky A, Clifford C. Validation of a self-administered diet history questionnaire using multiple diet records. *J. Clin. Epidemiol.* 1990; **43**: 1327–35.
13 Mackerras D, Irwig L, Simpson JM, *et al.* Randomised double-blind trial of beta-carotene and vitamin C in women with minor cervical abnormalities. *Br. J. Cancer* 1999; **79**: 1448–53.
14 Simmonds, A. Evaluation of a food frequency questionnaire for assessing dietary intake of beta-carotene. MPH treatise, University of Sydney, 1993.
15 Commonwealth Department of Human Services and Health. *NUTTAB 95 Nutrient Data Table for Use in Australia.* Canberra: Australian Government Publishing Service, 1995.
16 Commonwealth Department of Health. *National Dietary Survey of Adults: 1983, No. 1, Food Intakes.* Canberra: Australian Publishing Service, 1987.
17 Subar AF, Heimendinger J, Patterson BH, Krebs-Smith SM, Pivonka E, Kessler R. Fruit and vegetable intake in the United States: the baseline survey of the five a day for better health program. *Am. J. Health Promotion* 1995; **9**: 352–60.
18 Schofield WN, Schofield C, James WPT. Basal metabolic rate. *Hum. Nutr. Clin. Nutr.* 1985; **39C**(Suppl. 1): 1–96.
19 Goldberg GR, Black AE, Jebb SA, *et al.* Critical evaluation of energy intake data using fundamental principles of energy physiology: 1. Derivation of cut-off limits to identity under-reporting. *Eur. J. Clin. Nutr.* 1991; **45**: 569–81.
20 Willet WC, Stampfer MJ. Total energy intake: implications for epidemiologic analysis. *Am. J. Epidemiol.* 1986; **124**: 17–27.
21 NH&MRC. *Recommended Dietary Intakes for Use in Australia.* Canberra: Australian Government Publishing Service, 1991.
22 Commonwealth Department of Health. *Towards Better Nutrition for Australians.* Report of the Nutrition Taskforce of the Better Health Commission. Canberra: Australian Government Publishing Service, 1987.
23 Krebs-Smith S, Heimendinger J, Subar AF, Patterson GH, Pivonka E. Using food frequency questionnaires to estimate fruit and vegetable intake: association between number of questions and total intakes. *J. Nutr. Ed.* 1995; **27**: 80–5.
24 Australian Bureau of Statistics and Department of Health and Aged Care. *National Nutrition Survey. Nutrient Intakes and Physical Measurements, Australia 1995.* Canberra: Australian Bureau of Statistics, 1998.
25 Mackerras D, Caffin NA, Fenn AM, Comparison of fruit and vegetables questionnaires used in three statewide surveys. *Proc. Nutr. Soc. Aust.* 1995; **19**: 204.