Table 2.2. Validation of dietary assessment methods in pregnant women

Reference	Study Population	Test Method (TM)	Reference Measurement (RM)	Design Features	Correlation Between TM and RM	Mean Intake Difference Between TM and RM
DOUBLY LABELED WATER (DLW) METHOD FOR TOTAL ENERGY EXPENDITURE (TEE) MEASUREMENT						
Goldberg et al., 1993 (14)	Pregnant women 12 Followed longitudinally at 6 wk intervals from 6 to 36 wks. gestation Caucasian, healthy, middle and upper SES UK	TEE by DLW Method	7d weighed FR (4d weighed FR, off for 7d, then 3d weighed FR)	Purpose of study was to examine energy requirements during pregnancy. Subjects received whole body calorimetry, indirect calorimetry and DLW dosing. Women visited in home after first day of weighed FR to review understanding of procedures. When snacks and meals eaten away from home not weighed, researchers purchased similar foods and weighed portions. DLW spot urine specimens collected daily for 14d after dosing.	Not specified	**DLW Method vs. FR** TEE measured by DLW greater than FR energy intake at non-pregnancy, and at 6, 12, 18, 24, 30, and 37 wks gestation. 6 wks. = 6% 12 wks. = 15% 18 wks. = 12% 24 wks = 18.8% 30 wks. = 24% 37 wks. = 23% Four subjects FR implausible based on 1.14 times BMR; 2 more were questionable.
Forsom et al., 1992 (15)	Pregnant women 22 Followed longitudinally from pre-pregnancy, at 16-18 wks., and at 30 wks. gestation Healthy; Swedish Stockholm	TEE by DLW Method before pregnancy and at 16-18 wks.	4d weighed FR before pregnancy	DLW spot urine specimens collected 6 and 13d after dosing. FR kept 3 weekdays and 1 weekend day after dosing.	Not specified	**DLW Method vs. FR** 27% overestimation 10.7 $\pm$ 1.9 vs. 8.4 $\pm$ 1.8 MJ/d.

Table 2.2. Validation of dietary assessment methods in pregnant women, continued

Reference	Study Population	Test Method (TM)	Reference Measurement (RM)	Design Features	Correlation Between TM and RM	Mean Intake Difference Between TM and RM
DIET HISTORY (DH)						
Tapsell et al., 2002 (16)	Pregnant women 14 @ beginning of 3rd trimester with gestational diabetes mellitus (GDM) 19 @ beginning of 3rd trimester without GDM mean age 30.7 yrs. New South Wales	Research DH (included a meal-based FFQ with space to record food specifications and a core food group checklist)	7d weighed FR	Research DH obtained on all women at beginning of 3rd trimester. Women without GDM kept 7d weighed FR and a 2nd DH two weeks later. Instruments administered before intervention counseling. Criterion validity (number reporting intake below cut off value of 1.14 of energy intake:BMR ratio) calculated in women with GDM.	Correlation and Confidence Interval r (CI) Energy = 0.27 (0.2. 0.64) Pro. % kcal = 0.56 (0.15, 0.80) p<0.05 Fat % kcal = 0.47 (0.03, 0.73) CHO % kcal = 0.42 (0.03, 0.73)	**DH vs 7d weighed FR** 4% kcal overestimation (p = 0.41) 10,238 + 1576 vs. 9804 +1443 KJ/d Non significant differences for % kcal from protein, carbohydrate and fat, and for % fat from SFA, PUFA, and MUFA
24-HOUR RECALL (24HR)						
Klebanoff et al., 1998 (17)	Pregnant women 239 <26 wks. Multiparous, with risk factors for reduced fetal growth, and with normal pregnancy outcomes for current pregnancy Birmingham, AL	Serum caffeine and paraxanthine	24HR	On the day of the first 24HR during first prenatal visit, serum drawn for storage. Women divided into quartiles based on reported caffeine use from 24HR.	**Pearson Correlation** **24H caffeine intake vs. serum paraxanthine** = 0.50 for smokers and 0.53 for nonsmoker. **24H caffeine intake vs. serum caffeine** = 0.37 for smokers and 0.52for nonsmokers. Values comparable to correlation between reported smoking and serum cotinine in pregnancy.	Not applicable

Table 2.2. Validation of dietary assessment methods in pregnant women, continued

Reference	Study Population	Test Method (TM)	Reference Measurement (RM)	Design Features	Correlation Between TM and RM	Mean Intake Difference Between TM and RM
FOOD FREQUENCY QUESTIONNAIRE (FFQ)						
Parra et al., 2002 (18)	Pregnant women 35 in 3rd trimester 19-41 yrs.; healthy; Mexican; without habitual drug or alcohol use or on prescription medications Mexico City	104-item FFQ Semi-quantitative Interviewer administered Past year intake	Erythrocyte cell membrane content of fatty acids in 35 women	The goal of the study was to evaluate the validity of the FFQ for assessment of the dietary intakes of PUFAs (n-3 and n-6) against a biochemical marker of fat intake. FFQ administered to 146 women during last trimester. First 35 had erythrocytes analyzed for fatty acid status.	Linear regression coefficients **Erythrocyte PUFA vs. log transformed dietary PUFA** 18:3n-3 = 0.52 (95% CI-0.020-1.10 p=0.61) 22:6n-3 = 0.30 (95% CI 0.007-0.60 p=0.045) 20:4n-6 = 0.49 (95% CI 0.010-0.98 p=0.044)	Not Applicable Other results: Women classified in the highest and lowest quartiles of dietary intake by FFQ were also classified in such quartiles by the erythrocyte alpha linoleic acid (18:3n-3**).**
De Vriese et al., 2001 (19)	Pregnant women 26 Followed longitudinally 1st and 3rd trimester Primagravid; singleton pregnancy; diastolic blood pressure <90 mm Hg; not diabetic, no proteinuria, no renal or cardiovascular disease. Belgium	180-item FFQ Semi-quantitative Interviewer administered with colored photographic booklet to estimate portion sizes (adapted Dutch FFQ) Past month intake	7d Estimated FR	The main objective of the FFQ was to estimate the dietary intake of fat and fatty acids in the preceding month. Dietitian administered FFQ in home and reviewed 7d FR every two days in the home in first and third trimester.	Pearson correlations Total fat = 0.64 SFA = 0.63 MUFA = 0.62 PUFA = 0.68 18:2n-6 = 0.66 All significant p<0.0001	**FFQ vs. 7d FR** **1st trimester** Total fat = -1.5 g/d SFA = -1.2 g/d MUFA = -3.7 g/d PUFA = 1.0 g/d 18:2n-6 = 2.6 g/d (p=0.05) **3rd trimester (g/d)** Total fat = 1.7 g/d SFA = -0.6 g/d MUFA = -1.6 g/d PUFA = 1.0 g/d 18:2n-6 = 2.3 (g/d p=0.01) 83% classified in the same quartile with FFQ and FR

Table 2.2. Validation of dietary assessment methods in pregnant women, continued

Reference	Study Population	Test Method (TM)	Reference Measurement (RM)	Design Features	Correlation Between TM and RM	Mean Intake Difference Between TM and RM
FOOD FREQUENCY QUESTIONNAIRE (FFQ), CONTINUED						
Erkkola et al., 2001 (20)	Pregnant women 113 in 3rd trimester Mean age 29.6 yrs., education representative of Finnish women in general Finland	181-item FFQ Semi-quantitative Self-administered Past month intake	2 5d FRs, at least 1 wk. apart	From August 1995 to July 1996, 113 women completed the FFQ at the beginning of the 8th mo. and 1 mo. after delivery, and FRs for two 5d periods separated by at least 1 wk. during the 7th mo. of pregnancy. Another group of 111 women completed FFQ twice at 1 mo. intervals at beginning and end of 8 mo. of pregnancy.	Pearson correlation, Energy and Attenuation Adjusted 24HR & FFQ Kcal = 0.50 Range of 0.04 to 0.86 for foods; 0.22 to 0.74 for nutrients.	**FFQ vs. FR** FFQ1 estimate for foods 138% higher than 10d of FRs; FFQ2 136% higher. FFQ mean estimate for kcal 125% higher than FRs. Other results: An average of 70% (52-94%) of women were classified by both methods into the same or adjacent quintiles according to their food intake, and an average of 69% (58-81%) were classified as such according to nutrient intakes.
Rifas-Shiman et al., 2000 (21)	Pregnant women 185 after prenatal visit (1st trimester) 39% black 61% white Members of a managed care organization in New England	Harvard FFQ modified for use in pregnancy Semi-quantitative Self-administered 1st trimester intake = intake since last menstrual period	Red blood cell concentrations of fatty acids, alpha carotene, lycopene, lutein, and gamma-tocopherol	Mean nutrient intakes in each of eight categories of HFFQ-estimated intake (energy-adjusted nutrient specific deciles 1,2,3, 4+5, 6+7, 8, 9, 10) compared with level of the same nutrient in a blood specimen composed of pooled blood from all of the subjects in that HFFQ category. Separate pools were created for black and white participants.	Spearman correlation coefficients (r) N-3 fatty acids = 0.98 white; 0.93 black Trans fatty acids = 0.75 white; 0.57 black; alpha-linoleic acid = 0.07 white; 0.07 black; lycopene = 0.88 white; -0.02 black; lutein= 0.95 white; 0.52 black; gamma-tocopherol = 0.29 white; 0.81 black	

Table 2.2. Validation of dietary assessment methods in pregnant women, continued

Reference	Study Population	Test Method (TM)	Reference Measurement (RM)	Design Features	Correlation Between TM and RM	Mean Intake Difference Between TM and RM
FOOD FREQUENCY QUESTIONNAIRE (FFQ), CONTINUED						
Brown et al., 1996 (22) Diana Project	Pregnant women 56 in mid pregnancy 51% of eligible and willing women; 94% with >HS education; 96% white, 72% employed full time; healthy Minnesota	Harvard FFQ Semi-quantitative Self-administered Modified to reflect intake over past 1-mo. period and to include 3 additional foods (custard, decaffeinated coffee, and broth-type soups)	4d weighed FR	FFQs self-administered and returned by mail @ 65±87 d pre-conception and 135±39 d after conception. The 4d FR mailed to participants along with food-weighing scale @ 79±84 d pre-conception and 123±36 d after conception. Participants were women served by a large health maintenance organization in the Minneapolis-St Paul, Minn. area.	Spearman rank correlation Ranged from .75 for vitamin C to .02 for cholesterol and averaged.48. It was .45 for energy-adjusted values. Correlations greater than 0.5 for energy and 7 of 15 nutrients.	**FFQ vs. 4d FR** Prepregnancy 8% kcal underestimation 1758 ± 533 vs. 1909 ± 404 kcal/d FFQ intake lower for all nutrients except calcium Mid-pregnancy 10 % kcal underestimation 2031 ± 613 vs. 2258 ± 344 FFQ intake lower for all nutrients except iron and calcium Prepregnancy to mid-pregnancy change FFQs vs. 4d FR. Mean energy –76 ± 466 kcal Protein –0.2 ± 19.8 g Iron 0.7 ± 7.3 mg

Table 2.2. Validation of dietary assessment methods in pregnant women, continued

Reference	Study Population	Test Method (TM)	Reference Measurement (RM)	Design Features	Correlation Between TM and RM	Mean Intake Difference Between TM and RM
FOOD FREQUENCY QUESTIONNAIRE (FFQ), CONTINUED						
Robinson et al., 1996 (23)	Pregnant women 569 in 2nd trimester Community-based sample; mean age 26.4 yrs.; equal distribution among SES groups; 100% white UK	100-item FFQ Semi-quantitative Interviewer-administered Past 3-month intake	4d estimated FR	In 1991-92, women with first prenatal visit before 17 wks. visited in home at 15 wks. for FFQ administration by interviewer followed by prospective 4d FR. At a second home visit one wk later, FRs were reviewed and edited. Non-fasting blood sample taken at first prenatal visit to estimate serum vitamin C.	Spearman rank correlation Ranged from 0.27 (protein and CHO) to 0.37 (fat), all were strongly significant ($p<0.001$). Trend for the strength of correlation between FFQ and 4d FR fell as the degree of nausea experienced rose	**FFQ vs. 4d FR** 23.5% kcal overestimation Median energy intake with 25^{th} and 75^{th} percentiles = 9.76 (7.89, 16.4) vs. 7.9 (6.57, 9.28) MJ/day FFQ mean intakes higher than 4d FR for all nutrients. Both FFQ and 4dFR were correlated with fasting serum Vitamin C (0.227 FFQ) and 0.38 FR, both $p< 0.001$). Using serum vitamin C as an independent biomarker of intake, the percentage of individuals classified to the correct quarter of intake was similar for the FFQ and FR (34% and 37%) with 8% (FFQ) and 6% (FR) miss classified.

Table 2.2. Validation of dietary assessment methods in pregnant women, continued

Reference	Study Population	Test Method (TM)	Reference Measurement (RM)	Design Features	Correlation Between TM and RM	Mean Intake Difference Between TM and RM
FOOD FREQUENCY QUESTIONNAIRE (FFQ), CONTINUED						
Forsythe and Gage, 1994 (24)	Pregnant and Lactating women 80 Age 22-43 yrs.; HS education; recruited from 8 prenatal clinics; mixed ethnicity (32 from Ghana, Nigeria, and Kenya, and 48 from Caribbean) US	82 item multicultural FFQ Semi-quantitative Self-administered Modified Harvard FFQ for African and Caribbean foods. Time period not specified, but designed to assess weekly patterns of food intake	3 24HR 1st in-person following FFQ, 2nd and 3rd by telephone Bogalusa Heart Study protocol	Evaluated an FFQ developed for pregnant and lactating women of Carribbean and African descent at 8 centers in US. Three hours after FFQ administered, first in-person 24HR completed. Within 3 wks. 2nd and 3rd 24HR completed by telephone. 24HR used Bogolusa Heart Study protocol. In a random subset, FFQ and 24HR protocol repeated.	Not Reported	**FFQ vs 24HR** 34% kcal overestimation ($p<.05$) 10,755 $\pm$ 6030 vs. 8021 $\pm$ 2382 kJ/d Protein, CHO, fat, calcium iron, zinc, and alcohol estimates all significantly higher on FFQ ($p<.05$)

Table 2.2. Validation of dietary assessment methods in pregnant women, continued

Reference	Study Population	Test Method (TM)	Reference Measurement (RM)	Design Features	Correlation Between TM and RM	Mean Intake Difference Between TM and RM
FOOD FREQUENCY QUESTIONNAIRE (FFQ), CONTINUED						
FNS, USDA, 1994 (25)	Pregnant women 150 Breastfeeding (BF) women 150 Postpartum (PP) women 150 Children 1-4 yrs. 150 WIC participants distributed evenly between black, white, and Hispanic ethnic groups US	Harvard Women FFQ (WFFQ) NCI-Block HHHQ Self-administered Intake period not specified in Executive Summary	3 24HR by telephone	Data collection from July 1993 through January 1994. In each category, half the sample received WFFQ followed by 3 non-consecutive telephone 24HR and a second administration of the WFFQ. The other half of the sample received the HHHQ followed by 3 non-consecutive 24HR and a second administration of the HHHQ.	**FFQ vs. 24HR** Pregnant women WFFQ/HHHQ Kcal 0.22/0.3 Pro. 0.29/0.32 Vit. A 0.29/0.26 Vit. C 0.12/0.18 Iron 0.32/0.05 Calcium 0.41/0.37 All Women WFFQ/HHHQ Kcal 0.19/0.37 Pro. 0.24/0.35 Vit. A 0.21/0.32 Vit. C 0.13/0.30 Iron 0.20/0.26 Calcium 0.29/0.42	Not specified **Other results:** HHHQ more valid for white and black women than WFFQ Neither FFQ valid in Hispanic women or in children
Greeley et al., 1992 (26)	Pregnant women 50 Followed longitudinally during 2nd and 3rd trimester 20-35 yrs.; healthy; 40% 1st pregnancy, 74% employed; race ethnicity not specified North Dakota, US	Harvard FFQ 2 times. Semi-quantitative Self-administered Modified to evaluate daily food intake during past 2 mo. period	4 24HRs	Between June 1988 and February 1989, convenience sample from an urban community in eastern ND recruited. 24HR interview completed in the home 4 times (16, 21, 30 and 35 wks.). Recall days at convenience of participant so weekdays/weekend days was 4/1. 24HR were conducted with a single-page form that included a checklist for five food/beverage categories, time of day, quantity, and preparation. FFQ completed in home at 21 and 35 wks.	**Pearson correlation** Mean 24HR and HFFQ 2nd trimester only vitamin C and folacin significant (0.48 and 0.39, p = 0.01) 3rd trimester fat (0.28), CHO (0.32), iron (0.56), calcium (0.48), vitamin C (0.52), and folacin (0.48) all significant ($p \leq 0.05$)	**HFFQ vs Mean 24HR** 2nd trimester 7.3% kcal overestimation 2157 vs. 2009 kcal/d (NS) Pro (g/d) 15.38 ($p<01$) CHO, Fe, Ca Vit C and Folacin all overestimates ($p \leq 0.05$) 3rd trimester 6.9 % kcal overestimation 2182 vs. 2041 kcal/d (NS) Pro (g/d) 11.6 ($p<01$) CHO, Fe, Ca Vit C and Folacin all overestimates ($p \leq 0.05$)

Table 2.2. Validation of dietary assessment methods in pregnant women, continued

Reference	Study Population	Test Method (TM)	Reference Measurement (RM)	Design Features	Correlation Between TM and RM	Mean Intake Difference Between TM and RM
FOOD FREQUENCY QUESTIONNAIRE (FFQ), CONTINUED						
Suitor et al., 1989 (27)	Pregnant women 295 Trimester = 12% 1st, 40% 2nd, and 47% 3rd; aged 14-43 yrs.; low income; 48.3% white; 27.5% black; 24.2% Hispanic; 13% <18 yrs.) Massachusetts	Harvard FFQ Self-administered with help provided as needed Modified to evaluate daily food consumption during past 4 wk. period; no portion sizes; contained open ended question on type of supplements used	3 24HR on randomly selected subset of 95 women 2D Food Portion Visual	HFFQ administered twice, 2 wks. apart. In recall subset, HFFQ followed by 3 24HR by telephone or in-person and then completed a 2nd HFFQ. The second HFFQ in both groups sent to participants by mail for return by mail. Return rate for second FFQ 60% and not representative of total sample (mostly white women with HS education and above poverty level).	Observed and Adjusted Pearson correlation 24HR & 1st HFFQ Energy = 0.47, 0.54 95% CI = 0.30, 0.71 Pro. = 0.44, 0.54 95% CI = 0.27, 0.73 Calcium = 0.60, 0.71 95% CI = 0.48, 0.84 Iron = 0.43, 0.55 95% CI = 0.26, 0.76 (Values also reported for Zn, vit A, B6, and C)	**HFFQ1 vs. 24HR** 13% kcal overestimation 2518 ± 921 vs. 2226 ± 709 kcal (outliers excluded) Other results: HFFQ adjusted correlation coefficients and quintile comparisons indicated the HFFQ could correctly identify a high proportion of women having low intake of selected nutrients.
Wei et al., 1999 (28) (same data set as Suitor, 1989)	Pregnant women 101 Trimester = 54.4% 1st, 26.5% 2nd, and 19.1% 3rd; aged 14-43 yrs.; low income; 63.4% white; 18.8% black; 17.8% Hispanic; 13% <18 yrs.) Massachusetts	Harvard FFQ	24HR (at least one of 3 completed)	The purpose of the Wei study was to broaden the scope of the 1989 validation by assessing the validity of the HFFQ for 17 additional nutrients. This analysis included a randomly selected sub-sample of 101 participants who had provided at least one 24HR and reported intake of less than 4,500 kcal.	Pearson Correlation, Energy-Adjusted and Corrected for Measurement Error: Range of .07 (B12) to .90 (zinc). Mean correlation for 17 nutrients = 0.47; 54% were over 0.4.	**HFFQ1 vs 24HR** **Mean kcal ± SD** 11% kcal overestimation 2561.5 ± 893.9kcal vs. 2276.6 ± 782.2