2.0 PREGNANCY AND LACTATION

2.1 Pregnancy

The most intensive period of human growth and development occurs during the nine months of pregnancy (11). Assessing the food and nutrient intake of pregnant women is complicated because conception triggers an array of complex and sequential physiological changes that affect maternal nutrient absorption and metabolism, energy and nutrient needs, appetite, and meal patterns (12). Individual physiologic and behavioral responses to the stress of reproduction vary widely (13), and both the type and amount of food consumed may fluctuate depending on the period of pregnancy. Nausea, which is estimated to occur in 50-80 percent of pregnancies (11), may begin as early as 4 to 6 weeks gestation, usually peaks around 8 to 12 weeks, and then declines thereafter. Heartburn and constipation are other common ailments that may trigger changes in usual food habits. Pregnant women may develop food preferences and aversions due to changes in the sense of taste and smell. Pica, an eating disorder characterized by the compulsion to eat substances that are not food, affects more than half of pregnant women in some locations in the southern part of the United States (11). Maternal concerns about optimal fetal growth and development, weight gain, and parenting may increase maternal awareness of nutrition and focus personal and health care provider attention on food habits and supplement consumption. Misrepresentation of intake, particularly with regard to alcohol and supplements, may be an issue because of respondents' fear of noncompliance.

2.2 Validation studies in pregnant populations

Validation of dietary assessment methods in pregnant women is limited. Table 2.1 presents a summary of 15 validation studies; additional information on each study is included at the end of this chapter in Table 2.2. Two studies examining energy expenditure using the DLW method to measure TEE also evaluated reported energy intake. In 12 Cambridge women, reported energy intake from 7-day weighed food records underestimated TEE measured by the DLW method by 6 to 15 percent in the first trimester, 12 to 18 percent in the second trimester, and 24 percent in the third trimester (14). Although large differences between individuals in the metabolic cost of pregnancy was found, application of the Goldberg cut-off limits based on EI:BMR ratios identified under-reporters. Energy intake measured by 4-day weighed food records kept before conception by 22 Swedish women, underestimated TEE at 6 to 18 weeks gestation by 27 percent (15). In a review of six different data sets containing 228 DLW TEE measurements

Table 2.1.Summary Table: Validation Studies on Pregnant Women

	Sample Size	Reference Method					Racial Ethnic					Includes Low SES	Supplement Intake Assessment Method	Results
		TEE by DLW Method	Other Biomarkers	Weighed FR	Estimated FR	24-Hour Recall	Caucasian	African American	Hispanic	Asian	Other			
Total Energy Expenditure (TEE) by Doubly Labeled Water (DLW) Method														
Goldberg et al., 1993 (14)	12			7d			✓							6-23% under reporting by FR
Forsom et al., 1992 (15)	22			4d			✓						NS*	27% under reporting by FR
Diet History														
Tapsell et al., 2002 (16)	33			7d			✓						NS	Non-significant differences
24HR														
Klebanoff et al., 1998 (17)	239		✓			1							NS	Serum caffeine and paraxanthin correlated significantly with 24HR intake of caffeine at <26wks.
FFQ														
Parra et al., 2002 (18) 104-item semi quantitative interviewer administered FFQ, Mexico City	35		✓						✓			✓	NS	Erythrocyte PUFA correlated significantly with dietary intake of PUFA.
DeVriese et al., 2001 (19) 181-item semi quantitative interviewer administered FFQ, Belgium	26			7d			✓						NS	Correlation between FFQ and 7dFR total fat, PUFA, MUFA, and EFA all above 0.6. 83 % classified in same quartile by both methods.
Erkkola et al., 2001 (20) 181-item semi quantitative self administered FFQ, Finland	113			10d			✓							FFQ overestimated foods by 36-38%; 69% classified into same or adjacent quintiles
Rifas-Shiman et al., 2000 (21) Self administered, modified, semi-quantitative Harvard FFQ	185		✓				✓	✓					NS	Correlation between FFQ and serum N-3 fatty acids, trans fatty acids, and alpha-linolenic fatty acids 0.98, 0.75 and 0.07 in whites and 0.98, 0.57 and 0.07 in blacks.

*NS = Not Specified

Table 2.1.Summary Table: Validation Studies on Pregnant Women

	Sample Size	Reference Method					Racial Ethnic					Includes Low SES	Supplement Intake Assessment Method	Results
		TEE by DLW Method	Other Biomarkers	Weighed FR	Estimated FR	24-Hour Recall	Caucasian	African American	Hispanic	Asian	Other			
FFQ														
Brown et al., 1996 (22) Self-administered, modified, semi-quantitative Harvard FFQ	56			4d			✓						NS	FFQ underestimated EI by 10%. Correlation greater than 0.5 for 7 of 15 nutrients.
Robinson et al., 1996 (23) 100-item, semi-quantitative, interviewer-administered	569		✓		4d		✓						FFQ 4dFR	FFQ overestimated EI by 23.5%. Both FFQ and 4dFR were correlated with fasting serum Vitamin C (0.227 FFQ) and 0.38 FR, both p< 0.001).
Forsythe et al., 1994 (24) 82-item self administered, modified semi-quantitative, Harvard FFQ	80					3		✓			✓		NS	FFQ overestimated EI by 34%. Protein, CHO, fat, calcium iron, zinc, and alcohol estimates all significantly higher on FFQ (p<.05)
FNS, USDA, 1994 (25) Harvard FFQ in half of sample, HHHQ in half of sample, self-admin.	150					4	✓	✓	✓			✓	NS	Correlation between FFQ and 24HR higher with HHHQ than HFFQ for kcal, protein, Fe, Ca, and Vitamin A and C.
Greeley et al., 1992 (26) 116-item, self-administered Harvard FFQ 2 times	50					4							NS	FFQ overestimated EI by non-significant 7% in 2nd and 3rd trimester. CHO, Fe, Ca, Vitamin C, and folacin all overestimated by HFFQ.
Suitor et al., 1989 (27) 111-item self-administered, semi-quantitative modified Harvard FFQ twice	295					3 (n=95)	✓	✓	✓				FFQ	HFFQ overestimated EI by 13%. HFFQ could correctly identify a high proportion of women having low intake of selected nutrients.
Wei et al., 1999 (further analysis of data collected by Suitor) (28)	101					1-3	✓	✓	✓				FFQ	Mean correlation between HFFQ and 24HR for 17 nutrients = 0.47; 54% >0.4.

*NS = Not Specified

in pregnant and lactating women or non pregnant, non-lactating controls in Europe and Gambia (including the DLW studies in Table 1), Prentice and colleagues (13) recommend caution in the overinterpretation of dietary intake records. Their data show food intake records can be "extremely misleading and this is only revealed when there is some external validation such as the doubly labeled water method" (13).

Three other validation studies in Table 2.1 (and 2.4 at end of the chapter) included a biological marker to assess reported intake. Erythrocyte cell membrane fatty acid content was compared with fat intake reported on an FFQ in a study of 185 New England women in the first trimester (21) and on 35 third trimester Mexico City women(18). Both studies found significant correlations between erythrocyte alpha linoleic acid and dietary intake of the fatty acid, and that women were classified into the same intake ranges by both the FFQ and this biological marker. Serum levels of caffeine and paraxanthine were examined as a biological marker to validate caffeine intake reported on a 24HR, with correlations between the two measures comparable to correlations between reported smoking and serum cotinine in pregnancy (17).

No other studies validating energy or nutrient intake assessed by the 24HR method in pregnancy populations were found. The 10 FFQ validation studies in Table 2.1 (and Table 2.4) are difficult to compare because the populations differ, the FFQ instruments differ, the studies cover various periods of pregnancy, and they differ in their reference methods and in the number of days of dietary recording. There are also statistical differences between the studies. Three FFQ studies on European pregnant women compared FFQ intake with weighed or estimated FRs (19;20;23). Each found the FFQ overestimated energy intake, but generally classified the women into the same or adjacent nutrient intake category as the FR. In the US, six studies have examined the validity of the Harvard FFQ (HFFQ) modified in various ways for pregnancy in each study and assessing intake usually for the past 1 to 3 months. Comparisons with multiple administrations of 24HR interviews in 4 studies found the Harvard FFQ overestimated energy intake (25-28). However, compared with 4-day weighed FRs, the modified Harvard FFQ underestimated energy intake by 10 percent during mid-pregnancy in a population of educated, white Minnesota women (22). A large study of low income pregnant women comparing the HFFQ with three 24HR interviews concluded the HFFQ provides a reasonably accurate measure for the majority of nutrients and can appropriately rank individuals relative to one another even if absolute intakes may not be precise (27;28). However, the exclusion of 14 to 18% of the women reporting caloric intakes above 4,500 on the HFFQ suggests a significant proportion of the low-income women were unable to complete the HFFQ adequately (28). The NCI-Block HHHQ was found more valid for white women and black pregnant WIC participants than the HFFQ, based on correlations between each FFQ and three 24HR interviews for energy and five nutrients. Neither FFQ was valid in Hispanic women (25).

Although most of the FFQ instruments in the validation studies in Table 2.1 collected information on supplement intake, validation of reported supplement intake was not discussed.

2.3 Lactation

The benefits of breastfeeding for both mothers and infants are well established and rates of breastfeeding have been increasing across all socioeconomic and ethnic groups in the US during the last decade. In 2001, the prevalence of the initiation of breastfeeding and breastfeeding until 6 months of age increased to 69.5% and 32.5%, respectively, and breastfeeding rates are projected to increase at least 2 percent per year through 2010 (29). Yet very few studies have applied specific measures of nutritional status to the lactating mother.

Lactation is an anabolic state with an even greater maternal nutritive burden than pregnancy (12). Infants double their birth weight in just 4 to 6 months postpartum. The energy value of the milk excreted in just 4 months is equivalent to the total energy cost of pregnancy (12). Complex hormonal interactions orchestrate mammary gland development, milk production and secretion, and redirection of nutrients to the mammary gland for transfer to the infant (12). As in pregnancy, the lack of validated biological markers of nutrient intake during lactation is a significant methodological barrier to dietary assessment research. The growth of the breastfed infant and the quantity and nutrient content of the breast milk are often used as proxies to assess maternal nutritional adequacy during lactation (12). Another issue has been a lack of a consistent definition of breastfeeding behaviors (e.g., exclusive, partial) in the lactation literature (30). Presenting additional challenges is the variation in breast milk output and composition between women and within the same woman from day to day, from feed to feed, and during a single lactation (31;32). Among the multitude of factors with the potential to affect self report of dietary intake are maternal concerns about her breast milk adequacy and ability to successfully support infant growth and development, the challenge of parenting a newborn infant, maternal fatigue and time constraints, desire to quickly return to pre-pregnant maternal weight, concerns about infant colic and food sensitivities, and cultural beliefs about diet and botanical supplement use during lactation (33).

2.4 Validation Studies in Breastfeeding Women

Only four studies examining the validity of dietary assessment methods in breastfeeding women were found (Table 2.3 at the end of this chapter). Two small European studies examining the energy costs of lactation provided an opportunity to evaluate the validity of self-reported weighed FRs. Basal Metabolic Rate (BMR), TEE by the DLW method, physical activity plus thermogenesis (TEE-BMR), changes in body fat stores, milk energy transfer, and energy intake reported in a 7-day weighed FR were studied in 10 Cambridge women at 4, 8, and 12 weeks of

lactation and when not pregnant and not lactating (34). Reported energy intake for the group was within 10-20% of measured energy output. However, data examined for individuals found the largest degree of under-reporting of energy intake only in the overweight subject (BMI 29.9). In 22 exclusively breastfeeding Swedish women, 4-day weighed FRs at 2 months postpartum reported only two-thirds of the measured energy costs of lactation (TEE by DLW method + BM Energy Output from 24-hour infant test weighing) (15).

In 1983, Stuff and colleagues (35) measured dietary intake in 40 lactating women with a 7-day estimated FR and a 105-item FFQ. Interclass correlations for measuring agreement between methods for calories and five nutrients showed poor agreement between the FFQ and 7-day FR (r = 0.00 to 0.24). FFQ estimates were higher than FR estimates for energy and all nutrients examined. Analysis of randomly selected 1- and 3-day FRs from the 7-day FR, showed that the 3-day FR did not provide good individual estimates of nutrient intake, but did provide reasonable estimates of group intake. When individuals were classified into high, medium, and low intake groups by each method, none of the intakes was found to agree with the 7-day FR classification. Intra-individual variation was found to be greater than inter-individual variation in this study.

In 150 breastfeeding WIC participants, the NCI-Block HHHQ was found to be more valid than the Harvard FFQ, based on correlations between each FFQ and three 24HR interviews for energy and five nutrients (25). Neither FFQ was valid in Hispanic women.

2.5 Surveys of Pregnant and Breastfeeding Women

Table 2.4 presents summary data from several epidemiologic surveys collecting food and supplement intake data from pregnant or lactating women. More details on the specific surveys are included in Table 2.5 at the end of this chapter. The two most recent US nutrition monitoring surveys, the 1999-2000 National Health and Nutrition Examination Survey (NHANES) and the 1994-96 Continuing Survey of Food Intake of Individuals (CSFII), each included 24HR interviews to assess diet and supplement intake. Neither survey included a sizable number of pregnant or lactating women. Table 2.6 presents the diet-related questions in each of these surveys as well as those in the integrated What We Eat in America-NHANES survey, which is currently in the field. The rationale for instrument selection for the integrated survey as well as the history of past CSFII and NHANES surveys was recently reviewed (9). The integrated What We Eat in America-NHANES includes two 24HR interviews, one in-person and one by telephone, and a propensity questionnaire (100-item NCI DHQ without portion size information). Supplement use is queried in a separate questionnaire on frequency, dosage, and duration of use of specific products. Neither the current survey, nor past NHANES or CSFII surveys, query pregnant or lactating participants any differently from other non-pregnant or non-lactating

participants. No additional information related to their diet or supplement use is collected. Lactation is defined as any breastfeeding reported by the participant.

In 2000, the Danish National Birth cohort enrolled 60,000 pregnant women and achieved a 77% response rate for a 300-item self-administered FFQ (36). This national survey will enroll 100,000 women and follow their offspring for 20 years. Women are interviewed by telephone twice during pregnancy (12 and 30 weeks) and when the infant is 6 and 18 months. The Avon Longitudinal Study of Pregnancy and Childhood (ALSPAC) also uses an FFQ to examine the average daily intake of more than 12,000 women at 32 weeks gestation (37). This geographically-based cohort study is investigating factors influencing the health and development of infants and children. The FFQ in this survey contains questions on 43 food group items as well as detailed questions on 8 basic foods.

The US National WIC evaluation assessed intake of almost 4,000 women with two 24HR interviews (38). A survey of more than 2,000 pregnant women in North Carolina used the HHHQ (39), while Project Viva in Eastern Massachusetts studied more than 2,000 women with the HFFQ (40) and was able to estimate the extent to which this population changed fish consumption habits after a federal advisory recommending limited intake during pregnancy.

In 1990, the Institute of Medicine report *Nutrition During Lactation* identified a need for data on dietary intakes by, and nutrition status among, lactating women and their relationship to lactation performance. As evident from the limited data on lactating populations in Table 2.6, this recommendation remains relevant.

Table 2.4 Summary Table: Surveys of pregnant or breastfeeding populations

	Pregnant Women (n)	Breastfeeding Women (n)	Ethnically Diverse	Longitudinal	Cross sectional	Assessment Method				Nutrient Biomarkers	Supplement Intake Assessment Method	Outcomes
						Weighed Food Record (no. days)	Estimated Food Record (no. days)	24-Hour Recall (n)	FFQ Type			
National Nutrition Monitoring Surveys												
US National Health and Nutrition Examination Survey (NHANES) 1999-2000 (41)	298	NS*	✓		✓			1; 2 in 10%		✓	Quest.& 24HR	Food, nutrient, physical activity, and chemical exposures
Continuing Survey of Food Intake of Individuals (CSFII) 1994-96 (42)	80	43	✓		✓			2		✓	24HR	Food and nutrient exposures, diet and health knowledge
Danish National Birth Cohort (Better Health for Mother and Child) (36)	100,000	--	NS	✓					300-item	✓	FFQ	Food, nutrient, and chemical exposures
Population Surveys of Food and Nutrient Exposures												
Avon Longitudinal Study of Pregnancy and Childhood (ALSPAC) Avon, UK (37)	12,104	--	NS	✓					Non-quant. FFQ		FFQ & Quest.	Energy intake, nutrient exposures from foods and supplements.
Better Beginnings, Better Futures Initiative (Ontario, Canada) (43)	--	183	✓		✓			1			24HR	Kcal and intake of 10 nutrients
National WIC Evaluation (US) (38)	3,967	--	✓		✓			2			NS	Birth outcomes, kcal and nutrient exposures
New Zealand Breastfeeding Study (44)	--	73	NS		✓			2			NS	Kcal, 15 nutrients
Pregnancy, Infection, and Nutrition Study (PIN) (North Carolina) (39)	2,065	--	✓		✓				HHHQ		Tel. Quest	Birth outcomes, meal patterns, Diet Quality Index
Project Viva (Eastern Massachusetts) (40)	2,235	--	✓		✓				HFFQ	✓	NS	Fish consumption
Survey of Breastfeeding Women in Italy (45)	--	125	NS		✓			2				Maternal meal patterns and nutrient intake, infant growth, infant milk intake by test weighing for 1d
Survey of Pregnant WIC Participants in Minneapolis (46)	95	--	✓		✓				HHHQ	✓	NS	Kcal and 6 nutrients

*NS = Not Specified

Table 2.4. Summary Table: Surveys of pregnant or breastfeeding populations, (continued)

	Pregnant Women (n)	Breastfeeding Women(n)	Ethnically Diverse	Longitudinal	Cross sectional	Assessment Method				Nutrient Biomarkers	Supplement Intake Assessment Method	Outcomes
						Weighed Food Record (no. days)	Estimated Food Record (no. days)	24-Hour Recall (n)	FFQ Type			
Other Studies												
Calcium for Preeclampsia Prevention (CPEP) Trial (US) (47)	156		✓	✓			7d				NS	Kcal, 23 nutrients, differences in intake between 2nd and 3rd trimesters.
Calcium intake and tibia bone lead in breastfeeding residents of Mexico City (Hernadez-Avila et al., 1996, 1997) (48;49)		95	✓		✓				128-item	✓	NS	Milk and cheese consumption, tibia bone lead
Neural Tube Defect Case-Control Study (US) (50)	467		✓		✓				HFFQ		Quest.	Dietary folate and supplement folate
Premature Rupture of Membranes Case Control Study (US) (51)	92		NS		✓				HHHQ		HHHQ	Kcal, 12 nutrients
Reynolds et al., 1984 (52)	36	36	NS	✓		3d					3d FR	Kcal; protein and iron from weighed FR; B6, Zn, Cu, and Mg from duplicate diet
State College, Pennsylvania Lactation Study (Mackey et al., 1998) (53)		52	NS	✓				2			Suppl. Trial	Milk output (3d test weighing;, infant weight, length, and head circumference; kcal and 23 nutrients
Patterns of Supplement Use in WIC Pregnant Participants (Massachusetts), Suitor and Gardner 1990 (54)	344		✓		✓				HFFQ		HFFQ	Patterns of vitamin and mineral supplement use
Song et al., 1984 (55)		43	--		✓	2d				✓	2d FR	Panothenic acid intake
Survey of Upper SES Pregnant Women in Gainesville, FL, Turner et al., 2003 (56)	63		--	✓			3d				NS	Maternal weight gain, infant birthweight, kcal, 12 nutrients

*NS = Not Specified

Table 2.5 Summary of diet-related questionnaires in 1994–1996, 1998 CSFII, NHANES 1999–2001, and the integrated What We Eat in America–NHANES[1,2]

Topic	1994–1996, 1998 CSFII	NHANES 1999–2001	Integrated survey, 2002+
Dietary recall	In-person; 2 d per person Information on where food was obtained, consumed at home or away	In-person; 1 d per person; 10% d 2 sample Where food consumed asked; where food obtained not asked	2 d per person: d 1 in person and d 2 by telephone Where food consumed asked; where food obtained info collected
Comprehensive FFQ (propensity questionnaire)	No	No	Modified National Cancer Institute diet history questionnaire (self-administered 100-item food questionnaire no portion size info); ages 2+ yrs targeted
Lactation definition	Any breastfeeding as defined by parent/guardian	Any breastfeeding as defined by parent/guardian	Any breastfeeding as defined by parent/guardian
Breastmilk intake assessment method	Time each feeding began in 24HR interview	Time each feeding began in 24HR interview	Time each feeding began in 24HR interview
Formula intake assessment method	Formula type, form, preparation, mixture, and amount consumed	Formula type, form, preparation, mixture, and amount consumed	Formula type, form, preparation, mixture, and amount consumed
Age child interviewed independently	>11 years	>11 years	>11 years
Procedures to assess child intake at school or with childcare provider	Data retrieval from school (menu query) or childcare provider if food description or amount missing	Data retrieval from school (menu query) or childcare provider if food description or amount missing	Data retrieval from school (menu query) or childcare provider if can identify meal but cannot remember all foods eaten.
Water intake	Yes: EPA questions used	Yes	NHANES adopted CSFII/EPA drinking water questions
Salt use	Table salt use: frequency and type Preparation salt information obtained for certain foods	Table salt use: frequency and type Preparation salt information obtained for certain foods	Table salt and preparation salt use: type and frequency; not food-specific
Dietary supplements	Categories of products and frequency of use	Specific products used in past 30 d; frequency, dosage, duration of use	NHANES questions adopted

[1]Adapted from Dwyer, J., et al (9) with addition of information relevant on infant and child assessment from NHANES and CSFII procedure manuals (57-59).

[2] Abbreviations: CSFII, Continuing Survey of Food Intakes by Individuals; EPA, Environmental Protection Agency; NHANES, National Health and Nutrition Examination Survey.

Table 2.5. Summary of diet-related questionnaires in 1994–1996, 1998 CSFII, NHANES 1999–2001, and the integrated What We Eat in America–NHANES, continued

Topic	1994–1996, 1998 CSFII	NHANES 1999–2001	Integrated survey, 2002+
Medications	No	Prescription drugs, antacids and some over-the-counter pain products	NHANES questions adopted
Food security	USDA food sufficiency indicator	US household food security survey module; individual level for persons < 12 yrs and 16+ yrs in 2001 dietary interview; USDA food sufficiency indicator in dietary interview	US household food security survey; household and individual level assessments
Special diet	Yes	Household interview: modified diets for high blood pressure and elevated serum lipids	CSFII question adopted
Program participation	Yes	Yes, essentially identical to CSFII	Yes
Milk consumption history (lifetime use questions)	No	Yes, household interview NHANES 1999+	Yes
Milk frequency and type of milk consumed (past 30 d)	No	Household interview, NHANES 1999+	Yes
Green leafy vegetables consumption frequency (past y)	No	Household interview NHANES 2000+	Yes
Legume consumption frequency (past 30 d)	No	Household interview, NHANES 2000+	Yes
Fish frequency (past 30 d; species-specific)	No	Examined sample, NHANES 1999+	Yes
Shellfish frequency (past 30 d; species-specific)	No	Examined sample, NHANES 1999+	Yes
Alcohol frequency (past 30 d and more)		Household interview. Mobile examination center interview (more private setting) for persons 12+ y of age include alcohol questionnaires	Yes

[1]Adapted from Dwyer, J., et al (9) with addition of information relevant on infant and child assessment from NHANES and CSFII procedure manuals (57-59).

[2] Abbreviations: CSFII, Continuing Survey of Food Intakes by Individuals; EPA, Environmental Protection Agency; NHANES, National Health and Nutrition Examination Survey.

2.6 Research needs in pregnant and lactating populations.

The identification and study of additional biomarkers of energy and nutrient intake will advance validation efforts and lead to a better understanding of the biases and sources of measurement error in dietary assessment instruments in pregnant or lactating populations. Currently very limited information is available on systematic measurement error, including both group-specific bias and person-specific bias in these populations for the 24HR, FR or FFQ instruments. While difficult and expensive, large scale studies of free-living pregnant women at various stages of pregnancy using biomarkers such as the DLW method for measurement of TEE paired with the various dietary assessment instruments would be helpful. Similar studies with lactating women at various postpartum stages would be useful. Research is needed to identify other pregnancy or lactation-specific laboratory indexes for nutritional evaluation. Research is also needed to identify sensitive, noninvasive and specific biomarkers of functional reproductive outcomes (12). Yang and Erickson reviewed surveys of folic acid status in non pregnant or lactating women of reproductive age and have examined the relationship of blood folate concentrations to reported supplement and food intake. They found significant reporting error in supplement use. Similar studies in pregnant or lactating women are needed (63).

Certainly the methods research priority recommendations from the "Future Directions for the Integrated CSFII-NHANES" 2002 workshop (9;64) can be applied to pregnant or lactating women. Among the recommendations are:

- Determining ways to identify and remove bias associated with under- and over-reporting of food, beverage, and supplement intake in 24HR interviews;
- Further development and pilot testing of propensity questionnaires (frequency-type questionnaires) to augment information collected in 24HRs and estimate the proportion of users of infrequently consumed foods;
- Development and validation of improved methods for assessing dietary supplement use; and
- Determining the best way to assess severity of inadequacy and excess nutrient intake (9;64).

In a longitudinal survey, the optimal timing and frequency of dietary assessment in pregnant and lactating women should be examined. The impact of social desirability bias, body-mass index, and maternal weight gain on self-reports of food, beverage, and supplement intake at various stages of pregnancy and lactation have not been well studied. Further work is needed on the most appropriate instruments for low-literacy populations, various ethnic groups, and adolescent pregnancies. Validation of automated or web based dietary assessment methods is needed.

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

Table 2.3. Validation of dietary assessment methods in breastfeeding women

Reference	Study Population	Test Method (TM)	Reference Measurement (RM)	Design Features	Correlation Between TM and RM	Mean Intake Difference Between TM and RM
DLW METHOD FOR TOTAL ENERGY EXPENDITURE (TEE) MEASUREMENT						
Goldberg et al., 1991 (34)	10 exclusively breastfeeding women Followed longitudinally at 4, 8, and 12 wk. pp Middle to upper SES, Caucasian, healthy, nonsmoking Cambridge, UK	DLW method	7d weighed FR (4d weighed FR, off 7d, then 3d weighed FR)	The purpose of this study was to examine energy balance in well-nourished lactating women. TEE, BMR, BM output, and energy intake were studied at 36 wks. gestation, and at 4, 8, and 12 wks. pp while nursing, and in the non-pregnant, non-nursing state. DLW dose followed by 21d urine or saliva collection from nursing mother and infant. Breast milk output measured by dose-to-the mother technique (DLW dose administered to lactating women).	Not specified	**TEE vs. Weighed FR** Differences between sum of TEE, milk-energy transfer, and energy deposited as fat and energy intake from weighed FR: 4 wks. pp = 9.6 $\pm$ 16.6% overestimation 8 wks. pp = -1.3 $\pm$ 19.3% underestimation 12 wks. pp = 4.9 $\pm$ 13.7% overestimation Data examined for individuals found largest degree of under-reporting of energy intake only in the overweight subject (BMI 29.9).
Forsom et al., 1992 (15)	23 exclusively breastfeeding women Followed longitudinally @ 2 and 6 mo. pp Stockholm	DLW method @ 2 mo. pp	4d Weighed FR @ 2 mo. pp	DLW spot urine specimens collected 6 and 13 d after dosing. At 2 mo. pp BM output measured by 24h test weighing of infant before and after each feeding. FR kept 3 weekdays and 1 weekend day after dosing.	Not specified	**TEE + BM Energy Output vs. Weighed FR** 33% overestimation (3.1 MJ/d) 2 mo. pp TEE + BM energy output = 12.7 $\pm$ 2.1 MJ/d vs. FR energy intake 9.5 $\pm$ 2.5 MJ/d

Table 2.3. Validation of dietary assessment methods in breastfeeding 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)						
Stuff et al., 1983 (35)	40 exclusively breastfeeding women 3 wk to 6 mo. pp; mean 2.7 mo. pp Caucasian, healthy by history, nonsmoking, no medications; infants growing within normal limits Texas	105-item FFQ Interviewer-administered with replica food models, measuring cups, and spoons. Current intake	7d Estimated FR	Nutritionist administered FFQ in home interview and then provided instructions for keeping 7d estimated FR**.** FR returned by mail; follow-up telephone calls clarified questions on FR. Random days selected for 1d FR and 3d FR analysis.	Interclass correlations FFQ vs. 7d FR kcal = 0.09 Protein, fat, CHO calcium , and iron ranged from 0.00 to 0.24 (all not significant) 1d FR vs. 7d FR kcal = 0.45 p<0.005 Protein, fat, CHO calcium , and iron ranged from 0.42 to 0.66 (all p<0.0050 3dFR vs. 7d FR kcal = 0.79 p<0.005 Protein, fat, CHO calcium, and iron ranged from 0.42 to 0.66 (all p<0.0050	**FFQ vs. 7d FR** FFQ 9% higher (177 kcal difference) FFQ = 2206 ± 478 kcal 7d FR = 2029 ± 357 kcal 1d FR = 2057 ± 609 kcal 3d FR = 2059 ± 444 kcal FFQ estimates higher than FRs for all other nutrients. Intra-individual variation greater than inter-individual variation.

Table 2.3. Validation of dietary assessment methods in breastfeeding 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 BF women 150 PP women 150 Children 1-4 yrs 150 WIC participants distributed evenly between black, white, and Hispanic ethnic groups	Harvard Women FFQ (WFFQ) NCI-Block HHHQ Intake period not specified in Executive Summary	3 24HRs by telephone	Data collection from July 1993 through January 1994. In each category, half the sample received WFFQ followed by 3 non-consecutive telephone 24HRs 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** Breastfeeding women WFFQ/HHHQ Kcal 0.23/0.25 Pro. 0.18/0.22 Vit A 0.23/0.26 Vit C 0.05/0.22 Iron 0.06/0.28 Calcium 0.17/0.31 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 reported in Executive Summary **Other results:** HHHQ more valid for white and black women than WFFQ Neither FFQ valid in Hispanic women or in children

Table 2.6. Nutrient and/or food intake surveys in pregnant or breastfeeding populations

Reference/ Survey Name	Study Population	Diet Assessment Method	Objective and Design Overview	Nutrients and Outcomes Assessed
FOOD RECORDS (FR)				
Turner et al., 2003 (56)	Pregnant women 63 low-risk women Followed longitudinally from 1st trimester 19-39 yrs.; 94% white; 90% college education; middle to upper income HH; 67% response rate Gainesville, FL	3d Estimated FR completed monthly until delivery 2 weekdays and 1 weekend day	Objective: To determine whether nutrient intake from food alone was adequate across trimesters in middle and upper income pregnant women and whether food intake exceeded the tolerable upper intake level for any nutrient. Design: From July 1995 to July 1998, women recruited at first prenatal visit to an obstetrics office in a university community. Participants first completed a questionnaire about dietary habits and work schedule. Then completed 3d estimated FR every month until delivery. FR returned by mail. Follow-up reminder telephone calls made. Supplement Intake: Not specified; intake from food only reported Instrument Selection Rational: Not specified	Maternal weight; self-reported infant birth weight; energy, protein; thiamin, riboflavin, niacin; Vitamins B-6, B-12, and C; magnesium, iron, zinc, selenium
Giddens et al., 2000 (47) Calcium for Preeclampsia Prevention (CPEP Trial)	Pregnant Adolescent and Adult Women Followed longitudinally @ 19-21 wks. and 29-31 wks. 59 adolescents: 13-18 yrs.; 27% black; 19% BMI >29 97 adults: 19-40 yrs.; 43% black; 30% BMI >29 Ohio	7d Estimated FR completed twice FR1 @ 19-21 wks. FR 2 @ 29-31 wks.	Objective: To examine dietary intake of pregnant adolescents during the 2nd and 3rd trimester. Design: Two 7d estimated FR were completed; the first at enrollment into CPEP Trial after nausea of pregnancy subsided and the second in the third trimester. Instructions given by registered dietitian. Subjects given a gift certificate incentive, food guide with 2-dimensional models, and a checklist by food category. Reminder postcards mailed and subjects contacted by telephone to review recording and answer questions. 86% return rate for FR in adolescents and 89% in adults. Supplement Intake: Supplement prescribed as part of clinical trial. Instrument Selection Rational: 7d FR has been shown to better reflect variability in intake of a free-living population than a 24HR or food logs of a shorter duration.	Energy, protein, fat, CHO, dietary fiber, cholesterol, Vitamins A, C, E, D, B-6. and B-12, calcium, iron, zinc, copper, selenium, thiamin, riboflavin, niacin, folate, phosphorus, and magnesium. There was no difference between mean intakes in second and third trimester.

Table 2.6. Nutrient and/or food intake surveys in pregnant or breastfeeding populations, continued

Reference/ Survey Name	Study Population	Diet Assessment Method	Objective and Design Overview	Nutrients and Outcomes Assessed
FOOD RECORDS (FR), CONTINUED				
Mackey et al., 1998 (53)	Lactating women 52 Followed longitudinally at 3 and 6 mo. pp Mean age 33 yrs.; apparently healthy; term pregnancy without complications; non smokers; normal BMI; planning to nurse at least 6 mo. State College, PA	2d Estimated FR completed twice FR1 @ 3 mo. FR2 @ 6 mo.	Objective: To assess longitudinally nutrient intakes of lactating women during the postpartum period. Design: Successfully lactating women kept 2d estimated FRs at 3 and 6 mo. Infant growth assessed. 2-dimensional Food Portion Visual provided to aid portion size estimation. Supplement Intake: All subjects were part of a randomized, double-blind study examining folate status during lactation. Subjects discontinued usual supplements and were randomized into experimental protocol which provided specific supplements. Instrument Selection Rational: Not specified	Milk intake from 3d infant test weighing; infant weight, length, head circumference; intake of energy, protein, fat, cholesterol, CHO, fiber, calcium, iron, magnesium, phosphorus, zinc, copper, selenium, thiamin, riboflavin, niacin, folate, and , vitamins A, C, E, D, B-6, and B-12.
Reynolds et al., 1984 (52)	Pregnant and lactating women 36 Followed longitudinally @ 37 wks. of pregnancy and @ 1, 3, and 6 mo. pp 18-36 yrs.; 15 yrs. mean education; upper middle class Beltsville, MD.	3d Weighed FR and 3d duplicate diet completed @ 37 wks. and @ 1, 3, and 6 mo. pp	Objective: To more accurately determine the vitamin B6 intakes of lactating women, Design: Women kept 3d FR and duplicate diet at 37 wk. and 1, 3, and 6-mo. pp. Supplement Intake: Women recorded their intake of supplements. Instrument Selection Rational: The duplicate diet method eliminates errors associated with incomplete or inaccurate record keeping and incomplete databases.	Energy, protein, and iron intake calculated from FR; B6, zinc, copper, and magnesium analyzed in composites of duplicate diet.

Table 2.6. Nutrient and/or food intake surveys in pregnant or breastfeeding populations, continued

Reference/ Survey Name	Study Population	Diet Assessment Method	Objective and Design Overview	Nutrients and Outcomes Assessed
FOOD RECORDS (FR), CONTINUED				
Song et al., 1984 (55)	Lactating women: 26 with full term infants 17 with pre term infants (28-34 wk. gestation) Followed longitudinally @ 2 and 12 wks. pp 20 to 35 yrs.; Caucasian; middle SES Utah	2d Weighed FR @ 2 wk. and 12 wk. pp.	Objective: To evaluate the pantothenic acid status of lactating mothers; to determine and compare pantothenate content of both fore and hind samples of term and preterm human milk; to correlate human maternal status with milk pantothenate content. Design: Mothers of term infants kept 2DFR at 2 and 12 wks. pp and collected 2 24h urine samples on days of 12 wk. FR. All mothers took sample of for and hind milk from first feeding on day fasting blood sample drawn. Supplement Intake: Assume FR since data analysis separated supplement users from non-users. Instrument Selection Rational: Not specified	Pantothenic acid
24-HOUR RECALL (24HR)				
Giammarioli et al., 2002 (45)	Lactating women 125 27-36 yrs.; healthy, mean BMI of 24.0; 56% 9-13 yrs. education; 11.2% > 14 yrs. education Italy	Written 24HR (Mother recalled intake and portion sizes for 2 days and recorded on form at pediatric clinic)	Objective: To assess the energy and macronutrient intakes of exclusively breastfeeding Italian women. Design: Healthy lactating women were recruited from three major geographical areas in Italy. At visit to pediatric center mother asked to record all food and drink consumed in previous 24hrs. Photographs of serving sizes and household measures aided portion size recall. Records with incomplete portion sizes or details on food rejected. 210 recalls collected; 125 accepted. Supplement Intake: Not specified Instrument Selection Rational: Not specified	24h test weighing of infant BM intake; infant growth; maternal meal patterns; maternal energy and nutrient intake.

Table 2.6. Nutrient and/or food intake surveys in pregnant or breastfeeding populations, continued

Reference/ Survey Name	Study Population	Diet Assessment Method	Objective and Design Overview	Nutrients and Outcomes Assessed
24-HOUR RECALL (24HR), CONTINUED				
Doran and Evers, 1997 (43) Better Beginnings, Better Futures Initiative	Lactating women 183 @ 3 mo. pp Mean age 28.9 yrs.; healthy; low income; 24% <HS education; ethnically diverse Ontario, Canada	24HR and interviewer administered questionnaire on demographic, personal, social and cultural factors related to infant feeding	Objective: To assess the energy and nutrient intakes of women who are breastfeeding in relation to the RDAs for energy and nutrients during lactation. Design: Data collected in home within 2 wks. of child's 3 mo. birthday. 24HR on mothers still breastfeeding. Supplement Intake: Use of supplements noted in 24HR Instrument Selection Rational: A 24HR provides a good estimate of the average dietary intake of a group.	Maternal energy intake and intake of protein, fat, niacin, riboflavin, thiamin, folate, calcium, iron, zinc, and vitamin A and C.
Levine et al., 1996, 1997 (65;66) Calcium for Preeclampsia Prevention (CPEP Trial)	Pregnant women 4,589 Enrolled @ 13-21 wks. and followed longitudinally Healthy; nulliparous; no hypertension; negative proteinuria; no medications 5 university medical centers in US	24HR 1 @ 91-153d 24HR 2 @ 32-34 wks.	Objective: To determine if calcium supplementation (2000 mg) in 4 chewable tablets in healthy pregnant nulliparous women reduced the incidence of preeclamsia Design: Double blind randomized clinical trial launched in 1992. Women received either a 2g calcium supplement daily until term or placebo. 24HR at randomization and 32-34 wks. gestation. Serum and urine specimens collected at baseline, 26-29 wks. and 36 wks. Supplement Intake: Questionnaire on supplement compliance and return of blister packs. Instrument Selection Rational: Purpose of 24HR was to determine the amount of calcium obtained from sources besides CPEP study tablets. Rationale for selection of 24HR not discussed.	Pregnancy Associated Hypertension (PAH); Pregnancy-associated. Proteinuria (PAP); preeclampsia; eclampsia; HELLP syndrome; placental abruption, cerebral hemorrhage or thrombosis, elevated liver enzymes; acute renal failure; disseminated intravascular coagulation; calcium intake from diet and supplements.

Table 2.6. Nutrient and/or food intake surveys in pregnant or breastfeeding populations, continued

Reference/ Survey Name	Study Population	Diet Assessment Method	Objective and Design Overview	Nutrients and Outcomes Assessed
24-HOUR RECALL (24HR), CONTINUED				
Todd et al., 1994 (44)	Lactating women 73 exclusively BF @ 3 mo. pp Mean age 30 yrs.; 41% with tertiary education; mainly European origin New Zealand	24HR 2x, separated by 2 wks. 2nd 24HR sometimes by telephone	Objective: To assess the adequacy of dietary intakes of a group of healthy women exclusively breastfeeding for 3mo. Design: Demographic data and two 24HR taken 2 wks. apart collected. Supplement Intake: Not specified Instrument Selection Rational: Not specified	Energy; protein; carbohydrate; fat; PUFA; dietary fiber; sodium; calcium; iron; zinc; niacin; vitamins A, B6, B12, C; and folate
Rush et al., 1988 (38) National WIC Evaluation	Pregnant women: 3,967 in 1st or 2nd trimester 75% random subsample of new registrants to WIC in 1st two trimesters; 48.7% white; 13.6% white Hispanic; 34.9% black; and 2.7% other for participants with known perinatal outcomes US	24HR 2x 24HR 1 @ enrollment 24HR 2 @ approx. 36 wks.	Objective: This paper describes the methodology for the National WIC Evaluation. The goals of the longitudinal study of pregnant women, the study of children, and the food expenditure survey in this survey were to assess the impact of the WIC program on participants. Design: National probability sample of WIC participants in 174 WIC clinics in 58 areas in 48 states, and in 55 low-income prenatal clinics without WIC programs. Pregnant women completed 2 24HRs, histories of food expenditures, health care utilization, health and sociodemographic status, and anthropometric assessment. Birth outcome abstracted from medical records for 3863 WIC and 1057 control women. Supplement Intake: Not specified Instrument Selection Rational: Not specified	Birth outcomes; dietary intake (analysis not specified)

Table 2.6. Nutrient and/or food intake surveys in pregnant or breastfeeding populations, continued

Reference/ Survey Name	Study Population	Diet Assessment Method	Objective and Design Overview	Nutrients and Outcomes Assessed
FOOD FREQUENCY QUESTIONNAIRE (FFQ)				
Oken et al., 2003 (40) Project Viva	Pregnant women 2,235 @ various stages of pregnancy 67% white; 89% > HS education Eastern Massachusetts	Harvard FFQ modified for use in pregnancy 1st trim. = intake since last menstrual period 2nd trim. = intake for previous 3 mo. 3rd trim. = fish intake in month before delivery. Self-administered	Objective: Estimate extent pregnant women changed fish consumption habits after federal advisory recommended limiting consumption during pregnancy. Design: Interrupted time series analysis of semi-quantitative FFQ completed by women visiting obstetric group practice between April 1999 through December 2000 and April 2001 through February 2002. Subjects completed one FFQ each trimester. Subjects completing at least one FFQ included. Supplement Intake: Not specified. Instrument Selection Rational: Well-validated FFQ selected and calibrated with first trimester red blood cell concentrations of long-chain omega-3 fatty acids (Rifas-Shiman SL, Fawzi W, Rich-Edwards JW, Willett WC, Gillman MW. *Validity of semi-quantitative food frequency questionnaire (SFFQ) during pregnancy*. Paediatr Perinat Epidemiol 2000;14(4):A25-6.) (21)	Consumption of total fish and of four fish types: canned tuna, dark meat fish, shellfish, and white meat fish.
Thompson et al., 2003 (50)	Postpartum women 179 mothers of infant with neural tube defect (NTD) 288 case matched controls with healthy infant Cases: 79% white; 82% > HS education Controls: 69% white, 84% > HS education South Carolina	Harvard FFQ Questionnaire on supplement intake Intake for past 3 month period	Objective: Investigated whether multivitamin folic acid supplementation, dietary folate, or total folate in the periconceptional period reduces risk of having a first occurrence NTD affected pregnancy. Design: Population based case-control study. Women with first 1st occurrence, singleton, isolated NTD infant in SC 1992-97 and matched controls. Women completed HFFQ retrospectively for the period 3 mo. before conception and through the 1st 3 mo. of pregnancy. Women interviewed in person. Supplement Intake: Questionnaire on supplement intake adapted from CDC Birth Defect Risk Factor Surveillance Mother's Questionnaire. Multivitamin supplement types, brand name, period of use, quantity, and frequency of use per day, week or month from 3 mo. before conception to delivery. Instrument Selection Rational: Not specified	Dietary folate; supplement folate; and total folate intake in periconceptional period

Table 2.6. Nutrient and/or food intake surveys in pregnant or breastfeeding populations, continued

Reference/ Survey Name	Study Population	Diet Assessment Method	Objective and Design Overview	Nutrients and Outcomes Assessed
FOOD FREQUENCY QUESTIONNAIRE (FFQ), CONTINUED				
Ferguson et al., 2002 (51)	Pregnant women 46 with PROM between 23 and 35-36 wks. 46 without PROM matched to cases for gestational age and vitamin supplementation Ontario, Canada	NCI-Block HHHQ Intake period not specified;	Objective: To estimate if there were dietary or socioeconomic factors associated with premature rupture of the membranes (PROM). Design: Case-control study. Cases identified on admission to 3 hospitals. Fasting blood taken for homocysteine, complete blood count, red blood cell folate, B12, albumin and creatinine. At delivery fetal homocysteine analyzed from umbilical artery and vein blood. Cases and controls completed HHHQ at time of study enrollment. Supplement Intake: Not specified but cases and controls matched on supplement intake. Instrument Selection Rational: Not specified	Kcal, % kcal from protein, CHO, and fat, calcium, thiamin, riboflavin, niacin, vitamins C, E, B6, folate and alpha or beta carotene.
Olsen et al., 2001 (36) Danish National Birth Cohort (Better Health for Mother and Child)	Pregnant women and their infants 100,000 (60,000 pregnant women enrolled by August 2000) Denmark	300-item FFQ @ 25 wks. Self-administered; 77% completion rate; Past month intake	Objective: To study pregnancy complications and diseases in offspring as a function of factors operating in early life, fetal growth, and its determinants. Plan to follow cohort for 20 years. Design: Pregnant women recruited by general practitioner (GP) or midwife at first prenatal visit. GP takes blood sample twice during pregnancy and blood from umbilical cord shortly after birth. Mother participated in computer-assisted telephone interview twice during pregnancy (12 and 30 wks.) and when infant is 6 and 18 mo. old. All women complete FFQ by mail. Have permission to follow cohort for 20 yrs., but protocol for followup after 18 mo. not described. Supplement Intake: FFQ includes questions on vitamin and food supplements. Instrument Selection Rational: Not specified	Food, nutrient, and chemical exposures (article describes design of study and initial recruitment results and not results of FFQ or interviews).

Table 2.6. Nutrient and/or food intake surveys in pregnant or breastfeeding populations, continued

Reference/ Survey Name	Study Population	Diet Assessment Method	Objective and Design Overview	Nutrients and Outcomes Assessed
FOOD FREQUENCY QUESTIONNAIRE (FFQ), CONTINUED				
Siega-Riz et al., 2001; Bodnar and Siega-Riz, 2002 (39;67) Pregnancy, Infection, and Nutrition (PIN) study	Pregnant women 2,065 @ 24 to 29 wks. gestation 15-35 yrs.; lower to middle income; 51% white; 21% no high school; 54% single mothers North Carolina	120-item modified NCI-Block HHHQ Modified to focus on 3 mo. time period; to be specific for pregnancy; to include local foods; to include the latest recommendations for improving diet quality; and to add question on usual meal pattern.	Objective: To characterize meal patterns of pregnant women and to examine the relation between these meal patterns and both early and late preterm delivery as well as the clinical presentations leading to prematurity. Design: Women recruited from August 1995 to December 1998 completed FFQ and other study questionnaires at recruitment. Follow-up telephone interview collected demographic, medical history and health habits. Blood and urine collected at recruitment (24-29 wks. gestation). Supplement Intake: Women asked about supplement use in follow-up telephone interview Instrument Selection Rational: Not specified	Birth outcomes (gestational age, preterm delivery, premature rupture of membranes) from hospital delivery logs Self reported number of meals and snacks In follow-up analysis used a Diet Quality Index for Pregnancy to quantitatively differentiate diets (Bodnar and Siega-Riz, 2002)
Swensen et al., 2001 (46)	Pregnant women 95 Minneapolis and St. Paul, Minnesota	60-item version of the NCI-Block HHHQ Past month usual intake.	Objective: To evaluate nutrient intake from dietary sources for 95 women enrolled in the Special Supplemental Food Program for Women, Infants, and Children (WIC) Design: Between January and June of 1999, women less than 20 wks. gestation recruited at 6 WIC clinics. In-person 1-hr. interview included HHHQ, physical activity assessment and height and weight measurements. Venous blood sample for serum ferritin. Supplement Intake: Not specified; results reported on intake for food only. Instrument Selection Rational: Not specified	Protein, calcium, iron, vitamins A and C, folic acid, and total energy intake.

Table 2.6. Nutrient and/or food intake surveys in pregnant or breastfeeding populations, continued

Reference/ Survey Name	Study Population	Diet Assessment Method	Objective and Design Overview	Nutrients and Outcomes Assessed
FOOD FREQUENCY QUESTIONNAIRE (FFQ), CONTINUED				
Brown et al., 2000 (68)	Postpartum women 430 <20 to 40 yrs; 40% >9 grade education Mexico City	116 item FFQ Past year intake	Objective: To investigate determinants of bone and blood lead concentrations in lactating Mexican women during the early postpartum period and the contribution of bone lead to blood lead Design: Between April 1994 and June 1995, participants recruited from hospitals in Mexico City. Maternal venous lead measured at delivery and pp.; bone lead concentrations measured pp; and FFQ completed pp. FFQ validated previously in population of non-pregnant women. Other study questionnaire collected data on environmental lead exposure, and demographic characteristics. Supplement Intake: Not specified Instrument Selection Rational: Validated with 4d FR and repeat 24HR for 1 yr. in Mexico City population.	Hb, MCV, serum lead, bone lead measured by K-s ray fluorescence; calcium intake quartile
Rogers and Emmett, 1998 (37) Avon Longitudinal Study of Pregnancy and Childhood (ALSPAC)	Pregnant women 12,104 @ 32 wks. gestation (86 % response rate) Mean age 27.9; mean BMI 22.9 (SD 3.8); residents of Avon, England UK	Non-quantified FFQ Frequency of consumption (never or rarely, once in 2 wks, 1-3 x/ wk., 4-7 x/wk, and more than once a day) of 43-food groups and food items plus detailed questions on 8 basic foods; questions on alcohol added midway through study. Past 3 month intake	Objective: ALSPAC is a geographically-based cohort study investigating factors influencing the health and development of infants and children. As part of ALSPAC, this study examined average dietary intake in a group of over 10,000 women. Design: Pregnant women enrolled between April 1991 and Dec. 1992. Information collected from medical records and mailed questionnaires. FFQ mailed to ALSPAC cohort participants when 32 wks. gestation Supplement Intake: FFQ included questions on use of various supplements in previous 3 mo. A previous questionnaire asked about use in early pregnancy, Instrument Selection Rational: FFQ approach chosen because of the large number of subjects and also because, although they do not provide such accurate quantitative information as weighed intakes, they give a reasonable estimate of the habitual diet. The FFQ used was not validated.	Energy Intake: Under-reporting of energy intake based on 120% of calculated BMR (38% of respondents classified as under-reporters) Nutrients from food: Energy, protein, fat, MUFA, PUFA, SFA, sugar, NME sugar, fiber, Ca, total Fe, heme Fe, vegetable Fe, vegetable Zn, total Zn, meat Zn, Mg, K, carotene, folate, retinol equivalents, niacin, riboflavin, thiamin, and vit. B-6, C, and E Nutrients from supplements: Fe, Zn, Ca, folic acid, 'Vitamins,' other.

Table 2.6. Nutrient and/or food intake surveys in pregnant or breastfeeding populations, continued

Reference/ Survey Name	Study Population	Diet Assessment Method	Objective and Design Overview	Nutrients and Outcomes Assessed
FOOD FREQUENCY QUESTIONNAIRE (FFQ), CONTINUED				
Hernandez-Avila et al., 1996, 1997 (48;49)	Lactating women: 95 @ 1 mo pp Mexico City	128-item FFQ Past year intake	Objective: Cross-sectional study of the interrelationships between environmental, dietary, and lifestyle histories, blood lead levels, and bone lead levels in postpartum women in Mexico City. Design: Blood samples at delivery for lead and hemoglobin analysis. At 1mo. Pp. FFQ, bone lead measurements (x-ray fluorescence), blood sample, and BM sample. Supplement Intake: Results include Ca supplement intake, but does not specify how collected. Instrument Selection Rational: FFQ validated previously in women of reproductive age in Mexico City.	Milk and cheese consumption; patelia and tibia bone lead.
Suitor and Gardner, 1990 (54); Suitor et al., 1990 (69)	Pregnant women 344 @ various stages of pregnancy 14-43 yrs; low income; 43% white; 25% black; 32% Hispanic and other Massachusetts	Harvard FFQ modified for pregnancy 3-24HRs on subset of 95 women Intake period for FFQ not specified in article; supplement intake covered period before pregnancy	Objective: To examine patterns of vitamin/mineral supplement use among several demographic subgroups Design: Pregnant women recruited from 3 health centers serving primarily low-income clientele. HFFQ administered once; 3 24HRs on subset of 95. 89% completed HFFQ independently, 7% were interviewed, and 4% did not complete or return HFFQ. Supplement Intake: HFFQ included 5 items on supplement use, all of which were at the end of the 4-page form. Medical records were reviewed for supplement prescriptions. Instrument Selection Rational: Not specified	Patterns of vitamin/mineral supplement use.