

Design, Use and Interpretation of Food Frequency Questionnaires

ATC2: Techniques for Assessment of Exposure to FRs, Thursday 15 September

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Design, Use and Interpretation of Food Frequency Questionnaires

In order to study the relationship between diet and health we need instruments to accurately assess dietary intake of the individuals in a population.

Design, Use and Interpretation of Food Frequency Questionnaires

“The assessment of dietary intake is one of the most difficult tasks a physiologist can undertake”
Garrow, 1974

Dietary assessment: the “weakest link” in nutrition epidemiology

Assessing dietary intake involves:

- A report of all food consumed by an individual over time
- Quantification of the portion size for each food item
- Identification of the appropriate foods in a food composition database
- Calculation of the intake of energy and single nutrients and compounds

There are no methods that will measure the dietary intake of individuals without error.

The appropriate tool for dietary assessment will depend on the purpose for which it is intended.

Dietary assessment methods:

Prospective:

- ✓ Food records (weighed or estimated)
- ✓ Duplicate diets

Retrospective:

- ✓ 24-hour recalls
- ✓ Food Frequency Questionnaires (FFQ)
- ✓ Biological markers of food intake



Dietary assessment methods:

Prospective:

- ✓ Food records (weighed or estimated)
- ✓ Duplicate diets

Retrospective:

- ✓ 24-hour recalls
- ✓ **Food Frequency Questionnaires (FFQ)**
- ✓ Biological markers of food intake

There is no method that will measure the dietary intake in free-living individuals without error

The food frequency questionnaire (FFQ)

- A method that ask about the average intake over a given time period of foods and dishes in a defined food list
- The time period asked for vary, usually intake over the past 12 months
- The questionnaires may include questions about portion sizes or pictures
- The answer alternatives range from never to several times daily
- Can be self-administered or through telephone or web

National Health and Nutrition Examination Survey (NHANES) FFQ

Over the past 12 months...

28. How often did you eat **COOKED greens** (such as spinach, turnip, collard, mustard, chard, or kale)?

NEVER

1–6 times per year

7–11 times per year

1 time per month

2–3 times per month

1 time per week

2 times per week

3–4 times per week

5–6 times per week

1 time per day

2 or more times per day

29. How often did you eat **RAW greens** (such as spinach, turnip, collard, mustard, chard, or kale)?
(We will ask about lettuce later.)

NEVER

1–6 times per year

7–11 times per year

1 time per month

2–3 times per month

1 time per week

2 times per week

3–4 times per week

5–6 times per week

1 time per day

2 or more times per day

33. How often did you eat **string beans** or **green beans** (fresh, canned, or frozen)?

NEVER

1–6 times per year

7–11 times per year

1 time per month

2–3 times per month

1 time per week

2 times per week

3–4 times per week

5–6 times per week

1 time per day

2 or more times per day

34. How often did you eat **peas** (fresh, canned, or frozen)?

NEVER

1–6 times per year

7–11 times per year

1 time per month

2–3 times per month

1 time per week

2 times per week

3–4 times per week

5–6 times per week

1 time per day

2 or more times per day

35. Over the past 12 months, did you eat **corn**?

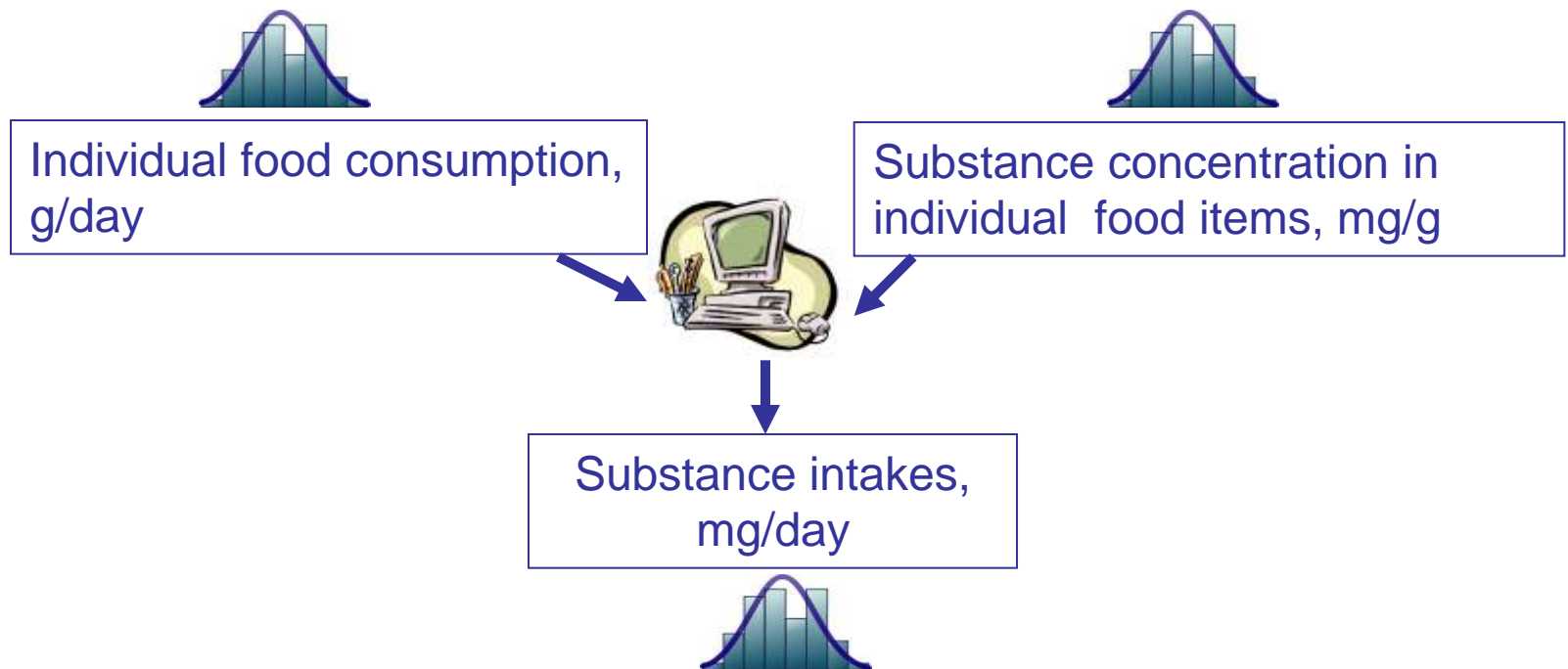
The European Prospective Investigation into Cancer (EPIC) Norfolk FFQ

PLEASE PUT A TICK (✓) ON EVERY LINE

FOODS AND AMOUNTS	AVERAGE USE LAST YEAR								
	Never or less than once/month	1-3 per month	Once a week	2-4 per week	5-6 per week	Once a day	2-3 per day	4-5 per day	6+ per day
BREAD AND SAVOURY BISCUITS (one slice or biscuit)									
White bread and rolls							✓		
Brown bread and rolls			✓						
Wholemeal bread and rolls		✓							
Cream crackers, cheese biscuits							✓		
Crispbread, e.g. Ryvita		✓							
CEREALS (one bowl)									
Porridge, Readybrek			✓						
Breakfast cereal such as cornflakes, muesli etc.		✓							

Conversion of food frequencies into food amounts and single substance intakes:

- Conversion of intake frequencies to daily intakes (g/day) using standardized portion sizes
- Conversion of food intakes into nutrient/single substance intakes by multiplying with values in a food concentration database



The FFQ – method has been subject to much criticism

Food frequency dietary assessment: how bad is good enough?

Byers, Am J Epidemiol, 2001; 154, 1087-1088.

Is it time to abandon the food frequency questionnaire?

Kristal et al. Cancer Epidemiol Biomarkers Prev, 2005; 14, 2826-2828.

Food frequency questionnaires are simple and cheap – but are they valid?

Hackett, Mat Child Nutr 2011;7:109-11

Food Frequency Questionnaires (FFQ)

Strengths:

- ✓ Convenient for large populations
- ✓ Easy and simple administration
- ✓ Low respondent burden
- ✓ May capture foods eaten rarely

Weaknesses:

- ✓ Limited by the foods included
- ✓ Estimation of portion sizes
- ✓ Needs to be validated
- ✓ Low precision at the individual level
- ✓ Does not capture day to day variation
- ✓ Possible misreporting

Food Frequency Questionnaires (FFQ)

FFQs are limited by their food list and are not suitable for all population groups

Self-report by FFQ requires literacy and challenges the respondents with rather complex cognitive tasks; recall, abstraction/estimating the average over time

FFQs are better suited for ranking individuals than for precise numeric estimation

Food and nutrient intakes by FFQs can be examined at the level of

- ✓ Dietary patterns
- ✓ Single foods or food groups
- ✓ Single nutrients or compounds

Food and nutrient intakes by FFQs are used to:

- ✓ Evaluate population intakes relative to reference values
- ✓ Rank individuals and identify high and low consumers
- ✓ Examine how food intakes relate to a marker of exposure or disease (identify dietary predictors)

The design, development and use of a new food frequency questionnaire in Norway


A new FFQ was developed for assessment of diet during pregnancy in the Norwegian Mother and Child Cohort study (MoBa)

Difficult decisions: Which method to choose, which time of pregnancy to cover, which foods to include, how to handle portion sizes, nausea/vomiting, food aversions etc?

Mor & barn undersøkelsen

Questionnaire 2

Your Diet

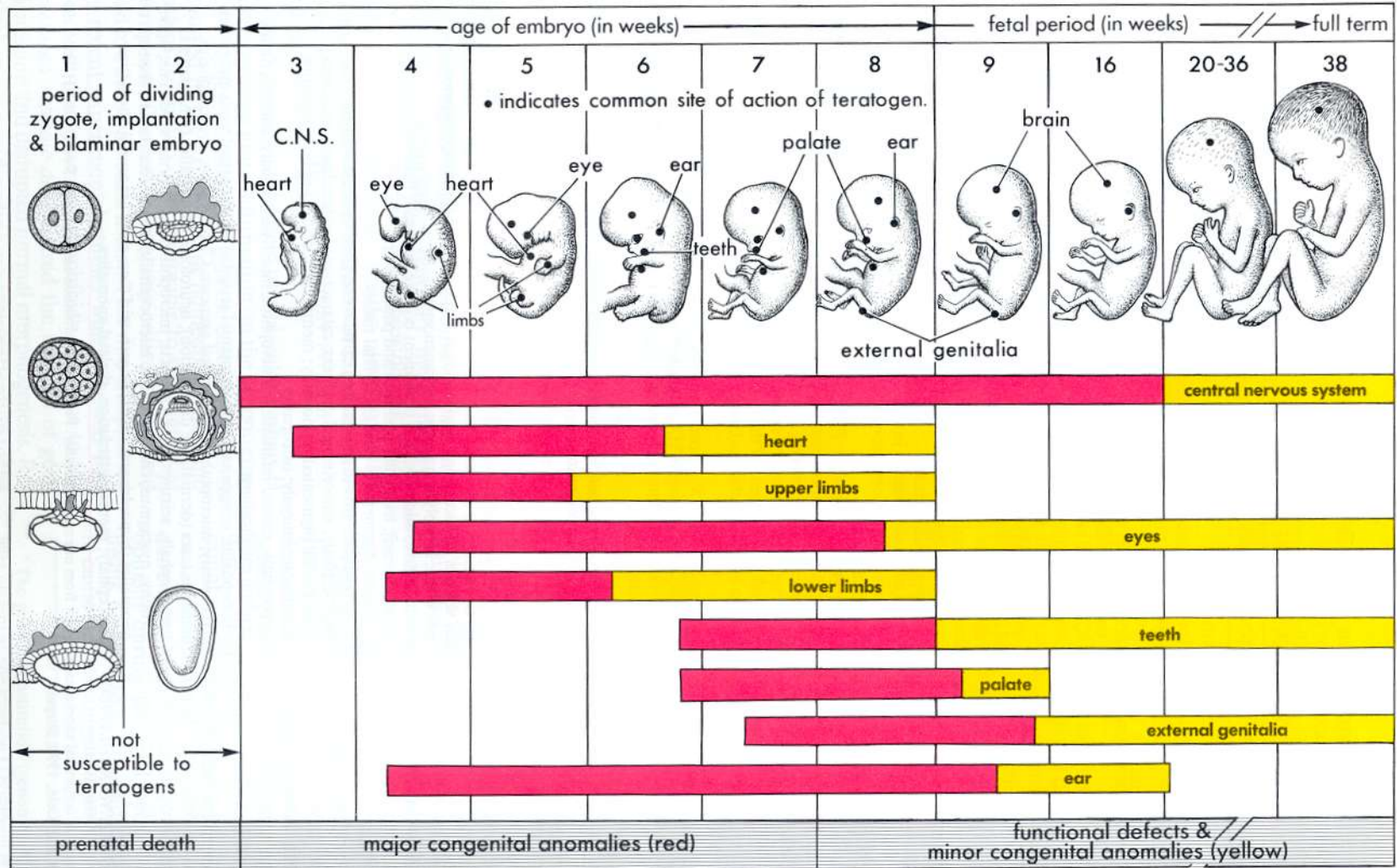


Please fill in today's date:

<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
day	month	year			

Meltzer et al. Methodological challenges when monitoring the diet of pregnant women in a large study: experiences from the Norwegian Mother and Child Cohort Study (MoBa). *Matern Child Nutr* 2008;4:14-27.

Critical periods in fetal development



Red: Highly sensitive periods
 Yellow: Less sensitive periods

Moore & Persaud: The developing human


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Mor & barn undersøkelsen

Questionnaire 2

Your Diet



Please fill in today's date:

<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
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day month year

In this questionnaire we ask you what you have eaten since you became pregnant until now. We therefore ask you to remember what you have eaten in the last three to four months.

We know that many of you have experienced nausea and perhaps still are nauseous part of the day in a way that has affected your diet. We would still like to have information about your actual diet during this period.

We greatly appreciate your cooperation in this study, and wish you good luck for the remaining part of your pregnancy.

Meltzer et al. Methodological challenges when monitoring the diet of pregnant women in a large study: experiences from the Norwegian Mother and Child Cohort Study (MoBa). *Matern Child Nutr* 2008;4:14-27.

The MoBa FFQ was developed to collect as much detail as possible in order to obtain information about:

- ✓ Dietary patterns
- ✓ Individual foods or food groups, with special emphasis on foods known to accumulated POPs
- ✓ Dietary supplements
- ✓ Single nutrients
- ✓ Non-nutrients including bioactive compounds and environmental contaminants
- ✓ Gut health (probiotic foods, distinguish between raw and cooked vegetables etc)
- ✓ Organic foods
- ✓ Dietary changes related to pregnancy

We ended up with a 12 page FFA consisting of:

- 340 questions organized into 40 groups according to a Norwegian meal pattern
- 255 questions about individual food items
- Global questions for scaling of individual questions

We ended up with a 12 page FFA consisting of:

- 340 questions organized into 40 groups according to a Norwegian meal pattern
- 255 questions about individual food items
- Global questions for scaling of individual questions
- One page for recording dietary supplements
 - 13 named items, and 6 open lines for women to fill in names

39. Do you use, or have you used supplements during this pregnancy? Yes No

40. If yes, we ask you to name and quantify the supplements you have used/are using

(ts = 3.5 ml (teaspoon), bs = 5 ml (2 x teaspoon), ss = 10 ml (3 x teaspoon))

Liquid supplements	Times per week									Amount			
	7	6	5	4	3	2	1	<1	0	1 ts	1bs	1ss	
1. Cod liver oil	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
2. Omega-3 cod liver oil	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
3. Sanasol	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
4. Biovit	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
5. Liquid iron mixture (Floradix etc.)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Other liquid supplements													
6. Name:	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
7. Manufacturer:													
8. Name:	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
9. Manufacturer:													
Capsules/tablets	Times per week									Number(s) per time			
	7	6	5	4	3	2	1	<1	0	1	2	3	4+
10. Cod liver oil capsules	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
11. Fish oil capsules	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
12. Vitaplex, B vitamins	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
13. Kostpluss/nyco plus multi	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
14. Nyco plus folic acid 0.4 mg	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
15. Spektro (Solaray)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
16. Hemofer	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
17. Duroferon durretter, Ferro Retard	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Other supplements													
18. Name:	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
19. Manufacturer:													
20. Name:	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
21. Manufacturer:													
22. Name:	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
23. Manufacturer::													
24. Name:	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
25. Manufacturer:													

More than 80% of pregnant Norwegian women report intake of at least one dietary supplement

The most commonly reported supplement is cod-liver oil or fish oil (fluid or capsules)



All FFQs must to be validated before intake data can be published

How well does the method give an accurate measure of the aspect of diet it is intended to measure?

Validity is always a matter of degree. A validation study demonstrate the agreement between the “test” method (FFQ) and reference measures

Reference measures usually include an alternative dietary method as well as “objective” markers of dietary intake



Validation study, MoBa FFQ

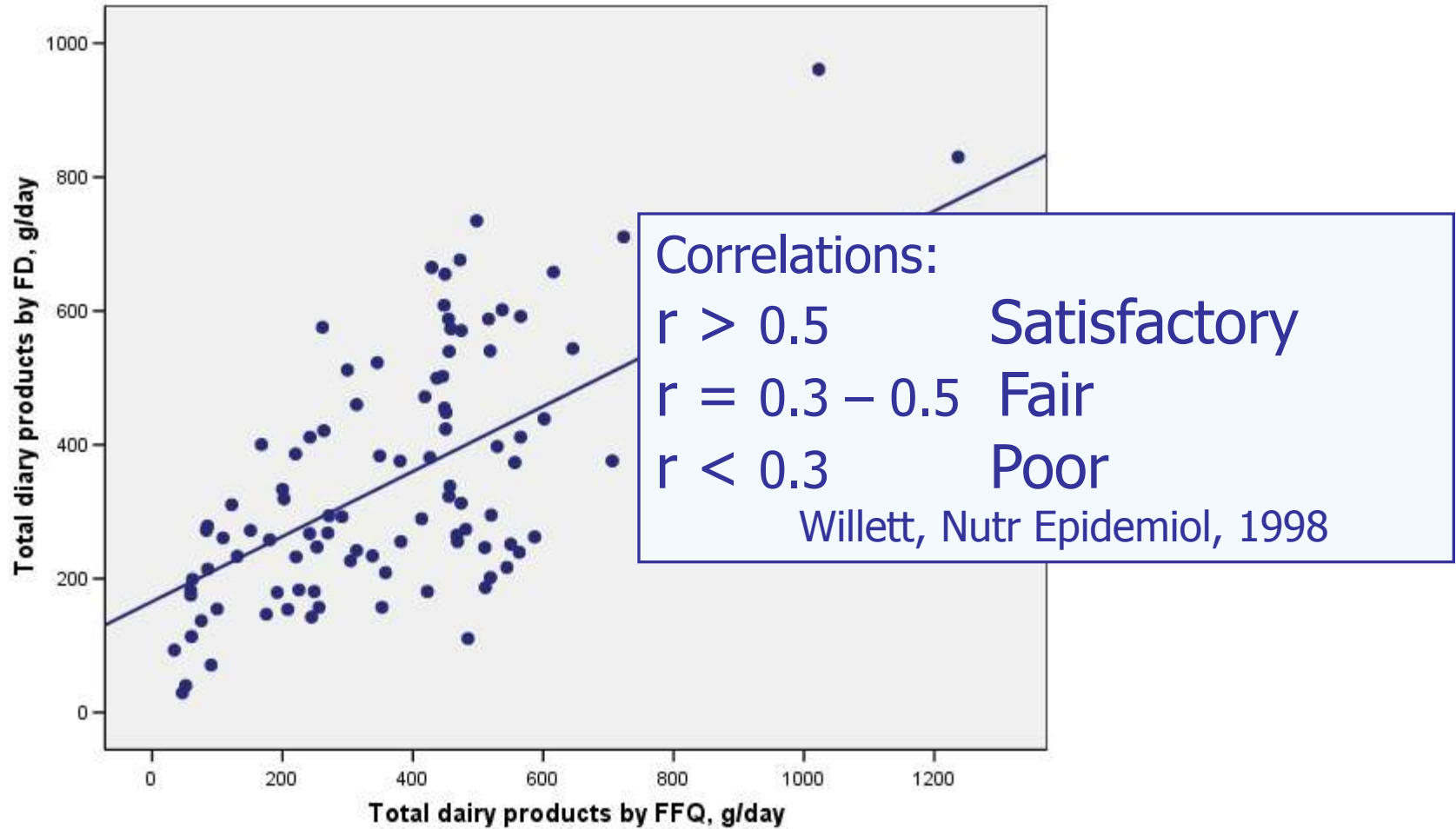
n=119, 4 day FD, blood and a 24-h urine sample and 4-d motion sensor



Taking care of a lot of urine...

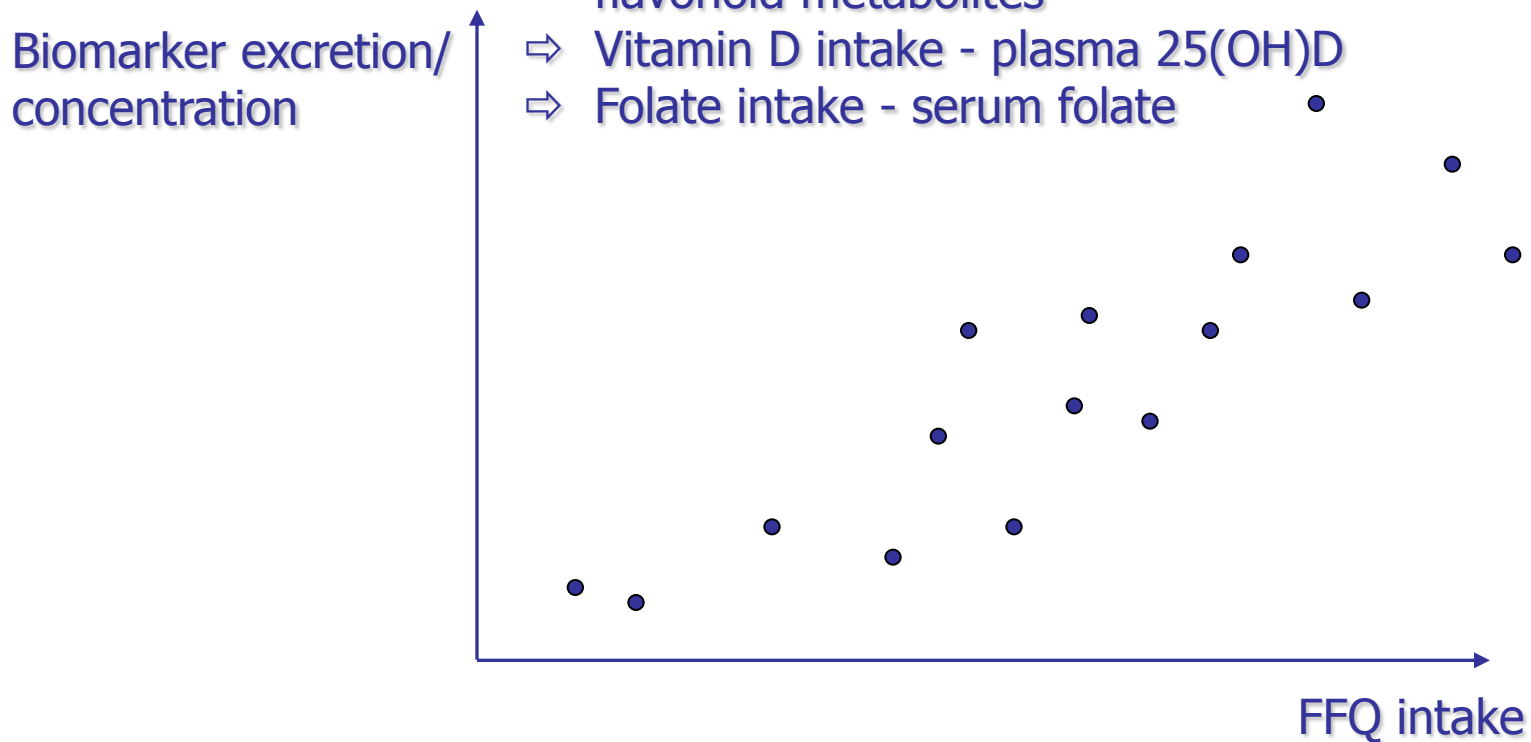


Comparison of intakes estimated by the FFQ and a 4-day weighed food diary

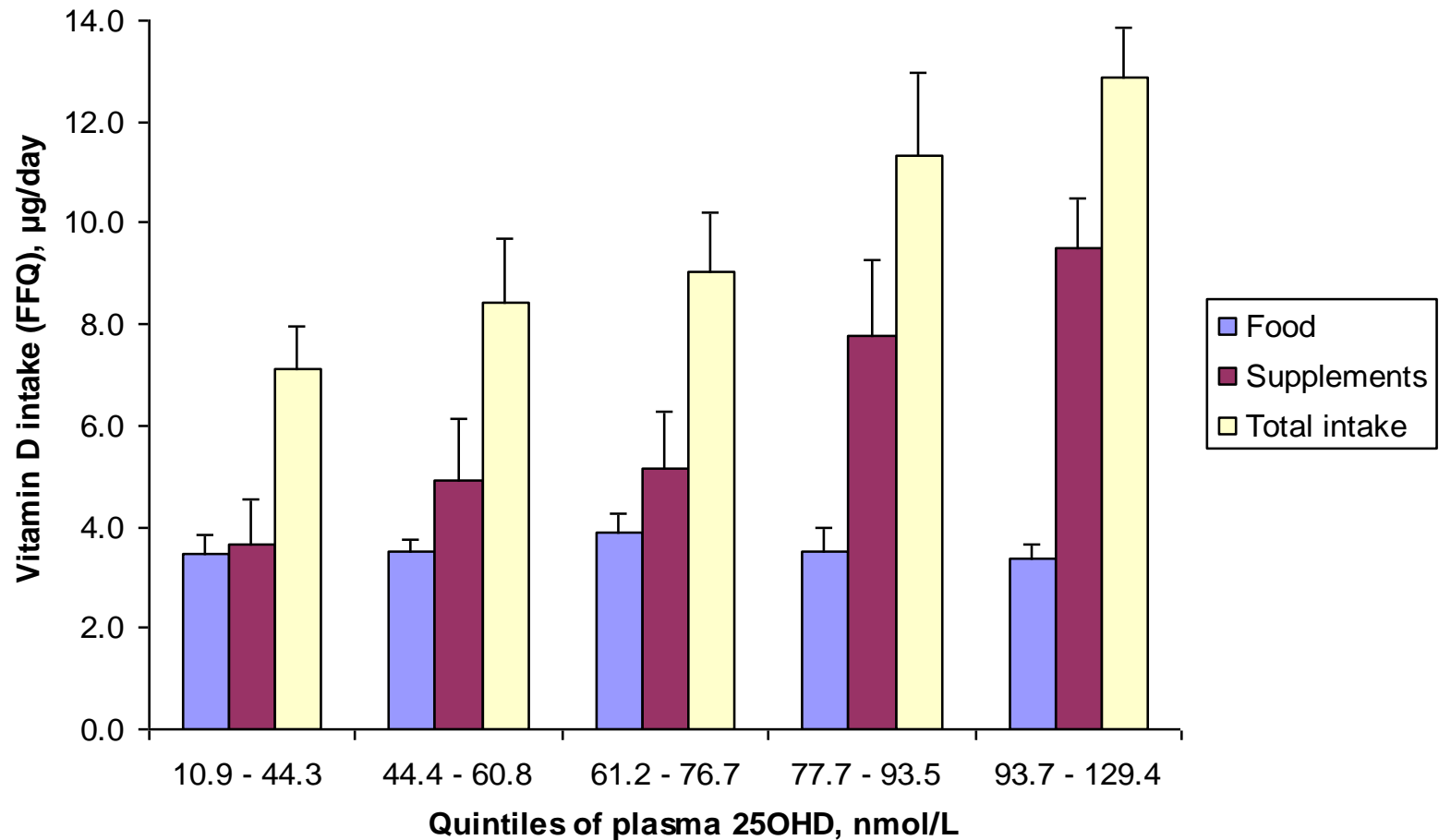


Association between of intake estimates by the FFQ and biological markers of intake

- ⇒ Protein intake - 24-h urinary nitrogen
- ⇒ Iodine intake - 24-h urinary iodine
- ⇒ Fruit and vegetable intake - 24-h urinary flavonoid metabolites
- ⇒ Vitamin D intake - plasma 25(OH)D
- ⇒ Folate intake - serum folate



Vitamin D intake estimated by the FFQ according to quintiles of 25(OH)vitaminD



Brantsæter et al., Ann Nutr Metab 2007;51:146-54.

Validation study, MoBa FFQ

- ✓ Acceptable agreement between the FFQ and the FD for all nutrients and major foods
- ✓ Biomarkers confirmed that the FFQ estimates were valid for fruit, juice, vegetables, tea, fish, milk/dairy foods, protein, vitamin D, folate, iodine, n-3 fatty acids
- ✓ The MoBa FFQ provide valid estimates of nutrients supplied by dietary supplements

Publications from validation of the MoBa FFQ:

- Validity of energy, nutrients and major food groups (Brantsæter et al, MCN 2008)
- Validity of nutrients from dietary supplements (Brantsæter et al, ANM 2007)
- Validity of fruit, juice, vegetables and tea intake relative to urinary flavonoid metabolites (Brantsæter et al, PHN 2007)
- Validity of milk and dairy products relative to urinary iodine (Brantsæter et al, EJCN 2009)
- Validity of fish and seafood intake relative to several biological markers (Brantsæter et al, PHN 2010)
- Validity of dietary acrylamide exposure relative to urinary acrylamide metabolites (Brantsæter et al, FCT 2008)

Validity of dietary acrylamide exposure relative to urinary acrylamide metabolites

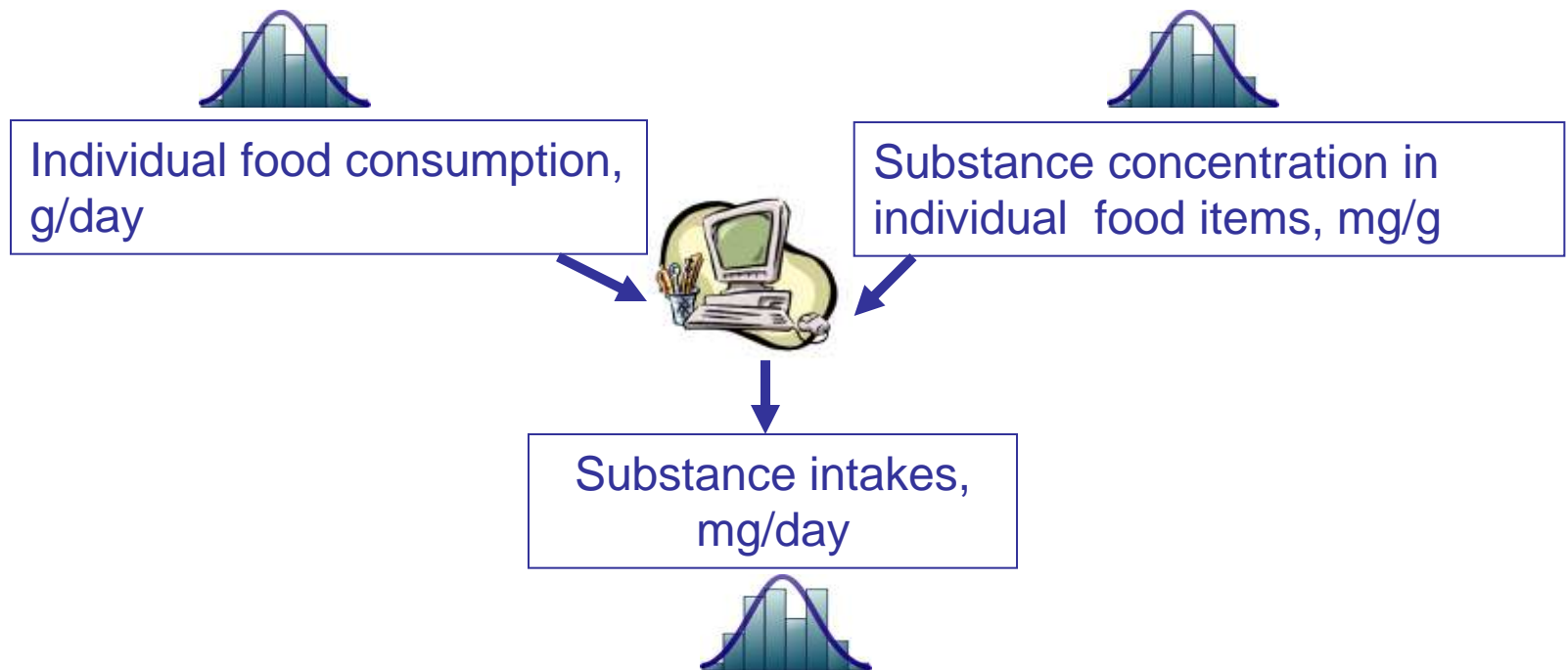
- 1) To examine whether estimated intake of acrylamide was associated with the amount of urinary acrylamide metabolites excreted in 24 h urine
- 2) Identify food groups that could explain the variation in urinary acrylamide metabolites excreted in 24 h urine

$$y = \beta \text{ crispbread} + \beta \text{ crisps} + + +$$

Publications: Maternal diet and pregnancy outcomes

- Mediterranean diet - Preterm birth (Haugen et al, 2007)
- Dietary patterns – Preeclampsia (Brantsaeter et al, 2009)
- Vitamin D intake – Preeclampsia (Haugen et al, 2009)
- Folic acid intake – Infant birth weight (Nilsen et al, 2010)
- Probiotic milk products – Spontaneous preterm delivery (Myhre et al, 2011)
- Maternal seafood intake – Infant birth weight/length (Brantsæter BJN 2011)
- Probiotic milk products – Preeclampsia (Brantsæter, AJE 2011)

We need to build country specific databases for contaminants because the concentrations in many foods differ between countries (seafood, game etc)



We need to build country specific databases for contaminants because the concentrations in many foods differ between countries (i.e. seafood, with concentrations depending on origin and depth)

Many other issues related to food classification and use of food databases – but those issues relate equally to all dietary methods, not only FFQs

EFSA Scientific Colloquium Summary Report, Parma June 2010: The unambiguous ambiguity - the challenge of describing food .

At the Norwegian Institute of Public Health we are currently holding databases for the following substances in Norwegian foods:

- Mercury, caffeine, cadmium, acrylamide
- Individual congeners of dioxins and polychlorinated biphenyls (PCB),
- Perfluorinated compounds
- Phthalates and BpA
- Polybrominated diphenyl ethers (PBDEs) and hexabromocyclododecane (HBCD)

Dietary estimates of these compounds have been examined in a population study of Norwegians with a wide range of seafood consumption using a modified version of the MoBa FFQ

Publications: Evaluation of dietary exposure to contaminants in non-pregnant populations

- Knutsen et al: Dietary exposure to **brominated flame retardants** correlates with male blood levels in a selected group of Norwegians with a wide range of seafood consumption. Mol Nutr Food Res. 2008 52 (2):217-227.
- Thomsen et al: Consumption of fish from a contaminated lake strongly affects the concentrations of **polybrominated diphenyl ethers and hexabromocyclododecane** in serum. Mol Nutr Food Res. 2008 52 (2):228-237.
- Kvalem et al: Role of dietary patterns for **dioxin and PCB exposure**. Mol Nutr Food Res. 2009; 53(11):1438-51.
- Haug et al: Diet and particularly seafood are major sources of **perfluorinated compounds** in humans. Environ Int. 2010 36: 772-778.

Knutsen et al: Dietary exposure to **brominated flame retardants** correlates with male blood levels in a selected group of Norwegians with a wide range of seafood consumption. Mol Nutr Food Res. 2008 52 (2):217-227.

- The exposure to sum 5 PBDEs based on LB occurrence levels in food was 1.4 (mean) and 1.1 (median) ng/kg bw/day
The largest contributors to the mean sum 5 PBDE exposure was BDE-47 (69%), BDE-47 (14%) and BDE-99 (11%)
- The exposure to BDE-209 was 1.5 (mean) and 1.4 (median) ng/kg bw/day
- The mean exposure to HBCD was 0.3 ng/kg bw/day

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- The exposure to BDE-209 was 1.5 (mean) and 1.4 (median) ng/kg bw/day
- The mean exposure to HBCD was 0.3 ng/kg bw/day
- While the concentrations in foods were similar to those found elsewhere in Europe, the estimated intake exposures were higher than what had been estimated in other countries and may be explained by high seafood consumption

Thomsen et al: Consumption of fish from a contaminated lake strongly affects the concentrations of **polybrominated diphenyl ethers and hexabromocyclododecane** in serum. Mol Nutr Food Res. 2008 52 (2):228-237.

- The estimated dietary exposure to sum 7 PBDEs was 30 (median) ng/kg bw/day, with fish from the contaminated lake contributing 98.7% of this
- For men, serum levels of PBDE were strongly correlated with the calculated dietary exposure except for BD-209
- For women, only serum levels of BDE-47 and -99 correlated with calculated dietary exposure.
- The differences between men and women may be explained by
 - women excreting PBDE during lactation periods OR
 - by larger variance in the calculated intake in men OR
 - by metabolic differences

Design, Use and Interpretation of Food Frequency Questionnaires

- ✓ Food and nutrient intakes by FFQs have provided valuable information
- ✓ All FFQs have to be validated in the relevant population and age groups
- ✓ It is important to understand the strengths and limitations of the instrument

Design, Use and Interpretation of Food Frequency Questionnaires

FFQs are useful for:

- ✓ Evaluating population intakes relative to reference values
- ✓ Ranking individuals and identify high and low consumers
- ✓ Examining associations between food intakes and biological markers of exposure or disease

