UNIVERSITY OF SOUTHAMPTON

METHODOLOGICAL CONSIDERATIONS IN ASSESSING FOOD AND NUTRIENT INTAKES IN CIGARETTE SMOKERS

by

Rachel Louise Thompson

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ABSTRACT

FACULTY OF MEDICINE
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The methodological issues of using a food frequency questionnaire as an alternative to a weighed record to assess dietary habits have been investigated using the observed dietary differences between smokers, ex-smokers and never smokers as a model. A food frequency questionnaire has been compared with a 10 day weighed record in 301 smokers. A good agreement between the dietary methods was obtained using conventional calibration methods but a graphical method that looked at the agreement between the methods over the range of intakes showed that the agreement was not the same across all intakes for energy, fat and types of fat in men and vitamin C in women. The comparison revealed some differences in agreement between the methods by method of recruitment of subjects, in particular for vitamin C and alcohol in men. A 'correction' method based upon the graphical calibration method has been employed so that the corrected absolute nutrient intakes derived by the food frequency questionnaire were similar to those estimated using a weighed record.

Using the food frequency questionnaire in its corrected form a comparison was made between cigarette smokers, ex-cigarette smokers and never smokers and showed that the smokers consumed more beverages (with added sugar), spread on bread and fat in cooking than non-smokers. Whereas non-smokers consumed a diet higher in breakfast cereal, cakes and biscuits, and bread than smokers. These differences in food patterns lead to different nutrient intakes with smokers consuming more energy, fat, saturated fat and sugar than non-smokers. Non-smokers consumed more polyunsaturated fat, carbohydrate, fibre and vitamins than smokers.

The cigarette smokers were encouraged to stop smoking and dietary changes in those who quit were compared with those who continued to smoke. The results showed that although food and nutrient intakes had increased by 11 weeks after cessation, by 46 weeks the diet of the quitters was not substantially different from their baseline diet despite gaining 3 to 6 kg in body weight. Hence, long term dietary change after smoking cessation does not appear to occur within one year.

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1. Thompson RL, Margetts BM and Wood DA. Comparison of energy, ascorbic acid and fibre estimates by a food-frequency questionnaire and a 10 d weighed record in smokers. Proceedings of the Nutrition Society 1993; 52: 112A.

2. Thompson RL, Pyke S, Scott EA, Thompson SG and Wood DA. Fat consumption, smoking habit and coronary disease. Acta Cardiologica 1993; 48:326-327.

3. Thompson RL, Pyke S, Scott EA, Thompson SG and Wood DA. Changes in dietary fat consumption after smoking cessation. Acta Cardiologica 1993; 48:322-323.

4. Thompson RL, Pyke S, Scott EA, Thompson SG and Wood DA. Stopping smoking and changes in dietary fat consumption. European Heart Journal 1993; 14S: 381.

5. Thompson RL, Margetts BM and Wood DA. Correction for measurement error in fat intakes estimated by a food frequency questionnaire. Proceedings of the Nutrition Society 1993; 52: 335A.

Papers

1. Thompson RL, Margetts BM, Wood DA and Jackson AA. Cigarette smoking and food and nutrient intakes in relation to coronary heart disease. Nutrition Research Reviews 1992; 5:131-152.

2. Thompson RL, Pyke S, Scott EA, Thompson SG and Wood DA. Cigarette smoking, polyunsaturated fats and coronary

heart disease. Annals of the New York Academy of Sciences 1993; 686:130-139.

3. Thompson RL and Margetts BM. Comparison of a food frequency questionnaire with a 10 day weighed record in cigarette smokers. International Journal of Epidemiology 1993; 22:824-833.

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Definitions and abbreviations

Listed below are terms which have been used to describe smoking habits in published literature. Precise definitions differ between studies and this is discussed in more detail in chapter one.

Definitions

Ex-smoker	- not currently smoking but smoked cigarettes daily in the past
Never smoker	- has never smoked regularly
Non-smoker	- not currently smoking (includes never and ex-smokers)
Quitter	- Ex-smoker with baseline data as a smoker and follow-up data as an ex-smoker
Smoker	- currently smoking cigarettes

Abbreviations

BMI	- body mass index
Cho	- carbohydrate
FFQ	- food frequency questionnaire
Mufa	- monounsaturated fat
Pufa	- polyunsaturated fat
Sfa	- saturated fat
EPA	- eicosapentaenoic acid
Vit	- vitamin
WR	- weighed record

1. INTRODUCTION

There are several dietary assessment methods available for use in epidemiological studies. The choice of the method depends on the objective of the study and the projected population, as well as the constraints of time, finance and personnel. Alternative short-cut methods to the weighed record have been sought for use in large-scale epidemiological studies. Burke in 1947, developed the diet history questionnaire which comprised of three sections, one of which was a checklist of foods consumed over the previous month. From this checklist has evolved the structured food frequency questionnaire (FFQ) which is often used in epidemiological studies today to assess and compare the diets of groups of individuals.

The relative validity/calibration of food frequency questionnaires is often compared with weighed records. The subjects used to calibrate FFQs are often volunteers, or subjects who may differ in gender, age, occupation group, lifestyle characteristics and region of residence from the projected study population. It is therefore unclear whether questionnaires are valid when used in different sample populations. In theory, calibration studies can be carried out for both foods and nutrients, however, they are often only assessed for nutrients. The calibration of foods is important to determine the sources of error so that the performance of the FFQ can be improved.

There have been no studies validating/calibrating a food frequency questionnaire in a group of smokers. Differences in dietary habits by smoking status have been observed but it is possible that these differences in diet may arise at least partially from differential bias in the measurement of diet between smokers and non-smokers.

At present there have been only a few studies, largely using volunteers, looking at the effects of smoking cessation on diet. More prospective data are needed to determine whether in fact smoking does influence diet or whether smokers who quit have different diets to those who continue to smoke.

The work presented here has been carried out within Professor David Wood's group at the University of Southampton as part of a larger study funded by the Medical Research Council investigating the effect of stopping smoking on diet and clotting factors. This study has been used as a model to investigate the methodological issues of using a food frequency questionnaire in place of weighed records in cross-sectional design studies and to determine whether the agreement between the methods is affected by subject recruitment method. To obtain further evidence that cigarette smoking affects dietary habits a prospective study of dietary changes after smoking cessation has been carried out with the aid of a research nurse, Elizabeth Scott, who ran smoking cessation classes.

1.1 AIMS AND OBJECTIVES

Hypotheses

Food frequency questionnaires can be as reliable as weighed records in determining differences between food and nutrient intakes between groups/populations.

The hypothesis has been tested using differences in dietary habits between smokers and non-smokers as a model. The hypothesis relating to cigarette smoking and diet was that:

Smoking cigarettes alters both food pattern and nutrient intake in such a way as to increase the risk of coronary heart disease and consequently after stopping smoking dietary habits revert to pre-smoking habits hence reducing coronary risk.

The aims of this thesis were:

1. To investigate the methodological issues of using a food frequency questionnaire compared with a weighed record.

2. To determine whether source of recruitment of subjects affects the agreement between the food frequency questionnaire and weighed record.

3. To examine the effect of confounding variables on the relationship between cigarette smoking and dietary habits.

4. To carry out a prospective study of cigarette smokers as they quit to determine whether smokers' diets do change after smoking cessation and if so over what time period this occurs.

The primary aim of this thesis was to investigate dietary methodological issues using cigarette smoking and diet as a

model. Although it is acknowledged that cigarette smoking has been described as the largest preventable cause of mortality (Secretary of State, 1991) the mechanisms by which cigarette smoking causes disease and the affect of diet on these were only of secondary interest in this thesis.

The layout of the thesis is as follows; chapter one describes the dietary assessment methodologies and definitions of smoking status used in published studies. It reviews the published literature from observational and experimental dietary studies of relationships between diet and smoking. These are followed by a discussion of the effect of smoking on body weight both in observational and experimental studies; and lastly comments on the relationship between diet, smoking and coronary heart disease. Chapter two describes the study design, sample size calculations and relevant methodologies. Chapter three reports the recruitment of subjects and response rates for attendance at baseline and follow-up, and participation in the dietary assessment survey. Chapter four describes the comparison of nutrient intakes derived using the food frequency questionnaire with those derived using a 10 day weighed record. It also gives details of a method by which the nutrient estimates from the FFQ can be 'corrected' to those of the WR. This is followed by the calibration of the FFQ with the WR between randomly recruited subjects and volunteers for both food and nutrient intakes. Chapter five investigates whether there are differences in nutrient intake between the randomly recruited subjects and volunteers. Chapters six and seven report the dietary results from the observational study of cigarette smokers, ex-cigarette smokers and never smokers of food and nutrient intakes. The effect of occupation group on the relationship between diet and smoking is also discussed. Chapters eight and nine report results from the prospective study of smoking

cessation and lastly chapter ten presents the final discussion and future work.

1.2 INTERPRETATION OF STUDIES

Before reviewing the published data on cigarette smoking and dietary habits it is important to consider methodological issues such as assessment of diet, the design of studies and definition and confirmation of smoking status.

1.2.1 Dietary Assessment Methodology

Dietary surveys have been conducted to compare mean nutrient intakes between groups or to rank individuals within a group. The strengths and weaknesses of different dietary survey methods commonly used are discussed. These can be divided into two groups, those requiring current daily recording of diet (record techniques) and those using interview techniques to assess recent or distant past diet (Nelson *et al*, 1993). Methods in which data are not collected from individuals but from groups/families such as the household survey are excluded. Other issues involved in the choice of a dietary method are discussed along with problems related to cross-sectional studies and experimental studies. Studies in which one dietary method is compared against another have been referred to as calibration studies and not validation studies. This is because measurement of true diet is not possible at present and validation studies tend to assume one method is correct.

1.2.1i *Record techniques*

This group includes the estimated and weighed record methods. These require the subject to record all items of food and

drink consumed over a specified time period, normally one to seven days. Data may be collected to determine nutrient intake at a certain time. For example, a 7 day dietary assessment might be carried out four weeks after smoking cessation to look at the effect of not smoking after four weeks. Data may also be collected to get a picture of the average diet over a time period of several months or a year. This has been referred to as the 'usual diet'.

The estimated record methods eliminate weighing and portion sizes can be estimated by either household measurements (eg. cups, spoons etc), with the use of food models or photographs or to eliminate any judgement by the subject average/standard portions can be used. Careful coding and calibrating of household measures/ models/ photographs is then necessary to estimate portion size. Whereas, with the weighed record all food and drink items consumed at home are weighed individually and items consumed outside the home are usually estimated. The estimated and weighed record methods demand a high degree of co-operation from the subject, especially if they are required to keep the record for several days. There are certain subjects, however, for which these methods would not be suitable, these include people who are illiterate, poor sighted or physically handicapped (unless the record is completed with the help of another person). Subjects who consume most of their meals away from home will find the weighed record difficult to complete but should be able to keep an estimated record.

It is possible that due to the intrusive nature of estimated and weighed records subjects may alter their usual diet whilst keeping the record. Subjects might choose items that are easy to record. They might also consume less snacks between meals. This results in a true record of the diet that is eaten but not a true record of the subject's usual diet. Alternatively, subjects may not record food items they have eaten, give insufficient information about composite

dishes for correct coding, incorrectly record the weight of food items which will give rise to an incorrect measure of diet. Other subjects may weigh a regularly eaten food once and assume they have eaten the same weight of food on further occasions. Thus data from a estimated or weighed food record may not always represent the usual diet and may not even be a true record of diet for the recording period. This problem is not easy to remedy but it should be impressed upon the participants that a true record of their usual diet is the aim of the study.

Information on meal pattern and times of meals can also be obtained from these methods.

Due to problems with the heavy demand on subjects and problems trying to obtain a true record of usual diet some workers have tried to modify the record technique. In an attempt to improve subject compliance and reduce subject burden and yet not reduce its accuracy various alternatives have been sought. These methods have included photography, a food recording electronic device (FRED) and a portable electronic tape recording automated scale (PETRA) and are described below.

Photography

This method involves the subject placing their meal on a table, making sure all foods are visible and pies and sandwiches are opened up (Bird & Elwood 1983). To ensure the photograph is taken at the same distance from the plate each time, a string is placed under the plate and the photograph is taken when the string is taut. All food items are photographed along with any leftovers. The film is then developed as slides and converted to weights by a trained nutritionist. This task can be made easier by the use of slides with standard weights of foods with which to compare the subjects' slides.

Bird & Elwood, (1983) calibrated this method in 17 office workers against a four day weighed record. The weighed record and photographs were completed simultaneously. They found no significant differences in absolute or percent of energy and nutrient intakes between the methods. However, the time spent in converting the slides into weights was just as long as to code the weighed records. Other problems involved subjects not using the flash on the camera, some foods being obscured and sandwiches not being opened up. The authors also recommended that at some stage in a record some food items should be weighed to enable estimated weights to be checked. The cost of the equipment is another disadvantage over conventional weighed records; this involved the cost of cameras, films and developing of slides.

Food recording electronic device (FRED)

The equipment consists of a pair of electronic scales connected to a microprocessor with a keyboard (Stockley *et al*, 1986a). The keyboard is labelled with six control keys and 55 food code keys. To use, the subject switches on the machine places a plate on the scales, presses the start button, serves a food item onto the plate and presses the appropriate food code. Waste items can also be weighed. As there is a limitation to the number of keys available subjects complete a preliminary questionnaire to determine their usual food choices. Foods are grouped for the ease of the subject and practical reasons.

A calibration of FRED against a weighed record was carried out (Stockley *et al*, 1986b). Twenty-nine volunteer subjects recorded their diet for seven days by a weighed record and FRED simultaneously. Weighed records were coded by the same food groups as FRED or conventionally by individual foods. The results showed no difference in energy, protein or fat intakes by coding the weighed records using food groups or individual foods but using FRED energy intakes were 628kJ lower and protein and fat underestimated by about 5g each.

The authors found some technical problems with FRED as it was slow to accept items. Subjects attempted to record items but as FRED was not ready they were not accepted thus resulting in an underestimation of intake. Subjects were keeping the weighed record at the same time and sometimes forgot to press the food code key and hence the food was not recorded. However, the authors were confident that these problems could be corrected and as food grouping did not appear to affect the accuracy of the method it would be useful. Another advantage is that observer time could be dramatically reduced; it was envisaged that the weighed record would take 1.5 days to process and FRED took only 1.5 hours. Despite the equipment being costly this has to be balanced with a reduction in nutritionists' time in coding and processing the records.

Both the previous calibration studies were carried out on small samples which would make statistically significant differences between the methods less easy to detect. In addition the demand of keeping both methods simultaneously may have affected the accuracy of both methods.

Portable electronic tape recording automated (PETRA) scale

To use, the subject places a plate (previously recorded) and food on the scales, presses a button and verbally describes the item as it is served onto the plate. The scale records the description and the weight. This is later decoded using the PETRA master console (Barker *et al*, 1988).

PETRA was calibrated in 80 subjects, 40 using the PETRA method and 40 using conventional scales (Barker *et al*, 1988). As subjects did not complete both methods the results are less easy to interpret than for the previous two methods. There were no differences in nutrient intakes between the methods. Subjects also completed a questionnaire to determine preference for either method. In general subjects who used PETRA found it was easier to use, interfered less with their

lives, did not alter their normal eating pattern and was less time consuming than conventional scales. However, the cooperation rates were similar for both groups. Therefore PETRA was more user friendly but achieved the same results as scales. The method proved expensive both due to the cost of equipment and in observer time as PETRA took two hours longer to process than the weighed records. For both FRED and PETRA the subject is unaware of the actual weight of food. Therefore they cannot record the weight of a food item without weighing it. With the WR a subject might not weigh a food item when it is eaten on further occasions but copy the weight of the item recorded on the first time it is consumed. Table 1.1 shows the strengths and weaknesses over the weighed record of these alternative methods.

Table 1.1: Comparison of modifications to the weighed record with the weighed record

	Subject ease	Observer time	Cost	Accuracy	Copy weight
Photos	+	+/-	-	+/-	+/-
FRED	+	+	-	- (+/-)	+
PETRA	+	-	-	+/-	+

+/- no difference, + advantages over record techniques, - disadvantages over record techniques

Other workers have tried to simplify the method by using food groups and not individual codes, and software packages now enable foods to be coded as they are entered on the computer. There is a need to make the method simpler to use by a wider range of subjects but it should also ideally be made time and cost efficient for the observer without losing accuracy.

1.2.1ii *Interview techniques*

These techniques include the 24 hour recall, diet history and food frequency questionnaires.

The 24 hour recall

By this method the subject recalls the actual food and drink consumed on specific days, usually the immediate past 24 hours but sometimes for longer periods. This method may also be repeated at various intervals to increase the number of days of dietary information collected from each subject.

Diet history method

This method was originally developed by Burke in 1947 (Burke, 1947). This method aims to look at the usual intake of the subject over a relatively long period of time and can also be used to look at past dietary habits. The diet history method generally obtains intake of food and drink consumed in terms of frequency of consumption and quantity eaten. It may also include questions on cooking methods. This method has often been modified when used by other workers. In its original form it consisted of three parts; the overall pattern of eating which included a 24hour recall coupled with questions such as 'What do you normally eat for breakfast?' (Portion sizes were estimated by household measures). The second part, the 'cross-check' was composed of a detailed list of foods and the subjects were asked questions on their likes and dislikes, purchasing and cooking methods of these foods. This section was used to verify and improve information received from the first part. The final part consisted of a three day menu (which did not include portions) recorded by the subject. Burke used this part for additional checking.

The diet history method is relatively time consuming for the nutritionist but in some studies lay persons have been trained in the procedure. Problems may arise due to errors in estimating portions and omissions of foods eaten. Good correlations with a weighed food record have been achieved although estimates are generally 5% higher using the diet history method, (Bingham, 1987). Borrelli *et al*, (1989) in a study of elderly subjects found intakes to be 15% higher with the diet history method compared with a three day diary.

Jain *et al*, (1980) compared their diet history method with seven and 30 day diet diaries with estimated portion sizes. Rank order correlation coefficients were better for the 30 day records with the diet history than for the seven day records with the diet history.

Food frequency questionnaires

In recent years food frequency questionnaires (FFQ) have become popular methods of dietary assessment for epidemiological studies. FFQs permit the assessment of present and retrospective dietary habits and can be relatively short and inexpensive. They can be tailored to meet the objectives of the study. If the aim is to measure intake of one specific nutrient, for example iron; the questionnaire can be relatively short and only foods that contribute to iron intake need to be included. Alternatively the FFQ can be used to assess overall diet. FFQs may be administered by the interviewer or completed by the subject at an appointment or by post. Food frequency questionnaires if administered in a clinic situation are likely to obtain dietary information from nearly 100% of subjects (Jørgensen, 1992). Both 24hour recalls and FFQs can be conducted over the telephone or by post. Compared with the WR the FFQ is less demanding for both subject and observer and therefore relatively more FFQs than WRs can be collected over the same time period. In designing a study careful consideration is needed to choose between data collection from a large sample using the FFQ, more precise data collected from a smaller sample using the WR.

The FFQ consists of a food list and a frequency of consumption section varying from never to number of times per day. Food lists can be compiled by using data collected by a recording method or diet history questionnaire. In theory the ultimate aim is for the food list to contain 100% of foods that contribute to a particular nutrient. However, in practice this may not be possible as weighed records permit

composite dishes to be broken down into individual ingredients, such as, eggs, flour, margarine and sugar for cake; whereas, the FFQ relies on composite dishes and therefore a direct comparison between the methods cannot be made (flour is unlikely to be included as an individual food on the FFQ). There are different methods for selecting food groups for inclusion in the FFQ and these depend on the objective of the study. The method used by Overvad *et al*, (1991) was as follows; contributions to total nutrient intake were calculated for each of 247 foods and recipes. A stepwise multiple regression was used to predict individual nutrient intake; foods that contributed 90% of the between person variability were included in the FFQ (although some contributed very little to the actual nutrient intake). These foods contributed on average 55% of the total nutrient intake. Foods that had a major contribution to nutrient intake but were not important discriminators were also included so that finally 81% of total nutrient intake was accounted for. This method of food selection will be unable to give precise absolute intakes as it on average only accounted for 85% of nutrient intake, however, it has been designed to be able to discriminate between subjects with different intakes. Other workers Block *et al*, (1986) and Cade & Margetts (1988) ranked foods in order of contribution to nutrient intakes and included those foods that contributed approximately 90% of the total intake for each nutrient. It is possible that some foods that discriminated between groups but contributed little to nutrient intake were omitted which may reduce the ability to detect differences between groups. There is a trade off between the length of the questionnaire and subject acceptability. If all possible foods were included the FFQ would be extensive and this might affect the numbers of subjects willing to complete it. It might also affect the quality of the answers and thus reduce some of the benefits over the weighed record. In summary if the aim is to determine precise nutrient estimates extended questionnaires may be necessary but if the aim is to rank

individuals and discriminate between groups shorter questionnaires can be used.

To calculate nutrient intake from an FFQ, frequency of consumption of each food item/group is multiplied by a portion size to determine a gramme amount eaten. Portion sizes can be estimated using food models or photographs. Alternatively standard portions may be calculated from mean portion sizes of foods eaten by the same population or a similar one. Alternatively published tables of portion sizes could be used. Another method is for the subject to record the frequency of consumption of a predefined portion of food. This method is easily used for foods which come in natural units for example, one potato, two slices of bread etc. Some workers use a combination method in which foods that are easy to quantify such as slices of bread, eggs, fruits, and milk are recording by number of slices per day, number of eggs per week etc and foods such as meat, fish and vegetables that are less easy to quantify are converted to weights by average portion weights. This type of FFQ is referred to as a semi-quantitative FFQ.

The FFQ can be administered by an interviewer using standard forms or may be completed by the subject. If the FFQ is self-administered careful checking is required to ensure subjects have understood and completed all questions correctly. Subjects with regular eating habits will find the food frequency question easier to complete than those who have irregular eating patterns. Some subjects not involved in shopping and cooking at home may have some difficulty in knowing types of fats used for spreading on bread and cooking. Both this method and the diet history aim to show usual nutrient intakes and therefore do not have the problems of food records which may be kept over an unrepresentative selection of days.

There are several assumptions using FFQs. If a standard portion size is assumed this may not be applicable for the study population especially if the mean portion size used was calculated for a different population. If portion size does not vary between subjects the effect of using mean portion sizes on ranking will be minimal. If portion size does vary between subjects the estimate of portion size will be incorrect on an individual basis but may still be correct for the whole group. For some subjects the portion size will be underestimated and for others it will be overestimated. If a comparison were to be made between populations at the extremes of the range of portion size the FFQ using mean portion size would not be able to detect any difference whereas one that incorporated a range of portion sizes (say small, medium and large) might be able to detect the difference. It may also be true that portion size varies within individuals so that even if a variety of portion sizes were available, if only one could be chosen it might be incorrect. It is also assumed that all commonly eaten foods by the population being investigated are included in the questionnaire. For a group classification of food items eg. beef this will include roast, mince, stewing steak etc. The nutrient composition and portion size may be calculated from a predominant food or weighted by each constituent. This predominant food or weighting may not be the same in all populations. Unless the questionnaire is designed for use on specific groups such as smokers or various ethnic groups it may contain inappropriate foods and omit other commonly eaten foods. Therefore before use or if the FFQ is to be used in a different population it should be calibrated in the projected population.

As there is no perfect measure of diet FFQs are usually calibrated against another dietary survey method. As no dietary method is without errors, the method for comparison should be subject to different errors to the method being calibrated. Otherwise, incorrectly high estimates of

agreement might be observed. The errors associated with FFQ are a fixed list of foods (foods may have been omitted), grouping of foods (food groups are commonly used in FFQs and nutrient intakes are based on the contribution of each food group, which may not be correct), reliance on memory, estimated portion sizes (portions may be under or over-estimated) and interpretation of the questions, these are minimized by the weighed record. Therefore the actual validity of the FFQ may be underestimated rather than overestimated. It is possible that the true estimate of diet lies somewhere between the two methods. Calibration studies are usually carried out in selected groups of subjects, often volunteers who may differ in gender, age, occupation group, lifestyle characteristics and region of habitation from the study population. It is therefore unclear whether the results of such calibration studies are equally valid in a wider study sample. FFQs tend to measure average diet and therefore to make the comparison valid the weighed record should be kept for sufficient days to estimate usual diet (see number of days of recording page 32). If the calibration is to be carried out with two software programmes each with a nutrient database it is necessary to check to see whether the databases are identical. Otherwise differences between the methods might be observed which are really just differences between the databases.

Agreement between the methods is generally determined by mean differences (absolute and percent) between the methods. If the objective of the study for which the FFQ is to be used is ranking of individuals and absolute measurements are not required mean differences between the methods may not be important if there is a constant bias across all groups and range of intakes. If the FFQ has been constructed based upon foods that contribute 90% or less of nutrient intake expectation of an exact agreement between methods is not realistic. In fact if an exact agreement is found it is likely that the FFQ overestimates intakes of some foods and

food groups. Subjects can be classified into thirds or fifths of the distribution with those of most interest being those who are grossly misclassified that is classified in the highest proportion by one method but in the lowest by the other method. Correlation coefficients such as the Pearson correlation coefficient are used although these tend to indicate association and not agreement and are often used inappropriately on non-normally distributed data. It is assumed that the relationship between the two normally distributed variables is linear. Non-normally distributed data should be transformed or a non-parametric test such as Spearman rank correlation coefficient can be used. The Bland Altman technique (Bland & Altman, 1986) although described several years ago is not yet commonly used. The method assumes that the average of the dietary methods gives a better indication of the truth than the weighed record alone. This graphical technique in which the difference between the two methods is plotted against the mean of the two methods for each subject has advantages over other comparison methods as agreement can be assessed across the range of intakes and will determine whether there is any differential misclassification. Agreement between the methods may be better in one range and poor in another. One disadvantage is that plots need to be constructed for each nutrient being calibrated. Also the plots are subject to individual interpretation and cannot be given a single numerical estimate like a correlation coefficient. Calibration studies are often carried out and most studies show some deviations from the comparison method, however, in general, there appears to be no attempt to correct for this difference which may or may not lead to bias if used in an epidemiological study. To be able to correct for measurement error one would need to assume one dietary method is more accurate than the other. This would depend on the exposure being measured, for example if the exposure was energy intake a weighed record may be nearer the truth as it does not have a fixed list of foods. Alternatively, for nutrients with a large day to day

variation such as vitamin A an FFQ may be better than a 3 day weighed record.

Some workers have looked at the importance of the method of determining portion sizes. There appears to be large within person variance in portion sizes compared to between person variance (Hunter *et al*, 1988) hence usual portions for individuals are difficult to ascertain. In addition subjects find describing their portions extremely difficult (Guthrie, 1984). Samet *et al*, (1984) looked at the contribution of portion size questions to the ranking of individuals and found that portion questions provided little extra information. Willett, (1990) found that common portion sizes (standard weights of foods where the subject indicated the number of standard servings of the food he/she consumes) and portion sizes derived from an interview using food models were highly correlated ($r \geq 0.90$). Block *et al*, (1986) used a slightly different method of portion size determination. Portion sizes from a large data set (11658 adults) were ranked and the median portion size was determined. The median was used in preference to the mean as it is not affected by some individuals with excessively small or large portions. Portion sizes were then calculated separately for men and women and for different age groups deriving age and gender specific portion sizes. When answering the questionnaire respondents indicated whether their usual portion size was small, medium or large. Hence much more information of portion size was gained for these subjects but without the time constraints of using food models. Samet *et al* (1984) and Pickle & Hartman (1985) showed that for most foods, portion sizes vary less among individuals than do frequencies of use and therefore most of the variation in intake is explained by frequency of use.

The influence of various variables on the agreement between food frequency questionnaires and weighed records in the assessment of overall diet has been investigated using

published data (Yarnell *et al*, 1983; Willett *et al*, 1985; Flegal *et al*, 1988; Pietinen *et al*, 1988a & 1988b; Margetts *et al*, 1989; Block *et al*, 1990; Engle *et al*, 1990; Bolton-Smith & Milne 1991; Tjønneland *et al*, 1991; Posner *et al*, 1992; Rimm *et al*, 1992). The variables that have been examined are gender, number of items on FFQ (divided into three groups 0-90, 91-200, > 200), the number of days the WR was kept for (divided into three groups < 7, 7-14, > 14 days), portion sizes (using food models or photographs, semi-quantitative, average portions) and whether the FFQ was completed before or after the WR.

Agreement was measured as percent mean difference between FFQ and weighed record estimates for energy, fat and vitamin C. The smallest sample size was 50. Table 1.2 shows the results using analysis of variance with gender, portion size, number of items, number of days and order of administration as factors. The table shows that agreement between the methods by gender was better in men for vitamin C, no difference for fat, and better in women for energy. As the number of items in the FFQ increased the differences between the methods decreased for energy and fat but there appears little advantage in including more than 100 items. For vitamin C as the number increases so does the difference between the methods. One possible explanation is that most vitamin C containing foods might be overestimated and inclusion of more foods would then lead to further overestimation. For portion size, the use of food models and semi-quantitative portions produced a better agreement than average portions; in fact, for fat and vitamin C the semi-quantitative method appeared to be the best. There were no statistically significant differences for order of administration of the methods although for vitamin C agreement was improved when the WR was administered first. For number of days the WR was kept for there did not appear to be any trends except that the longest period of WR achieved the best agreement for energy. For energy; gender, number of items included in the FFQ and

Table 1.2: The effect of different variables on the agreement between food frequency questionnaires and weighed records

Variable	Percent mean differences FFQ compared with WR†		
Gender	**Men**	**Women**	
Energy	-9.4	0.1*	
Fat	-12.6	-11.9	
Vitamin C	4.9	39.8	
No. Items	**< 70**	**70-100**	**> 100**
Energy	-26.7	6.9	6.6**
Fat	-24.8	-2.6	-2.9
Vitamin C	-16.9	21.7	45.9
No. days WR	**< 7**	**7-14**	**> 14**
Energy	15.4	-19.3	1.5**
Fat	3.5	-21.8	-5.1*
Vitamin C	-	11.1	19.9
Portion size	**Models/ photographs**	**Semi-quantitative**	**Average**
Energy	-4.2	-5.3	-16.8
Fat	-13.7	-8.9	-27.3
Vitamin C	26.1	3.3	38.4
Order of administration	**WR first**	**FFQ first**	
Energy	-8.8	-4.1	
Fat	-17.0	-9.6	
Vitamin C	5.2	22.1	

† Analysis of variance, means adjusted for gender, number of items, number of days, portion size and order of administration where appropriate.
* $P < 0.05$, ** $P < 0.01$ for difference between categories

number of days of recording the WR had the greatest influence on the percent mean differences between the methods. The agreement for fat did not appear to be affected by gender, but was affected by number of items on the FFQ and number of days of WR. These factors did not appear to explain the differences between the methods for vitamin C.

In summary, the best combination to assess overall diet appears to be a semi-quantitative questionnaire with between 70 and 100 items.

Table 1.3: Strengths and weaknesses of different dietary survey methods

	Weighed record	Diet diary	24hr recall	Diet history	FFQ
Groups & individuals	+	+	-	-	-
Reliant on memory	-	-	+	+	+
Specific nutrients only	-	-	+	+	+
Prospective	+	+	-	-	-
Retrospective	-	-	+	+	+
Trained interviewers	+	+	+	+	+/-
High subject burden	+	+	-	+	+/-
Affects eating habits	+	+	-	-	-
Response affected	+	+	-	-	-

Methods which measure average dietary habits depend on the memory of the subject; the advantages and disadvantages of survey methods are summarized in table 1.3.

1.2.1iii *Issues in the choice of a dietary method*

One such issue is **response rate**. Bingham, (1987) suggested a response rate of 80% would be necessary to ensure a representative sample from a randomly selected population. However, even with a high response rate (80-90%) no information is obtained from at least 10% of subjects. To help attain a high response rate consideration should be made in the design of studies. The study should appear interesting to the subjects, this may involve financial rewards or informing subjects of their results. Blood cholesterol levels may be of particular interest to the population and a reflotron measurement gives an instant result and could be built into the design of the study. Another consideration is timing and location of appointments if the subject is required to attend a clinic. The subject is likely to be put off attending if there is a long distance to travel, or inadequate parking facilities. Daytime appointments maybe difficult for subjects who work and the possibility of weekend and evening appointments should be considered.

It is largely believed that response rates tend to decrease with increasing complexity of the survey method. Despite this response rates in excess of 80% have been achieved using weighed records (Fehily *et al*, 1984). Response rates for dietary studies of smokers and non-smokers using a weighed record ranged between 68% and 88% for those eligible. There is some evidence that as the food record progresses towards one week that bias is introduced because of drop-puts and decreased quality of records (Gersovitz *et al*, 1978).

Therefore three days of recording is likely to achieve a greater number of completed records than 28 days.

A low response rate, a high drop-out rate or a high proportion of exclusions may result in an unrepresentative study sample and hence the results may not give a true picture of the diet of the original population. Those taking part may have different dietary habits to those refusing, perhaps due to different lifestyles. This was considered by Jørgensen (1992) in a Danish study. The authors stated of the most likely participant in a weighed record study with a response rate of 49% that "She is middle-aged, has been to school for up to 10 years and may have had vocational training. She is married, a non-smoker and consumes only a few glasses of wine per week. Her food habits are generally good with daily intakes of vegetables, fruit and cheese". They measured diet in all subjects using a food frequency questionnaire and found no major differences in diet between the groups. Therefore although lifestyle differences were found no differences in dietary habits were detected. This study however was unable to evaluate the 21% of the initial subjects that failed to participate in the study and these may have differed from those participating. It is often considered that those who take part will be more motivated, and perhaps have more 'healthy diets' and therefore give a biased picture of usual diet. The problem of different response rates between smokers and non-smokers is important in studies of smoking and diet. Haste *et al*, (1990) calculated response rates for the smokers and non-smokers in her study and found the response rate for smokers was lower at 68% compared with 75% for non-smokers.

The effect of non-responders consuming a different diet from responders is considered. The following tables are based on a theoretical daily fat intake in responders of 100g for smokers and 90g for non-smokers. Therefore, if there is a 100% response from both smokers and non-smokers their

respective mean fat intakes would be 100g and 90g. The effect of dietary differences in fat intake between responders and non-responders is shown in table 1.4. Table 1.4i shows calculated fat intakes for smokers at different response rates, table 1.4ii shows the same results but for non-smokers. For example, if the response rate for smokers is 60% and 40% are non-responders and if the non-responders consume 10% more fat than the responders then calculated the fat intake from attenders would be 100g and that of the non-responders 110.

Therefore the true mean is:-
(response rate of attenders x 100g fat) - (response rate of non-responders x 110)
or
(60/100 x 100) + (40/100 x 110) = 104g compared with the estimated mean of 100g.

Table 1.4: The effect of different response rates

i) Smokers

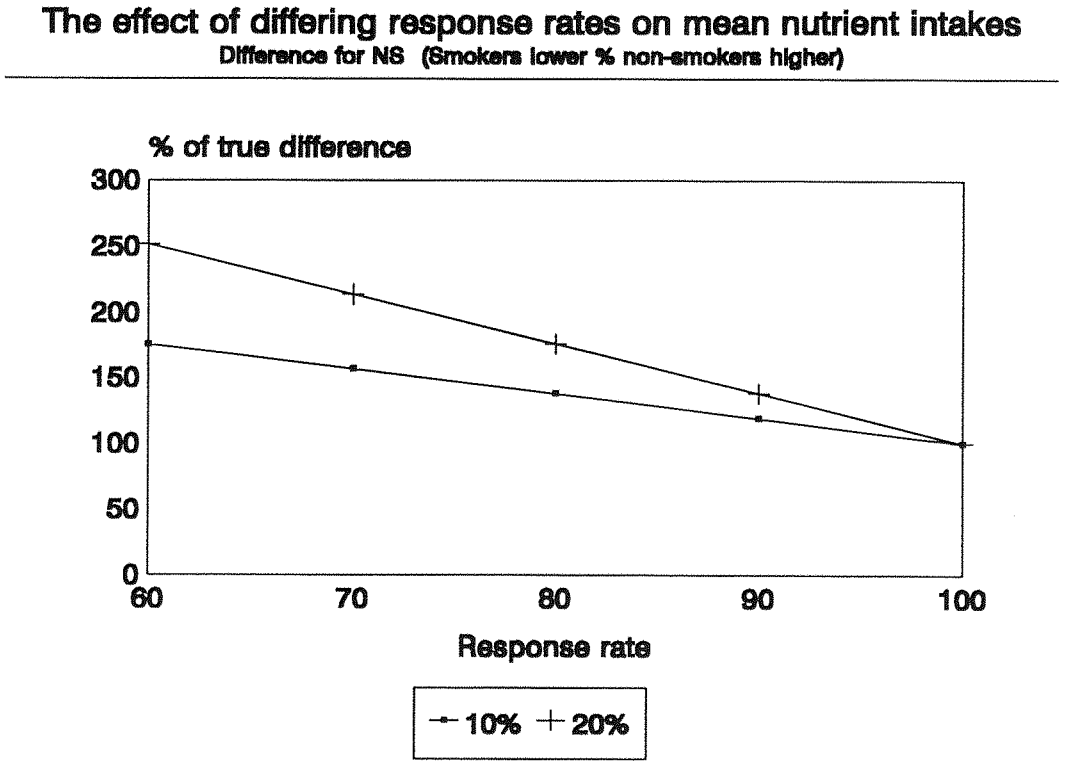
Response rate	Difference in fat intakes of non-responders (%)			
	-10	**10**	-20	20
60%	96	**104**	92	108
70%	97	103	94	106
80%	98	102	96	104
90%	99	101	98	102

ii) Non-smokers

Response rates	Difference in fat intakes of non-responders (%)			
	-10	10	-20	20
60%	**86.4**	93.6	82.8	97.2
70%	87.3	92.7	84.6	95.4
80%	88.2	91.8	86.4	93.6
90%	89.1	90.9	88.2	91.8

These data have been presented in graphical form and to illustrate the point two situations are shown (figure 1.1). The first is that the smokers who do not attend have higher fat intakes than those who do attend and conversely the non-smokers who do attend have lower fat intakes than the responders. The second situation is the reverse with non-responding smokers having lower fat intakes than the responders and non-responding non-smokers having higher intakes than those who attend. The data were based on the same response rate for smokers and non-smokers and an observed difference between smokers and non-smokers of 10g of fat. For ease the differences in fat intakes between responding and non-responding smokers and responding and non-responding non-smokers were the same percentage (but in the opposite direction).

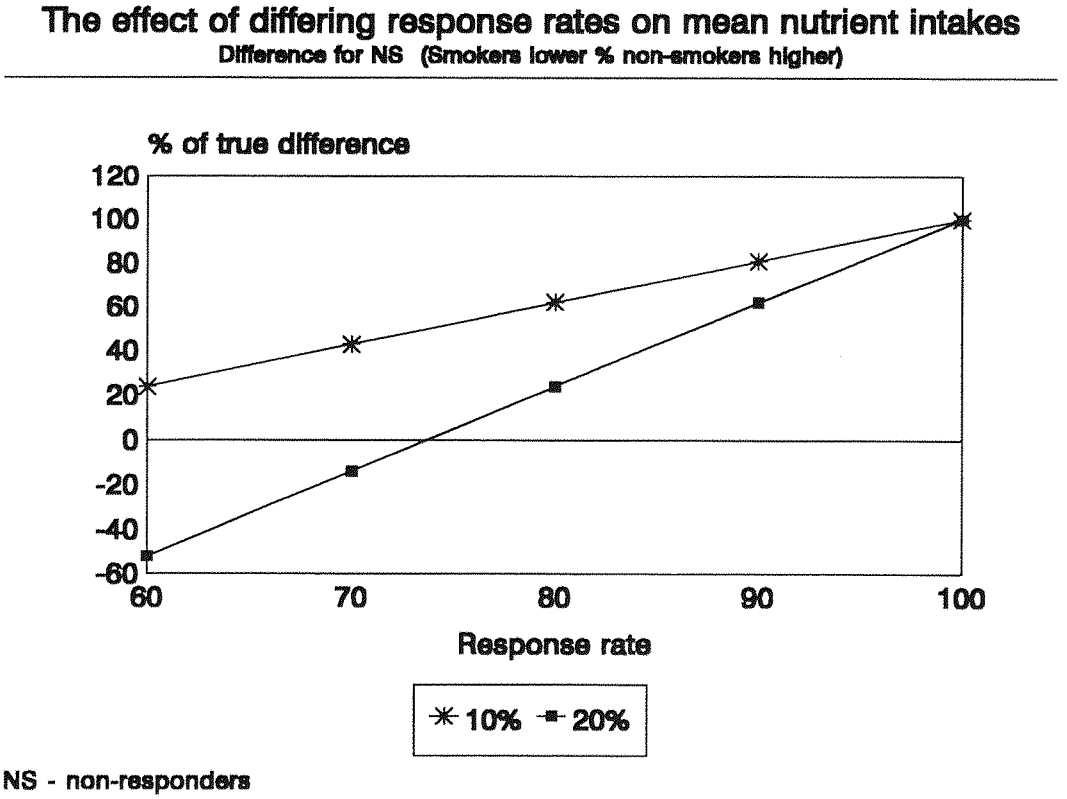
Figure 1.1i) Non-responding smokers with higher fat intakes than responders and non-responding non-smokers with lower fat intakes than responders.



Therefore in case 1.1i if the response for both groups is 60% and the real fat intake of smokers (responders 10% higher intakes) is 104 and that for non-smokers (non-responders 10% less than responders) is 86.4. Then the real difference is 104 - 86.4 = 17.6. As a percent of the estimated difference is 17.6 / 10 x 100 = 176%.

The graphs show the nutrient differences between the smoking categories at different response rates as percent of the detected difference (shown as 100%). It appears that deviation from the true mean increases with decreasing response rate in a linear fashion. In figure 1.1i) the difference seen is smaller than the real difference making differences in fat intakes between the groups difficult to

Figure 1.1ii) Non-responding smokers with lower fat intakes and non-responding non-smokers with higher intakes than corresponding responding groups.



detect. In figure 1.1ii) the opposite is true with the observed difference being greater than the true difference thus making differences easier to detect. Even at 90% the difference that should have been observed was 1.5 times that was seen if non-responders consumed 20% more fat this rises to 2.5 times with a 60% response rate. However in the real situation the results are not likely to be so extreme but differences in non-responders can be important. Therefore as much information as possible must be gained from subjects not completing the survey method. This could include age, sex, body mass index, occupation group and any other factors relevant to the study question. It may be possible to use a less invasive method such as a one day record or food frequency questionnaire for which information will be

collected from everyone in addition the method of choice. It would then be possible to see if the non-responders differed from those co-operating. This would not help with subjects who did not attend their appointment. It is necessary to see if these subjects can be excluded, for example, if they have moved away or died. The post office may return some letters that are incorrectly addressed or if subjects have moved. Further invitations can be sent as the time may have not been convenient. To obtain some information from the non-attenders a random sample could be contacted by telephone or home visit and questions relating to factors that might influence the results can be asked. Such factors could include age, occupation group or smoking status. In addition it might be possible to obtain some dietary information in the form of a short questionnaire.

Another issue is **validity** which can be divided into internal and external validity. The validity of a method is the extent to which it measures what is true.

Internal validity is the validity within a study and refers to whether the method actually measures what it is supposed to measure accurately. For example whether a food frequency questionnaire used to measure fat intake measures it accurately.

To determine whether a study is **externally valid** is more difficult and will depend on the objective of the study. If the aim is to determine actual nutrient intake of a population then the study sample should be representative of the wider population. However, as the true situation may not be known this can only be inferred by judgement. If the aim is to determine the effect of an intervention, say smoking cessation, one would have to show that the effect of smoking cessation on diet differed in different groups of subjects for the study not to be generalisable. Studies of smoking cessation are often carried out in subjects who volunteer to

stop smoking and not randomly recruited subjects. For these studies to be shown not to be generalisable one would have to show that the changes observed in those who volunteer to quit differ from those who quit after being advised to stop smoking. To be externally valid the study must be internally valid. Problems of calibration of dietary studies have been considered in the context of calibrating a FFQ (page 15).

Estimating food and nutrient intakes from dietary assessments is not without error. These errors may be random or systematic. Below is a description of the error, how it affects the results and what can be done to correct it.

Within person error

If first we consider random within person errors, these arise due to daily variation in the diet of individuals and measurement error on any one day. One day of recording is unlikely to give a truly representative dietary intake and in addition this estimate will be confounded by measurement error. To correct for this error the number of measurements per subject needs to be increased. In theory the amount of random within person error can be measured in a reproducibility study in which the measurement is repeated in the same sample of subjects. This point is further discussed on page 40.

Alternatively there may be within person systematic error in which the same error occurs in repeated measurements in the same subject. For example, for a subject to underestimate the number of cups of tea consumed per day by three each time the method is repeated. Another example is if an FFQ with a fixed list of foods is used. If an important food item is missing this error will be repeated each time the questionnaire is administered but only for those subjects who consume the food item. These within person systematic errors may not apply to all subjects and are randomly distributed.

As a result of within person errors the individual mean estimates for each subject may not reflect true intake. If there is no systematic bias within person and the error is purely random the bias can be reduced by increasing the number of measurements per subject.

Between person error

Random error exists between persons (variability in diet between subjects) and can result from too few measurements per subject. However, if sufficient subjects are included the population mean may represent true diet. As the range of intake is greater than in the real situation (due to some subjects underestimating and others overestimating intake) the standard deviation estimate will be increased.

Finally, there is systematic bias between persons which results from systematic within person error that affects subjects non-randomly. If the same error affects all subjects equally then the group mean will be incorrect but the observed standard deviation will be correct. However, if all subjects are not affected equally then the standard deviation will be incorrect as well as the group mean estimate. This might be the result of omission of an item from a FFQ or under-reporting of food items constantly on a food record.

Random errors tend to decrease correlation coefficients so the likelihood of finding an association is reduced but this can be remedied by increasing the number of measurements on each person or by increasing the number of subjects in the study. The choice depends on the study, in principal it is relatively easy to increase the number of days of recording for weighed records although seven or more days may result in a decline in the number of satisfactory records. However, dietary questionnaires are rarely repeated more than once, there may be problems with learning effect and remembering previous responses and it may be more appropriate to increase

the number of individuals. Systematic bias is not easily remedied and therefore has serious consequences on relationships between diet and disease.

Measurement and observer errors are often considered as random errors. In dietary studies division of between and within subject variability into measurement error and true variability is not easy. This is because of daily variation in nutrient intake and therefore within and between subject variances include measurement error. Described below are errors that are involved in the collecting and processing of dietary survey methods. All methods require coding of foods either in the development stage or when data are processed to enable computer analysis of the data. Errors could arise due to incorrect coding by the observer and/or problems in coding foods not included in the database. If more than one observer codes the data all records should then be checked by only one observer to ensure that coding is consistent between all the records and that any differences found are not due to observer bias. For example, if coder 1 codes all the records for the control population and coder 2 those of an intervention group then differences in the results between the groups might be due to observer bias, this is in fact between person systematic bias. A further error often forgotten is the nutrient data in the database. These values are averages of a selection of different brands of a particular food item, therefore estimates of individual intakes may not be as accurate as group estimates. Although new food composition tables have recently been published (Holland *et al*, 1991) it takes some time before computer software programmes incorporate the new data and none of the UK based studies reviewed have used these data. The analysis is based upon food composition data published in 1978 (Paul & Southgate, 1978) although some updates may have been included for individual studies. There do appear to be nutrient differences for some foods (for example, fruit, breakfast cereals and bread) between the two editions which may result

from different practices in animal feeding and improvements in recipe development and analytical techniques. Also a larger number of foods has been included in the recent version thus making coding easier and possibly more accurate. Another problem is errors in data punching which can be reduced by checking the data.

Another issue in the planning of a study is which days and how many days diet should be recorded on. It is essential to know how many days the subject is required to complete to estimate a nutrient with sufficient accuracy for the purposes of the study. The number of days depends on the ratio of within- to between-subject variances and the unknown correlation between the observed and true mean nutrient intakes of individuals over the period of observation (Nelson *et al*, 1989).

A high proportion of records from one particular day of the week could affect the results as nutrient consumption appears to vary with day of week (Thomson *et al*, 1988). Thomson *et al*, (1988) in their study of 164 men found that mean intake of energy and selected other nutrients varied by day of the week. At weekends the men on average consumed more energy, alcohol and had a lower ratio of polyunsaturated fats to saturated fats (P:S ratio), than on weekdays. To overcome this problem of variation in dietary intake by day of the week, subjects could keep records for one week or at least include some weekdays and weekend days in each record. Another solution would be to collect one day records from a larger sample ensuring that the proportion of records kept for each day of the week is the same. Thomson *et al*, (1988) showed within- person variances to be greater than between person- variances. Therefore a one day record would be unlikely to estimate individual nutrient intake accurately but can be used to estimate group means. Hartman *et al* (1990) showed that correlations between consecutive days of recording were larger than non-consecutive and advocated

using non-consecutive days. Also if data are only collected over a few months say April to June it could be subject to seasonal variation. This would be more important in countries which rely on home-produced food and less important for countries with large imports. If a comparison between different groups was being made and difference between the groups rather than usual intake was the objective as long as all the groups were surveyed over the same period seasonal variation would be less important. The exception would be if difference between the groups was subject to seasonal variation.

There is consensus amongst workers that seven days are sufficient for most nutrients but that more days are required for fatty acids and some vitamins (Bingham *et al*, 1987; Thomson *et al*, 1988; Nelson *et al*, 1989).

The coefficient of variation (sd / mean x 100) gives an overall measure of the variability of a nutrient. Table 1.5 shows the coefficient of variation for polyunsaturated fats, a variable with a relatively high variance, calculated for different methods. It can be seen that the coefficient of variation tends to decrease with number of days of recording and that FFQs appear to have a similar variability to three day weighed records and therefore a higher variability than seven day weighed records. As the coefficient of variation for food items is greater than that for nutrients, if food consumption patterns are required consideration of the appropriate method should be made at the design stage. For example if the consumption of oily fish is of interest and this is not eaten on a weekly basis a longer term assessment method such as an FFQ might be more appropriate.

Table 1.5: Coefficients of variation for polyunsaturated fats by survey method

Study	Sex	1 day record*	3/4 day records	7 day record	> 7day record	FFQ
Willett *et al*, (1985)	F				19.9	35.0
Posner *et al*, (1992)	F	50.0	29.7			32.9
Posner *et al*, (1992)	M	34.5	31.8			31.2
Pietinen *et al*, (1988)	M			20.7		27.8
Stuff *et al*, (1983)	F	29.6	21.6	17.6		21.7
Yarnell *et al*, (1983)	F			22.3		28.1
Tjønneland *et al*, (1991)	M			20.4		21.5
Tjønneland *et al* (1991)	F			36.9		36.5
Jain *et al* (1980)	M			21.7	19.1	
Morgan *et al*, (1978)	F	54.5	30.3			

* includes 24hr recall

The degree of error that is acceptable will depend upon the study its objectives and likely results. For example, if the likely difference to be detected is large more error will be acceptable than if the difference is small. It will depend on whether associations, ranking or absolute intakes are required. Absolute intakes tolerate the least amount of error.

1.2.1iv *Issues relating to cross-sectional studies*

Cross-sectional studies are carried out at one point in time and are relatively cheap and easy. They are often used to assess the usual diet of groups of individuals. They can be used to determine group mean intakes and differences between groups and are able to rank individuals according to intake. Let us consider the relationship between nutrient variance, power, sample size and detectable nutrient difference. The following equation was used to calculate sample size for figure 1.2:-

$$n = 2\sigma^2 \frac{(Z_{\alpha/2} + Z_{\beta})^2}{d^{*2}}$$

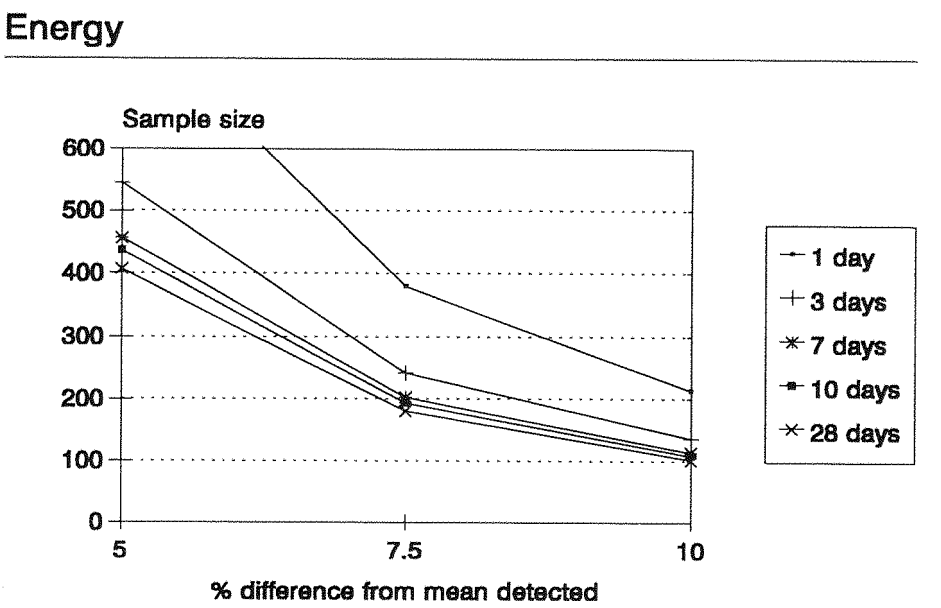
Where σ is the standard deviation of the variable, α and β the type I and type II error levels and d^* the difference between the groups to be detected. The power of a study can be defined as the probability of accepting the alternative hypothesis if it is true.

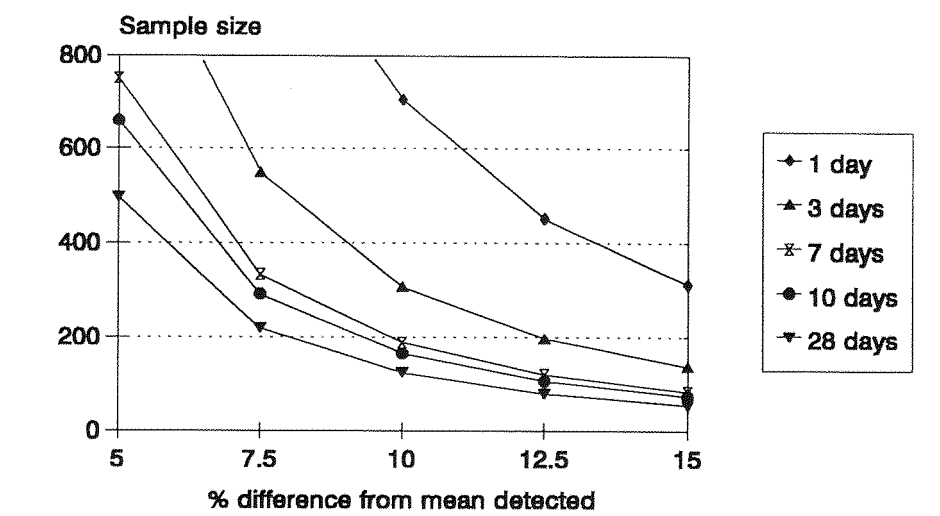
$$\sigma^2 = s_{b^2} + \frac{s_{w^2}}{k}$$

σ also varies with the number of days of recording a weighed record as above, where k is the number of days of recording, s_b the between person standard deviation and s_w the within person standard deviation.

Using means and within person and between person standard deviations for energy and polyunsaturated fat from Nelson *et al*, (1989) (Energy, mean 2815 kcal, s_w = 662 and s_b = 607; Polyunsaturated fats, mean = 10.7g, s_w = 6.8 and s_b = 2.4), variance was computed for weighed records kept for 1, 3, 7

Figure 1.2: Relationship between variance, percent nutrient difference detected and sample size





Variance shown by number of days of weighed record

and 10 days using the equation above. These nutrients were chosen to illustrate the effects on sample sizes for nutrients with high and low variance (polyunsaturated fats, high variance).

Using the sample size equation with power set at 90% power and α set at 0.05, sample sizes for each group were calculated for percent differences between means of 5 to 15% for different lengths of weighed records. The results are shown in figure 1.2.

Firstly for energy, to detect a difference of 10% between means there seems to be no advantage gained by increasing the number of days of collection beyond seven days. A small reduction in sample size is achieved by using seven days compared with three days. However, if a one day record is used the sample size necessary to detect a 10% difference is approximately twice that of a seven day record. As percent differences decrease then the difference in sample sizes between the number of days of weighed record increases. To detect a difference of 5% a one day record requires in excess of 600 subjects (850) in each group whereas less than 500 subjects in each group are needed with records of seven or more days.

For polyunsaturated fats there is much more variation in sample sizes required according to the length of weighed records. At the higher end to detect a difference of 15% there seems little benefit in using more than seven days. If a one day record was used to detect a difference of 15% then the sample size required would be three times that needed for a seven day record. To detect differences of 10% or less there appears to be some advantage in increasing the length of the records. At 5% approximately 500 subjects in each group would be required compared using 28 days and 750 would be needed using a seven day weighed record.

In summary, for a nutrient with less variability such as energy there is no benefit in recording diet for more than seven days, and three days are sufficient for differences of greater than 10%. For polyunsaturated fat with a greater variability advantage is gained by increasing the number of days to detect a difference of 10% or less but for differences between 10 and 15% seven days are sufficient.

Once the power is decided and the difference to be detected known, the choice of dietary method can be made in terms of required sample size. If the nutrient of interest is polyunsaturated fat which has a high variance it is necessary to decide between an increased sample size used with a one day method, a reduced sample size with a FFQ or a three day record or an even smaller sample size with an extended WR. This choice depends on expected response rate, available number of subjects and cost of increasing the number of subjects compared with increasing the number of days of recording. Diet may only be one component that is being measured and sample sizes for other analyses (which may be expensive) maybe smaller, and therefore it may be preferable to use a smaller sample size and use a food frequency questionnaire or weighed records kept for extended periods.

1.2.1v *Issues relating to experimental studies*

The term experimental studies refers here to studies in which an intervention takes place such as smoking cessation. Subjects are seen at baseline, intervention takes place in one sample and all subjects are seen at follow-up. These studies enable changes in dietary habits to be measured over time and the changes that occur in one group are compared with those in other groups. These studies may not require estimation of usual diets in the context of long term dietary habits but aim to measure diet over a specified period. For example, in a smoking cessation it may be important to look

at dietary changes that occur after one month of stopping smoking.

Response rates of the baseline sample in these studies may not be so important as differences over time are being investigated. Generalisability will depend on whether differences in baseline characteristics between the subjects taking part and those not participating affect the differences observed after follow-up. Loss to follow-up at any stage is a more important consideration and could introduce bias. The changes in those subjects not followed up may differ from those attending. Those attending are more likely to cooperate with the study, for example give up smoking. They may have also changed their diets for other reasons. It should be possible to see if the subjects who failed to return at follow up differed by dietary habit or lifestyle characteristics at their baseline appointment from the subjects who returned. In a smoking cessation study it is likely that those who are successful in stopping smoking return, but the non-attenders should also be contacted to see if they are still smoking. The same methods as for cross-sectional studies can be employed to discover whether non-attenders have died or moved and to gain some information from them.

Experimental studies are often carried out on a smaller sample size than cross-sectional studies and therefore it may be necessary to reduce the variance of the measure of dietary intake by increasing the number of days of recording or by using a more accurate method. Thus experimental studies may require a greater cooperation from subjects especially if they are to be followed-up for a long period of time.

Another problem may be that the act of observing diet may produce changes in dietary habits that would not have happened otherwise. Subjects will be more aware of their dietary habits as well as changes in other parameters

measured at clinic appointments such as body weight and blood cholesterol and this awareness may cause the subjects to change their diets. Hence the any observed changes may occur as a result of being in the study and not due to the intervention. Although it is impossible to avoid this kind of bias, if a control population which undergoes the same protocol as the intervention group is used, changes due to taking part in the project will occur in both groups and therefore changes as a result of intervention can be measured.

The repeatability of dietary assessment methods is another concern. Repeatability is the level of agreement between replicate measurements and it represents the degree of stability of both subject and the observer (or measurement technique). To ensure that the results of prospective studies are true the method of assessment must be repeatable. There are problems in determining the repeatability of a dietary assessment method. To assess repeatability at least two measures of diet are required. In theory these should be far enough apart so that the subject cannot recall their diet in the previous assessment but also not so far apart that changes in the diet have occurred. In practice even a short interval between the repeated measures may involve dietary change. There may also be a learning effect after the subject has completed one assessment whether it is a food frequency questionnaire or weighed record they are now familiar with the tool and therefore subsequent measures may be affected.

If the aim is to detect differences that occur over time and not to measure absolute intakes in a group of subjects undergoing some intervention such as smoking cessation a control population which is subject to the same measurements with the exception of the intervention as the intervention group could be used. It is then assumed that the effect of repeating the dietary assessment is the same in both groups

and that any differences that occur between the groups are a result of the intervention.

In planning a study, the choice of dietary method is important and will not only depend on the objective of the study but also on personnel, time, finance, nutrients to be studied and their variance, expected response rates, sample size and power.

1.2.2 Concurrent and Past Smoking Habits

Ideally, to investigate the relationships between smoking and dietary habits, a group of life-long non-smokers would need to be studied and the effect of commencing smoking on diet measured. This would require a study of children or young adults that would raise both practical and ethical problems. An alternative approach is to study the changes consequent on giving up smoking. These data are limited to observational studies in which smokers volunteer to stop smoking. There is no information, as yet, on random samples of smokers as they quit smoking. It is therefore, not possible to determine whether the differences in dietary patterns between different categories of smoker represent lifetime differences or change associated with smoking. Friedman *et al*, (1979) compared baseline characteristics of smokers who became ex-smokers with those who continued to smoke. They found that those who quit had a higher body weight, consumed less alcohol and smoked fewer cigarettes. In fact, those who quit appeared to be more like non-smokers than smokers in the above criteria.

1.2.3 Definition of Smoking Habit

Smoking categories in general are defined as smokers, ex-smokers, never smokers and non-smokers; although, precise definitions vary between studies. Groups of smokers maybe

made up of those currently smoking cigarettes but may also include pipe and cigar smokers. Some authors have specified regular smokers as those smoking a minimum number of cigarettes per day (eg. at least one cigarette a day (Whichelow *et al*, 1988). Never smokers are life-long non-smokers and ex-smokers are those who smoked in the past. The term non-smokers refers to subjects not currently smoking. However, these may include never and/or ex-smokers and also pipe, cigar and infrequent smokers in some studies.

In general, little consideration has been given to time since quitting. Larkin *et al*, (1990), Armellini *et al*, (1993) and Hebert & Kabat, (1990) defined ex-smokers as those who had stopped smoking for at least one year. It is possible that the length of time since quitting is associated with different dietary habits. An additional piece of useful descriptive information sometimes given is the mean (range) time since quitting of subjects (Cade & Margetts, 1991). Groups containing small numbers such as pipe and cigar smokers and infrequent smokers could be excluded from the analysis or analysed separately.

A weakness in most studies is that smoking status and number of cigarettes smoked per day are generally reported by the subject, although, a few studies have used smoking validation techniques (Bolton-Smith *et al*, 1991a; Strickland *et al*, 1992; and Armellini *et al* 1993). There may have been incorrect classification of some subjects as they may have been reluctant to admit that they smoked and hence were recorded as non-smokers. Defining someone as a non-smoker when they are a smoker clearly gives a conservative bias to any comparisons between these groups. Table 1.6 gives details of biochemical markers commonly used to validate reported smoking status. Carbon monoxide (CO), a product of tobacco smoke can be assessed by measuring percent carboxyhaemoglobin (%COHb). Alternatively CO levels can be measured in expired breath samples giving instant readings.

Other sources of CO are workplace exposures and car exhaust. Readings are dependent on pulmonary ventilation and cardiac activity and hence the presence of respiratory diseases may reduce the estimate.

Table 1.6: Validation methods of smoking status

Method	Measured in				Half-life	Normal serum levels/ smoking	
	Saliva	Blood	Breath	Urine		Yes	No
Carbon monoxide	-	+	+	-	1-4 hrs	0.5-2.0 %	>2.0%
Thio-cyanate	+	+	-	+	6-14 days	3.5 μmol/L	156 μmol/L
Cotinine	+	+	-	+	7-37 hrs	1 ng/ml	300 ng/ml

from Lee, 1988

Thiocyanate can be used as a marker but its level is affected by many exogenous sources such as diet, and workplace exposure (eg. steel and gas industries).

Nicotine, a major component of tobacco smoke, is not entirely specific to tobacco but has been detected in foods such as tomatoes, peppers and aubergines although not in significant amounts. Nicotine has a half life of only 2 hours and is only useful as an indicator of recent smoking status, however, cotinine, which is a metabolite of nicotine has a longer half life of between 7 and 37 hours. The average smoker will still have a cotinine concentration above that of a non-smoker for up to four days after cessation. Other sources of cotinine include nicotine chewing gum and foods which have been exposed to nicotine insecticide. Thus if an ex-smoker is taking nicorette chewing gum they may have readings similar to smokers. The same may apply if non-

smokers consume large quantities of foods exposed to nicotine insecticide. The use of two methods to confirm reported smoking status will help to reduce bias introduced this way. Cotinine can be measured in saliva, plasma or urine (24hour collection). CO and thiocyanate were popular in the 1970's but more recently cotinine has become the preferred method. There is concern over the detrimental effects of passive smoking on health therefore it is important to be able to detect passive smoking by these methods; cotinine has been shown to be able to discriminate between non-smoking subjects not exposed to cigarette smoke and those who are exposed (Jarvis *et al*, 1991; Woodward *et al*, 1991).

Pérez-Stable *et al*, (1992), compared the criteria used for cutoffs for non-smokers and percent of smokers misclassified as non-smokers in ten studies using cotinine as the biochemical marker. Misclassification ranged from 0 to 10% with a mean of 4% in these ten studies. Misclassification for the six studies with a cut off for non-smokers of <30ng/ml was 6% on average.

Half-life is an important consideration with choice of marker to be used. A marker with a short half-life will only give an indication of smoking within the last few hours. At best these markers can detect smoking in the last few days, as yet there is no marker suitable for long-term validation. This is also a problem in smoking cessation studies as the time since smoking the last cigarette cannot be validated. The marker needs to be specific to tobacco to avoid false positives. (False positive results occur when true non-smokers are classified as smokers). To reduce detection of false positives questions should be asked regarding other potential sources. The marker should also be reliable and accurate. Other considerations are cost and ease of sample collections. For example 24-hour urine collections necessary for urinary cotinine estimates put an extra burden on the

subject, and extra costs include collection of samples and storage space.

When looking at a dose response relationship between smoking and diet, subjects are usually classified as light, moderate or heavy smokers. However, the number of cigarettes smoked in each category varies between studies, for example Fulton *et al*, (1988) used the following categories for light, moderate and heavy smokers; one to ten, eleven to twenty and greater than twenty cigarettes per day. Whereas Fehily *et al*, (1984) and Subar *et al*, (1990) used one to fourteen, fifteen to twenty-four and twenty-five or more cigarettes as their categories.

Sutton *et al*, (1982), however, showed that total volume of smoke puffed from a cigarette was a more important determinant of peak blood nicotine, than tar yield of cigarettes, length of cigarette smoked or reported number smoked. Therefore, when investigating a dose response effect it may not be appropriate to use number of cigarettes smoked as a method of categorising dose but better to use a biochemical method or questions on smoking habit including those on inhalation and length of cigarette smoked.

Woodward *et al*, (1991), with cross-sectional data from 10,359 randomly selected Scottish men and women showed that Spearman's rank correlation coefficients for CO, thiocyanate and cotinine with reported number of cigarettes smoked were 0.60, 0.41, 0.49 for men respectively and 0.47, 0.47, 0.46 for women. The authors also grouped the reported number of cigarettes smoked into intervals whose centres were exact multiples of five and plotted the median of each biochemical marker against these intervals of reported number of cigarettes smoked and found a curvilinear relationship with an apparent levelling out at 25 cigarettes per day for cotinine and thiocyanate and 40 cigarettes per day for CO. Therefore it appears that heavy smokers do not receive the

same nicotine intake from each cigarette as do light smokers. This may be a result of differences in smoking methods as suggested by Sutton *et al* (1982) or inaccurate reporting.

The use of biochemical markers in studies of smoking cessation is particularly important as misclassification of a smoker as an ex-smoker may be as high as 20% (Lee, 1988). If they are to be used in smoking cessation studies it is essential that the biochemical markers are sensitive enough to be able to discriminate between current smokers and those who have stopped smoking.

Richmond & Webster, (1986) measured blood concentrations of cotinine, carboxyhaemoglobin and thiocyanate in 188 smokers and 198 non-smokers (Table 1.7). At six months, smokers only were required to undergo a second test. The results revealed that blood concentrations of all three analytes were significantly lower in non-smokers compared with smokers.

Table 1.7: Blood cotinine, carboxyhaemoglobin and thiocyanate concentrations and cigarette consumption

		Cotinine (nmol/l)		Carboxyhaemoglobin (%)		Thiocyanate (μmol/l)	
	NO.	Mean	SD	Mean	SD	Mean	SD
Non-smoker	198	23	76	0.93	0.5	33	15
Light smoker	56	1430	1090	3.47	1.8	98	40
Heavy smoker	132	2107	1304	4.85	2.1	114	47
Quitter	34	60	181	1.03	0.5	44	18

from Richmond & Webster, 1986.

The concentrations were related to cigarette consumption with heavier smokers recording higher values than light or moderate smokers. Those smokers who had abstained for three months had lower concentrations than those who continued to smoke. Measurements of continuing smokers remained unchanged. The authors also found that time of blood sampling since last cigarette made minimal contribution to the blood concentrations (13% for carboxyhaemoglobin, 1% for thiocyanate, 10% for cotinine). Validation of smoking habit is particularly important in studies of smoking cessation. Cotinine estimates are the preferred method but at best will only detect smoking in the last few days; as yet there is no marker suitable for long-term validation. Therefore, markers are useful for determining regular smokers but may not detect intermittent smokers or distinguish between a subject who has never smoked and an ex-smoker.

Without use of a biochemical measurement or specific questions on smoking, (such as those on inhalation and amount of the cigarette that is smoked, as used by Troisi *et al*, (1991)) the dose response effect of cigarette smoking may be difficult to interpret.

1.3 PUBLISHED OBSERVATIONAL STUDIES

The following sections report the results from published studies of diet and smoking. This section reports data from observational (largely cross-sectional) studies. The possibility that the relationship between diet and smoking habit varies between occupation groups and between different regions of the UK is also discussed. When discussing food and nutrient intake, several confounding factors should be taken into account. These factors include occupation group, age, height, weight and alcohol consumption.

Mortality from coronary heart disease has been reported to be higher in the manual occupation groups III (manual), IV, and V than non-manual groups I, II and III (non-manual) (Khosla, 1972, Rose & Marmot, 1981 and Cox *et al*, 1987). A higher prevalence of smoking, which is a major risk factor for coronary heart disease, in the lower socio-economic groups compared with non-manual groups could partially account for this. Manual occupation groups generally have poorer living conditions, suffer more unemployment and may be less responsive to preventive medicine. They may also have less time and money to take up some leisure pursuits such as sports. In addition higher socio-economic groups are thought to consume a diet more in line with the national nutritional recommendations (NACNE, 1983; COMA, 1984) (Fulton *et al*, 1988, Bolton-Smith *et al*, 1991b; Haste *et al*, 1990) than lower socio-economic groups. Therefore if a poor diet contributes to coronary risk this could explain some of the excess risk in the manual occupation groups. Food and nutrient intakes may also vary by age (Bingham *et al*, 1981; Bolton-Smith *et al*, 1990) and therefore age should be taken into account. Other important variables are height, weight as these may affect energy and nutrient intakes. Early life factors may also affect the risk of coronary heart disease in later life. Nutrition during prenatal and early postnatal life may predispose to adult heart disease (Barker and Osmond, 1986). Height is an important as an indicator of early life experience. Alcohol is another important factor as smoking and drinking alcohol tend to be associated. Also drinking alcohol may be associated with different dietary habits (La Vecchia *et al*, 1992). In particular heavy alcohol drinkers consumed less fruit than non-drinkers. Physical activity also has an effect on weight and energy intake.

Table 1.8 lists most of the studies that have been reviewed here and gives details of sample population, smoking categories and method of dietary assessment. The main dietary assessment methods used were the food frequency

questionnaire and weighed record (usually seven days). Most studies were carried out on population samples although some studies used volunteers or hospital databases. Data analyses were often carried out adjusted for covariates but these tended to vary between studies. Adjustment for age was used in all studies except for some UK studies (Haste *et al*, 1990; Fehily *et al*, 1984; Cade & Margetts, 1990/1991) and also one from America (Klesges *et al*, 1990). Occupation group/poverty index ratio/years of education was used by all except for Fisher & Gordon, (1985); Kato *et al*, (1989); Klesges *et al*, (1990); Morabia & Wynder, (1990); Troisi *et al*, (1991); La Vecchia *et al*, (1992); and Armellini *et al*, (1993). In addition some workers have adjusted for alcohol consumption (Nuttens *et al*, 1992; Midgette *et al*, 1993; Armellini *et al*, 1993) or physical activity, (Larkin *et al*, 1990 and Armellini *et al* 1993). Some studies have adjusted for anthropometric measurements. Haste *et al*, (1990) included height; Larkin *et al*, (1990) self-reported weight, and Morabia & Wynder, (1990); Nuttens *et al* (1992) and Armellini *et al*, (1993) BMI. If BMI is included as a covariate no information is obtained as to whether any effect is due to either height or weight and therefore it may be more appropriate to include height and weight separately.

Table 1.8: Details of studies on diet and cigarette smoking

Study	Country	No.	Age	Method*	Smoking†	Sample
Armellini *et al*, (1993)	Italy	601 (M/W)	20-60	FFQ	3	Popn
Bolton-Smith *et al*, (1991a)	UK	9692 (M/W)	40-59	FFQ	2	Popn
Cade & Margetts, (1990/1991)	UK	2340 (M/W)	35-54	1D DR	2	Popn
Fehily *et al*, (1984)	UK	493 (M)	45-59	7D WR	1	Popn
Fisher & Gordon, (1985)	USA	4374 (M/W)	20-59	24hr	1	Popn
Fulton *et al*, (1988)	UK	164 (M)	45-54	7D WR	1	Popn
Gregory *et al*, (1990)‡	UK	2197 (M/W)	16-64	7D WR	1	Popn
Haste *et al*, (1990)	UK	184 (W)	pregnant	7D WR	3	Popn
Hebert & Kabat, (1990)	USA	2191 (M/W)	-	FFQ	2	Hosp
Kato *et al*, (1989)	Japan	30,916 (M/W)	≥ 40	FFQ	2	Popn
Klesges *et al*, (1990)	USA	210 (M)	23-53	FFQ	1	Vol
Larkin *et al*, (1990)	USA	1338 (W)	19-50	24hr	2	Popn
La Vecchia *et al*, (1992)	Italy	1774 (M/W)	21-74	FFQ	2	Hosp
Midgette *et al*, (1993)	Australia	451 (W)	20-74	FFQ	2	Popn
Morabia & Wynder (1990)	USA	7860 (M/W)	< 74	FFQr	2	Hosp
Nuttens *et al*, (1992)	France	1126 (M)	45-64	3D DR	1	Popn
Strain *et al*, (1991)	UK	590 (M/W)	16-64	7D WR	1	Popn

Cont	USA	3495 (M/W)	24-75	FFQ	2	Popn
Strickland *et al*, (1992)						
Subar *et al*, (1990)	USA	11260 (M/W)	19-74	24hr	2	Popn
Troisi *et al*, (1991)	USA	765 (M)	43-85	FFQ	1	Vol
Whichelow *et al*, (1988 - 1991)	UK	9003 (M/W)	18-99	FFQ	1	Popn

* 1D, 1 day; FFQr, retrospective FFQ; 24hr, 24hr recall, DR, diet record (estimated portion sizes); popn, population sample; vol, volunteers; hosp, sample from hospital database.
† Smoking categories 1, smokers and non-smokers; 2, smokers, ex-smokers and never smokers; 3, smokers and never smokers.
‡ Also further analysis of these data by Margetts & Jackson (unpublished)
used, how the sample was recruited and dietary assessment methods.

If any of these adjustments have a large effect on the data, comparisons between studies including a covariate in the analysis and those not including the covariate are difficult to make.

Most studies have used log transformed data as nutrient intakes do not usually conform to a normal distribution although this is not clear for all studies.

Most of the studies were carried out in 1980's with the exception of Fisher & Gordon (1985) whose study was carried out between 1972 and 1976 and Subar *et al*, (1990) whose study was between 1976 and 1980. The range of the length of survey period ranges from a few months (Larkin *et al*, 1990) to 10 years (Morabia & Wynder, 1990), with most studies carried out over 2 years. None of the studies with a long survey period mentioned any adjustment that was made for the length of the

study. This could lead to a bias if the different smoking categories were not recruited at the same rate and dietary changes have occurred. If the smokers were seen in the early stages of the study and non-smokers predominately at the end and if the quality of diets have improved over the survey period this may lead to differences being detected erroneously. Also patterns between smoking categories may have changed over a number of years, and this in a lengthy study may affect results.

There have been few studies on the effect of passive smoking or living with a smoker on dietary habits. Sidney *et al*, (1989) found that non-smokers exposed to passive smoking at home had a lower dietary intake of β carotene than non-smokers not exposed to passive smoking at home. One possible explanation is that the diet of non-smokers who live with smokers is influenced by the diet of the smokers. If this is true, and there is a large proportion of non-smokers living with a smoker and thus altering their diet towards that of a smoker, then differences between smokers and non-smokers may be smaller and therefore not so easy to detect.

1.3.1 Food patterns

Information on meal patterns and on the frequency of consumption of foods was collected in the Health and Lifestyle Survey (Whichelow *et al*, 1988, Whichelow & Erzinglioglu, 1990). Food frequencies of consumption were described as frequently (at least once a day and most days) and infrequently (twice a week or less). The results are shown in Table 1.9. After logistic regression analysis to allow for age and occupation, non-smokers (never and ex-smokers combined) of both sexes were significantly more likely to consume fruit in winter, fruit juice and salad in summer and winter, breakfast cereals, brown bread (included all bread except white), biscuits, cakes, puddings, light

desserts, jam and low fat milks frequently than smokers. Non-smokers also had a greater preference for polyunsaturated or low fat margarines than butter or ordinary margarines than smokers. Smokers were more likely to eat chips and processed meats frequently and to consume more alcohol and more cups of tea and coffee with more sugar in these beverages than non-smokers.

Table 1.9: Differences between current smokers and non-smokers in the frequency of consumption of selected foods

Consumed more frequently by smokers	Consumed more frequently by non-smokers
Alcohol	Biscuits and cakes
Butter	Breakfast cereals
Chips	'Brown bread'
Fried foods	Fruit and fruit juice
Processed meats	Low fat milk
Tea & coffee	Jam
Sugar in drinks	Polyunsaturated and low fat margarines
	Puddings and light desserts
	Salads

Whichelow *et al*, 1988
Whichelow, 1989
Whichelow & Erzinglioglu, 1990

Whichelow *et al*, (1991) re-examined these data using different smoking categories; heavy smokers (≥ 16 cigarettes per day), light smokers (1-15 cigarettes per day), ex-smokers and never smokers. Odds ratios for frequent consumption of food groups for heavy smokers, light smokers and ex-smokers compared with never smokers were calculated for men and women separately. These data were adjusted for age and occupation group. There appeared to be a trend of increasing likelihood of frequent consumption of some food groups from heavy smokers to light smokers to ex-smokers. This was observed in

both men and women for fruit, fruit juice, salad in winter, 'brown' bread, breakfast cereals, cakes, biscuits, puddings, light desserts, skimmed milk, jam and fat spread (polyunsaturated margarines, low fat margarines or no spread). The same trend was also observed for the frequent consumption of breakfast.

A trend for decreasing likelihood of frequent consumption of food groups from heavy smokers to ex-smokers was observed for chips, greater than six cups of tea and/or coffee daily, greater than eight teaspoons of sugar used daily and for moderate/heavy alcohol consumption (> 10 units a week for men and > 5 units a week for women). Heavy smokers compared with never smokers also were more likely to frequently consume processed meats but less likely to frequently consume poultry. For fried foods the heavy smokers were more likely and the ex-smokers less likely than never smokers to frequently eat fried foods. For most food groups there were no differences between never and ex-smokers with the exception of breakfast cereal, cakes and puddings in men and cakes in women. The ex-smokers were less likely to consume these items frequently compared with never smokers. In addition ex-smokers were more likely to consume frequently skimmed milk and nuts.

Portion sizes were not evaluated, hence nutrient intakes could not be determined and it is unclear whether there were any differences in overall nutrient intakes. For example, smokers consumed more sugar in drinks but less in the form of cakes and biscuits than non-smokers.

Kato *et al*, (1989) also used rate ratios but between past smokers (by duration of abstinence from smoking) and current smokers. Without any adjustment in men, compared with current smokers past smokers consumed less rice, miso soup, pickles, instant noodles and coffee, and conversely past smokers consumed more bread, fish, milk, vegetables, fruit

and black tea than current smokers. In women, past smokers compared with current smokers consumed less rice, pickles and coffee, but differences were not influenced by duration of smoking cessation. Past women smokers consumed more bread, eggs, milk, vegetables and black tea than current women smokers. In men and women daily alcohol drinking was more common in smokers compared with ex-smokers. After adjustment for age, occupation group and number of cigarettes smoked before cessation, in men the most important differences by duration of smoking cessation were for coffee and pickles, fruit and milk and in women they were for coffee, fruit, milk and black tea

Perrin *et al*, (1961) looked at fat intakes between smokers and non-smokers using a diet history method and found that although fat intakes did not differ between the groups the sources of the fat did. Smokers consumed more fat in the form of eggs and meat but less in the form of cakes, sweets and chocolate.

Subar *et al*, (1990) reported that after adjusting for poverty index ratio, age, energy intake and sex, more smokers than non-smokers over a 24hour period consumed whole milk and processed meats. There was no difference between smoking categories in red meat consumption, although non-smokers ate more vegetables, fruit, poultry/fish, skimmed milk and vitamin supplements than smokers.

La Vecchia *et al*, (1992) estimated average intake of selected foods in relation to smoking habit adjusted for age. In men, smokers more frequently consumed processed meats and drank more coffee and alcohol. Intakes of green vegetables and fruit were inversely related to smoking with the highest intakes of fruit and vegetables in non-smokers. In women, smoking was positively associated with eating pastries, processed meat, coffee and alcohol and negatively associated with eating milk and apples. There was evidence that female

ex-smokers consumed more fruit and vegetables than never smokers.

Bennett *et al*, (1970) in a sample composed of mainly male hospital patients found that there was a positive association between cigarette smoking and sugar intake. Smokers consumed more hot drinks daily and were more likely to use sugar in their drinks than non-smokers. Morabia & Wynder, (1990) and Hebert & Kabat, (1990) both used data collected from hospital patients in which a food frequency questionnaire related to dietary habits before their illness was used. Both studies found diets of ex-smokers to be similar to never smokers and that smokers ate significantly less fruit than non-smokers. Morabia & Wynder, (1990) also reported that smoking was positively related to meat consumption and negatively related to cereal consumption in males. Both male and female smokers consumed fewer vegetables but more alcohol and coffee than people who had never smoked. It is possible that current illness affected recall of past diet and that diets changed as a result of illness biasing the results.

The only study to calculate amounts of food eaten was by Larkin *et al*, (1990) who found that smokers ate more eggs, sugar and beverages (both alcoholic and non-alcoholic, with the exception of diet drinks) and less fruit and vegetables.

Information from daily documentation methods is limited. Although, Nuttens *et al*, (1992) using a three day record (with estimated portion sizes) found that after adjusting for age, body mass index, centre, level of education, family size and alcohol consumption, smoking cigarettes was negatively associated with dairy products (milk, yoghurt, cream), cheese and vegetables, and positively associated with sucrose. Strain *et al*, (1991) and Fulton *et al*, (1988) using weighed records reported that smokers consumed less cereal products and, cakes and puddings than non-smokers. Fulton *et al*, (1988) also reported a higher consumption of polyunsaturated

margarines by non-smokers compared with smokers. Gregory *et al*, (1990) found that a 'traditional' meat and vegetable diet was associated with smoking cigarettes. A 'traditional' diet included the following food items; white bread, bacon, ham, sausage, meat pies, vegetables and potatoes (in any form). Margetts & Jackson, (1993) carried out a further analysis of these data and shows that smokers consumed more white bread, sugar, cooked meat dishes, butter and whole milk compared with non-smokers. Non-smokers consumed more wholemeal bread, high fibre breakfast cereal, fruit and carrots than smokers. Similar to Whichelow *et al*, (1991) they also looked at the effect of heavy (> 20 cigarettes per day) versus light (< 20 cigarettes per day) smoking and found a graded relationship in the order heavy smokers, light smokers, non-smokers.

Despite difference in methodology results from these studies show that both men and women smokers eat less fruit and vegetables, sweet products and polyunsaturated margarines than non-smokers; but more processed meats, white bread and beverages including alcohol, tea and coffee, and are more likely to use sugar than non-smokers.

1.3.1i *Occupation group*

Whichelow, (1989) looked at amount and choice of spread used by smokers and non-smokers of differing social class as assessed by occupation (Table 1.10). Smokers showed a preference for butter compared with non-smokers with the smallest difference being for men with manual occupations. Smokers tended to use ordinary margarine rather than low-fat or polyunsaturated margarine compared with non-smokers. For men differences between manual and non-manual occupation groups were small. Women smokers of non-manual occupation groups tended to use more polyunsaturated margarine, although

Table 1.10: Percent differences between smokers and non-smokers for amounts and type of spreads used by gender and occupation group (Non-smoker = 100%)

	MEN		WOMEN	
	Non-manual	Manual	Non-manual	Manual
Butter	124	110	119	120
Margarine	114	116	107	105
Pufa margarine	54	59	88	64
Low-fat margarine	63	56	58	48
None	170	96	92	154
Amount	122	131	135	134

Whichelow, 1989

still less than for non-manual non-smokers. The greatest difference was in those who used no spread; among men with non-manual occupations more smokers than non-smokers used no spread. However, in women it was the manual group in which smokers were more likely to use no spread. Smokers, irrespective of occupation group used more spread than non-smokers. This appeared to be the result of using more spread per slice of bread rather than consuming greater quantities of bread. It is possible as smokers preferred butter, that their intakes were increased as butter is generally spread more thickly than margarines, especially polyunsaturated margarines (Wise *et al*, 1990). The amount of spread was calculated from the subject's answer to number of slices of bread or rolls per day and thickness of spread used categorised; as 'thick', 'medium', 'thin' or 'just a scrape'. These categories may have been difficult for the subjects to answer as one subject's idea of a medium spread of fat would be another's thin.

There is little information on dietary differences between smoking categories by occupation group. There are some data

on choice of fat spreads. For men more non-manual smokers than non-smokers used no spread on bread. In women, smokers of non-manual occupations were more likely to use polyunsaturated fats and those from manual group more likely to use no spread than non-smokers in their respective groups (Whichelow, 1989).

These data demonstrate that the whole dietary pattern of smokers is different from that of non-smokers.

1.3.2 Nutrient intakes

Dietary studies investigating differences in nutrient intake (macronutrient and micronutrient) between smoking categories are reported. The effects of occupation group and region of residence are discussed. As the relationship between nutrient intake and smoking is being discussed in relation to coronary heart disease the literature review has been restricted to energy, protein, fat (types of fat), carbohydrate, sugar, fibre, alcohol, vitamin A (also β carotene), vitamin C and vitamin E.

1.3.2i *Macronutrient intakes*

Two UK studies have shown lower energy intakes in men who had never smoked compared with men who smoked (Bolton-Smith *et al*, 1991a; Cade & Margetts, 1991). In these two studies daily energy intakes in the male smokers were 10.54 and 11.0 MJ and in never smokers 9.28 and 10.2MJ respectively with intakes of ex-smokers intermediate. Strickland *et al* (1992) found that smokers had a significantly higher energy intake than ex or never smokers. Other workers in the USA found similar trends although not statistically significant for energy (Klesges *et al*, 1990; Subar *et al*, 1990; Troisi *et al*, 1991). La Vecchia *et al*, (1992) compared never smokers

and heavy smokers (≥ 15 cigarettes) and found energy intake was highest in the smokers (9.1 and 9.4 MJ in men and in women 7.2 and 7.4 MJ respectively). Nuttens *et al* (1992) found that for unadjusted energy intakes in men increasing tobacco consumption was associated with increasing energy intake. However, when energy from food was used, the relationship was not significant, implying that alcohol contributed to the higher energy intakes associated with smoking.

Gregory *et al*, (1990) showed that women who smoked consumed less energy than non-smokers. Similar trends although not statistically significant were found by Strain *et al*, (1991) (6.9 & 7.29MJ for smokers and non- smokers). However, both Bolton-Smith *et al*, (1991a) and Cade & Margetts, (1991) found marginally higher intakes in women smokers compared with never smokers, with lowest intakes in ex-smokers. It is possible that the low intakes in ex-smokers were a result of dieting.

Several studies have looked at both men and women which gives the opportunity to look at differences between men and women in the same populations, at the same time, using identical methods. Men who smoke have been shown in some studies to consume a diet higher in energy than non-smokers (Bolton-Smith *et al*, 1991a; Cade & Margetts, 1991) with ex-smokers intermediate but the pattern is less clear in women. This may be a result of some women using cigarette smoking to control their weight and energy intakes (Rodin, 1987).

Protein, expressed as percent of energy (alcohol included), derived from food frequency questionnaires, has been shown to be lower in men smokers compared with non-smokers (Klesges *et al*, 1990; Bolton-Smith *et al*, 1991a). Absolute intakes assessed using a weighed intake have also been statistically significantly lower (Gregory *et al*, 1990 and Strain *et al*,

(1991). In women, Bolton-Smith *et al*, (1991a) found significantly lower protein intakes expressed as percent of energy in smokers compared with never and ex-smokers. Armellini *et al* (1993) showed that in women, smokers had a lower protein intake than never smokers but found no differences between smokers and never smokers for other nutrients.

Total carbohydrate consumption does not seem to differ between smoking categories (Fehily *et al*, 1984; Fulton *et al*, 1988; Cade & Margetts, 1990; Gregory *et al*, 1990), although when Margetts & Jackson, (1993) using the same data as Gregory *et al*, (1990) compared non-smokers, light smokers and heavy smokers, the smokers appeared to have a lower carbohydrate intake than non-smokers after adjusting for covariates not including energy. However, sugar intake in men was statistically significantly higher in smokers compared with non-smokers both when expressed as absolute values and as % energy (Bolton-Smith *et al*, 1991a; Gregory *et al*, 1990; Cade unpublished data). In women, sugar intake (g) was lower in smokers compared with non-smokers (Strain *et al*, (1991) but higher as %energy (Bolton-Smith *et al*, 1991a). Bolton-Smith *et al*, (1991a) also showed that men who smoked consumed a higher %energy as sugar than women (17.7 and 16.4 respectively).

Data from two studies showed that women smokers consumed a diet higher in fat as %energy (39.9 and 38 %) than men (34.3 and 36 %) (Bolton-Smith *et al*, 1991a; Cade & Margetts, 1991 respectively) with alcohol energy counted. These differences between men and women may be as a result of higher alcohol intakes in men. In general differences in fat intakes between smoking categories are limited to quality of fat consumed. However, Fisher & Gordon, (1985) showed that subjects who reported smoking consumed more fat than non-smokers (130g/day compared with 117g/day). Some workers have looked at %energy contribution from saturated fatty acids

using questionnaire methods (Bolton-Smith *et al*, 1991a; Troisi *et al*, (1991) and weighed intakes (Gregory *et al*, 1990) and found higher intakes in men smokers compared with never smokers and ex-smokers. However, there were large differences in saturated fat intakes as %energy for smokers between the studies (15.2% and 26.2% for Bolton-Smith *et al*, 1991a and Troisi *et al*, 1991 respectively). Other studies (Fulton *et al*, 1988 & Cade unpublished) found no difference in absolute intake of saturated fatty acids expressed between men non-smokers and smokers with the exception of Gregory *et al*, (1990) who found higher intakes in smokers compared with non-smokers.

Nuttens *et al* (1992) found no difference in saturated fat intake, but after adjusting for BMI, age, alcohol, education and family size, smoking was negatively associated with polyunsaturated fat intake. Fulton *et al*, (1988) found both linoleic acid and total polyunsaturated fat intakes were lower in smokers compared with non-smokers. This was confirmed by lower percent linoleic acid in adipose tissue (an indication of long term dietary intake of this fatty acid, Beynon *et al*, 1980) of smokers compared with non-smokers (8.4% & 9.3% respectively). In fact, those men smoking more than twenty cigarettes daily had the lowest proportion of adipose tissue linoleic acid (7.9%) compared with those smoking between eleven and twenty per day (8.8%) and ten or less (8.6%). Polyunsaturated fat intake was also lower in both men and women smokers (Wood *et al*, 1984) compared with never smokers. Lower polyunsaturated fat intakes in smokers compared with non-smokers have also been found by Bolton-Smith *et al*, (1991a) for polyunsaturated fat as percent of energy, and by Margetts & Jackson, (1993) for polyunsaturated fat both unadjusted and adjusted for energy. Mean polyunsaturated to saturated (P:S) ratios have been calculated for several studies and were in the range of 0.22 to 0.30 for men and women smokers and 0.26 to 0.35 for

non-smokers in the UK (Fulton *et al*, 1988; Bolton-Smith *et al*, 1991a & Cade & Margetts, 1991).

Gregory *et al*, (1990) and Bolton-Smith *et al*, (1991a) found men and women smokers consumed more alcohol as %energy than non-smokers (7.1 and 5.0 % for men and 3.0 and 1.9 % for women; Bolton-Smith *et al*, 1991a). Strain *et al*, (1991) also found a higher alcohol intake in men and women who smoked compared with non-smokers. Fehily *et al*, (1984) found male smokers consumed slightly more alcohol than non-smokers, although this was not statistically significant. A recent study of 17 year old adolescents showed that more smokers than non-smokers regularly drank 8g or more of alcohol a day (Townsend *et al*, 1991).

Dietary fibre intakes have been shown to be lower in smokers than non-smokers both for absolute amounts (Fehily *et al*, 1984; Fulton *et al*, 1988; Gregory *et al*, 1990; Klesges *et al*, 1990; Subar *et al*, 1990; Strain *et al*, 1991; Cade & Margetts, 1991; Troisi *et al*, 1991; Nuttens *et al*, 1992) and nutrient densities (grammes/1000kcal) (Haste *et al*, 1990; Larkin *et al*, 1990; Bolton-Smith *et al*, 1991a). As yet there is no information on non-starch polysaccharide intakes by smoking category.

Table 1.11 summarises data from six studies carried out in The United Kingdom (five studies with men, four with women) using food diary methods (Fehily *et al*, 1984; Fulton *et al*, 1988; Gregory *et al*, 1990; Haste *et al*, 1990; Cade & Margetts, 1991 & Cade unpublished; Strain *et al*, 1991). Studies showing statistically significant differences(SD) are shown together with studies finding similar results for smokers and non-smokers. Plus and minus signs indicate the direction of differences between smokers and non-smokers. Table 1.11 shows that for P:S ratio and fibre there is consistent agreement between studies with smokers consuming lower intakes than non-smokers.

Table 1.11: Comparison of nutrient intakes between smokers and non-smokers from five UK studies for men and four for women using food dairy methods

Numbers of studies showing no statistically significant differences (NS) and those showing statistically significant differences (SD)

	MEN			WOMEN		
Nutrient	NS	SD		NS	SD	
Energy (Kcal/MJ)	1,2,3, 6	5	(++)*	4,5,6	3	(--)
Protein (g)	1,2,5	3,6	(--)	ALL	-	
Fat (g)	ALL	-		ALL	-	
Pufa (g)	5	2	(--)	5	-	
Sfa (g)	5,2	-		5	-	
P:S	-	2,3,5	(--)	3	5	(-)
Cho (g)	1,2,5	6	(---)	4,5	6	(-)
Sugar (g)	1,6	3,5	(+)	3,5	6	(-)
Fibre (g)	-	ALL	(---)	-	ALL	(---)
Alcohol (g)	1,2,3	6	(+++)	-	3,6	(++)
Retinol (μg)	3,5	1	(-)	3,4	5	(-)
β carotene (μg)	-	1,5	(--)	-	4,5	(--)
Vitamin C (mg)	5	1,3	(--)	-	3,4,5	(--)
Vitamin E (mg)	-	5,6	(--)	-	4,5,6	(--)

* (+) higher intakes in smokers compared with non-smokers
(-) lower intakes in smokers compared with non-smokers

Sources:
1. Fehily *et al*, 1984;
2. Fulton *et al*, 1988;
3. Gregory *et al*, 1990;
4. Haste *et al*, 1990;
5. Cade & Margetts, 1990/1991 & unpublished
6. Strain *et al*, 1991;

Differences in macronutrients between smokers and non-smokers are relatively small, except for alcohol which is higher in smokers compared with non-smokers.

1.3.2ii *Micronutrient intakes*

Lower intakes of micronutrients have been found in smokers compared with non-smokers, expressed both in absolute amounts (Fehily et al, 1984, Strain et al, 1991; Subar et al, 1990; Cade & Margetts, 1991; Margetts & Jackson, 1993) and as nutrient density (per 4.18MJ) (Haste et al, 1990; Larkin et al, 1990; Bolton-Smith et al, 1991a). In particular, amounts of antioxidant vitamins, vitamin C, vitamin E and β carotene were lower in smokers than non-smokers. Amounts of vitamin C consumed by women who smoke were between 65 and 80% of those consumed by non-smokers (Haste et al, 1990; Larkin et al, 1990; Bolton-Smith et al, 1991a). Women appear to consume a diet which has a higher micronutrient density (Bolton-Smith et al, 1991a) than men, although absolute intakes are less as a result of lower energy intakes in women. Table 1.11 shows that for most micronutrients there is consistent agreement between studies, with smokers consuming less than non-smokers. There is general agreement between studies that smokers consume a diet which is lower in micronutrients than non-smokers. However, intakes are not considered low in comparison with dietary recommendations (DH, 1991). Requirements for micronutrients may, however, be higher in smokers than non-smokers, and the goals may therefore not be an appropriate frame of reference in this group. This point will be further discussed in section 1.6.

1.3.2iii *Regional variation*

Table 1.12 looks at differences in diets of male smokers and non-smokers between different regions in the United Kingdom.

Studies included in the table used the weighed inventory method of dietary assessment, except a study carried out in three towns in England (Ipswich, Stoke and Wakefield) in which a one day record with estimated portion sizes was used (Cade & Margetts, 1991). Smokers were classified into non-smokers (never for one study (Cade & Margetts, 1991)) and current smokers. In the Scottish study, Fulton et al, (1988) manual and non-manual occupation groups are presented separately. There was little difference in energy intakes

Table 1.12: Regional comparison of levels of nutrients for male smokers compared with non-smokers

Percentage difference of smokers compared with non-smokers (non-smokers = 100%)

	1	2	3	4	
Regions	England	Wales	Northern Ireland	Scotland	
				Manual	Non-manual
Age (years)	35-54	45-59	16-64	45-54	45-54
Number	512	77	111	52	25
Energy	108	100	96	99	100
Protein	104	99	93	94	101
Fat	103	97	94	98	97
Cho	106	100	88	94	100
Fibre	85	86	84	90	86
Alcohol	-	120	289	155	124

Sources:
1. Cade & Margetts, 1990/1991
2. Fehily et al, 1984.
3. Strain et al, 1991.
4. Fulton et al, 1988.

between the regions. Energy intake of smokers as percent of

non-smokers was similar for men in Scotland and Wales, but smokers in Northern Ireland consumed less energy than non-smokers, the opposite being reported in the English study. Differences in protein, fat and carbohydrate intakes were similar between the regions although somewhat larger in Northern Ireland. This could possibly be explained by a lower energy intake in smokers compared with non-smokers. Intakes of fibre were lower in smokers compared with non-smokers with no apparent regional variation. The largest variation between regions was in alcohol consumption, with smokers in Northern Ireland consuming nearly three times as much alcohol as non-smokers. In Wales and non-manual Scots, the difference in alcohol consumption between smokers and non-smokers was smaller. Comparison of diets of women smokers and of micronutrient intakes in men could not be made due to insufficient data.

Similar trends in macro- and micronutrient intakes between smoking categories were seen in American studies (mainly 24 hour recall and questionnaire methods) and UK studies (weighed inventories). However, there does appear to be a difference in quality of fat consumed. UK studies show non-smokers consume a diet with a higher P:S ratio resulting from a higher polyunsaturated intake in non-smokers and possibly a higher saturated fat intake in smokers. American studies by Subar et al, (1990) using a 24 hour recall method found no differences in linoleic acid content of the diet of men and women smokers and non-smokers in different age bands although they showed a higher saturated fat intake in the older age bands 30-74 years for smokers compared with non-smokers. Troisi et al, (1991) using a questionnaire found higher saturated fat intakes in smokers compared with never and ex smokers. Klesges et al, (1990) using the Willett Food Frequency Questionnaire found no differences in polyunsaturated and saturated fats as percent of energy between smoking categories. P:S ratios were not measured in the American studies but are likely to be in the

same direction as in the UK studies, although differences in saturated fat instead of polyunsaturated fat intake appear to account for differences between smokers and non-smokers in the P:S ratio. If percentage differences of smokers compared with non-smokers are calculated for linoleic acid between a Scottish study (manual workers (Fulton et al, 1988) and an American study, (Subar et al, unpublished), Scottish smokers consume 65% of the linoleic acid of non-smokers compared with 107% in the American study.

Regional differences in diets of smokers are small but further work needs to be carried out using the same dietary assessment method on a national sample of the population before any clear conclusions can be made. Within the UK there are differences in the consumption of alcohol by region. In comparison with the USA, the main difference in the diet of smokers is the consumption of linoleic acid with American smokers consuming higher intakes than smokers in the UK but having similar intakes to American non-smokers. However, P:S ratios are probably similar to UK.

1.3.2iv *Occupation group*

Fulton et al, (1988) found little difference in dietary habits between men smokers of manual and non-manual occupations (Table 1.12), although, manual workers who smoked appeared to consume less carbohydrate and more alcohol than manual workers who did not smoke. However, if a different comparison is made between non-manual and manual workers who smoke, non-manual workers who smoke consumed a diet higher in fibre, lower in alcohol and P:S ratio than manual workers who smoke (106%, 76% and 92% respectively). When non-manual and manual workers who do not smoke were compared non-manual workers consumed more fibre (110%) and had a higher P:S ratio (109%) than manual workers. Alcohol intakes were similar (95%) between the occupation groups.

The study carried out by Haste et al, (1990) of pregnant women in London looked at differences between non-smokers and smokers of differing occupation groups. Women whose husbands were employed in non-manual occupations consumed more energy, protein and fat than women whose husbands were employed in manual occupations for both non-smokers and smokers. Among women whose husbands were employed in manual occupations fibre intakes were not statistically different across smoking groups (15.4g non-smokers and 12.9g smokers) but larger differences were seen in women whose husbands were employed in non-manual occupations (22.9 and 13.1 respectively). Similar trends were seen for vitamin C, vitamin E and β carotene.

The British Regional Heart Study showed pronounced differences in the prevalence of smoking and alcohol consumption between occupation groups (Cummins et al, 1981). Men with manual occupations were more likely to smoke and to drink moderate to heavily than men with non-manual occupations. In addition, men with a high daily consumption of alcohol were more likely to smoke than those who were weekend drinkers. Heavy drinkers also consumed more energy, saturated fats, total fat as percent energy, and folate, but less fibre, sugar and protein than light drinkers (Gregory et al, 1990).

Information is limited but smoking appears to have a greater effect on diet particularly on micronutrients than occupation group. However, occupation group does have an effect within smoking groups especially in higher socio-economic groups.

Summary

While there were differences in the dietary methodology used in the different studies, a number of general patterns emerge on the basis of comparisons within studies. There appear to be differences between smokers and non-smokers in the consumption of a wide range of foods leading to differences

in many nutrients and particularly types of fat, dietary fibre and micronutrients. The diet of smokers compared with non-smokers tends to be less like those currently being recommended to reduce risk of disease.

1.4 PUBLISHED EXPERIMENTAL STUDIES

Some prospective studies on the diet of smokers as they quit have been carried out. There are no data on differences by occupation group or regional variation.

Studies reviewed here include those in which smokers quit for a number of weeks and do not include those investigating differences in taste perception by smoking category. Subjects participating have generally been volunteers and not randomly selected from the general population as in the observational studies.

There are few data on changes in food patterns after cessation with the exception of those reported by Stubbe et al, (1982) who found that extra snacks were eaten between meals.

1.4.1 Nutrient intakes

With the exception of Stubbe et al, (1982) who used a dietary questionnaire, the dietary method chosen has been a prospective food record in which portions were recorded as household measures (Stamford et al, 1986; Rodin, 1987; Moffatt & Owens, 1991) or as a weighed food diary (Robinson & York, 1986); Hall et al, 1989). Changes in macronutrient and micronutrient intakes following smoking cessation are reviewed.

1.4.1i *Macronutrient intakes*

Stamford et al, (1986) found an increase of 950kJ per day from 7.4MJ in the baseline period to 8.3MJ per day after cessation. During the baseline period, the average percentages of energy derived from protein, carbohydrate, fat and alcohol were 16, 43, 41 and 3.4 respectively. During cessation, the percentages were 15, 44, 41 and 2.7 for %energy derived from protein, carbohydrate, fat and alcohol respectively. The constituents did not change even though the subjects reported a perceived increase in the consumption of sweets. Stubbe et al, (1982) also showed increased energy and fat intake 4 to 6 weeks after smoking cessation. Rodin, (1987) showed that quitters who maintained weight or lost weight reduced energy intake, but weight gain was associated with decreased protein and increased carbohydrate consumption following smoking cessation. Robinson & York, (1986) found that after seven days of not smoking energy intake increased by 11% (881kJ). Moffatt & Owens, (1991) showed that after 30 days of non-smoking ex-smokers energy intake had increased by 5.7% (500kJ). Hall et al, (1989) found energy, fat and sucrose intakes had increased by four weeks after the quit date. Energy intake rose by 13% (1054kJ) by four weeks. However, by 26 weeks of abstinence, subjects' mean energy intake was lower than that at baseline even though abstainers had gained 4.1kg in weight. These studies tend to show increases in energy intake in the short-term after stopping smoking, but they may not last beyond a few months after cessation.

Small studies with close monitoring of diet may affect the subjects' eating patterns leading to lower weight gains, and therefore these data may not be representative of the pattern in the general population.

There are some changes in macronutrient intakes after giving up smoking. There is an increase in energy intake in some

quitters whilst others reduced energy intake. The excess energy consumed appears to come from fat and carbohydrate and may be due to extra snacks between meals. Weight gain immediately after cessation may result in lower energy intakes to reduce the excess weight gained.

1.4.1ii *Micronutrient intakes*

Micronutrient intakes differ between smoking categories in observational studies so it might be expected that on quitting smoking, micronutrient intakes would rise. In the short-term cessation studies only Rodin (1987) measured micronutrient intakes, but found no changes in the intake of vitamin A or vitamin C after cessation.

Further work is required to assess change in nutrient intakes upon stopping smoking.

1.4.2 Experimental *v.* cross-sectional studies

Cross-sectional studies report that smokers compared with ex-smokers consume less polyunsaturated fat, more energy and saturated fat and have lower antioxidant vitamin and fibre intakes. Hence, if upon smoking cessation the diets of smokers do change to that observed in long term ex-smokers (from cross-sectional studies) the results from experimental studies would be expected to show increases in polyunsaturated fats, fibre and vitamins and decreases in energy and saturated fat. The results from the short-term cessation studies appear to be contrary to this with increases in energy and fat after smoking cessation. It is possible that this is a result of the withdrawal of smoking and that in the short term subjects replace cigarettes with food. There is some evidence to suggest that it may take four years of smoking cessation before the pattern of ex-

smokers is similar to never smokers and that differences between smokers and ex-smokers are not detected until after six months for some nutrients (fibre in women) and up to three years for others (energy, fat, carbohydrate and P:S ratio in men) (Bolton-Smith et al, 1993). Therefore these short-term changes do not reflect long term changes and longer cessation studies would be required to determine if in fact these changes do occur, and whether subjects who quit smoking have different diets to those who continue to smoke. In addition not all the smokers in these short-term cessation studies will remain ex-smokers and it is possible that smokers who quit and then restart smoking differ from long term ex-smokers and so confound the results.

1.5 ANTHROPOMETRY

This section firstly compares measures between smokers and non-smokers from cross-sectional studies, then examines changes in weight that occur after smoking cessation and finally discusses potential causes for weight differences.

1.5.1 Anthropometry and cross-sectional studies

Mean body mass index (BMI) has been shown to be lower in male smokers compared with non-smokers (Fehily et al, 1984; Gregory et al, 1990; Cade & Margetts, 1991 & Troisi et al, 1991 (for former smokers only)). When smokers were divided into light, moderate and heavy smokers Fehily et al, (1984) showed that moderate smokers had the lowest mean BMI with light smokers a higher BMI than heavy smokers (25.8, 25.3 25.6kg/m^2 for light to heavy smokers). Similar results were shown by Gregory et al, (1990), 25.2, 24.2 & 24.6 kg/m^2, for mean BMI for non-smokers, those smoking less than twenty cigarettes daily and those smoking more than twenty.

Larkin et al, (1990), using self-reported body weights found that in women aged between 41 and 50 years, smokers weighed less than never-smokers but had similar weights to ex-smokers. Within smoking categories moderate smokers were the lightest and light smokers the heaviest as found in men (means 67.6 62.8, 65.7kg in those women who smoked 1-10, 11-20 and more than 20 cigarettes per day respectively). Also, in women, Cade & Margetts, (1991) but not Gregory et al, (1990), found a lower BMI in smokers compared with non-smokers (26.2 in non-smokers and ex-smokers, and 24.9kg/m^2 in smokers).

A recent study of 17-year-old adolescents showed regular smokers had a statistically significantly higher BMI than those who had never smoked regularly (Townsend et al, 1991).

The possible relation between obesity and cardiovascular disease has been the subject of great controversy. BMI is generally the measure used for defining obesity and a level of 30kg/m^2 or greater is considered to constitute obesity. In a cohort of Swedish men and women the incidence of heart disease was compared according to baseline measures of obesity during a 13 year follow up period (Larsson et al, 1984). BMI was positively associated with coronary disease and the relationship was independent of smoking, blood pressure and age. Manson et al, (1990) also found that after controlling for smoking, a BMI of 23kg/m^2 or more was associated with an increased risk of heart disease in middle-aged women. They also showed that current smokers who were obese had an excess risk of heart disease. The relationship between body weight or adiposity and smoking is further confounded by alcohol consumption. Alcohol consumers generally weigh less than non-drinkers at similar or higher energy intakes (Hellerstedt et al, 1990).

The relationship between diet, smoking and coronary heart

disease is complicated by associations between diet, alcohol and body mass index.

1.5.2 Smoking cessation and body weight

Changes in body weight from cessation studies are reviewed. Not all studies used a control population and therefore the weight increases shown are not necessarily attributable to smoking cessation in all cases.

Table 1.13 shows a summary of some studies that recorded weight changes at different times after cessation. The studies measuring weight within days of stopping smoking detected little change (Robinson & York, 1986; Feher et al, 1990). Rodin, (1987) found that smokers who quit gained an average of 1.4kg over six to eight weeks but that some lost weight. In those who gained, weight increased by 2.6kg and in those who lost or maintained weight an average weight loss of 0.6kg was found. The weight gain attributable to smoking cessation was 1.3kg. Bosse et al, (1980) in a review article, looked at the relationship between smoking and weight gain over a five year period in a large cohort of adult men. They found that 36% of quitters either lost weight or maintained the same weight after quitting. Characteristics associated with weight gain were heavier tar consumption, younger age and leanness of body build. Dallosso & James, (1984) found a mean weight gain of 1.8kg attributable to smoking cessation in subjects who had quit for six weeks. They also showed a 4% drop in resting metabolic rate and an increase in energy intake of 6.5%. Stamford et al, (1986) found a weight gain in women subjects who had quit for 48 days of 2.2kg; of which 96% was fat and 4% lean tissue and water, but they used no control population. They found no change in resting metabolic rate over the 48 days. Moffatt & Owens, (1991) showed that 12 adult women smokers significantly increased their mean body weight within the first 30 days of smoking cessation by

1.8kg. This increased a further 1.8kg by day 60. Nine subjects continued to smoke over the duration of the study These subjects were found to have similar increases in weight at day 30, but by day 60 their weight had decreased to baseline level.

Table 1.13: Weight gain after stopping smoking by time since quitting

	Subjects			
	Number (M/W)	Mean age (years)	% Weight gain (%)	Time Quit (weeks)
Robinson & York, 1986*	3/8	24	0.6	1
Feher et al, 1990	12/18	38	0	2
Moffatt & Owens, 1991*	0/12	37	0	4
Stubbe et al, 1982	10/0	38	2.3	4-6
Dallosso & James, 1984*	9**	47	2.7	6
Stamford et al, 1986	0/13	45	3.6	7
Moffatt & Owens, 1991*	0/12	37	6.0	8
Hall et al, 1989	27**	38	3.7	8-12
Hall et al, 1989	27**	38	6.5	22-26
Stamford et al 1986	0/3	45	22.0	52
Shimokata et al, 1989*	2680**	19-102	2.5	156

* Studies using control group and therefore weight gain attributable to smoking cessation is shown
** Total number of subjects men and women

Therefore weight increases attributable to smoking cessation were approximately zero at day 30 and 3.6kg at day 60. In addition body fat increased from 28.4% at baseline to 31.1% at day 60. No body weight or body fat changes were observed for non-smokers.

Williamson et al, (1991) related changes in body weight to changes in smoking habit in adults aged 25 to 74 years who were weighed between 1971-1975 and followed up between 1982-1984. Regardless of smoking status women tended to gain 1 to 2 kg more than men during the follow-up period. The mean weight gain attributable to the cessation of smoking (the difference between sustained quitters and continuing smokers) was 3.8kg in women and 2.8kg in the men. Weight of quitters increased and was comparable to that of non-smokers at the follow-up appointment. Major weight gain (>13kg) occurred in 9.8 % of men and 13.4% of women who quit smoking. The relative risk of major weight gain in quitters compared with smokers was 8.1 in men and 5.8 in women and it remained high regardless of the duration of cessation.

None of these studies took into account baseline weight, and it is possible that baseline weight may affect subsequent weight gain after smoking cessation.

Weight gain appears to increase with time since quitting for up to one year, but may level out thereafter, perhaps suggesting that initial weight gain is followed by reduction and then reaches equilibrium.

1.5.3 Other potential causes of weight gain

Dietary changes do not seem to account for the increase in weight upon cessation or differences in weight between non-smokers and smokers. It is possible that smoking decreases nutrient absorption or increases metabolic rate. Hofstetter et al, (1986) found an increased energy expenditure in smokers after 24 hours in a metabolic chamber but no changes in physical activity or mean basal metabolic rate. Perkins et al, (1989) reported an excess energy expenditure during light exercise attributable to smoking. Perkins et al, (1990) showed smoking had no greater effect on

metabolic rate than meal consumption. Robinson & York, (1988) found a greater magnitude of diet induced thermogenesis in smokers who were allowed to smoke than non-smokers after a 12 hour abstention from smoking. Moffatt & Owens, (1991) found that smoking cessation was associated with a decrease in metabolic rate of 16% by the sixtieth day after quitting. The drop in metabolic rate found here and not by Stamford et al, (1986) was attributed to the higher nicotine content of the cigarettes smoked by the women. Therefore, it is possible that smoking increases energy expenditure in the short-term and that regular smoking leads to a larger energy expenditure which declines when smoking ceases. However, these effects are small and the extent to which they could influence body weight is not clear and needs closer examination.

There appear to be changes in weight and dietary habits (although much of the work has concentrated on energy intakes) after smoking cessation. Weight gain appears to result partly from increases in energy intakes immediately on quitting and partly from decreases in resting metabolic rate, but further work needs to be carried out to examine other possible causes. Perkins et al, (1992) in a review paper put forward the hypothesis that smoking alters body weight set point. It is possible that nicotine alters body weight in the following way; smoking decreases the set point for body weight so that smoking cessation leads to an increase in weight up to the level of non-smokers. Increased eating in the short-term may be necessary to obtain this increased weight. If this were true it would mean that prevention of weight increase after smoking cessation would be particularly difficult. However, not all smokers gain weight after quitting and some even lose weight (Rodin, 1987). More information is necessary from smokers as they quit to see if all smokers change their diet on quitting or whether large differences in a select group of smokers account for overall differences in the sample mean. There is a need for studies

in which control populations of smokers are measured alongside smokers who quit to determine whether the observed changes are a result of smoking cessation.

1.6 DIET, SMOKING AND CORONARY HEART DISEASE

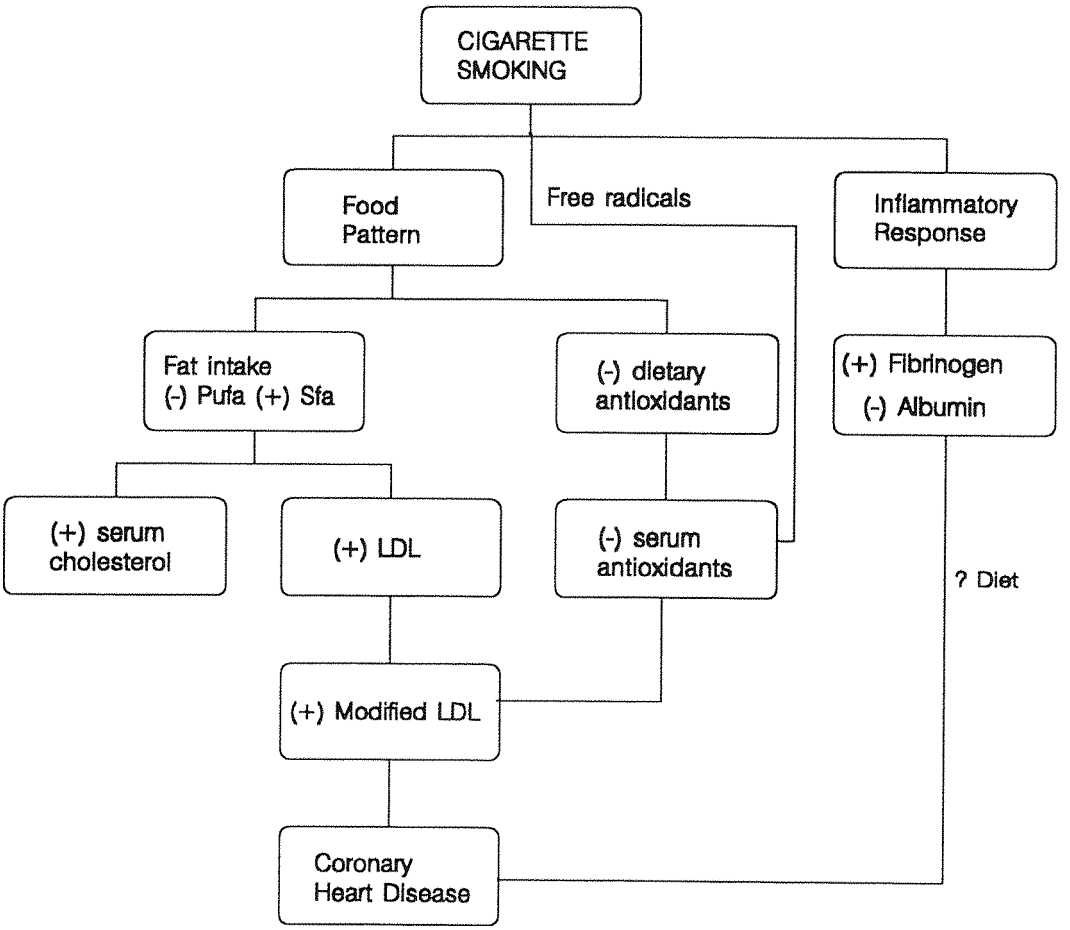
In this section possible relationships between nutrient intake, cigarette smoking and coronary heart disease are discussed. Blood lipid and lipoprotein concentrations have been measured in smokers and non-smokers. Craig et al, (1989) collated information from fifty-four published studies and showed smokers had significantly higher serum concentrations of cholesterol (3%), triglycerides (9.1%), low density lipoprotein cholesterol (1.7%) and significantly lower serum levels of high density lipoprotein cholesterol [HDLchol] (5.7%) compared with non-smokers. This gives smokers a more atherogenic lipid profile than non-smokers. The reviewed literature suggests that smokers consume more fat and saturated fat, but less polyunsaturated fat than non-smokers. These differences in fat intakes between smokers and non-smokers may partially explain the different lipid profiles of smokers and non-smokers (Cade & Margetts, 1989).

The literature also suggests that antioxidant vitamin intake in smokers is less than non-smokers. This is also confirmed by lower serum levels of antioxidant vitamins in smokers compared with non-smokers. Lower serum levels of vitamin C in smokers compared with non-smokers have been documented (Smith & Hodges, 1987; Kallner et al, 1981; Duthie et al, 1989a; Bridges et al, 1990; Riemersma et al, 1991; Margetts & Jackson 1993).

Lower plasma concentrations of β carotene have been found in smokers compared with non-smokers (Stryker et al, 1988; Herbeth et al, 1990; Bridges et al, 1990; Gregory et al, 1990; Margetts & Jackson unpublished).

Cigarette smoking itself may cause free radical damage and promote atherosclerosis. Cigarette smoking is a source of

Figure 1.3: Hypothesised relationships between diet, smoking and coronary heart disease



free radicals (Machlin & Bendich, 1987). Regular smokers are therefore subject to a high load of free radicals which have been shown to cause tissue damage (Duthie et al, 1989b). A balance between free radical production and level of antioxidants is necessary to protect cells. An overload of free radicals could lead to a chain of lipid peroxidation and tissue damage. This high free radical load and relatively low antioxidant status may result in an imbalance between free radical production and antioxidants which may render lipoproteins more atherogenic (Duthie et al, 1989b; Steinberg

et al, 1989; Diplock, 1991; Luc & Fruchart, 1991). Hypothesized relationships by which smokers increase their risk of coronary heart disease as a result of their dietary habits are shown in figure 1.3. Smoking cigarettes is associated with a different food pattern and altered nutrient intake, in particular more saturated fat, less polyunsaturated fat and a lower consumption of antioxidant vitamins. These dietary changes may increase the risk of coronary heart disease by increased serum cholesterol and LDL concentrations. The increased free radical load from cigarettes and the lower dietary antioxidants may result in an imbalance of free radical production and antioxidants which could lead to modification of LDL and atherosclerosis. It is also possible that cigarette smoking increases the risk of coronary heart disease by initiating an inflammatory response. Both increased plasma fibrinogen (Meade et al, 1987) and decreased serum albumin (Phillips et al, 1989) have been found in smokers compared with non-smokers. Much of these work relies on information from cross-sectional studies and this limits the extent to which causal inferences can be drawn.

2. STUDY DESIGN AND METHODOLOGIES

The dietary study of cigarette smoking and food and nutrient intake was carried out as part of a larger study investigating the relationship between cigarette smoking, dietary intake and clotting factors. The study design that follows includes only information that is relevant to the dietary study.

2.1 STUDY OBJECTIVES

The objectives of this study were largely to investigate methodological issues of using food frequency questionnaires compared with weighed records. The dietary differences between smokers and non-smokers was used as a model for these investigations. In chapter one, the relationship between diet, cigarette smoking and coronary heart disease was discussed, however, as the mechanisms underlying coronary heart disease are not an objective of this thesis this discussion will not be continued.

One aim was to establish whether differences in diet do exist between smoking categories and that observed differences seen in other studies are not result of bias in either dietary assessment or in the definition of smoking categories.

The next aim was to establish whether these differences are a result of smoking cigarettes and not some other lifestyle factor. Once this has been investigated the next step would be to look at the reasons for these differences and the mechanisms by which smoking may affect dietary habits. However, although the importance of this is recognised, as the main aim of the thesis is dietary methodologies, it has not been investigated.

The main and specific objectives of the study are shown in sections 2.1.1 and 2.1.2.

2.1.1 Main objectives

The main aims of the dietary study were :-

i) To use a cross-sectional comparison of the diets of cigarette smokers, life-long non-smokers and ex-cigarette smokers to look at the methodological issues of using a FFQ compared with a WR.

ii) To use this cross-sectional study to determine whether differences in diet between the smoking categories are due to cigarette smoking and not another lifestyle factor.

iii) To obtain further evidence that smoking cigarettes affects diet by using an experimental study in which smokers who are successful in stopping smoking are compared with those who continue to smoke.

2.1.2 Specific objectives

Cross-sectional study

i) To calibrate the FFQ with WRs and to look at the effect of gender and recruitment source on this calibration.

ii) To look at the effect of using the FFQ with and without 'correction' factors on the relationship between diet and cigarette smoking.

iii) To explore the role of other confounding factors in the relationship between diet and smoking, in particular

occupation group.

Experimental Study

i) To measure the changes in food and nutrient intakes that occur after smoking cessation compared with continuing to smoke over one year.

ii) To investigate whether these changes are influenced by characteristics at baseline such as gender, occupation group, body weight and reported number of cigarettes smoked.

2.2 STUDY DESIGN

The design consisted of both a cross-sectional and an experimental study which are described separately.

2.2.1 Cross-sectional study

This comprised of a cross-sectional analysis of three clearly defined smoking categories where smoking status was validated. The definition criteria used to classify subjects were as follows:-

i) **Cigarette smokers** reporting that they smoked at least one cigarette per day and with a breath carbon monoxide reading of more than 10ppm and a serum cotinine concentration of at least 14ng/ml. The group of smokers was sub-divided into two approximately equal groups (cotinine > 265 and < 265 ng/ml) of heavy and light smokers.

ii) **Ex-cigarette smokers** reporting that they were currently not smoking but who had smoked in the past. Present

smoking status was validated by a carbon monoxide reading of 10 or less ppm.

iii) **Never smokers** reporting never having smoked and with a breath carbon monoxide reading of 10 or less ppm.

Current and ex-smokers of pipes or cigars were to be excluded as these subjects were likely to form small groups if analysed separately and if included with the above subjects would increase the heterogeneity of the sample.

In addition in the larger study, subjects with a previous history of angina or myocardial infarction were to be excluded as dietary habits may have changed as a consequence of disease.

The age range for the study was 40 to 59 years as this age range would include a large number of subjects who had smoked for more than 20 years and therefore the effects of smoking on diet would be more apparent than in those who had only smoked for a few years.

The subjects participating in the cross-sectional study were recruited over the duration of the study (2.5 years). Priority was initially to be given to the recruitment of smokers as these would enter the experimental study and were required to be followed up over one year. The recruitment of the smokers would last about one year to control for seasonal variation. The ex- and never smokers would be recruited at the commencement of the study and continue to be recruited until the end of the study to spread the workload.

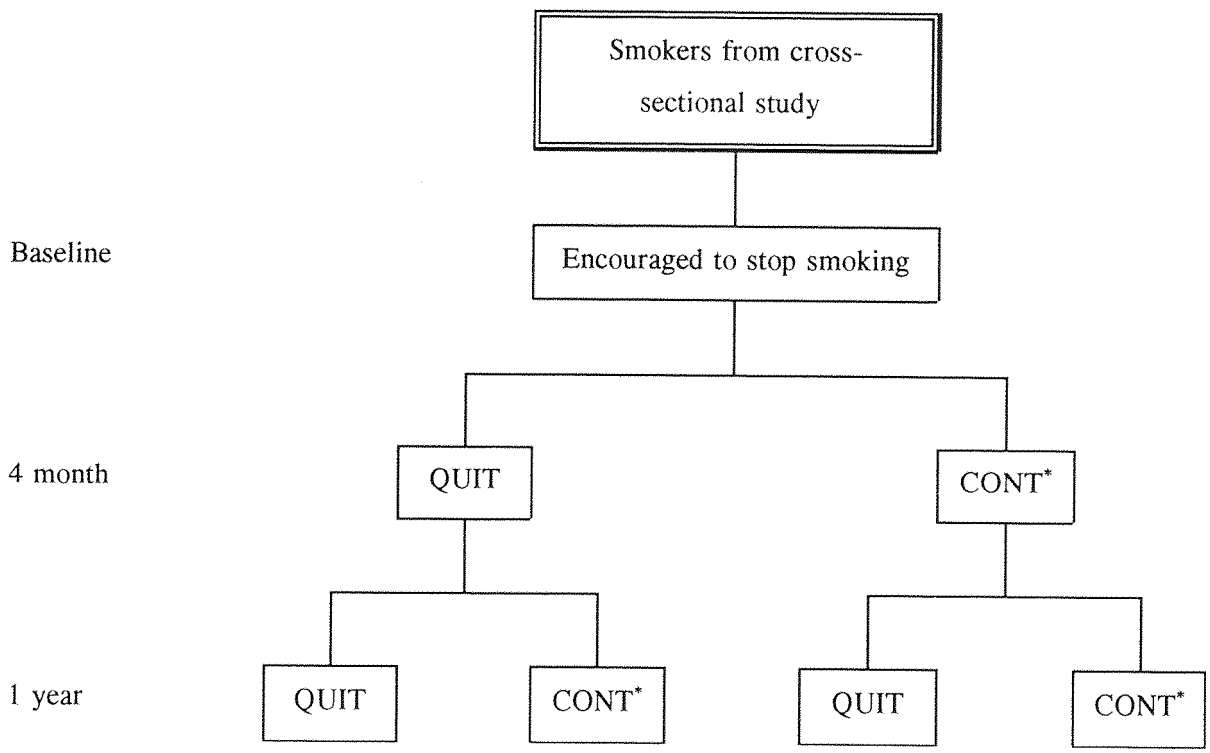
2.2.2 Experimental study

All cigarette smokers from the cross-sectional study were eligible for inclusion in the experimental study. In an ideal experimental study subjects are randomly selected to either the intervention group or the control group after the baseline appointment. With the exception of the intervention method all participants are treated in the same way. Analysis is then carried out comparing differences between intervention and control groups. For the larger study it was decided that as not all smokers that are encouraged to stop smoking will succeed, if the above procedure were carried out, with smoking cessation as the intervention method, it might result in very few subjects stopping smoking unless a large sample was used. In addition some of the control population might decide to quit smoking themselves. In order to simplify the study all smokers at baseline appointment were encouraged to stop smoking and the analysis was carried out comparing those smokers who were successful in stopping smoking and those who continued to smoke. Potential bias might arise due to subjects selecting themselves into control and intervention groups by stopping or not stopping smoking. To try to assess this bias estimates of non-dietary and dietary variables were to be compared at baseline between the smokers who went on to quit and those who continued to smoke. Subjects were helped to stop smoking by smoking cessation classes. These were self help groups run by the research nurse who was trained in smoking cessation techniques. The course consisted of a group of 8 to 10 subjects meeting once a week for five weeks. At the end of the course, follow-up (reunion) sessions were planned as necessary. Dietary advice often forms part of these cessation classes, but this was played down for the purposes of the study. The use of other methods of smoking cessation such as hypnosis and nicorette chewing gum was not particularly advocated, but subjects were allowed to partake of this methods if they desired. The smokers were followed up at approximately four months and one

year from baseline irrespective of whether they had stopped smoking or not.

The study design for the experimental study can be seen in figure 2.1. The design shows two possibilities at the four month appointment - that subjects have quit smoking or continue to smoke. The group of smokers continuing to smoke will include subjects smoking the same number of cigarettes as at baseline and those who have reduced or increased the number of cigarettes smoked. The main analysis will consider these as one group of subjects currently smoking. It is also possible that subjects have quit at four months but have restarted to smoke at the one year appointment. Yet another possibility is that subjects may not quit until their one year appointment.

Figure 2.1: Design of the experimental study



*CONT - Continued to smoke

The final analysis of the experimental study will investigate dietary changes that occur after smoking cessation firstly in those subjects with one follow-up dietary assessment and secondly in those with two follow-up visits compared with those who continue to smoke over the duration of the study.

Figure 2.2: Expected follow up of smokers in the experimental study

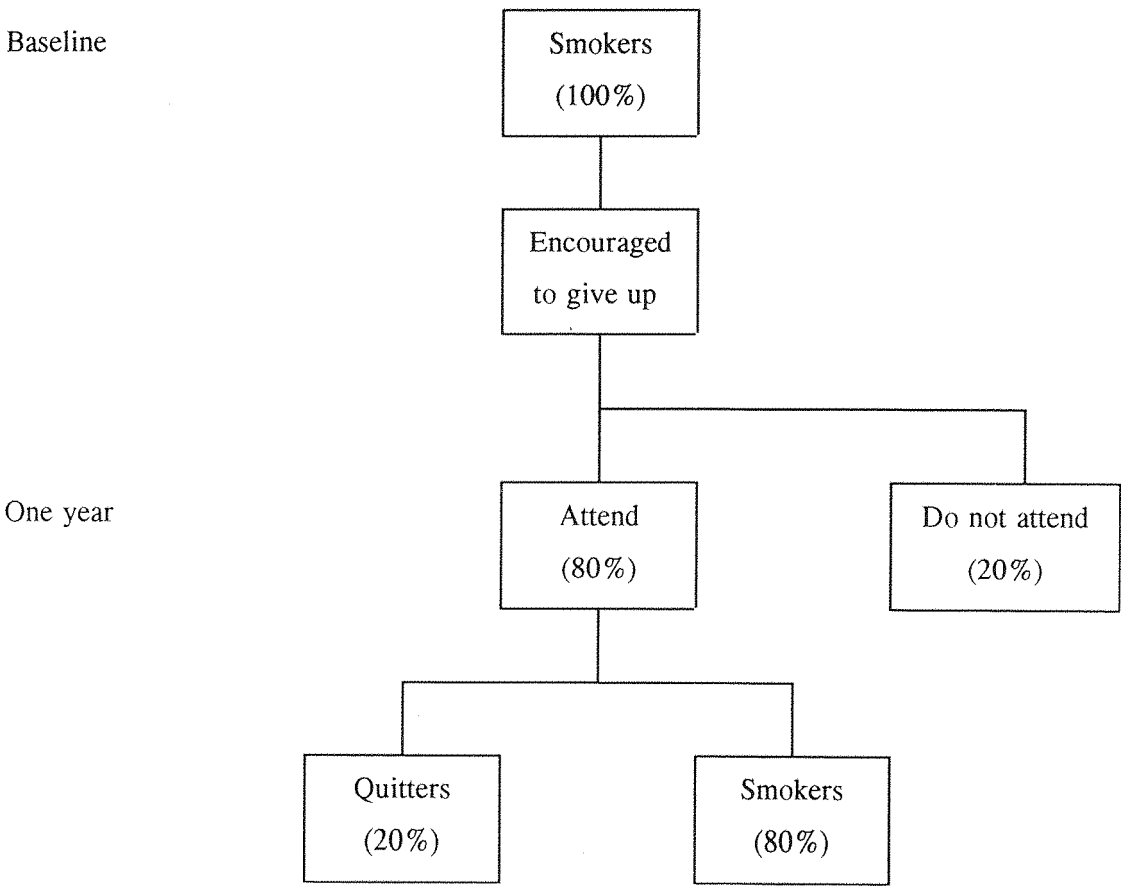


Figure 2.2 shows the expected follow up of smokers at one year. This was based on the assumption that 80% of the smokers would be followed up over one year and that 20% of these would be successful in stopping smoking (this value was obtained from rates of smoking cessation from other studies which ranged from 3% to 43%). It was thought with the aid of smoking cessation classes a response rate of 20% would be

possible. Therefore the expected ratio of continuers to quitters was 4:1.

2.3 SAMPLE SIZE CALCULATION

The sample size estimation was calculated using dietary polyunsaturated fat measurements as it has a large within and between person variance (see page 33) and therefore a method that estimates polyunsaturated fat consumption to the required accuracy was also likely to be sufficient for other nutrients. Using seven day weighed records, a study in Edinburgh (Fulton *et al*, 1988) found a difference of 3.5g/day in polyunsaturated fat consumption between men smokers and non-smokers. Using these data standard deviations for differing number of days of recording a weighed record were calculated as follows.

Standard deviations for 1, 3, 10 and 14 days of weighed record were calculated using:

$$sd^2 = s_b^2 + \frac{s_w^2}{k}$$

where sd = overall SD

s_b = between person SD

s_w = within person SD

k = number of days of diet recorded per subject

(Cole, 1991)

Figures of 2.8 for s_b and 7.5 for s_w for the difference were estimated from the Edinburgh study.

The overall sds ranged from 7.9 for a 1 day record, 5.2 for a 3 day record, 4.0 for a 7 day record, 3.7 for a 10 day record, to 3.4 for a 14 day record. A FFQ was assumed to have a similar sd to a three day WR (see section 1.2.1iii).

Data from Edinburgh showed the difference in dietary polyunsaturated fat consumption between smokers and non-smokers was 3.5g. It was assumed that the same difference would be observed in the Southampton study for the cross-sectional study. However, for the experimental study it was expected that the reversal from a smoker's diet to a non-smoker's diet would not be complete after one year and an estimated change of 2g was used in the calculations.

Calculation was first made for the experimental study:

The following equation was used to calculate sample size (n):

$$n = \frac{(r+1)\,\sigma^2\,(Z_{\alpha/2}+Z_{\beta})^2}{r d^{*2}}$$

Where σ = standard deviation of the variable
α and β = type I and type II error levels
d^* = difference between the groups to be detected
r = ratio of continuing smokers: quitters

The expected ratio of continuing smokers to quitters was 4:1 (see page 89).
Therefore the equation reads:

$$n = \frac{5\sigma^2\,(Z_{\alpha/2}+Z_{\beta})^2}{4 d^{*2}}$$

Using the above equation the required sample sizes to detect a difference of 2g in polyunsaturated fat between quitters and continuing smokers were calculated for one to fourteen

days of weighed record collection.

Table 2.1 shows the number of quitters needed for each dietary method. The number of subjects needing to be followed up was calculated from the ratio of 4 continuing smokers for each quitter. The expected attendance rate at one year was 80% and therefore the final column reflects the number to be seen at baseline after allowing for non-response. The table shows that as the number of days of recording increased the sample size decreased. If a FFQ were to be used 556 smokers would need to be seen at baseline whereas if a 10 day record were used approximately half that number (281) would be required to detect the same difference. There did not appear to be much extra benefit in using 14 days compared

Table 2.1: Calculated sample size required to detect a difference of 2g of polyunsaturated fat (Calculations based on 90% power at 5% significance level)

	Number of quitters (n)	Number of subjects followed up (5n)	total number of smokers seen at baseline
1 day	205	1025	1281
3 day/FFQ	89	445	556
7 day	53	265	331
10 day	45	225	281
14 day	38	190	238

with 10 days of weighed record. As a great deal of time would be required to follow-up 556 subjects it was decided to use the 10 day weighed record and therefore be able to concentrate on a smaller sample size. However, a 100% response to the weighed record for subjects with complete attendance was unlikely. If the completion rate for the WR

of those attending were 80% the required number of smokers seen at baseline would increase to 351 and if this figure were 70% the sample size would increase to 401. It was assumed that 75% of subjects would fully complete the weighed record thus producing a baseline requirement for 375 smokers if a 10 day weighed record were used.

The aim of the study was to be able to detect dietary differences as well as to correctly rank individuals. The following equation was used to determine the number of subjects that would be misclassified by classification into thirds using a 7 to 14 days weighed record:

$$r = \sqrt{\frac{d}{d + s_w^2 / s_b^2}}$$

where r = correlation between observed and true nutrient intakes

s_b = between person SD

s_w = within person SD

d = number of days diet record required per subject

Using values of s_b and s_w as before for polyunsaturated fat (2.8 and 7.5 respectively), the calculated corresponding r values for 7, 10 and 14 day records are 0.70, 0.76, 0.81. This means that for 10 days (r = 0.76) 69% of subjects will be classified in extreme thirds of the distribution and 5% will be misclassified in the opposite third of the distribution, for 14 days (r = 0.81) the values are 72% and 3% respectively (Nelson *et al*, 1989). It should also be noted that this estimate was carried out based on data collected in men only and results might differ in women. However, there were no data at the development stage of the project to determine estimates in women. There are data to suggest that women have higher within to between-subject variances than men (Nelson *et al*, 1989) and therefore the accuracy in women

might be poorer than in men.

A 10 day record was chosen for the experimental study as it would be able to detect a difference of 2g if at least 75% of those who completed the dietary assessment and only 5% of subjects would be misclassified into opposite thirds of the distribution of intake. There seemed little benefit in using a longer period of dietary assessment.

It was assumed that a sufficiently large sample to screen 375 smokers would also identify and screen 300 ex-cigarette smokers and 300 never smokers for the chosen age range (Data from General Household survey, 1984 ratio of smokers:ex:never 4:3:3). Thus the total number of subjects would equal 975.

The best dietary method for the cross-sectional study was then determined using the following equation based on a sample size of n = 300 and a difference to be detected of 3.5.

$$\sigma^2 = \frac{nd^2}{2\,(Z_{\alpha/2} + Z_{\beta})^2}$$

With 90% power and a significance level of 0.05 a method with a variance (sd) of 13.2 would be able to detect the required difference. As all methods had variances for polyunsaturated fat of less than this it was decided to use the FFQ on all subjects at baseline as this method could easily be completed at the clinic visit and therefore a 100% response in those who attended was not unreasonable. The FFQ is relatively cheap and requires minimal time in processing and as ranking of subjects was desired and absolute levels of intakes were not so important, it seemed the best choice.

In summary, 975 subjects were required for the cross-sectional study and diet was to be assessed using a FFQ. The

smokers in this sample (375) would also complete a ten day weighed record. The smokers only would be followed up at four months and one year. It was assumed that 80% of smokers would be followed up (300) and that 20% (60) would have quit smoking. It was also assumed that 75% of these would have a full dietary assessment using the weighed record (225).

2.4 RECRUITMENT METHODS

The recruitment methods for the cross-sectional and experimental studies were the same and are not discussed separately. However, subjects were to be recruited by two methods - randomly and as volunteers.

The numbers were to be achieved as follows:

i) A postal questionnaire to identify smoking category would be sent to 3000 subjects.

ii) The expected response rate was 65% which would yield 2000 replies.

iii) This sample should contain at least 500 cigarette smokers, 400 ex-cigarette smokers and 400 never smokers (total of 1300) the remainder being made up of subjects not fulfilling the recruitment criteria set out in section 2.2.1i.

iv) The expected attendance rate at the clinic was 75% yielding 375 smokers, 300 ex-smokers and 300 never smokers.

The following methods were used to recruit the required numbers:

i) Postal Questionnaire (Appendix 1)
The questionnaire asked details of current and past smoking

habits as well as information on date of birth, illnesses (heart disease (not hyperlipidaemias), kidney disease and high blood pressure), types of fats used in cooking and types of exercise undertaken. This method was used to identify smokers, ex-smokers and never smokers with no history of heart disease. Subjects recruited by this method formed the random sample.

ii) Newspaper recruitment
A further sample of smokers with a strong desire to stop smoking was recruited from adverts in local newspapers under the same criteria as for the randomly selected sample. It was necessary to use this sample as the cigarette smokers selected at random when seen at the clinic did not have a strong desire to stop smoking, although some might succeed in quitting over the duration of the project. Subjects recruited by this method are considered as volunteers.

The following describe the steps in recruitment of the random sample and volunteers.

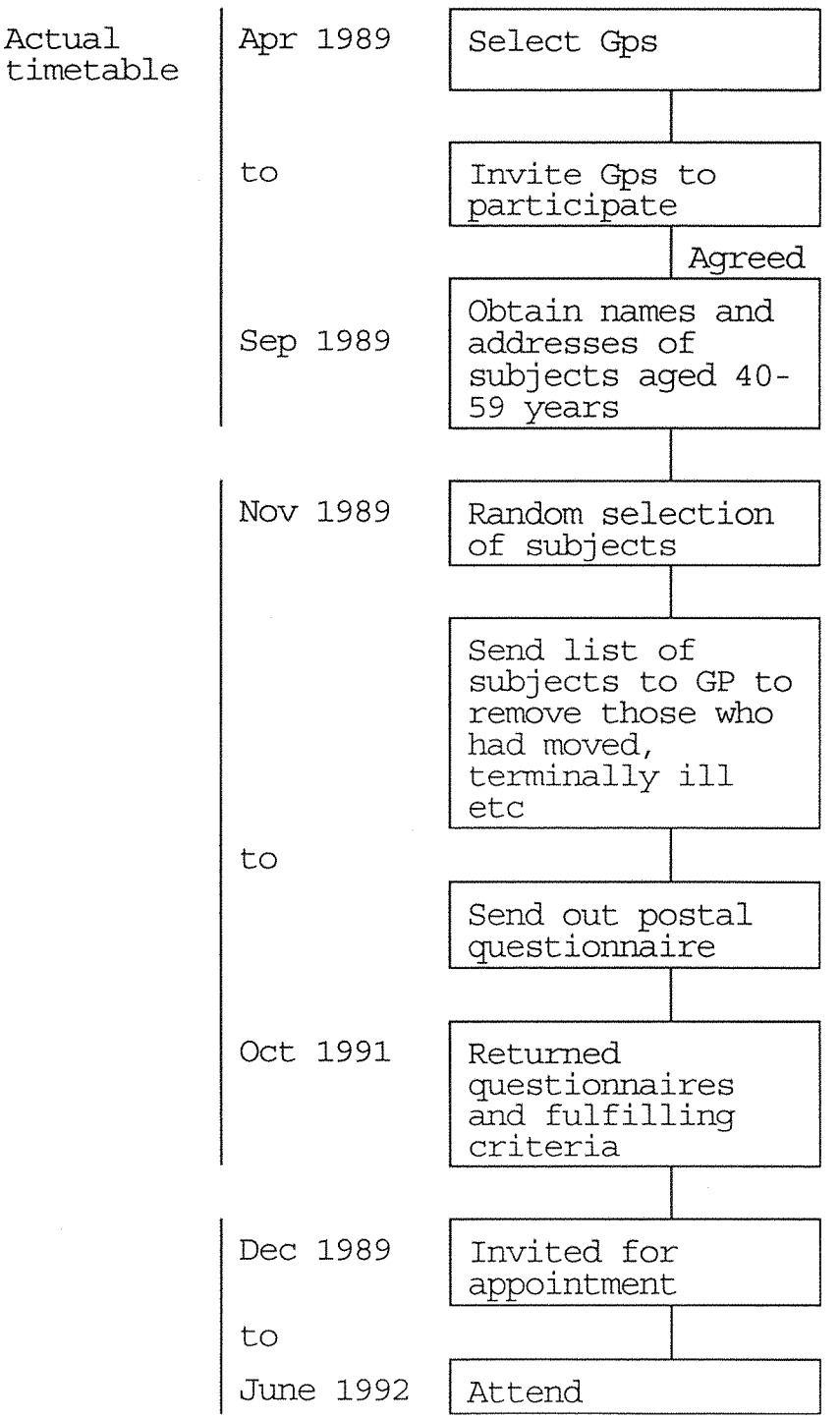
2.4.1 Random sample

The steps in the recruitment of subjects using the postal questionnaire for both the cross-sectional and experimental studies are shown in figure 2.2. A timetable of the process is also shown (figure 2.3).

Seven health centres were selected to cover different areas of Southampton. Two health centres declined to take part in the study due to re-organization and heavy workload; these were replaced by two further health centres. Once the agreement of the health centres was received a list of the names and addresses of all subjects aged between 40 and 59 years registered with each general practitioner was obtained for all health centres. This process took from April 1989

until September 1989. On obtaining the names and addresses of the subjects, a random sample of 1 in 5 was selected using a table of computer generated random numbers. Between 300 and 500 subjects were selected from each health centre

Figure 2.3: Method and dates of recruitment of subjects



depending on its size. The list of selected subjects was then sent to the general practitioners so that those subjects who were known to have moved away could be excluded. The general practitioners also excluded subjects who were terminally or mentally ill. Once this list was received the postal questionnaire was posted to the subjects that remained to identify smoking habit. As subjects participating in the cross-sectional study were to be recruited over the length of the study the postal questionnaires were sent out by practice over intervals between November 1989 and October 1991.

All subjects fulfilling the selection criteria (section 2.2.1i) were then invited to attend the Preventive Cardiology clinic for health screening. Subjects were screened at baseline between December 1989 and June 1992. However, the baseline screening of the smokers was complete by June 1991.

2.4.2 Volunteers

Three newspapers advertisements were placed in local newspapers between June 1990 and February 1991. Subjects returned a slip volunteering to take part. They were then contacted to explain the study and check to see if they fulfilled the selection criteria. In addition subjects were also aware they would be participating in a smoking cessation study and that they would be required to keep a record of their food and drink intakes. The smokers were screened between July 1990 and June 1991 in a similar fashion to the randomly recruited subjects.

2.5 METHODS USED AT THE CLINIC

The methods for the cross-sectional and experimental studies are considered separately.

2.5.1 Cross-sectional study

i) Dietary assessment: food frequency questionnaire for all subjects (choice of the questionnaire is discussed in chapter four).

ii) A health questionnaire designed for the larger study giving details of smoking habit (defined on page 84), occupation and details of special diets and medication taken (including vitamin and mineral supplements). Occupation was classified by longest occupation, coded from Classification of Occupations of the UK Office of Population, Censuses and Surveys (1980). Non-manual occupations were grouped as I, II, IIINM and manual occupations as IIIM, IV, V. Married women were classified by their husband's occupation and single women by their own occupation.

iii) Anthropometric measurements of height and weight were recorded. Height and weight were measured in indoor clothing with jacket and shoes removed. The same pair of digital Seca scales was used for all subjects for each appointment. The accuracy of the equipment was checked on a monthly basis. Body mass index (BMI) was calculated from weight(kg) / height^2 (m^2).

iv) Confirmation of reported smoking status using breath carbon monoxide using the definitions on page 84.

2.5.2 Experimental study

As for the cross-sectional study with the following additions:

i) 10 day weighed record (records of 7 or more days were accepted). Subjects completed 3 weekend days and 7

weekdays. Some subjects kept the record for ten consecutive days and others for two sets of five days over a 14 day period.

ii) Additional validation of smoking habit using serum cotinine. Definitions are shown on page 84. This is a more reliable method of validation of smoking for smoking cessation studies than breath carbon monoxide.

The follow up appointments at four months and one year were exactly the same as the baseline screening for smokers, however, only those smokers who satisfactorily completed the weighed record at baseline were eligible for records at follow up.

2.6 STATISTICAL ANALYSIS

The methods of statistical analysis are listed below:
All analyses were carried out using SPSS/PC V3.0. The first stage was to check the data for deviations from normality within gender groups using the Kolmogorov-Smirnov test. No untransformed nutrients or food groups conformed to normality. The data were then log transformed and the test applied again. After log transformation the distribution of the data approximated normality for nutrients by both methods (FFQ and WR) and for food groups determined by WR. For food groups by FFQ log transformation and other methods of transformation (reciprocal, square root, square, cubic) failed to produce a near normal distribution.

Untransformed data are shown in the tables with either 95% confidence intervals or standard errors.

Calibration study
Differences between the methods were analysed by mean nutrient differences between the methods with a two tailed t-

test. For food groups the Wilcoxon signed rank test was used to replace the two tailed t-test as the data were not normally distributed. This test uses ranking to test the hypothesis that there are no differences between the paired estimates of intake. Agreement was also assessed using the Spearman rank correlation coefficient on energy adjusted and energy unadjusted values.

Variation in energy intake between individuals largely results from differences in body size, physical activity and metabolic efficiency. Intakes of most nutrients tend to be positively correlated with energy intake. Therefore if energy intake is associated with a disease then so will the other nutrients that are associated with energy. It is then necessary to see if a particular nutrient is associated with the disease independently of energy intake. In many epidemiological studies, including those investigating nutrient intake and smoking status, adjustments for total energy intake are made. Therefore when carrying out a calibration study comparison of nutrient intakes that are adjusted for total energy intake should also be made.

One such method of energy adjustment is the use of nutrient densities. These are easily computed by dividing nutrient intakes by the energy intake or alternatively for macronutrients by expressing the nutrient as a percentage of the total energy intake. This method has several disadvantages. Firstly, dividing by a variable does not necessarily control for it. If a nutrient is weakly correlated with energy intake, dividing by energy may produce a variable that is highly related to energy. Additionally, there may be measurement error in the estimation of energy intake which will then effect calculations of nutrient densities.

An alternative method is to use energy-adjusted values computed as the residuals from the regression model with

energy intake as the independent variable and absolute nutrient intake as the dependent variable (Willett & Stampfer, 1986). Since residuals have a mean of zero and include negative values they do not give a value of intake. To overcome this a constant can be added such as the mean nutrient intake of the population being studied. If the usual assumptions for the regression analysis are met these energy-adjusted values should then be uncorrelated with energy intake.

The classification of data into fifths was also examined. An alternative graphical method to look at the agreement between the methods was also used, the Bland Altman technique (Bland & Altman, 1986) and was also used as a method of applying a 'correction' factor to the FFQ data. The contribution of food groups to nutrient intakes was also examined.

Cross-sectional study

Analysis of variance (ANOVA) was used to test the hypothesis that the group means of the smoking categories were equal. This analysis also allowed adjustment for confounding variables to be made. When adjustment was made for several confounding variables, tables of means adjusted for these variables are shown in addition to the unadjusted means. Adjustment for energy was made by including energy intake (measured at the same time as the other dietary variables) as a covariate in the model. Other confounding variables included in the model were age, occupation group, height, weight and alcohol intake.

Non-parametric tests were used for the analysis of food groups from the FFQ as the data were not normally distributed. The Mann-Whitney test was used to determine differences between two groups in place of a two-sample t-test. The analysis of variance was replaced by the Kruskal-Wallis one-way analysis of variance to compare more than two

groups. This tests whether k independent samples defined by a grouping variable (smoking habit) are from the same population. The cases are ranked in a single series and the sum of the ranks for each group is computed. If the sums are similar then there is no difference between the groups. If the sums vary this then indicates difference between the groups.

A discriminant analysis was used to simplify the dietary analysis to highlight foods that were most important in differentiating between smoking categories. It was also used to summarise dietary patterns of each smoking category. With n groups it is possible to derive n - 1 discriminant functions. The first function has the largest ratio of between-groups to within-groups sums of squares and therefore explains the greatest variation between the groups. The ratio is usually referred to as the discriminant or canonical root; the greater the discriminant root the greater is the separation between the groups. Successive functions are uncorrelated with previous functions and explain successively smaller percentages of variation. Mean discriminant scores for each smoking group are shown and indicate direction of trends between the groups. Standardised discriminant function coefficients for dietary and non-dietary variables were computed. These coefficients have a mean of zero and a standard deviation of 1. For ease of interpretation the coefficients were rotated (varimax rotation). The size and sign of each resulting discriminant mean indicates the relative ability of each function to differentiate between groups in the analysis. Large coefficient values irrespective of sign denote variables that have the greatest effect. If the function group mean has a large positive value then this group will be associated with positive discriminant function coefficients. The analysis has been carried out with four smoking categories heavy smokers, light smokers, ex-smokers and never smokers. Analysis of four groups gives three function groups with function one

contributing most to the variation between the categories. For ease only function one is shown and overall tends to differentiate between smokers and non-smokers.

Experimental study

In the experimental study comparisons were made between the differences between quitters and smokers taking into account the baseline measure, source of recruitment and time between appointments as well as other factors that were taken into account in the cross-sectional study.

Further details of the tests used are described in the relevant chapters where the results are shown.

3. RECRUITMENT AND RESPONSE RATES

Chapter three describes the method of recruitment of subjects into both the cross-sectional and experimental studies. The participation response rates for the different smoking categories in the cross-sectional study are shown. Also shown are response rates for attendance at follow-up and completion of the dietary survey in the experimental study.

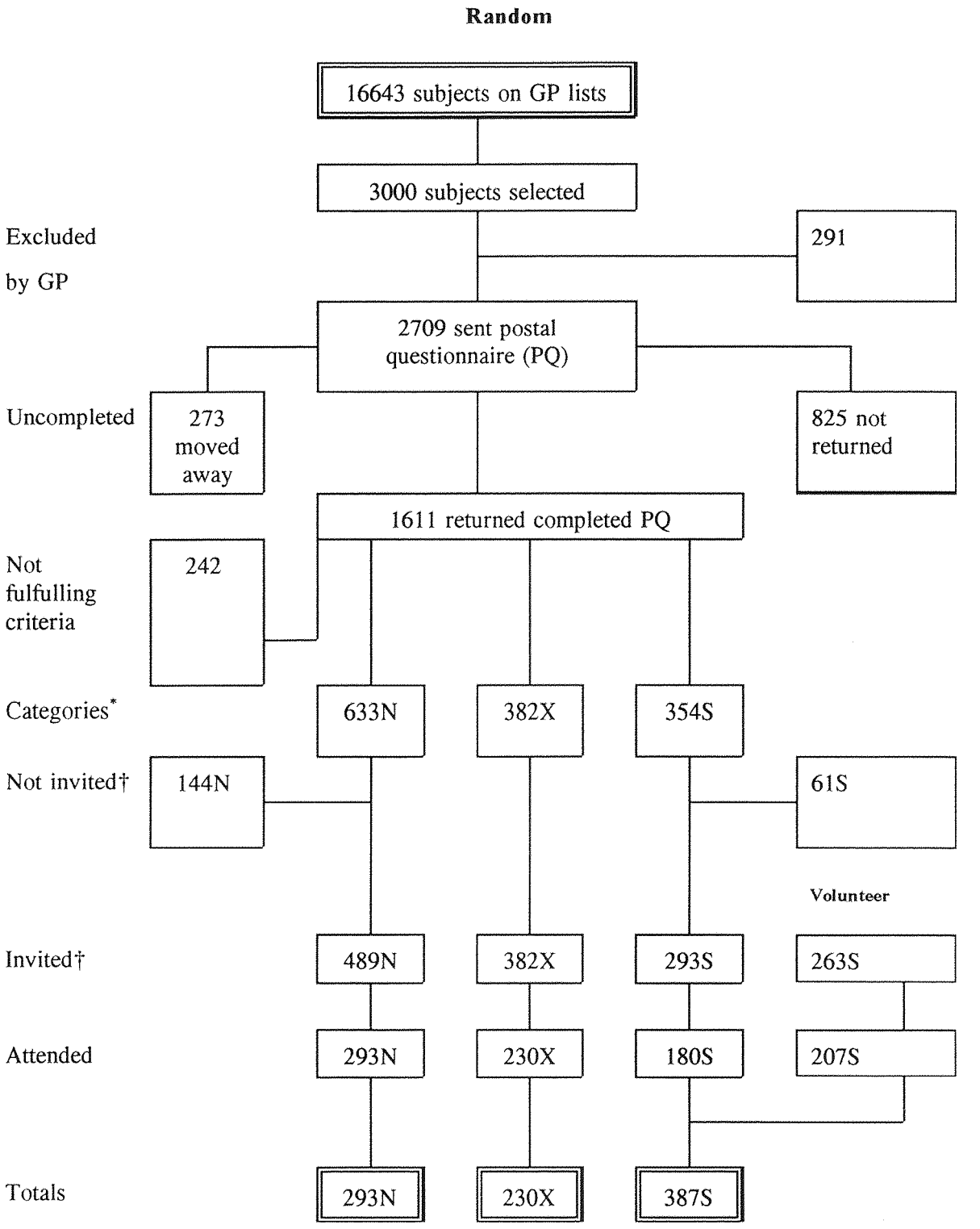
3.1 RECRUITMENT OF SUBJECTS-CROSS-SECTIONAL STUDY

The recruitment of subjects into the cross-sectional study is shown in figure 3.1. The number of subjects available from the general practitioner (GP) lists was 16643 (8421 men). A random selection of 3000 of these subjects was made using a table of computer generated random numbers. After checking the lists with the GPs, 291 subjects were excluded. The reasons for exclusion were: terminal or mental illness, previous heart disease, subjects were known to have moved away and the rest as one of the GPs originally agreeing to take part withdrew from the study due to a heavy workload. The remaining 2709 (1364 men) were sent the postal questionnaire to ascertain smoking habit. The postal questionnaire was sent out over a period of one year to spread the workload. A number (273) of the questionnaires were returned uncompleted as the subjects had moved away and a further 825 were not returned. The number of returned completed questionnaires was 1611 (725 men). The response rate for subjects returning the questionnaire if those who were known to have moved away (273) were excluded was 66%.

$$\left(\frac{1611}{2709-273}\right)100=66\%$$

The inclusion criteria (see page 85) were not met for 242 (196 men) subjects returning completed questionnaires.

Figure 3.1: Recruitment of subjects for baseline screening



* N, never smokers; X, ex-smokers; S, smokers

† Subjects were invited until approximately 375 S, 300 X and 300 N had attended.

These comprised 84 cigar/pipe smokers, 84 ex-smokers of pipe/cigars, 56 with a previous myocardial infarction or a history of angina and 18 with an incorrect date of birth. The composition of the subjects fulfilling the criteria (1369) was as follows; 633 (46%) never smokers, 382 (28%) ex-smokers and 354 (26%) cigarette smokers. Subjects were then invited to the clinic until the required numbers in each category were reached (ie. 375 smokers, 300 ex-smokers, 300 never smokers). Emphasis was placed on recruiting smokers first. Never and ex-smokers were recruited together, some whilst the smokers were being recruited but most in the latter part of the study. To achieve these numbers 489 never smokers were invited. All the ex-smokers were invited, but the required number was not reached before the end of the study. The smokers from the random study were supplemented with 207 smokers who volunteered to take part and the required number was exceeded (387) after all the volunteers and 293 randomly recruited smokers were invited. This left 144 never smokers and 61 smokers who were not invited to take part. As subjects were invited to the clinic by practice the remaining never smokers and smokers belonged to the last practice invited and hence cannot be considered a representative sample of subjects in the study.

The cross-sectional study thus comprised 293 never smokers, 230 ex-smokers and 387 smokers (207 volunteers).

The response rates for attendance at the clinic for those who were invited for an appointment were 62% for the never smokers and 61% for the ex-smokers and 61% and 79% for the randomly recruited smokers and volunteers respectively.

Table 3.1 shows the numbers of men and women in each smoking category with their respective response rates for attendance. The total number of women in the study was 570 and the total number of men was 340. The differences in numbers of men and women seen did not arise due to different proportions of men

and women in either the original sample (16643) or those sent the postal questionnaire (2709) as these samples contained approximately 50% men and 50% women. There were no differences in the proportion of men and women in the samples of never smokers and randomly recruited smokers not selected. The difference was partially due to more women than men returning completed questionnaires; 55% of the 1611 subjects returning the PQ were women. In addition the 242 subjects

Table 3.1: Numbers (%) of subjects attending appointment by gender and smoking status

	RANDOM SAMPLE			VOLUNTEER
	Smokers (n = 180)	Ex-smokers (n = 230)	Never smokers (n = 293)	Smokers (n = 207)
Men (n = 340)	78 (63%*)	105 (62%)	76 (48%)	81 (80%)
Women (n = 570)	102 (59%)	125 (59%)	217 (65%)	126 (78%)

* number attending/number invited x 100

who did not fulfil the criteria were mostly men (81%). This was largely due to very few women smoking pipes or cigars. Another possibility is that women were more likely to attend for screening. In fact there was no difference in attendance rates between men and women for smokers, ex-smokers or volunteers. However, women never smokers were more likely to attend (65%) than men never smokers (48%) (Table 3.1). Also, more women than men responded to the newspaper advertisements, 162 women compared with 101 men.

In summary, the unequal numbers of men and women attending was due to more women returning the questionnaire and replying to the advertisements, more men being excluded and a

poor attendance rate for men who had never smoked.

3.2 EXPERIMENTAL STUDY

Smokers recruited for the cross-sectional study were to form the sample for the experimental study. The required sample size for the experimental study was 375 (chapter 2) once this number had been achieved the additional smokers who attended were used in the cross-sectional study but were not eligible for the experimental study. The response rates are shown separately for attendance at follow-up and participation in the dietary survey.

3.2.1 Attendance

Table 3.2 shows the breakdown of the 375 smokers eligible for the experimental study by recruitment method. There were no differences in attendance rates between the gender groups, therefore data for men and women have been combined. The numbers (response rates) in each group attending at follow-up are also shown. Attendances for the four month appointment were not necessarily four months after the baseline appointment (average 4.8 months after the baseline

Table 3.2: Response rates for attendance in the experimental study by recruitment method

	Random	Volunteer	Total
Attended cross-sectional study	180	207	387
Included in experimental study	168	207	375
Seen for one follow-up	139 (83%*)	148 (71%)	287 (77%)
Seen for two follow-ups	80 (48%)	78 (38%)	158 (42%)

* Calculated using number included in the experimental study only

appointment; range 1.9-15.5 months). For the calculation of response rates the length between appointments was disregarded and response rates were calculated for subjects who returned for one follow-up appointment and for subjects who returned for two appointments (ie. those who attended all three appointments). Overall 230 subjects attended at baseline and first follow-up and 57 subjects at baseline and second follow-up. The table shows that response rates for attendance at either one or two follow-up appointments were higher in the random sample and that response rates for attendance at all three appointments were almost half that for attendance for one follow-up. The overall response rates for attendance were 77% for one follow-up and 42% for two follow-ups. During the follow-up period 14 subjects moved away and three died.

Subjects were recruited during 1990-1991 and of the randomly recruited smokers who were included in the cross-sectional study 28% of men and 24% of women were cigarette smokers. These appear lower than 1988 levels of 33% and 30% for men and women smokers, and may reflect a further decrease in smoking in this age group, a different occupation group structure (non-manual occupation are less likely to smoke) or a differential response to the questionnaire by smoking categories. Although the overall attendance rates for men and women were similar for all smoking categories it was not possible to determine the smoking status of those not returning the questionnaire. It is possible that the sample not returning the questionnaire included a higher proportion of smokers than non-smokers. Criqui *et al*, (1978) looked at differences between responders and non-responders in a population based cardiovascular disease study and found that non-responders were more likely to smoke cigarettes than responders.

A higher response rate for baseline attendance by volunteers is not surprising and shows the benefit of using volunteers

in studies. The response rate would have been even higher for volunteers but some subjects had to wait a couple of months before their appointment could be booked and by this time they had changed their mind about giving up smoking.

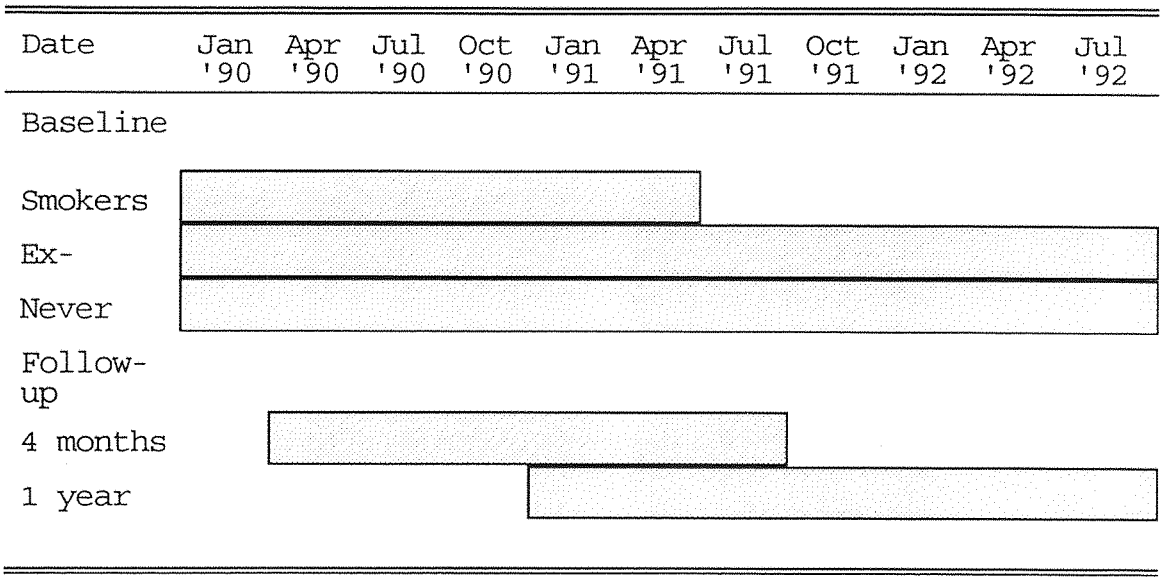
For follow-up appointments response rates for attendance were lower in general for volunteers than for randomly selected subjects. This may have been due to a poor attendance by subjects who were not successful in quitting smoking. A possible explanation for the unsuccessful quitters not attending was that they felt they had failed by not stopping smoking. They might have also felt that they had made the decision to attend initially and so could decide to drop out of the study if they no longer wished to give up smoking or were not successful. For the randomly recruited subjects the pressure to give up smoking was not so strong and many felt that as they had attended initially that they should complete the follow-up appointments.

In summary, response rates also were higher for randomly recruited subjects than volunteers. Attendance for one follow-up appointment was reasonably good (77%) but rates of full attendance were lower.

Figure 3.2 shows the timetable for screening the subjects. The baseline smokers were seen between January 1990 and June

1991. The ex and never smokers were seen throughout the project, from January 1990 until August 1992. The first follow-up lasted from March 1990 until September 1991 and the second from January 1991 until August 1992.

Figure 3.2: Timetable of study



3.2.2 Dietary study

Table 3.3 shows response rates by recruitment method for each dietary survey method at each visit. Response rates are calculated using numbers attending at baseline as the denominator (168 for the random sample and 207 for the volunteers). The response rates did not differ between men

Table 3.3: Response to dietary survey methods by recruitment method in the experimental study

i) FFQ

	Random (Total number 168)	Volunteer (Total number 207)	Overall number
Experimental study	167 (99%)	207 (100%)	374 (100%)
One follow-up	139 (83%)	148 (71%)	287 (77%)
Two follow-ups	80 (48%)	78 (38%)	158 (42%)

ii) WR

	Random (Total number 168)	Volunteer (Total number 207)	Overall number
Experimental study	117 (70%)	184 (89%)	301 (80%)
One follow-up	77 (46%)	92 (44%)	169 (45%)
Two follow-ups	50 (30%)	56 (27%)	106 (28%)

and women and therefore the table shows the composite results for men and women. The total numbers of FFQ obtained at baseline, with one follow-up and two follow-ups were 374, 287 and 158. To obtain a higher response rate the food frequency questionnaire was posted to some subjects (28) who failed to attend at the first follow-up and all who did not attend at the second follow-up. This increased the number of FFQs to 297 (79%) with one follow-up and 207 (55%) with two follow-ups (not shown in the table). For the WR the percentages of responders with the full ten days were 87, 92 and 84 respectively. Response rates for the dietary studies reflected the differences observed for attendance at follow-up with a reduction in response rates for one and two follow-ups. The response rates for the weighed record were lower than those of the FFQ for all appointments and did not appear to differ greatly between the recruitment groups except at baseline (70% random, 89% volunteer).

Randomly recruited subjects were unaware they would be participating in a dietary study designed to look at the effects of giving up smoking but were informed it was a research project on heart disease whereas volunteers were aware they would be required to keep records of food and drink consumed. This could explain the higher participation rate in the dietary study at baseline for volunteers. The

effect of non-response at follow-up is examined in chapters eight and nine.

In summary, the good response to the weighed record from volunteers declined at follow-up appointments to that of the randomly recruited subjects. The food frequency questionnaire achieved a higher response rate which declined at follow-up appointments due to subjects not attending.

These results show the beneficial effects on response rates of using a food frequency questionnaire compared with a 10 day weighed record.

In chapter one the effect of bias related to response rates was discussed. There is the possibility of bias in both the recruitment and follow-up stages. A low response rate for recruitment or a high drop-out rate may result in bias as those subjects participating may differ from those not taking part or not returning. The possibility of bias using the WR was greater than that with the FFQ as response rates were lower. Nearly 100% of subjects who attended completed the FFQ, therefore, as the FFQ was to be used in the cross-sectional study, bias due to poor response rate was limited to differences in those subjects who attended the clinic and those who were sent a smoking questionnaire but did not attend. Unfortunately information about the non-attenders was limited to age and gender. Therefore, the possibility of differences in dietary habits between the attenders and non-attenders cannot be excluded. The subjects were not all randomly selected and as response rates for attendance were not excellent, the findings may not be representative of a wider population. Thus the results from the cross-sectional study may not be generalisable to a wider population. In the experimental study the most important source of response bias was those subjects who attended at baseline and completed the weighed record but did not complete further weighed records at follow-up. It is possible that those returning may have

differed from subjects not returning in baseline characteristics or diet. A comparison of the baseline dietary habits of subjects who completed one WR with those who completed more than one is shown in chapter eight.

From chapter two the expected response rate for attendance at follow-up at one year for the experimental study was 80%; the actual response was 42%. In addition, not all returning subjects completed the weighed record, which was completed at baseline and first and second follow-up by 106 subjects. The calculation of differences detectable by the different dietary methods in table 2.1 was based on an expected change in polyunsaturated fat of 1.9g with at least 240 subjects returning for follow-up with complete dietary assessment. If the figures are re-calculated based on 106 subjects with complete assessment and an assumed quit rate of 20% (21 subjects quit) the detectable difference for polyunsaturated fat are 2.9g for 90% power and 2.5g for 80% power.

In conclusion, in general the required numbers for the cross-sectional study were obtained. Thus differences of at least 2g of polyunsaturated fat would be detectable between smoking categories. However, the response to follow-up and complete dietary assessment in the experimental study did not reach expectation which reduced the differences in polyunsaturated fat and other nutrients that could be detected, and introduced the possibility of response bias.

4. FOOD FREQUENCY QUESTIONNAIRE

This chapter describes the choice of the food frequency questionnaire used in the cross-sectional study and its calibration with a 10 day weighed record. The effect of using different methods of subject recruitment on the calibration was also investigated.

4.1 CHOICE OF FOOD FREQUENCY QUESTIONNAIRE

The food frequency questionnaire (FFQ) was developed by the MRC unit in Cardiff for the Caerphilly and Speedwell collaborative ischaemic heart disease surveys (The Caerphilly and Speedwell Collaborative Group, 1984; 1985) and was subsequently modified and improved for the Diet and Reinfarction Trial (Burr *et al*, 1989). Both these versions have been used by other research groups in the UK. The FFQ used in the Southampton study was a further modification of the questionnaire used in the DART study.

The FFQ was commercially available and its structure is detailed below. It contained a list of 84 foods or food groups, and subjects were required to state how often they usually ate each item. Estimates of the quantity consumed were obtained for some items - for example, number and size of slices of bread per day, amount of milk per day, number of eggs per week, number of fresh fruits per week and amounts of butter, margarine, cheese and cream per week. For other items such as meat, fish and vegetables an average portion size was used. These portion sizes were derived from mean portion sizes calculated from seven day weighed records collected from men and women in South Wales.

This FFQ had been calibrated previously (Yarnell *et al*, 1983; Fehily *et al*, 1988; Bolton-Smith and Milne, 1991) and was therefore expected to be valid in the Southampton population.

A self-administered version was also available. This self-administered version was chosen for the Southampton study due to restrictions on personnel and time; the FFQ could be administered while subjects were waiting to see the nurse (the FFQ took 20 minutes to complete), hence reducing waiting time and length of interview for the subjects. In addition, the use of mean portion sizes to calculate nutrient intake reduced the time needed for coding and analysis of the FFQ.

Although previous calibrations of the FFQ had been carried out it was necessary to carry out a further calibration as:

i) There have been no studies published to date calibrating an FFQ in a group of smokers. To check for errors due to differential bias in the measurement of diet between smokers and non-smokers it was necessary to carry out a calibration in smokers.

ii) No previous calibration of the FFQ had been carried out in Southampton. There may be regional variation in occupation group structure or food choices which could affect the agreement between the methods.

iii) Although the age range of subjects was similar to that in the IHD and DART studies, calibration had been carried out more extensively in men. Our study was to include both men and women and therefore it was necessary to examine the agreement between the methods by gender.

iv) The study required two sources of smokers, randomly recruited smokers and volunteers and it was possible that the agreement between the methods would differ depending on the source of the subjects. It might be expected that the agreement would be better for the volunteers than the randomly recruited subjects.

v) A 10 day record was to be used for the calibration whereas in Wales a seven day weighed record had been used. A longer period of recording may give a better indication of long term diet thus improving the agreement between the methods.

vi) The calibration of the DART study was carried out on subjects who had previously had a myocardial infarction and hence may have been better motivated or were more aware of their dietary habits.

vii) Portion sizes for the FFQ were derived from weighed records collected from the Welsh population and therefore may not be applicable to smokers or non-smokers from Southampton.

Due to differences in the characteristics of the subjects compared with other calibrations it was necessary to carry out a further calibration study.

The calibration study was to be carried out in the cigarette smokers only for practical reasons. It was not feasible to carry out the calibration study in never and ex-smokers due to the extra time and cost that this would involve. If a good agreement was achieved with smokers a similar if not better agreement could be expected in non-smokers. However, a poor agreement for smokers would not necessarily imply a poor agreement in non-smokers. This procedure for the calibration could be included in the study design without increasing the demand on subjects as both dietary methods were to be administered to smokers but not to non-smokers.

In summary, the calibration of the FFQ with a 10 day weighed record was to be carried out in men and women cigarette smokers.

4.2 CHARACTERISTICS OF SUBJECTS

The main characteristics of the subjects participating in the calibration study (ie. all smokers completing both dietary methods at baseline) are shown in table 4.1. These are shown separately for men and women by recruitment method. There were no statistically significant differences for age or body mass index between recruitment groups. However, volunteers reported smoking more cigarettes per day than the random sample. In men, reported number of cigarettes smoked per day was 19.4 for the random sample and 24.3 for volunteers. In women, reported number of cigarettes smoked was 15.6 and 22.0 for the random and volunteer samples respectively. There was, however, no difference in cotinine measurements between recruitment sources; this point is discussed on page 165.

Table 4.1: Subject characteristics; mean values (95% Confidence interval)

	MEN		WOMEN	
Source	Random	Volunteer	Random	Volunteer
Number	49	73	68	111
Age (years)	50.2 (48.5,51.9)	49.4 (48.2,50.5)	50.9 (49.3,52.4)	49.3 (48.3,50.4)
Body Mass Index (kg/m^2)	25.2 (24.3,26.1)	26.0 (25.2,26.7)	25.5 (24.3,26.7)	24.5 (23.8,25.2)
Number of cigarettes/ day	19.4 (16.8,22.0)	24.3* (22.3,26.4)	15.6 (13.9,17.3)	22.0* (20.3,23.6)
Cotinine (ng/ml)	276 (241,310)	299 (270,329)	241 (212,270)	266 (241,291)
Occupation† %manual/ %non-manual	57/37	44/49	53/38	39/51

Statistical analysis - group t-test except for occupation where chi-squared test was used

* $P < 0.001$

† Numbers do not add up to 100% as some subjects could not be classified -ie worked in armed forces; housewife.

There was also difference in occupation group distribution between recruitment groups. For men 57% of the random sample and 44% of volunteers had manual occupations and 37% of the random sample and 49% of volunteers had non-manual occupations. In women, 53% of the random sample and 39% of volunteers were classified into manual occupations and 38% and 51% respectively into non-manual occupations.

Comparison of smokers by recruitment method showed differences in occupation group and number of cigarettes smoked for men and women.

4.3 COMPARISON USING DIFFERENT NUTRIENT DATABASES

The analysis of the dietary data was carried out using two commercially available packages (DietQ version 2, Tinuviel for FFQ and Comp-eat version 4 for WR) both based on McCance & Widdowson's food composition tables (1978). Before analysis the nutrient databases were checked to ensure identical nutrient values for foods were used. If values were not the same, observed differences between the methods might be due to differences between the databases and could result in reducing or increasing the apparent agreement between the methods.

In fact, large discrepancies were found between the databases for some foods. In particular for potatoes, vegetables, breakfast cereals and bread. Therefore, as the Comp-eat version 4 database was more recent, all values from the FFQ database were converted to their respective values in Comp-eat 4. Table 4.2 shows percent mean differences calculated between the dietary methods before and after the FFQ food database was made consistent with the weighed record. Only nutrients which were affected by the difference in nutrient values between the databases are shown. Mean differences between the dietary methods altered little when

the databases were made consistent for energy, protein, fat, pufa, sfa and carbohydrate in men and women, and vitamin C in women.

Table 4.2: Comparison of percent mean differences between FFQ and WR before and after correction of the FFQ nutrient database

	% Mean difference*			
	Men		Women	
Nutrient	Uncorrected	Corrected	Uncorrected	Corrected
Fibre (g)	22	11	40	28
Vitamin A (μg)	49	39	77	60
Vitamin C (mg)	14	7	26	25
Vitamin E (mg)	-9	-18	7	-4

* $\frac{FFQ-WR}{WR} x100$

Substantial improvement in agreement as shown by a reduced percent mean difference was observed for vitamin C in men, and fibre and vitamin A for both men and women. Percent mean differences were reduced for vitamin E in women but increased in men after the databases were made consistent. Although, making the databases consistent reduced some of the difference between the methods, it only accounted for a maximum 50% of the difference. For most of the nutrients above differences between the methods were still in excess of 10% after correction.

In summary, differences between the two nutrient databases used in the analysis of the WR and FFQ appeared to decrease the agreement (as shown by percent mean difference) between the methods. Therefore the apparent validity increased when

the nutrient databases were made identical.

4.4 RESULTS OF THE CALIBRATION STUDY

The following section reports the results of the calibration study. The first part examines the effect of using consecutive day WR and a two stage WR, and the calibration of the FFQ with the WR in terms of nutrient intakes. The second attempts to determine which food items contributed to differences in nutrient intakes.

4.4.1 Nutrient intakes

The procedures used to calibrate the FFQ were mean nutrient differences, Spearman rank order correlation coefficients, classification into fifths of intake and graphical plots showing the agreement between the methods across the range of intakes.

Table 4.3: Comparison of mean intakes using continuous and separate days of weighed records

	Men		Women	
	Continuous	Separate	Continuous	Separate
Number	65	57	81	98
Energy (MJ)	10.0 (9.5,10.5)	10.3 (9.8,10.7)	7.2 (6.9,7.6)	6.9 (6.6,7.1)
Fat (g)	96.8 (91.3,102.2)	101.1 (95.5,106.6)	76.0 (70.6,81.5)	70.2 (66.2,74.2)
Vitamin C (mg)	58.1 (50.2,66.0)	57.4 (48.0,66.8)	56.3 (48.7,64.0)	53.7 (47.2,60.1)

Using a two tailed unpaired t-test no result between continuous and separate weighed records was statistically significant ($P < 0.05$)

The effect of using consecutive day WR and two stage WR is shown in table 4.3. This table shows nutrient intakes for

three nutrients for men and women using the two methods of WR. It might be expected that the consecutive days would result in lower nutrient estimates if the quality of WR declines as the length of recording increases. There were no statistically significant differences between the methods. There was no difference between the recruitment groups in number completing continuous or separate records.

4.4.1i *Mean differences between the methods*

Tables 4.4i and 4.4ii show the comparison of mean daily nutrient intakes between the FFQ and WR for men and women. Both mean differences and percent mean differences are shown. In men (table 4.4i), the FFQ tended to give lower estimates than the WR for energy and most macronutrients except sugar. Percent mean differences between the methods, however, were almost zero for protein and carbohydrate. They were in the range of -4 to -7 % for energy, saturated fat and alcohol, and 6% for sugar. Largest percent mean differences were seen for fat, polyunsaturated fat and fibre but did not exceed 11%. For micronutrients the FFQ tended to overestimate intakes compared with the WR with the exception of vitamin E. Agreement was within 10% for vitamin C, but poorer for vitamin E (-18%), and vitamin A (39%). The same results for women are shown in table 4.4ii. In contrast to men, the FFQ gave higher estimates than the WR for energy and macronutrients, except for fats and alcohol. Percent mean differences were close to zero for polyunsaturated fat and saturated fat, and less than 10% for energy, fat, carbohydrate and alcohol. Largest discrepancies as measured by percent mean difference were seen for sugar, protein and fibre. As in men vitamin A and vitamin C intakes were overestimated (60% and 25% respectively).

A two-tailed paired t-test was used to determine whether the mean differences between the methods were statistically

Table 4.4: Comparison of mean daily nutrient intake by the FFQ and WR

i) Men

	WR Mean (95% CI)	FFQ Mean (95% CI)	MD* (95% CI)	% MD†
Energy (MJ)	10.1 (9.8,10.5)	9.7 (9.2,10.2)	-0.4 (-0.8,0.0)	-4‡
Protein (g)	84.3 (82.1,87.3)	84.1 (80.3,87.9)	-0.2 (-4.1,3.9)	-0
Fat (g)	98.8 (94.9,102.6)	87.7 (82.3,93.0)	-11.1 (-16.6,-5.6)	-11‡
Polyunsaturated fat (g)	16.2 (15.2,17.2)	14.4 (13.0,15.8)	-1.8 (-3.0,-0.6)	-11‡
Saturated fat (g)	39.6 (37.8,41.3)	37.5 (35.0,40.0)	-2.0 (-4.4,0.4)	-5‡
Carbohydrate (g)	277.3 (264.3,290.2)	276.0 (260.6,291.3)	-1.3 (-15.0,12.4)	-1
Sugar (g)	130.4 (120.8,139.9)	137.8 (126.2,149.4)	7.4 (16.0,-1.2)	6
Fibre (g)	19.1 (18.0,20.2)	21.1 (19.9,22.3)	2.0 (0.8,3.2)	10‡
Alcohol (g)	21.0 (16.3,25.6)	19.6 (15.4,23.7)	-1.4 (-3.9,1.1)	-7
Vitamin A (μg)	1180 (1004,1356)	1639 (1400,1878)	458 (170,746)	39‡
Vitamin C (mg)	57.8 (51.8,63.7)	61.9 (57.1,66.8)	4.2 (-1.5,9.9)	7‡
Vitamin E (mg)	6.6 (6.1,7.0)	5.4 (4.9,5.8)	-1.2 (-1.8,-0.6)	-18‡

* MD, Mean difference (FFQ - WR); † ((Mean FFQ - mean WR) / mean WR) x 100; ‡ Two tailed paired t-test statistically significant $P < 0.05$.

ii) Women

	WR Mean (95% CI)	FFQ Mean (95% CI)	MD* (95% CI)	% MD†
Energy (MJ)	7.0 (6.8,7.3)	7.2 (7.0,7.5)	0.2 (-0.2,0.6)	3
Protein (g)	63.9 (61.6,66.1)	74.6 (71.9,77.4)	10.8 (7.9,13.7)	17‡
Fat (g)	72.8 (69.5,76.1)	68.1 (64.7,71.6)	-4.7 (-8.4,-1.0)	-6‡
Polyunsaturated fat (g)	11.3 (10.7,11.9)	11.1 (10.4,11.9)	-0.2 (-1.0,0.6)	-2
Saturated fat (g)	30.1 (28.5,31.7)	29.6 (27.8,31.5)	-0.5 (-2.1,1.1)	-2
Carbohydrate (g)	191.5 (183.5,199.5)	203.1 (193.6,212.7)	11.6 (2.8,20.4)	6‡
Sugar (g)	87.9 (81.6,94.2)	98.8 (92.1,140.5)	10.9 (5.2,16.5)	12‡
Fibre (g)	16.0 (15.1,16.8)	20.4 (19.3,21.5)	4.4 (3.4,5.4)	28‡
Alcohol (g)	6.1 (4.8,7.5)	5.9 (4.4,7.3)	-0.3 (-1.3,0.7)	-5
Vitamin A (μg)	1081 (942,1219)	1734 (1517,1952)	654 (419,889)	60‡
Vitamin C (mg)	54.9 (50.0,59.8)	68.3 (63.8,72.9)	13.5 (8.8,18.2)	25‡
Vitamin E (mg)	4.9 (4.6,5.2)	4.7 (4.5,5.0)	-0.2 (-0.6,0.2)	-4

* MD, Mean difference (FFQ - WR); † ((Mean FFQ - mean WR) / mean WR) x 100; ‡ Two tailed paired t-test statistically significant $P < 0.05$.

significant. In men, mean differences were statistically significant for all nutrients except protein, carbohydrate, sugar and alcohol and in women for all except for energy, polyunsaturated fat, saturated fat, alcohol and vitamin E.

In summary, there were statistically significant mean differences for most nutrients in men and women but mean differences were less than 10% for most macronutrients. Mean differences for micronutrients, however, tended to be much larger especially in women.

The WR was used as a bench mark but estimates using this method are subject to error (section 1.2.1i). In particular weighed records may underestimate energy and fat intakes

(Stockley, 1985). If this is true then the FFQ giving lower estimates of energy and fat in men is likely to be even less accurate than the weighed record in terms of absolute levels of intake. In women, however, energy intakes but not fat estimates were higher using the FFQ and therefore energy intakes using the FFQ may be nearer the truth. This difference in energy estimates between men and women may be partially explained by men underestimating fat intakes more using the FFQ than women (-11% for men and -6% for women). Alternatively there may have been a greater error in portion size estimation in men than in women. For most food groups the same portion size was used for men and women.

Several studies have been published comparing an FFQ with a three or seven day WR. Criteria used for studies for comparison were studies separately analysing men and women, and using random samples of more than 50 subjects. In agreement with our results other workers (Fehily *et al*, 1988; Pietinen *et al*, 1988; Tjønneland *et al*, 1991 and Posner *et al*, 1992) have found higher energy intakes in men estimated by the WR compared with the FFQ. In the women in our study the FFQ gave a higher energy estimate than the WR. Posner *et al*, (1992) was also in agreement but others were not (Willett *et al*, 1985; Tjønneland *et al*, 1991). The Southampton sample showed an underestimation of fat intake by the FFQ compared with the WR (-11.1g for men and -4.7 for women). Fehily *et al*, (1988) using the same FFQ but in the Welsh population, where it was developed, showed an excellent agreement with a 1g difference between the methods. However, other studies have shown discrepancies of -1.8 to -11g in fat estimates (FFQ - WR) between the FFQ and WR for women (Willett *et al*, 1985; Tjønneland *et al*, 1991; Posner *et al*, 1992) and -2.1 to -33g in men (Pietinen *et al*, 1988; Tjønneland *et al*, 1991; Posner *et al*, 1992; Rimm *et al*, 1992).

Fibre and vitamin C intakes in our smokers appeared to be overestimated by the FFQ compared with the WR. This

overestimation was also shown by Pietinen *et al*, (1988) for vitamin C, and Willett *et al*, (1985), Tjønneland *et al*, (1991) and Rimm *et al*, (1992) for vitamin C and fibre. Again Fehily *et al*, (1988) found similar estimates of vitamin C between the methods but a lower fibre intake using the FFQ than the WR.

Smokers in this study compare well with subjects in other calibration studies. However, in comparison with a similar form of the same questionnaire used in the Welsh male population (Fehily *et al*, 1988) the smokers performed less well for fat and vitamin C. This may be because the questionnaire was originally designed to be used in South Wales and portion sizes were calculated from WRs in this population. Hence agreement is likely to be less good in another population. Alternatively, the population in Southampton may have been more aware of nutritional guidelines as the study was carried out more recently and therefore were aware they should be reducing fat and increasing fibre intakes.

A similar calibration has been carried out in 40 Scottish men with the same FFQ and a 14 day weighed record and this calibration showed a lower fat estimate using the FFQ (-24.1g), lower fibre and vitamin C estimates, and also a much lower energy intake 8.6MJ compared with 10.8MJ (Bolton-Smith & Milne, 1991). Therefore there was closer agreement between the methods in Southampton than in Scotland.

Calibration studies have not been carried out separately in smokers and non-smokers. Obtaining similar results between this study of smokers and other studies of composite groups of non-smokers and current smokers might suggest that agreement between the methods is not affected by smoking habit.

4.4.1ii *Spearman rank order correlation coefficients*

Obtaining accurate absolute nutrient intakes was not an objective for the cross-sectional study for which the FFQ was to be used; the aim of the study was to detect differences in nutrient intakes by smoking status. The ability to correctly rank subjects within the range of intakes was therefore more important. The Spearman rank correlation coefficient was used to look at the ranking of individuals between the methods for both energy unadjusted and energy adjusted nutrient values. The method of energy adjustment as advocated by Willett & Stampfer (1986) was used.

Table 4.5 shows both energy-unadjusted and energy adjusted values for the Spearman rank order correlation coefficient in men and women. In men, rank correlation coefficients ranged from 0.18 for vitamin A to 0.83 for alcohol with a mean of 0.47. These improved after energy adjustment for all nutrients except sugar and vitamin A where they remained the same and alcohol where there was a reduction. The mean energy adjusted correlation coefficient was 0.58.

In women, rank correlation coefficients ranged from 0.31 for vitamin A to 0.81 for alcohol with a mean value of 0.49 - the same as in men. Energy adjusted values gave a mean of 0.57, slightly lower than for men, and improved for most nutrients except alcohol and vitamin C.

Spearman correlation coefficients for the smokers were compared with either Spearman or Pearson correlation coefficients from other studies. The coefficients for energy and fat were lower for the men smokers than those from other studies (Fehily *et al*, 1988; Pietinen *et al*, 1988; Tjønneland *et al* 1991). For energy, men smokers had a correlation coefficient of 0.38 compared with a range of 0.40-0.47 and for fat, men smokers had a value of 0.34 compared with 0.41-0.54 for other studies. The men smokers had correlation

coefficients similar to other studies (Fehily *et al*, 1988; Pietinen *et al*, 1988; Tjønneland *et al* 1991) for protein, vitamin C, polyunsaturated fat and vitamin A, but higher correlations for carbohydrate than Tjønneland *et al*, (1991) and Posner *et al*, (1992). In women, smokers' correlation coefficients were higher than those found by Willett *et al*, (1985) and Tjønneland *et al*, (1991) for protein, fat, polyunsaturated fat, fibre and carbohydrate but lower for

Table 4.5: Spearman rank correlation coefficients unadjusted (r) and adjusted for energy (r-adjusted) between the food frequency questionnaire and weighed records

	MEN		WOMEN	
	r*	r-adjusted*	r*	r-adjusted*
Energy (MJ)	0.38	-	0.36	-
Protein (g)	0.35	0.53	0.35	0.54
Fat (g)	0.34	0.61	0.44	0.53
Polyunsaturated fat (g)	0.56	0.70	0.44	0.67
Saturated fat (g)	0.45	0.69	0.59	0.61
Carbohydrate (g)	0.54	0.70	0.52	0.62
Sugar (g)	0.66	0.66	0.61	0.63
Fibre (g)	0.49	0.64	0.56	0.63
Alcohol (g)	0.83	0.75	0.81	0.77
Vitamin A (μg)	0.18†	0.18†	0.31	0.38
Vitamin C (mg)	0.51	0.54	0.52	0.38
Vitamin E (mg)	0.36	0.46	0.42	0.54

* Two tailed tests of significance $P < 0.001$, except for † not significant

vitamin C. In general most studies show lower correlations for women than men, but this was not observed in the smokers perhaps due to the larger number of women.

An exact agreement between the methods (a correlation of 1) is unlikely to occur due to within-person variation,

measurement errors in both the WR and FFQ, and any time delay between completing the two methods. Margetts *et al*, (1989) estimated Spearman rank correlation coefficients under various conditions for a one day estimated record and a food frequency questionnaire completed three years after the record. A simulation model with the following assumptions was used: i) the mean intakes at the time of the record study were normally distributed on the log-scale with the mean and standard deviation obtained from published data and ii) each of the sources of variation listed above introduced an independent multiplicative error which was normally distributed on the log-scale with mean zero. The authors calculated that the best Spearman rank order correlation achievable with no measurement error for a food frequency questionnaire and estimated record, and no drift over time was 0.60 for energy. In the Southampton study a comparison was made between a ten day weighed record and a food frequency questionnaire (which was completed a few days before the weighed record). Under these circumstances the correlation between the methods would be expected to be greater than that achieved by Margetts *et al*, (1989). In fact only a correlation of 0.38 in men and 0.36 in women was achieved. The situation of no measurement error is unlikely to occur and using the simulation model with a small amount of error reduced the correlation to 0.39 for energy (Margetts *et al*, 1989).

In summary, agreement between the methods by ranking of individuals improved after energy adjustment for most nutrients and the level of agreement was in general comparable to other studies. There still appears to be some room for improvement to obtain a good agreement between the methods for the Southampton study.

4.4.1iii *Classification into fifths*

Classifying individuals into fifths of intake will indicate the percent of subjects that are correctly classified (classified in the same fifth) and those who are grossly

Table 4.6: Percent of subjects classified in the same fifth, same fifth ± 1 fifth and opposite fifth of distribution by FFQ compared with WR

	MEN			WOMEN		
	Same fifth (%)	Same ± 1 fifth (%)	Opposite fifth (%)	Same fifth (%)	Same ± 1 fifth (%)	Opposite fifth (%)
Energy (MJ)	21	51	5	18	37	1
Protein (g)	20	54	2	16	36	2
Fat (g)	21	55	3	19	71	2
Pufa (g)*	36	75	0	26	66	2
Saturated fat (g)	25	70	1	38	74	1
Carbohydrate (g)	39	72	2	33	75	1
Sugar (g)	40	80	1	37	81	2
Fibre (g)	32	70	0	36	70	1
Alcohol (g)	52	94	1	55†	93†	0†
Vitamin A (μg)	25	59	6	27	64	6
Vitamin C (mg)	34	73	2	32	78	3
Vitamin E (mg)	26	66	4	28	66	1

* Pufa, polyunsaturated fat; † Abstainers by both dietary methods excluded

misclassified (classified in the opposite fifth - lowest fifth compared with the highest fifth and vice versa). Table 4.6 shows percent of individuals classified into the opposite fifth, same fifth and same fifth ± 1 fifth. If nutrient intakes were not adjusted for energy, 6% of subjects were

grossly misclassified for energy in men and vitamin A in men and women. No male subjects were grossly misclassified for polyunsaturated fat or fibre. There were no overall differences between men and women in classifying subjects into the opposite fifth. On average a third of subjects were classified into the same fifth of intake by both methods and only 2% of subjects were grossly misclassified. If nutrients values are energy adjusted (table 4.7), classification into the same fifth and the same fifth ± 1 fifth improves. In men, for fat and fibre there were no gross misclassifications after energy adjustment. In women, misclassification of protein was increased so that 9% were grossly misclassified. However, the percent of subjects grossly misclassified for vitamin A was reduced from 6 to 4%.

Table 4.7: Percent of subjects classified in the opposite fifth of distribution after energy adjustment of nutrients

	MEN			WOMEN		
	Same fifth (%)	Same ± 1 fifth (%)	Opposite fifth (%)	Same fifth (%)	Same ± 1 fifth (%)	Opposite fifth (%)
Protein	26	75	2	15	49	9
Carbohydrate	44	80	1	39	79	1
Fibre	34	80	0	40	79	1
Vitamin A	26	60	7	27	68	4
Vitamin C	27	74	2	40	77	3
Vitamin E	39	66	2	34	75	1

Other workers have looked at the classification into fifths of the distribution and found about 70% of individuals were classified in the same or same ± one fifth using energy unadjusted values (Pietinen *et al*, 1988; Margetts *et al*, 1989; Tjønneland *et al*, 1991). This is similar to the calibration in smokers with 72% of men and 70% of women in the same or same ± 1 fifth of consumption.

The FFQ although differing in the estimation of absolute nutrient values from the WR, appears to be able to rank

individuals in a similar way to the WR as shown by Spearman rank order correlation coefficients and by classification into fifths of intake. However, there is potential for some subjects to be grossly misclassified.

4.4.1iv *The Bland Altman technique*

The Bland Altman method can be used to look at the agreement between the methods across the range of intakes (Bland & Altman, 1986). The technique involves plotting the difference in nutrient value between dietary methods against their mean for each subject. The mean of the two estimates was used as there is no method to determine the absolute truth and the true value may lie between the estimates from each methods. Limits of agreement (Mean ± 2SD) are shown on the plots along with mean values. If a difference in mean values is detected this method can determine whether there is a constant bias (in which the same difference between the methods is apparent across the range of intakes) or a differential bias (in which agreement differs with the range of intake). Although regression lines are not normally shown on these plots they have been added to help with the interpretation.

The choice of nutrients for which to prepare plots was based on those showing a large percent mean difference between the methods, and in particular on those which may be affected by smoking status. However, this does not mean that for nutrients with a small mean difference that there is no differential misclassification across the range of intake. The nutrients chosen were energy, protein, fat and types of fat, fibre and vitamin C.

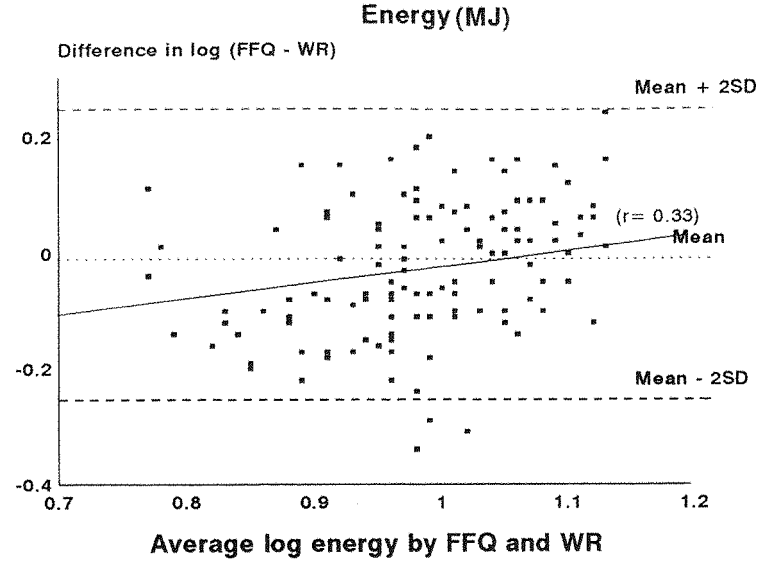
Figure 4.1 shows the plots for the selected nutrients for men and women. Firstly, for energy, in men the Bland Altman plot shows that at low intakes the FFQ gives a lower estimate for

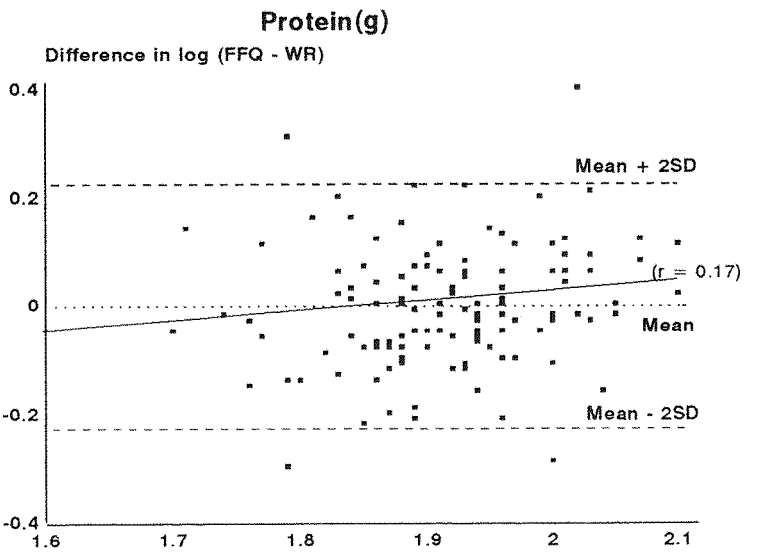
energy but at higher intakes it gives a higher estimate than the WR. However, in women, there appears to be a constant bias across intake with the mean around zero. The plots were constructed for protein in men and women as there was a large percent mean difference for protein in women but a good agreement in men tables (4.4i and 4.4ii). In women there appeared to be a constant bias with a general overestimation of protein using the FFQ at all levels of intake. In men there appeared to be no differential bias similar to that found for energy.

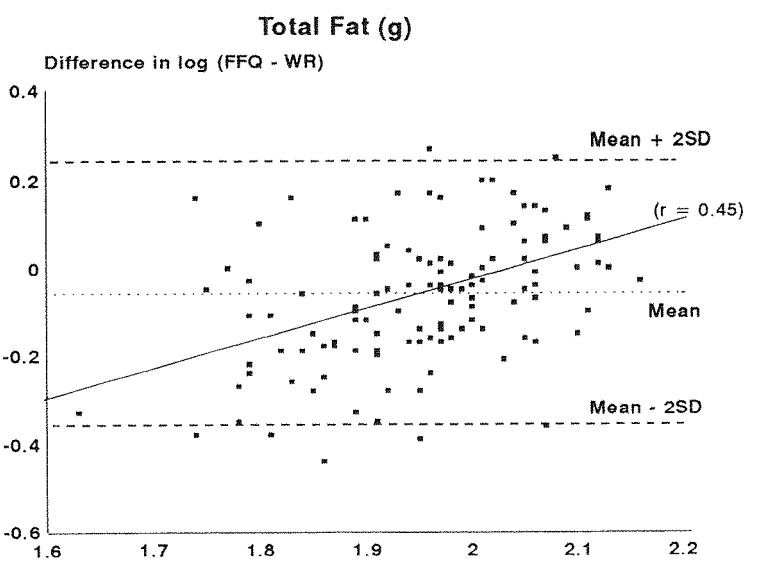
For fat and types of fat, in men, there seemed to be a differential bias for all three plots with subjects with lower intakes underestimating fat intake and those with the highest intakes overestimating fat intakes with the FFQ compared with the WR. In women, the differential bias was not so obvious, but there does appear to be a similar trend to that found in men.

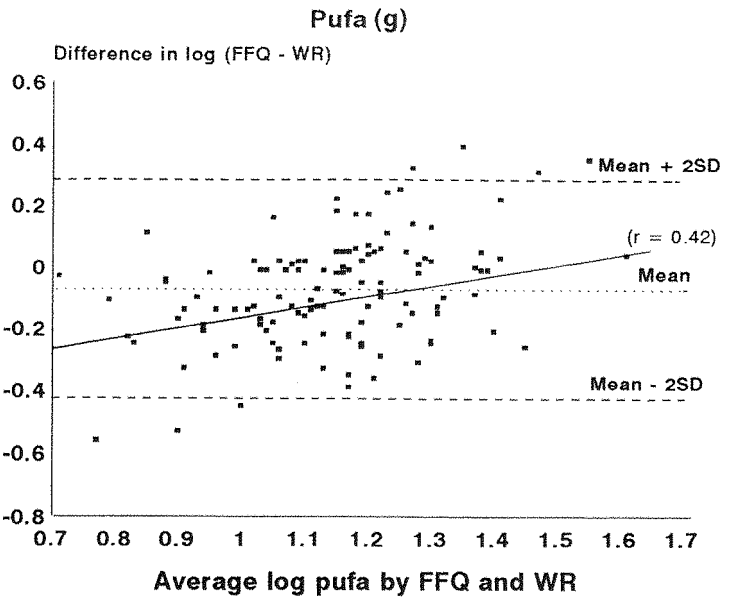
For fibre no differential bias was seen in men or women. For vitamin C a constant bias was seen in men, but in women there appears to be a trend with those subjects with lower intakes showing higher estimates with the FFQ and lower estimates at higher intakes than the WR. As intake increased there was closer agreement between the meaures.

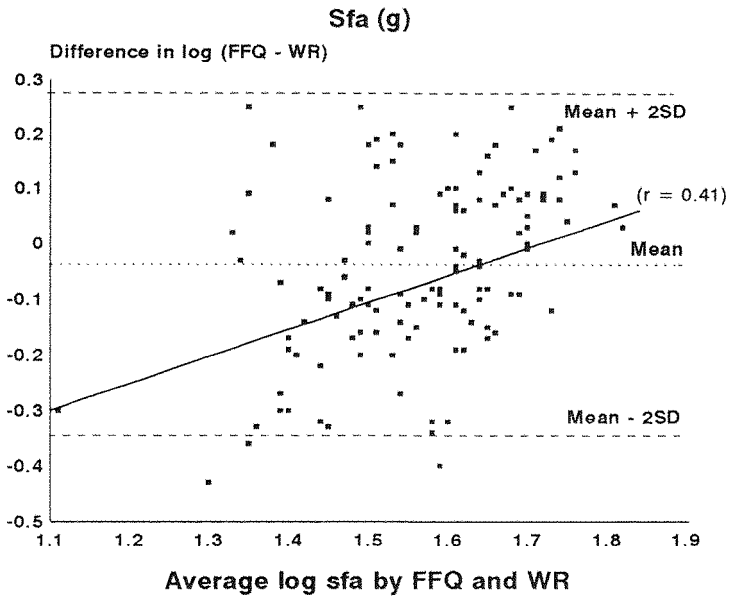
Figure 4.1: Bland Altman plots i) Men

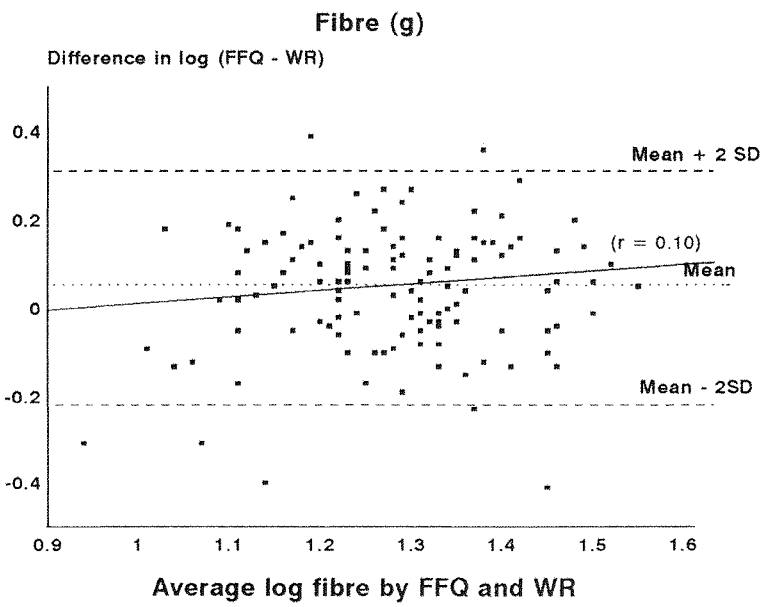




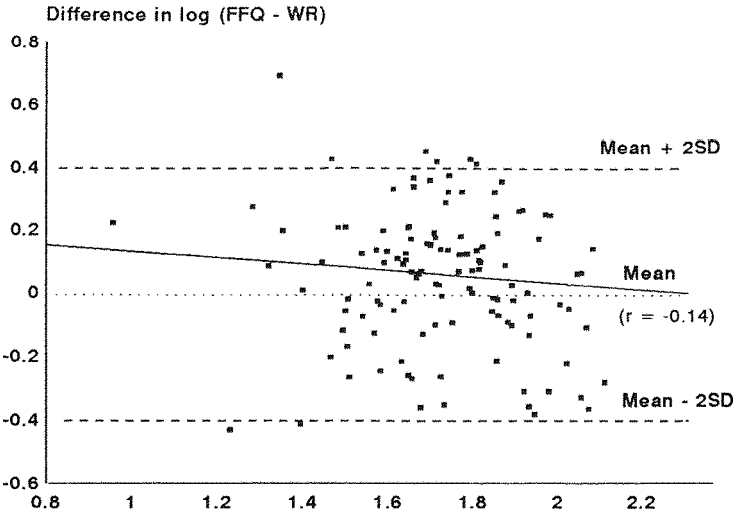



Pufa (g)
Difference in log (FFQ - WR)
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
0.7 0.8 0.9 1 1.1 1.2 1.3 1.4 1.5 1.6 1.7
Mean + 2SD
(r = 0.42)
Mean
Mean - 2SD
Average log pufa by FFQ and WR


Sfa (g)
Difference in log (FFQ - WR)
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
-0.5
1.1 1.2 1.3 1.4 1.5 1.6 1.7 1.8 1.9
Mean + 2SD
(r = 0.41)
Mean
Mean - 2SD
Average log sfa by FFQ and WR


Fibre (g)
Difference in log (FFQ - WR)
0.4
0.2
0
-0.2
-0.4
0.9 1 1.1 1.2 1.3 1.4 1.5 1.6
Mean + 2 SD
(r = 0.10)
Mean
Mean - 2SD
Average log fibre by FFQ and WR

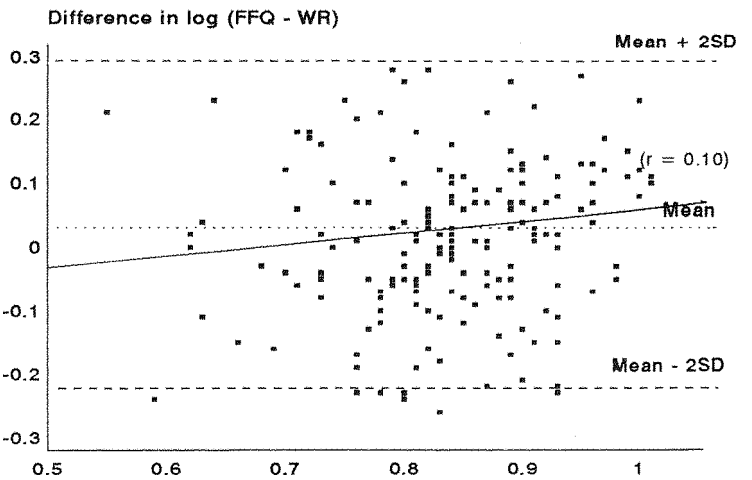
Vitamin C (mg)



Average log vitamin C by FFQ and WR

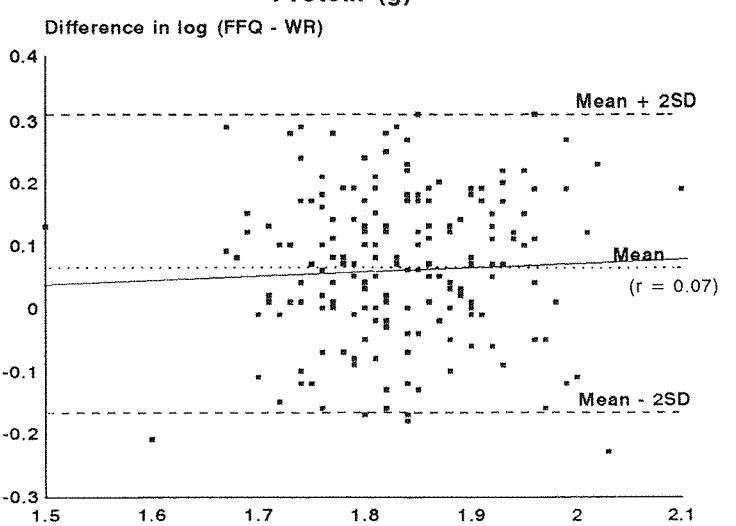
ii) Women

Energy (MJ)

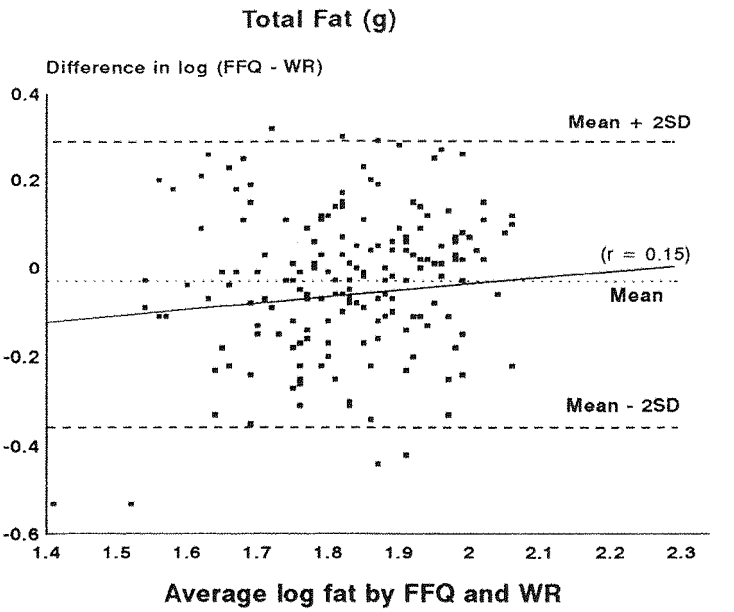


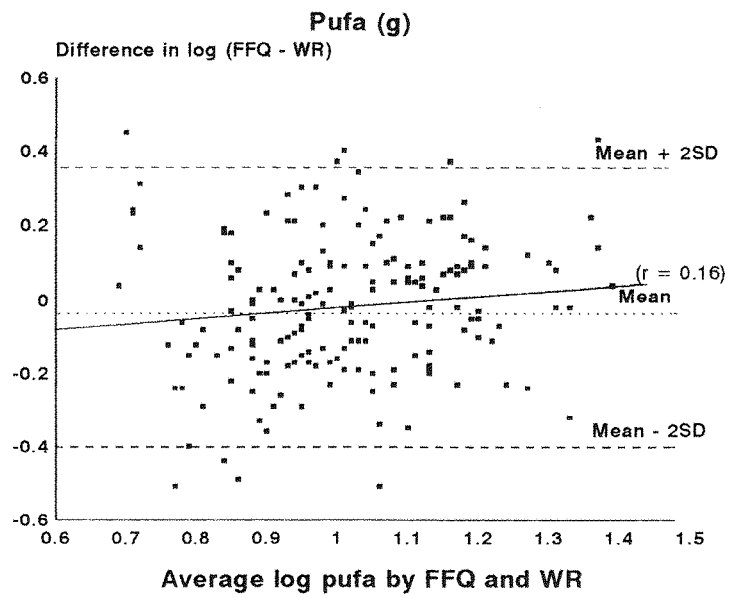
Average log energy by FFQ and WR

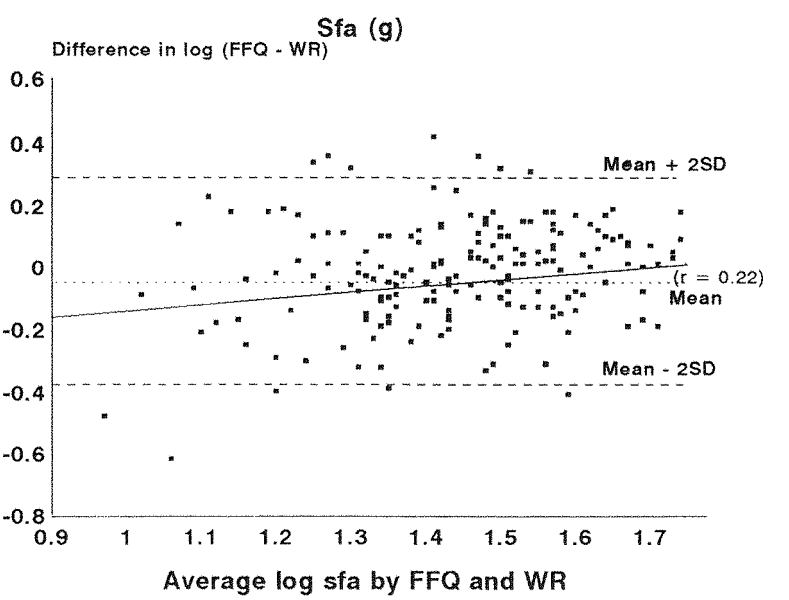
Protein (g)

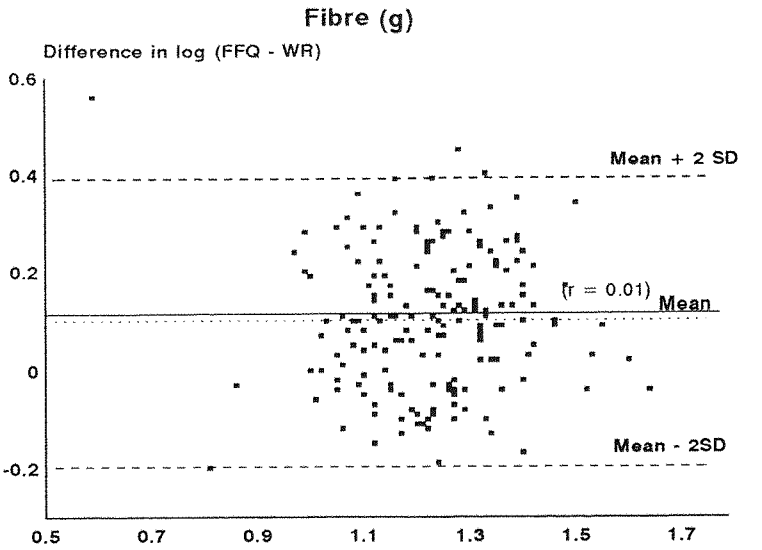


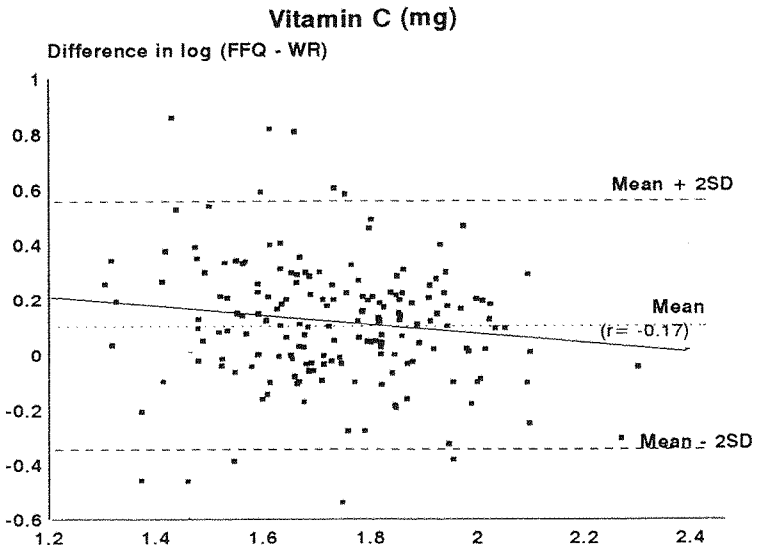
Average log protein by FFQ and WR


Total Fat (g)
Difference in log (FFQ - WR)
0.4
0.2
0
-0.2
-0.4
-0.6
Mean + 2SD
(r = 0.15)
Mean
Mean - 2SD
1.4
1.5
1.6
1.7
1.8
1.9
2
2.1
2.2
2.3
Average log fat by FFQ and WR


Pufa (g)
Difference in log (FFQ - WR)
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
Mean + 2SD
(r = 0.16)
Mean
Mean - 2SD
0.6
0.7
0.8
0.9
1
1.1
1.2
1.3
1.4
1.5
Average log pufa by FFQ and WR


Sfa (g)
Difference in log (FFQ - WR)
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
Mean + 2SD
(r = 0.22)
Mean
Mean - 2SD
0.9
1
1.1
1.2
1.3
1.4
1.5
1.6
1.7
Average log sfa by FFQ and WR


Fibre (g)
Difference in log (FFQ - WR)
0.6
0.4
0.2
0
-0.2
Mean + 2 SD
(r = 0.01)
Mean
Mean - 2SD
0.5
0.7
0.9
1.1
1.3
1.5
1.7
Average log fibre by FFQ and WR


Vitamin C (mg)
Difference in log (FFQ - WR)
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
Mean + 2SD
Mean
(r = -0.17)
Mean - 2SD
1.2
1.4
1.6
1.8
2
2.2
2.4
Average log vitamin C by FFQ and WR

At the lower end of intake several subjects were outside the limits of agreement.

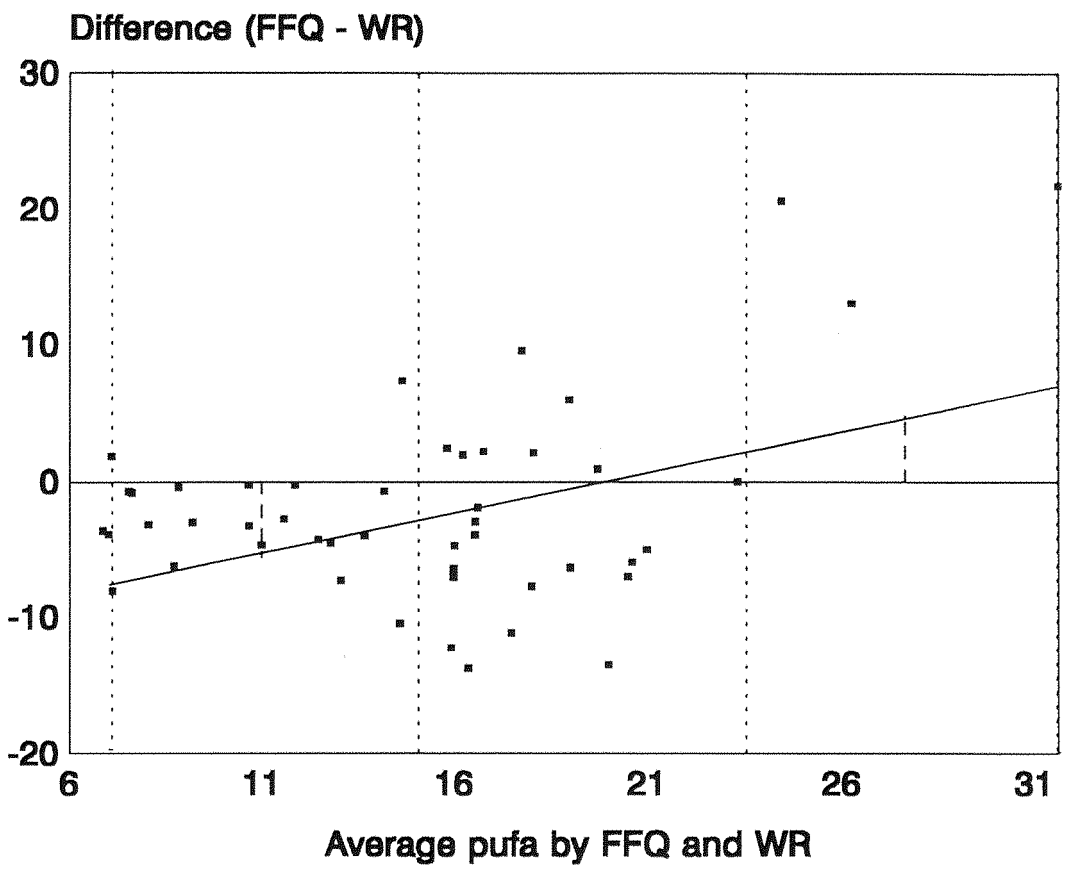
In summary, there appeared to be a differential bias for energy and fat in men with the FFQ underestimating intake at the lower intakes and overestimating intake at higher intakes, but there appeared to be a no bias for protein, fibre and vitamin C. In women, there seemed to be some differential bias for fat as in men, but there also was differential bias for vitamin C with overestimation of intake using the FFQ at low intakes and underestimation at higher intakes compared with the WR. The plots show that the FFQ may be appropriate for use in populations for nutrients with no differential bias but misclassification may occur if it is used for individuals as observed from the wide scatter of mean differences between the methods.

The effect of differential bias found in men for energy and fat (underestimation at lower intakes and overestimation at higher intakes) in the estimation of nutrient intake would result in larger apparent mean differences between populations at opposite ends of intake using the FFQ compared with the WR. In women, however, the differential bias is in the opposite direction for vitamin C with overestimation at low intakes and underestimation at higher intakes and would result in a smaller mean difference between populations at opposite ends of the intake using the FFQ as opposed to the WR. Therefore using the FFQ will make real differences in energy and fat for men easier to detect but real differences in vitamin C will be less easy to detect in women. These effects should be taken into account when interpreting the results of a dietary survey using the FFQ.

In conclusion, there were differences in intakes between the methods but these are consistent with other published calibrations. Ranking of individuals by correlation coefficients and classification into fifths was also

consistent with other studies. The use of the Bland Altman technique did show differential misclassifications which either exaggerate or underestimate differences in nutrient intakes if the FFQ is used. If estimated total intakes were not required the FFQ could be considered sufficiently accurate to determine nutrient differences between groups. At the present time there is not universal agreement about whether the WR or FFQ gives a better estimate of true diet. For the purposes of this study it has been assumed that the WR is a better measure of true diet than the FFQ. The Bland Altman plots were used as a basis for a 'correction' method by which absolute intakes from the FFQ could be adjusted so that values similar to those that would have been estimated using a weighed record were produced. This 'correction' should also remove the differential misclassification as

Figure 4.2: 'correction' method for FFQ using Bland Altman plots illustrated by pufa intake in randomly recruited men.



shown by the Bland Altman plots. The 'correction' method

involved plotting untransformed data (log plots are difficult to interpret) in the Bland Altman format (difference between the methods against the average of the two methods) as shown below for pufa intake in randomly recruited men (figure 4.2). If a true agreement between the methods existed across all intakes then the mean difference between the methods would be zero and the regression line would be superimposed over the mean difference equals zero line. If there was a constant bias and the same mean difference was observed across all intakes then the mean difference could be subtracted from the FFQ for any level of intake. In a situation where there is differential bias the method of adjustment is more complicated. In theory a 'correction' factor for each intake value could be calculated, however, this would be laborious. As the plots tend to shows poorest agreement at the extremes of intake and often a good agreement in the middle of the range, it was decided to divide the range of intake into three equal sections and apply a 'correction' factor to each section. This 'correction' factor was then subtracted from each FFQ value in the relevant section. The procedure is explained below:

The range of intake was divided into three equal sections (denoted by the dotted lines). A regression equation could have been used but would have been a more complex method. The mean difference between the methods ('correction' factor) for each section is shown by the dashed line. This is the difference between the regression line (solid line) and the line of mean difference equal to zero at the mid-point of the range of average values for each section (x axis). The plot for pufa shows that in the first section the FFQ underestimates pufa intake compared with the true values, in the second section there is a good agreement and in the final section the FFQ overestimates intake. Using the difference (y axis) and average of the two methods (x axis), FFQ estimates were calculated to determine the equivalent FFQ ranges. To 'correct' the FFQ data the FFQ estimates were

divided into the same three sections and were weighted by the 'correction' factors determined from the plots as above. Hence for pufa, the FFQ ranges were less than 14.2g, between 14.2 and 24.5g and greater than 24.5g. The 'correction' factors were -3.9, 0 and 3.9 for each section respectively. Therefore, a value of 10g of pufa would be corrected to 13.9g (10 - -3.9). An advantage of this method is that the absolute values obtained approximate to weighed record values and could be compared with weighed record studies.

To check the 'correction' method, plots were constructed for each gender and recruitment group and the 'correction' factors estimated. Data for both the recruitment groups were then combined and group means and 95% confidence intervals calculated. Table 4.8 gives the comparison of the corrected FFQ values and the WR estimates for men and women (data for random recruits and volunteers have been combined). Differences between the methods were very small.The largest difference was observed for fat, although this was only 2g. The table shows that this simple 'correction' method can be applied to FFQ data to reduce differential misclassification by this method compared to weighed records and to obtain absolute intake values close to those that would have been derived using WRs.

Table 4.8: Comparison of corrected mean nutrient FFQ values with WR for 121 men and 179 women

	MEN		WOMEN	
	WR	FFQ	WR	FFQ
Energy (MJ)	10.1 (9.8,10.5)	10.1 (9.8,10.5)	7.0 (6.8,7.3)	7.0 (6.8,7.2)
Protein (g)	84.3 (82.1,87.3)	84.1 (81.1,87.1)	63.9 (61.6,66.1)	63.2 (61.1,65.3)
Fat (g)	98.8 (94.9,102.6)	96.8 (93.2,100.1)	72.8 (69.5,76.1)	74.9 (71.7,78.0)
Pufa (g)	16.2 (15.2,17.2)	16.3 (15.0,17.5)	11.3 (10.7,11.9)	11.7 (11.1,12.3)
Sfa (g)	39.6 (37.8,41.3)	39.0 (37.8,40.7)	30.1 (28.5,31.7)	29.8 (28.2,31.4)
Cho (g)	277.3 (264.3,290.2)	278.0 (265.1,290.8)	191.5 (183.5,199.5)	189.1 (181.1,197.2)
Sugar (g)	130.4 (120.8,139.9)	130.0 (119.9,140.0)	87.9 (81.6,94.2)	89.0 (83.0,95.0)
Fibre (g)	19.1 (18.0,20.2)	19.1 (18.0,20.2)	16.0 (15.1,16.8)	16.0 (15.2,16.9)
Alcohol (g)	21.0 (16.3,25.6)	20.8 (16.5,25.1)	6.1 (4.8,7.5)	5.5 (4.1,6.9)
Vitamin A (μg)	1180 (1004,1356)	1106 (918,1295)	1081 (942,1219)	1047 (874,1220)
Vitamin C (mg)	57.8 (51.8,63.7)	57.7 (51.7,63.7)	54.9 (50.0,59.8)	54.1 (49.8,58.5)
Vitamin E (mg)	6.6 (6.1,7.0)	6.7 (6.2,7.1)	4.9 (4.6,5.2)	5.0 (4.7,5.3)

4.4.2 Food sources of nutrient differences

The aim of this section was to investigate the food group sources of nutrient intake differences between the methods. The nutrients studied were fibre, vitamin C and total fat, as these nutrients showed large discrepancies in mean differences between the methods.

The results are expressed as contributions to nutrient intake from each food group. Absolute contributions are presented as bar charts and percent contributions in brackets on the charts. The food groups are shown in appendix 3. For fat some food groups have been combined, for example, dairy and

milk products, meat and, fish and chicken. The food grouping may eliminate some differences between the methods due to daily variation in the intake of foods. For example meat may be consumed five days a week but the choice of meat may differ from the usual diet over the period of recording the WR.

The procedure used to construct the bar charts was as follows:-

i) The daily amounts of foods consumed were calculated for the FFQ as shown:

(portion size x times per week food item is consumed) / 7

ii) For ease of comparison the food items from the WR were grouped in the same way as by the FFQ.

iii) For each food item or food group the contribution to a specific nutrient intake was calculated as follows:-

a) Absolute intakes

= (amount of food (g) x nutrient composition/100g) /100.

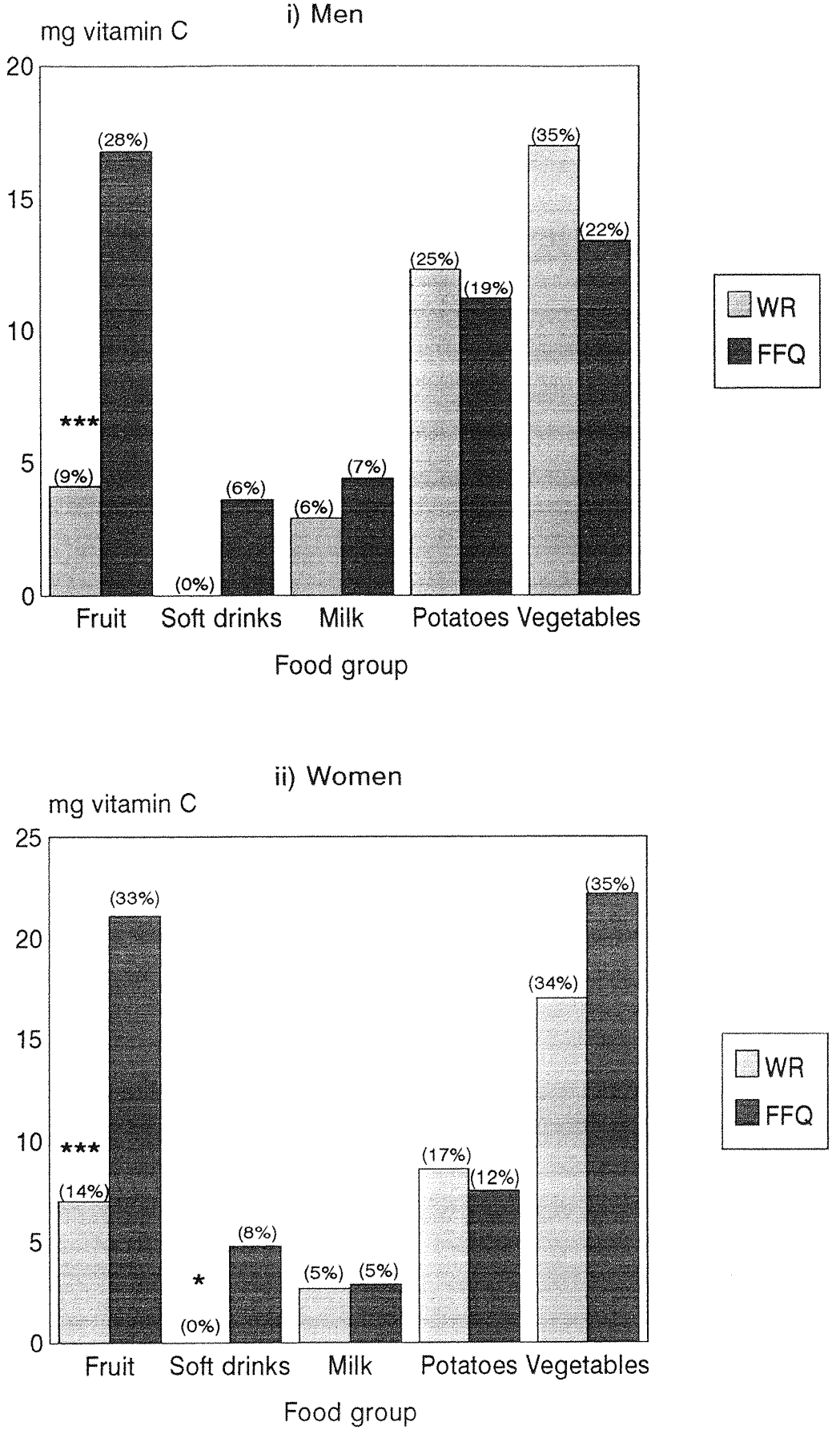
b) Percent amounts

= (absolute intake / total nutrient intake) x 100.

These were calculated for each individual and the median results were used to construct bar charts. Statistical significance was calculated using the Mann-Whitney test.

Median vitamin C intake for men was 60mg using the FFQ and 49mg using the WR. In women median vitamin C was 73mg using the FFQ and 56mg using the WR. Therefore in both men and women the FFQ method tended to overestimate vitamin C consumption compared with the WR. Figure 4.3 shows the

Figure 4.3: Contribution of food groups (mg/%) to vitamin C intake



Statistical significance between methods * p< 0.05, ** p< 0.01, *** p< 0.001

results for absolute contributions to vitamin C in men and women. The chart shows that in both men and women the amount of vitamin C estimated from fruit and soft drinks was overestimated using the FFQ compared with the WR (although the difference for soft drinks in men does not reach statistical significance). Similar amounts of vitamin C were contributed from milk and potatoes by both methods in men and women. The FFQ also estimated a slightly higher consumption of vitamin C from vegetables than the WR in women but in men the FFQ had a slightly lower estimate of vegetables than the weighed record. The percent contributions of the food groups to total vitamin C intake follow a similar pattern to the absolute intakes with a higher proportion of vitamin C from fruit and soft drinks. There was one exception, that of vegetable consumption in women, with the FFQ recording a higher intake in absolute amounts by the FFQ but that the percent contribution was similar between the methods.

Therefore the discrepancy in vitamin C intakes between the methods appears to be due to an overestimation of vitamin C from fruit and soft drinks in men and women and in men, but not women this is partially compensated for by a lower estimate of vitamin C from vegetables by the FFQ compared with WR. This is consistent with a larger difference between vitamin C estimates from the two methods in women compared with men.

The FFQ contained a composite group of green vegetables and salad for which the nutrient intake was calculated from three vegetables; cabbage, runner beans and brussel sprouts, each contributing one third of vitamin C intake in this group. The vitamin C intake from sprouts is high (60mg per 100g). From the WR it was apparent that sprouts only contributed about 10-15% (not 33% as used in the estimate of intake for the FFQ) of green vegetables and salad intake. This resulted in a vitamin C value for the composite vegetables group of 30mg per 100g when the real value was 20mg per 100g. If 20mg

and not 30mg had been used, the calculated amount of vitamin C from vegetables would have been reduced by 5-7mg. The difference in vitamin C from fruit appeared to be due to subjects over-reporting the amount of fruit consumed. In men the median amount of fruit consumed in grammes per day was 22 by the WR and 89 by the FFQ and in women 37 and 112 grammes respectively.

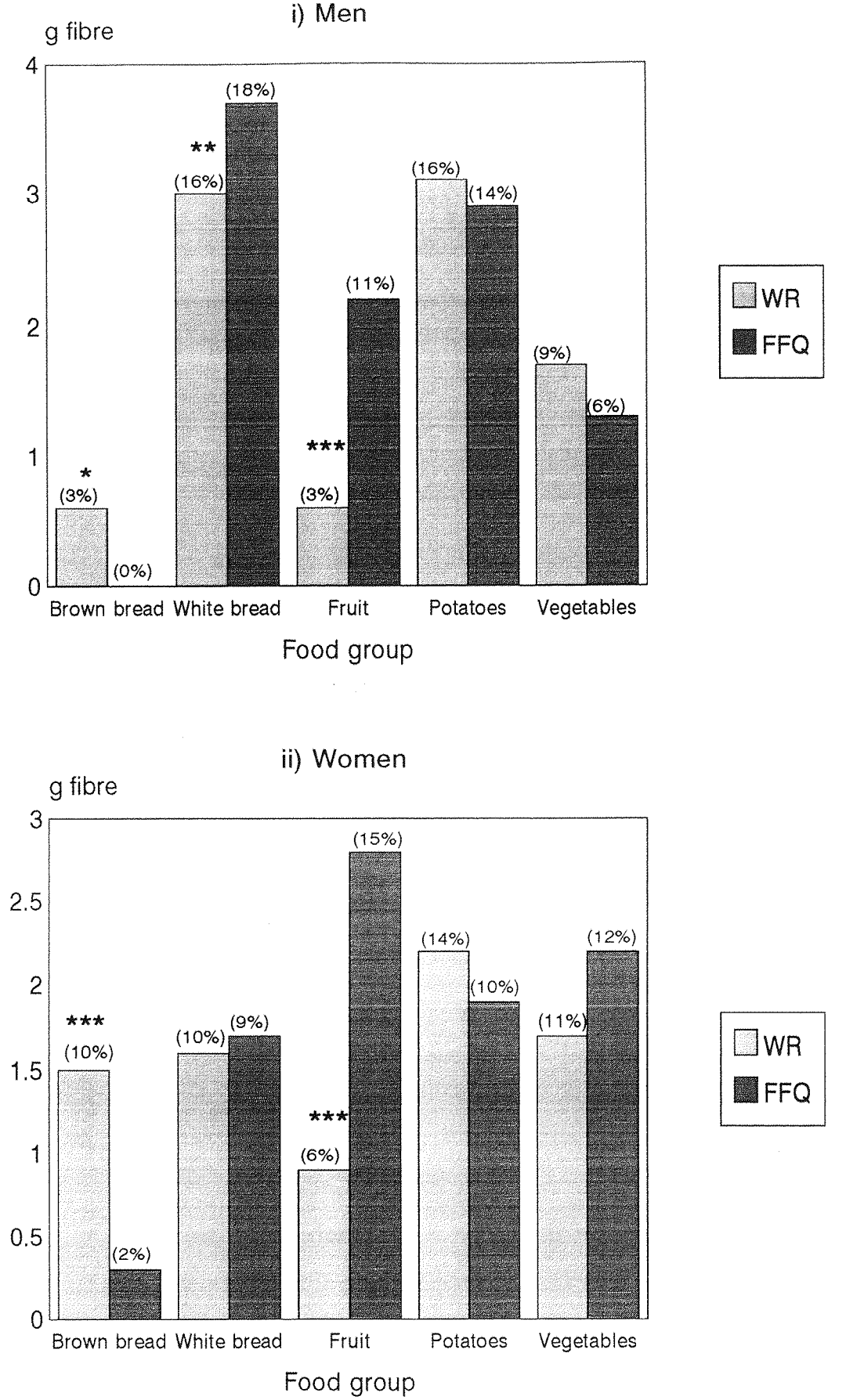
Therefore, the main source of error for vitamin C consumption from the subjects was the overestimation of fruit intake.

Figure 4.4 show the results for fibre. In men, the median intake of fibre was 20.1g by the FFQ and 18.8g using the WR. The respective intakes in women were 18.8 and 15.4g. Therefore the FFQ overestimated fibre intake compared with the WR. From figure 4.4 the main food group contributing to this difference was fruit in both men and women. In men, the intake of fibre from white bread was higher and that from brown bread lower using the FFQ as compared with the WR. In women there appeared to be a higher estimate of fibre from brown bread using the WR. As suggested by figure 4.3 for vitamin C vegetable intake in women appeared to be higher using the FFQ. The percent contribution tended to follow the absolute amount with the exception again of vegetables in women with approximately the same proportion of vitamin C from vegetables by both methods.

These results suggest that much of the overestimation of fibre by the FFQ compared with the WR is a result of more fibre being contributed from fruit in men and women, white bread in men and vegetables in women. This is consistent with the data for vitamin C as overestimation of fruit and vegetables by the FFQ compared with the WR will affect both fibre and vitamin C intakes.

The difference in fat intakes between the FFQ and WR was investigated as other studies have also reported lower

Figure 4.4: Contribution of food groups (g/%) to fibre intake

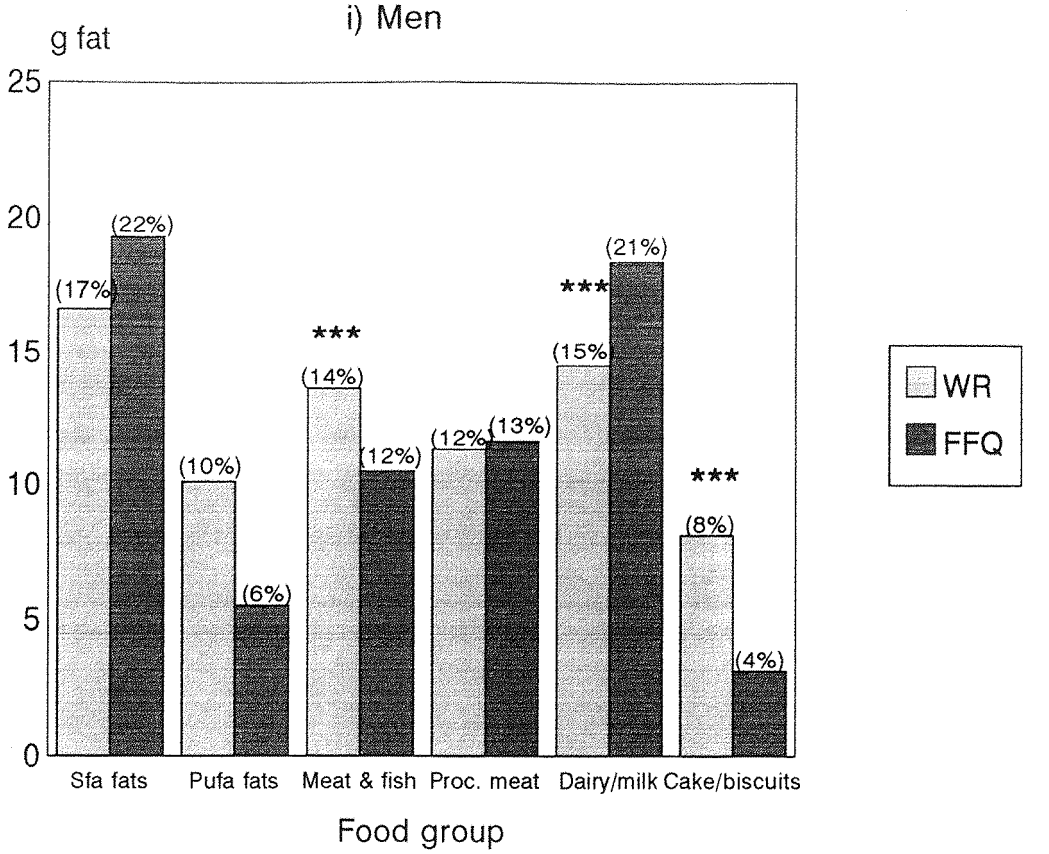


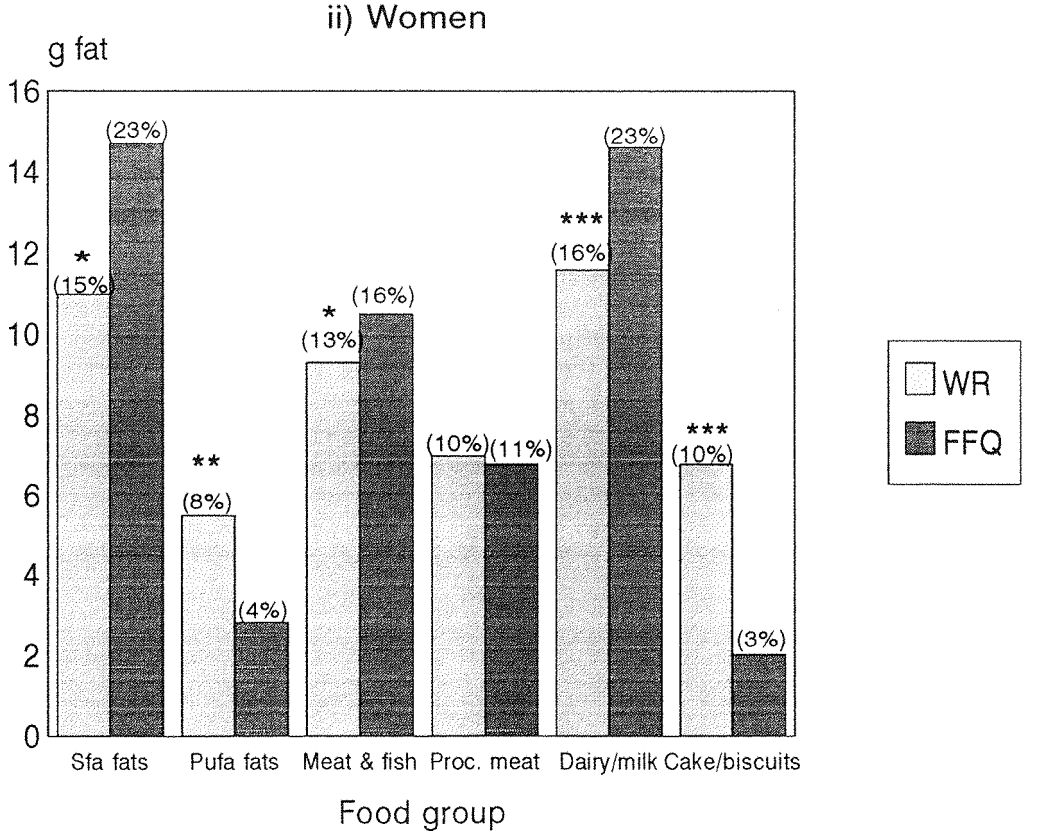
Statistical significance between methods * $p < 0.05$, ** $p < 0.01$, *** $p < 0.01$

intakes of fat estimated from FFQ than WR (Willett *et al*, 1985; Pietinen *et al*, 1988; Tjønneland *et al*, 1991; Posner *et al*, 1992 and Rimm *et al*, 1992). In men the mean difference between the methods was -11.1g and it was -4.7g in women. Figure 4.5 shows the contribution of food groups to absolute intakes for fat. The FFQ underestimated fat intakes from pufa fats, and cakes and biscuits in both men and women and from meat and fish in men. The FFQ, however, in both men and women gave a higher estimate of fat for sfa fats (especially in women) and milk and dairy products. In women only the FFQ gave a higher estimate of fat from meat and fish, the reverse situation to that found in the men. Similar results are reflected by the percent contributions of the food groups.

The differences in fat contributions from these groups appears to be related to different estimates of amounts consumed, rather than subjects reporting eating lower fat options of the same foods but in the same quantities. For meat and fish in men, grammes per day calculated from the WR was 111 and from the FFQ was 87. For women, the corresponding figures were 90 and 87. There appeared to be discrepancies between the estimate of fat intake from all food groups except for processed meats. The main groups that were underestimated using the FFQ were pufa fats, and cakes and biscuits. The discrepancies between the methods appear to be due to an under or overestimation of the amounts of food items consumed and through choosing different varieties of the same product for example reporting consumption of wholemeal bread when white bread is usually eaten. This may result from the use of an incorrect portion size and or incorrect reporting of frequency of consumption of foods by the subject. For oranges and pears in men a comparison was made between the mean portion size used by the FFQ and that calculated using the WR. There appeared to be a good agreement (oranges, 131g WR and 127g FFQ; pears, 143g WR and 140g FFQ). Although interpretation of portion sizes using

Figure 4.5: Contribution of food groups (g/%) to fat intake





Statistical significance between methods * $p < 0.05$, ** $p < 0.01$ *** $p < 0.001$

the WR is difficult with small sample sizes, it appears that error in the amount of fruit consumed was more due to over-reporting frequency than using an incorrect portion size. It is interesting that the foods other than bread that required the subject to estimate quantities of foods eaten (that is milk and fruit) were overestimated by the FFQ compared with the WR.

In conclusion, differences in fruit and soft drinks between the methods affected the agreement for vitamin C, and fruit and bread for fibre, while a wide range of food groups including meat and fish, dairy and milk products, sfa fats, pufa fats, and cakes and biscuits affected the agreement for fat.

4.5 CALIBRATION BY SOURCE OF RECRUITMENT

This section looks at the agreement between the methods for food and nutrient intakes by source of recruitment to see if method of recruitment affects the agreement between the methods and to determine whether groups of randomly recruited subjects and volunteers can be combined. The agreement is tested by mean differences, Spearman rank order correlation coefficients and classification into fifths as before.

4.5.1 Food groups

The composition of the food groups is shown in appendix 3. Table 4.9 shows the median differences (FFQ - WR) and Spearman rank order correlation coefficients between the methods.

In men median differences between the methods were significantly greater than zero for fruit, milk, cakes and biscuits, processed meat, meat and soft drinks for both

Table 4.9: Comparison of median differences and Spearman rank correlation coefficients between the methods by recruitment source

i) Men

	Random		Volunteer	
	Median† difference (5th,95th centiles)	Spearman‡ rank correlation coefficient	Median† difference (5th,95th centiles)	Spearman‡ rank correlation coefficient
Fruit	49*** (-134,131)	0.37*	48*** (-52,159)	0.69**
Vegetables	2 (-71,76)	0.43*	-12* (-98,56)	0.24
Potatoes	-7*** (-151,98)	0.61**	27 (-163,155)	0.23
Low fibre cereal	0 (-12,22)	0.58**	0 (-17,25)	0.73**
High fibre cereal	0 (-14,32)	0.80**	0 (-16,25)	0.69**
White bread	0 (-70,113)	0.78**	24** (-77,135)	0.62**
Brown bread	0 (-153,60)	0.61**	0 (-120,94)	0.54**
Cakes & biscuits	-20*** (-115,29)	0.45*	-20*** (-121,28)	0.31**
Milk	48* (-292,299)	0.48**	78*** (-239,360)	0.47**
Dairy	-3 (-39,54)	0.45*	5 (-34,86)	0.45**
Sfa fat	-1 (-30,33)	0.75**	1 (-27,38)	0.63**
Pufa fat	-1 (-23,36)	0.64**	-1 (-18,15)	0.75**
Processed meat	-13*** (-79,38)	0.55**	10* (-50,79)	0.35*
Meat	-11** (-81,38)	0.35	-18*** (-128,50)	0.23
Fish & chicken	0 (-69,65)	0.30	-7 (-63,63)	0.47**
Snacks	0 (-21,19)	0.51**	0 (-18,27)	0.55**
Tea & coffee	-52 (-2770,1080)	0.27	-5 (-1272,1371)	0.53**
Soft drinks	-22* (-211,175)	0.34	-30*** (-631,74)	0.60**
Sugar	0 (-57,94)	0.10	0 (-33,68)	0.84**
Beer	0* (0,1173)	0.86**	239*** (0,2323)	0.75**
Spirits	0 (0,156)	0.75**	0 (0,49)	0.50**

† Wilcoxon signed rank test * $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$

‡ Two tailed test * $P < 0.05$, ** $P < 0.01$

ii) Women

	Random		Volunteer	
	Median† difference (5th,95th centiles)	Spearman‡ rank correlation coefficient	Median† difference (5th,95th centiles)	Spearman‡ rank correlation coefficient
Fruit	41*** (-32,196)	0.64*	56*** (-39,193)	0.56**
Vegetables	-1 (-70,72)	0.20	-4 (-73,73)	0.27*
Potatoes	-1 (-112,118)	0.35*	7 (-102,99)	0.36**
Low fibre cereal	0 (-8,32)	0.47**	0 (-18,34)	0.48**
High fibre cereal	0 (-8,13)	0.87**	0 (-7,16)	0.76**
White bread	0 (-65,86)	0.52**	0 (-65,107)	0.65**
Brown bread	-2 (-95,85)	0.25	-6** (-81,50)	0.46**
Cakes & biscuits	-16*** (-80,22)	0.36*	-20*** (-60,11)	0.44**
Milk	91** (-342,256)	0.72**	78*** (-200,296)	0.50**
Dairy	6 (-28,38)	0.47*	9*** (-28,57)	0.46**
Sfa fat	-1 (-13,25)	0.60**	0 (-17,31)	0.61**
Pufa fat	-2* (-13,14)	0.57**	-1 (-13,18)	0.58**
Processed meat	-2 (-55,49)	0.28	-1 (-42,40)	0.43**
Meat	-10* (-50,40)	0.36*	-1 (-77,45)	0.45**
Fish & chicken	15** (-50,87)	0.29	20 (-37,86)	0.49**
Snacks	0 (-18,24)	0.54**	0 (-19,42)	0.48**
Tea & coffee	0 (-1509,898)	0.51**	0 (-1475,1069)	0.55**
Soft drinks	-4 (-137,124)	0.58**	0 (-301,87)	0.41**
Sugar	-1 (-33,38)	0.77**	0 (-21,36)	0.75**
Spirits	0 (0,27)	0.60**	0 (0,77)	0.66**

† Wilcoxon signed rank test * $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$
‡ Two tailed test * $P < 0.05$, ** $P < 0.01$

Drinkers only

Men

	Random		Volunteer	
	Median† difference (5th,95th centiles)	Spearman‡ rank correlation coefficient	Median† difference (5th,95th centiles)	Spearman‡ rank correlation coefficient
Number	29		56	
Beer	-62* (-684,470)	0.74**	50 (-673,978)	0.74**
Number	25		31	
Spirits	1 (-160,53)	0.75**	-3 (-54,64)	0.50**

Women

	Random		Volunteer	
	Median† difference (5th,95th centiles)	Spearman‡ rank correlation coefficient	Median† difference (5th,95th centiles)	Spearman‡ rank correlation coefficient
Number	26		48	
Spirits	-3 (-35,23)	0.60**	-1 (-35,60)	0.66**

† Wilcoxon signed rank test * $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$
‡ Two tailed test * $P < 0.05$, ** $P < 0.01$

recruitment groups. In volunteers they also differed for vegetables and white bread. On average Spearman rank correlation coefficients were 0.51 for the random sample and 0.53 for volunteers.

In women, median differences were greater than zero for fruit, milk and cakes in both groups; in the random sample only for polyunsaturated fats, meat and fish; and in volunteers only for brown bread and dairy foods. On average the Spearman correlation coefficients were 0.48 for both the

random sample and volunteers.For alcohol, shown separately for consumers, median difference for beer in men was statistically significantly greater than zero but no significant differences were observed for spirits in men or women.

Using the Mann-Whitney test to determine whether the differences in agreement between the methods differed by recruitment source revealed differences in men for vegetables (P = 0.02), processed meats (P = 0.0002), potatoes (P = 0.01) and beer (P = 0.002). In women no differences between recruitment groups were detected using the Mann-Whitney test.

Table 4.10 shows the percent of subjects who were grossly misclassified into fifths of the distribution for a selection of food groups. Less than 5% of subjects were grossly misclassified for most groups, exceptions were cakes in

Table 4.10: Classification into opposite fifths of the distribution (%)

	Men		Women	
	Random	Volunteer	Random	Volunteer
Fruit	4	0	1	2
Vegetables	2	4	0	1
White bread	0	0	3	2
Cakes	2	4	4	5
Meat pies	0	3	7	1
Meat	2	5	6	2

volunteer women, meat and processed meat in randomly recruited women, and meat in volunteer men and randomly recruited women.

These results show that there were some differences between the sources of recruitment in the agreement between the methods, particularly in men.

The 'correction' method using the Bland Altman plots (on page 140) was tried on the recruitment sources separately (table 4.11) in the same fashion as the 'correction' method for nutrients. A selection of food groups are shown in the table. For sfa fats the 'correction' method worked well with identical results for the 'corrected' FFQ and the WR. However, for fruit; cakes and biscuits, milk and meat although the 'correction' method reduced the difference between the methods there was still a large difference especially for fruit. The reasons for this poor agreement may be that the data for food intakes were further from a normal distribution than the nutrient data and also that individual differences between the methods were larger for foods than nutrients. Therefore as the 'correction method' did not appear reliable when applied to food groups future

Table 4.11: Comparison of uncorrected and corrected median food FFQ values with WR for 121 men and 179 women

	WR	FFQc*	FFQ
Fruit	22 (0,171)	37 (0,114)	89 (0,213)
Cakes & biscuits	37 (0,138)	32 (11,144)	14 (0,76)
Milk	284 (91,638)	349 (165,1136)	426 (284,568)
Sfa fats	18 (0,52)	18 (0,53)	21 (0,69)
Processed meat	42 (6,117)	47 (3,123)	43 (4,103)
Meat	63 (8,175)	54 (11,171)	45 (14,95)

* FFQ corrected using the Bland Altman plots

analyses of food groups using the FFQ will be based on the randomly recruited subjects only as differences in agreement

between the methods by the different recruitment sources may lead to bias.

4.5.2 Nutrient intakes

The agreement for nutrient intakes was first looked at by comparing mean nutrient differences between the groups. Table 4.12 shows the results of the calibration for volunteers and randomly recruited smokers by gender. Mean differences (95% CI) and percent mean differences are given. In men differences tended to be closer to zero for the volunteer sample than the random sample except for sugar and fibre. Largest discrepancies were seen for alcohol and vitamin C with the random sample underestimating their alcohol consumption and overestimating their vitamin C intake by the FFQ compared with the WR. In women estimates of energy intakes were the same for the random sample but for volunteers the measurement was larger for the FFQ than the WR. For other nutrients with the exception of fats and vitamin A were closer to zero for the random sample than the volunteer sample. Similar to men, the women from the random sample underestimated their alcohol consumption by the FFQ compared with the WR, however, estimates were similar for alcohol in volunteers.

A two tailed paired t-test showed that there were no statistically significant differences between randomly selected subjects and volunteers for estimates of intake derived from each method after log transformation of the data, although in men, vitamin C almost reached significance ($P = 0.05$). Therefore, there do not appear to be any large differences in mean nutrient intakes between the methods by source of recruitment.

Table 4.12: Comparison of randomly recruited subjects and volunteers, mean difference (95%CI) and % mean difference

i) Men

Source	Random		Volunteer	
	MD*	% MD	MD	% MD
Energy (MJ)	-0.8 (-1.6,0)	-8	-0.1 (-0.7,0.5)	-1
Protein (g)	-2.5 (-8.6,3.6)	-3	1.4 (-3.9,6.7)	2
Fat (g)	-14.3 (-23.3,-5.3)	-15	-8.9 (-15.8,-2.0)	-9
Polyunsaturated fat (g)	-1.9 (-3.9,0.1)	-11	-1.8 (3.4,-0.2)	-11
Saturated fat (g)	-3.8 (-7.7,0.1)	-10	-0.8 (-3.5,1.9)	-2
Carbohydrate (g)	-12.8 (-35.9,10.3)	-5	6.4 (-10.5,23.3)	2
Sugar (g)	0.7 (-13.8,15.2)	1	12.0 (1.2,22.8)	9
Fibre (g)	1.8 (0.0,3.6)	10	2.1 (0.5,3.7)	11
Alcohol (g)	-4.2 (-7.7,-0.7)	-20	0.5 (-3.0,4.0)	2
Vitamin A (μg)	577 (109,1045)	47	379 (14,744)	33
Vitamin C (mg)	11.3 (3.9,18.7)	22	-0.6 (-8.4,7.2)	-1
Vitamin E (mg)	-1.4 (-2.1,-0.6)	-21	-1.1 (-1.7,-0.5)	-17

* MD, Mean difference (FFQ-WR)

ii) Women

Source	Random		Volunteer	
	MD*	% MD	MD	% MD
Energy (MJ)	0.0 (-0.4,0.4)	0	0.4 (0.0,0.8)	6
Protein (g)	8.5 (4.0,13.0)	13	12.1 (8.5,15.8)	19
Fat (g)	-7.1 (-13.2,-1.0)	-10	-3.3 (-8.0,1.4)	-5
Polyunsaturated fat (g)	-0.6 (-1.8,0.6)	-6	0.0 (-1.0,1.0)	0
Saturated fat (g)	-1.4 (-3.9,1.1)	-5	0.1 (-2.1,2.3)	0
Carbohydrate (g)	4.6 (-13.6,22.8)	2	15.9 (5.3,26.5)	8
Sugar (g)	9.1 (-1.3,19.5)	10	12.0 (5.3,18.7)	14
Fibre (g)	4.0 (2.6,5.4)	27	4.7 (3.5,5.9)	28
Alcohol (g)	-0.9 (-1.9,0.1)	-18	0.2 (-1.2,1.6)	3
Vitamin A (μg)	715 (292,1138)	67	616 (338,894)	57
Vitamin C (mg)	12.8 (4.4,21.2)	24	13.9 (8.6,19.2)	25
Vitamin E (mg)	-0.1 (-0.7,0.5)	-2	0.2 (-0.2,0.6)	4

* MD, Mean difference (FFQ-WR)

The Spearman rank order correlation coefficient was used to test the ranking of individuals by recruitment method. Table 4.13 gives both energy unadjusted and energy adjusted values for selected nutrients. These nutrients were chosen to reflect results from the complete list of nutrients. The results may have been poorer in randomly recruited men as the sample size was smaller than the other groups (49 compared with 68 to 111). Mean energy unadjusted correlation coefficients for the nutrients were 0.43 for both sources of recruitment. Energy adjusted means were 0.55 for the random sample and 0.54 for volunteers. In women mean energy

unadjusted values were 0.49 for the random sample and 0.46 for the volunteers. Energy adjusted means were 0.51 for the random sample and 0.60 for volunteers. Therefore energy-adjustment substantially improved ranking in the volunteer sample but not in the random sample for women.

In general there was no consistent trend in the correlation coefficients for men but in women for the adjusted values volunteers had higher values than the random sample.

Table 4.13: Spearman rank order correlation coefficients by for randomly recruited subjects (R) and volunteers (V)

	MEN				WOMEN			
	Spearman-unadjusted		Spearman-energy adjusted		Spearman-unadjusted		Spearman-energy adjusted	
	R	V	R	V	R	V	R	V
Energy	0.24[ns]	0.47	-	-	0.38	0.32	-	-
Protein	0.33[ns]	0.33	0.57	0.45	0.40	0.33	0.47	0.58
Fat	0.30[ns]	0.35	0.61	0.61	0.49	0.43	0.34	0.59
Cho	0.44	0.60	0.72	0.71	0.37	0.59	0.46	0.72
Fibre	0.42	0.53	0.60	0.64	0.52	0.58	0.57	0.67
Alcohol	0.91	0.76	0.81	0.68	0.84	0.81	0.75	0.80
Vitamin A	0.27[ns]	0.05[ns]	0.24[ns]	0.17[ns]	0.44	0.24	0.51	0.20[ns]
Vitamin C	0.54	0.49	0.54	0.54	0.48	0.55	0.40	0.60
Vitamin E	0.42	0.32	0.36	0.54	0.47	0.38	0.54	0.60

[ns] not statistically significant

In summary, there do not appear to be any major differences in ranking of individuals using the Spearman correlation coefficient although ranking is improved substantially after adjustment for energy intake in all groups except for randomly recruited women.

The percent of individuals classified into the opposite fifth of consumption (grossly misclassified) is shown in table 4.14.

In men, for both random and volunteers no more than 5% of subjects were misclassified and results were similar by recruitment method for each nutrient. In women there appeared to be more variation between the nutrients than in men. In the random selected sample although mean energy intakes were identical 7% of subjects were grossly misclassified.

Table 4.14: Percent of subjects classified into the opposite fifth of distribution

	MEN		WOMEN	
	Random (%)	Volunteer (%)	Random (%)	Volunteer (%)
Energy	4	3	7	3
Protein	4	4	3	5
Fat	2	4	1	3
Cho	2	4	6	0
Fibre	2	0	0	2
Alcohol	0	1	0	0
Vitamin A	4	5	1	9
Vitamin C	0	1	4	3
Vitamin E	2	5	0	3

This greater gross misclassification for random women appears to be due to 6% of subjects being grossly misclassified for carbohydrate. However, no women volunteers were misclassified for carbohydrate. This is also reflected in a higher correlation coefficient for carbohydrate in women volunteers compared with the random sample. In volunteers 9% compared with only 1% of all subjects were grossly misclassified for vitamin A which is also reflected in the Spearman correlation coefficients.

In men and women, on average 2% of random subjects and 3% of the volunteers were grossly misclassified.

In summary, although there are differences for individual

nutrients the overall impression is that gross misclassification of individuals does not differ by method of recruitment.

As the 'correction' method using the Bland Altman technique was reliable for nutrients, any small differences in agreement between the methods could be reduced by applying the 'correction' method separately to the recruitment sources and then combining the sources into one group of smokers. Applying the 'correction' method would also reduce the differential misclassification which was apparent with the FFQ.

In conclusion, although there was a fairly good agreement between the methods based on mean differences, correlation coefficients and classification into fifths of the distribution the Bland Altman method showed that agreement between the methods was not consistent across the range of intake for some nutrients. Using the Bland Altman technique a 'correction' method has been used on the FFQ data which produces absolute estimates of nutrient intake similar to the WR using the FFQ and also facilitates the combination of recruitment groups. The 'correction' method did not prove reliable when applied to food groups, and hence differences in agreement between the groups could not be reduced and recruitment groups of smokers could not be combined.

5. COMPARISON OF SMOKERS BY SOURCE OF RECRUITMENT

In chapter four the FFQ was calibrated against a 10 day weighed record in cigarette smokers and there appeared to be no major differences in the agreement between methods by source of recruitment after 'correction'. However, before combining the FFQs of the two sources of smokers in the cross-sectional analysis it is necessary to determine whether randomly recruited smokers have similar dietary habits to volunteers. Both never smokers and ex-smokers were totally recruited from general practitioner lists, but smokers were recruited partly from these lists and partly through newspaper adverts. If the diets of volunteers who smoked were different from randomly recruited smokers this would bias comparisons between the three smoking categories. For example, assuming that smokers consume less vitamin C than ex-smokers; if volunteers consumed more vitamin C than the random sample this would increase the mean vitamin C intake consumption of smokers, hence reducing the difference in vitamin C intake between smokers and ex-smokers.

With a response rate for attendance for the random smokers of 61% we have no information about the diets of smokers who did not attend the clinic but returned the completed postal questionnaire. Nor is there any information about smokers who did not return their questionnaires. Therefore smokers who did attend could in fact be considered as volunteers. However, the reasons for volunteering between the sources were probably different as the random smokers were unaware the study was looking at a link between diet and smoking, and that smoking cessation classes would be available; whereas the volunteers were aware of the objectives of the study and replied because they wanted to give up smoking.

5.1 CHARACTERISTICS OF SUBJECTS

Table 5.1: Characteristics of the subjects by recruitment source

	Men		Women	
	Random (n = 78)	Volunteer (n = 81)	Random (n = 102)	Volunteer (n = 126)
Age (years)	50.1 (48.7,51.4)	49.2 (48.1,50.3)	50.4 (48.8,52.0)	49.2 (48.2,50.1)
Height (m)	1.74 (1.73,1.76)	1.75 (1.73,1.76)	1.62 (1.61,1.63)	1.62 (1.61,1.64)
Weight (kg)	78.5 (75.7,81.3)	79.0 (76.3,81.7)	67.4 (64.8,70.1)	64.2 (62.4,66.1)
Body mass index (kg/m^2)	25.7 (25.0,26.5)	25.8 (25.1,26.5)	25.7 (24.7,26.7)	24.4* (23.7,25.0)
Number of cigarettes/day	17.1 (14.8,19.4)	26.2** (23.4,28.9)	14.7 (13.2,16.1)	22.9** (21.2,24.5)
Serum cotinine (ng/ml)	267 (240,294)	306 (277,335)	230 (203,256)	269* (246,293)
Occupation† % manual / % non-manual	53/41	46/49	54/40	42/52
% taking vitamin supplements	19	17	36	37

* $P < 0.05$ ** $P < 0.001$ (within gender groups)

† Numbers do not add up to 100% as some subjects could not be classified -ie worked in the armed forces or housewife

Table 5.1 shows the main characteristics of the subjects by recruitment source. Approximately half the subjects were recruited randomly and half using advertisements. Volunteers appeared to be about one year younger than the random sample but this was not statistically significant. There were also no statistical differences for height, weight or occupation group by source of recruitment, although the random sample tended to contain more subjects from manual occupations and fewer from non-manual occupations than the volunteers. Body mass index was similar between recruitment groups for men but in women the volunteer sample had a statistically significantly lower body mass index than the random sample.

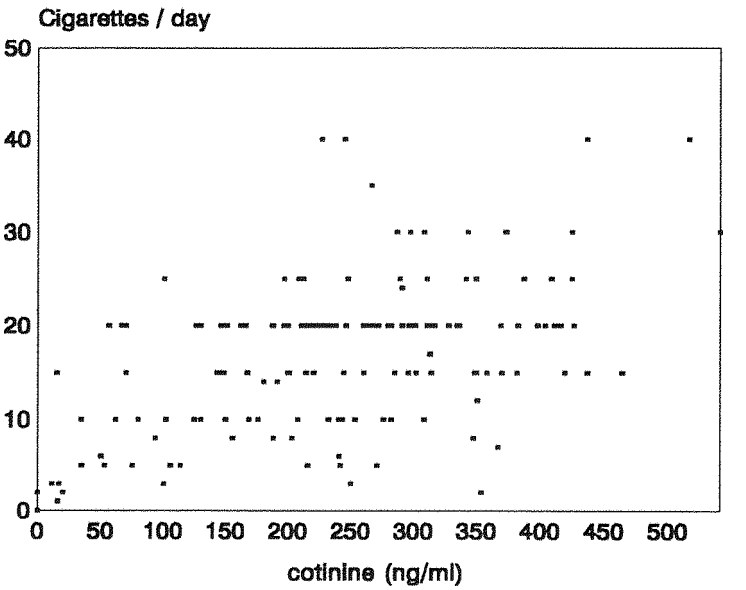
The percentage of subjects who reported taking vitamin supplements at the time of their appointment was similar by source of recruitment (19% and 17% in men for random and volunteer samples and 36% and 37% respectively in women).

The only statistically significant difference in both men and women was for reported number of cigarettes smoked daily. On average men who volunteered, smoked nine more cigarettes per day than those randomly selected, the corresponding difference for women being eight cigarettes per day. Volunteers tended to have slightly higher serum cotinine levels than the random sample as would be expected if they smoked more cigarettes. However, the percent difference between the groups was much smaller using the cotinine estimates than the reported number of cigarettes.

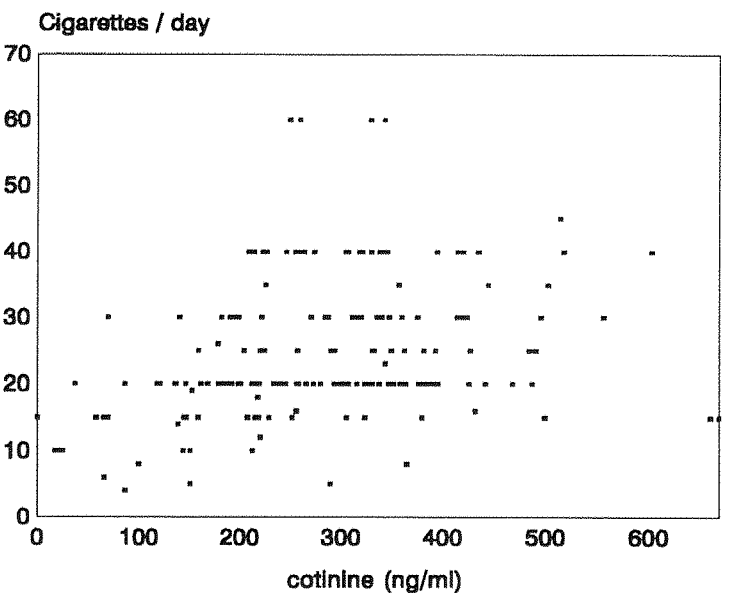
Figure 5.1 shows graphs of reported number of cigarettes smoked against serum cotinine measurement for the random sample and the volunteers. Results for men and women have been combined as trends were similar for each gender group. The correlation between the reported cigarette consumption and cotinine measurement in the random sample was higher than that in the volunteers (0.51 compared with 0.32). Woodward *et al* (1991) found a correlation of 0.49 in men and 0.47 in women between number of cigarettes smoked and serum cotinine; a similar result to the random smokers. As Woodward *et al*, (1991) found a curvilinear response with a levelling out around 25 cigarettes per day, correlations were made for subjects who reported smoking less than 25 cigarettes per day. However, the values did not alter.

Figure 5.1: Graphs of reported number of cigarettes smoked against serum cotinine

i) Random sample



ii)
Volunteer sample



The difference between reported number of cigarettes smoked and cotinine measurement between the recruitment groups may

arise because of variability between the groups in the strength of cigarettes smoked, differences in inhalation and in the lengths of cigarettes discarded. Alternatively, volunteers may have over-reported or randomly recruited smokers over-reported their cigarette consumption.

In future analyses using a measure of cigarette exposure cotinine measurements will be used in preference to reported number of cigarettes.

There appeared to be no major differences by source of recruitment in terms of age, height, weight, occupation group, cotinine and % taking vitamin supplements, although women who volunteered were leaner than those who were randomly selected. Volunteers reported smoking more cigarettes than the random sample.

5.2 COMPARISON OF MEAN DAILY NUTRIENT INTAKES

The possibility exists that the dietary habits of the subjects recruited from the two sources may differ. In chapter four the 'correction' method which takes into account differences in agreement between the methods for randomly recruited and volunteer subjects was described. The 'correction' technique was applied to men and women separately and for each recruitment group.

The mean nutrient intakes by source of recruitment both corrected and uncorrected are shown in tables 5.2i and 5.2ii for men and women respectively.

Table 5.2: Comparison of mean daily nutrient intakes (95% CI) with and without 'correction' between the random and volunteer samples .

i) Men (random n = 78, volunteers n = 81)

	Uncorrected		Corrected		Anova	
	Random	Volunteer	Random	Volunteer	P1*	P2**
Energy (MJ)	9.2 (8.7,9.7)	10.1 (9.5,10.7)	10.1 (9.6,10.5)	10.2 (9.8,10.7)	0.03	0.55
Protein (g)	80.6 (76.2,85.1)	86.9 (82.1,91.6)	84.5 (80.3,88.8)	84.2 (80.7,87.6)	0.09	0.91
Fat (g)	84.6 (77.5,91.8)	90.3 (83.9,96.7)	96.6 (91.2,102.0)	97.5 (93.4,101.6)	0.13	0.55
Pufa (g)	14.7 (12.8,16.5)	14.4 (12.8,16.1)	16.7 (15.3,18.1)	16.2 (14.6,17.9)	0.96	0.32
Sfa (g)	35.3 (32.1,38.5)	39.1 (36.1,42.0)	38.9 (36.4,41.4)	39.2 (37.3,41.0)	0.05	0.56
Cho (g)	262.8 (247.3,278.3)	284.2 (264.7,303.7)	277.9 (263.3,292.5)	277.9 (262.4,293.4)	0.08	0.94
Sugar (g)	128.8 (116.7,141.0)	142.4 (127.6,157.1)	128.1 (116.0,140.3)	129.1 (117.4,140.7)	0.13	0.72
Fibre (g)	20.6 (19.2,22.1)	21.6 (20.1,23.0)	18.7 (17.7,19.8)	19.5 (18.0,20.9)	0.35	0.92
Alcohol† (g)	23.5 (18.5,28.5)	26.4 (18.5,28.5)	29.3 (23.4,35.1)	25.9 (19.5,32.2)	0.99	0.06
Vit A (μg)	2049 (1644,2453)	1544 (1243,1846)	1472 (1067,1876)	1027 (843,1211)	0.09	0.58
Vit C (mg)	65.9 (58.9,73.0)	60.5 (54.7,66.2)	57.2 (50.8,63.5)	58.6 (50.2,67.1)	0.78	0.51
Vit E (mg)	5.3 (4.8,5.8)	5.6 (5.0,6.2)	6.7 (6.0,7.5)	6.8 (6.0,7.5)	0.12	0.29

* P1 for uncorrected values (transformed data)
** P2 for corrected values (transformed data)
† Alcohol consumers only (random n = 54, volunteer n = 79)

ii) Women (random n = 102, volunteers n = 126)

	Uncorrected		Corrected		Anova	
	Random	Volunteer	Random	Volunteer	P1*	P2**
Energy (MJ)	7.0 (6.7,7.4)	7.3 (7.0,7.7)	7.0 (6.7,7.4)	7.0 (6.7,7.2)	0.39	0.95
Protein (g)	72.8 (69.2,76.4)	74.6 (71.1,78.1)	62.9 (59.6,66.2)	62.8 (60.3,65.2)	0.36	0.84
Fat (g)	67.0 (62.3,71.7)	67.6 (63.0,72.1)	76.3 (71.0,81.7)	73.2 (69.6,76.9)	0.72	0.60
Pufa (g)	10.5 (9.7,11.4)	11.2 (10.2,12.2)	11.7 (10.9,12.5)	11.4 (10.7,12.2)	0.67	0.74
Sfa (g)	29.5 (26.9,32.1)	29.2 (26.9,31.6)	30.0 (27.3,32.6)	29.4 (27.6,31.3)	0.90	0.88
Cho (g)	196.7 (184.2,209.1)	206.7 (194.8,218.7)	188.8 (177.1,200.5)	189.2 (179.8,187.7)	0.56	0.87
Sugar (g)	98.0 (88.9,107.1)	99.9 (91.7,108.1)	90.2 (81.8,98.7)	88.8 (81.6,96.0)	0.71	0.63
Fibre (g)	19.1 (17.8,20.4)	20.7 (19.2,22.1)	15.1 (14.0,16.2)	16.1 (15.0,17.3)	0.44	0.51
Alcohol† (g)	9.7 (7.0,12.3)	13.0 (10.1,15.9)	10.9 (8.0,13.9)	11.2 (8.6,13.9)	0.06	0.78
Vit A (μg)	1829 (1506,2153)	1608 (1387,1828)	1230 (961,1498)	876 (717,1036)	0.91	0.12
Vit C (mg)	67.6 (62.2,73.1)	68.3 (62.5,74.0)	54.8 (49.4,60.3)	53.2 (47.8,58.6)	0.79	0.31
Vit E (mg)	4.6 (4.2,4.9)	4.7 (4.4,5.1)	4.9 (4.4,5.3)	4.9 (4.6,5.3)	0.73	0.55

* P1 for uncorrected values
** P2 for corrected values
† Alcohol consumers only (random n = 55, volunteer n = 70)

In men, after 'correction' the difference in energy intake between random and volunteer subjects was reduced and was no longer statistically significant. Differences between recruitment groups for protein, carbohydrate and vitamin A

which were marginally significant using uncorrected estimates were reduced after 'correction'. Differences between recruitment groups were reduced for all nutrients except for polyunsaturated fat and alcohol where 'correction' increased the difference between the methods from 0.3g to 0.5g for polyunsaturated fat and from 2.9 to 3.4 for alcohol. The difference did not reach statistical significance for polyunsaturated fat but was marginally significant for alcohol. Mean % differences (not shown) between recruitment groups for 'corrected' values were small (< 5%) for most nutrients but larger for vitamin A (30%) and alcohol (12%).

The 95% confidence intervals were also larger for the 'uncorrected' values. This appeared to result from subjects with low intakes underestimating intake using the FFQ and those with high intakes overestimating intake, thus increasing the range and standard error of estimates. This could be explained by the use of mean portion sizes: for subjects with low intakes the portion size may be too small and for subjects with high intakes it may be too large: whereas those with a middle of the range intake showed a good agreement. Also, it is possible that subjects with low intakes may under-report frequency and those with high intakes over report frequency, whereas those in the middle of the range may correctly estimate frequency of consumption.

In women, the 'corrected' values were closer than the 'uncorrected' values for most nutrients except for fat, saturated fat, vitamin A and vitamin C. However, differences were not statistically significant and differences in the 'corrected' estimates were less than 5% for most nutrients except for fibre (7%) and vitamin A (29%). Correcting the FFQ for alcohol intake reduced the difference between the sources from 3.7 to 0.3. Thus virtually all the difference between recruitment groups was due to differences in the agreement between the dietary methods and not real difference.

Difference in agreement between the dietary methods appears to account for most of the difference between recruitment groups. Overall, there appears to be close agreement between random recruits and volunteers after 'correction' of the FFQ values, with the exception of vitamin A in which randomly recruited men and women consumed higher intakes than volunteers. There were also differences for polyunsaturated fat and alcohol in men and fibre in women.

There were small differences in age, occupation group and cotinine measurement between the sources. To investigate the effect of these differences, means adjusted for age and occupation, and age, occupation and cotinine were calculated. Table 5.3 shows corrected values adjusted for age and occupation; and age, occupation and cotinine. The sample sizes are smaller as not all subjects were able to be classified into an occupation group and cotinine measurements were missing for 18 men and 36 women.

For men, differences between the adjusted means were small (< 5% not shown) after adjustment for age and occupation but larger for fibre (6%), vitamin A (34%) and alcohol (11%).

After the additional adjustment for cotinine measurements differences were more than 5% for polyunsaturated fat (6%), fibre (7%), vitamin A (33%) and alcohol (16%). In women, the differences were small except for vitamin A (20%) after adjustment for age and occupation. After the additional adjustment for cotinine the difference was more than 5% for vitamin A (22%) and alcohol (8%). However, no nutrient reached statistical significance in men or women.

Table 5.3: Nutrient comparisons by recruitment source using corrected values after adjustment for age, occupation group and serum cotinine.
(results shown for subjects with a complete data set (64 random, 70 volunteers)

i) Men

	Means adjusted for age and occupation		Means adjusted for age, occupation and serum cotinine			
	Random	Volunteer	Random	Volunteer	Anova P3*	Anova P4**
Energy (MJ)	10.1	10.3	10.0	10.4	0.40	0.38
Protein (g)	85.3	84.5	84.8	84.9	0.98	0.80
Fat (g)	96.4	98.5	96.5	98.4	0.42	0.48
Pufa (g)	17.1	16.5	17.1	16.5	0.37	0.39
Sfa (g)	38.1	39.5	38.2	39.4	0.28	0.35
Cho (g)	276.2	282.4	276.0	279.5	0.62	0.58
Sugar (g)	127.9	131.1	128.1	130.8	0.61	0.66
Fibre (g)	18.7	19.8	18.6	19.9	0.67	0.47
Alcohol (g)	29.9	26.7	30.3	26.4	0.10	0.08
Vit A (μg)	1594	1057	1583	1067	0.69	0.59
Vit C (mg)	59.2	59.0	59.0	59.1	0.31	0.31
Vit E (mg)	6.9	6.8	6.9	6.8	0.32	0.26

* Analysis of variance adjusted for age and occupation
** Analysis of variance adjusted for age, occupation and cotinine

ii) Women (random 78, volunteer 99)

	Means adjusted for age and occupation		Means adjusted for age, occupation and serum cotinine			
	Random	Volunteer	Random	Volunteer	Anova P3*	Anova P4**
Energy (MJ)	7.2	7.0	7.2	7.0	0.82	0.87
Protein (g)	64.0	63.7	63.6	64.0	0.98	0.78
Fat (g)	77.5	74.3	77.8	74.0	0.73	0.64
Pufa (g)	12.0	11.5	12.0	11.5	0.34	0.43
Sfa (g)	30.2	29.9	30.4	29.7	0.62	0.77
Cho (g)	193.2	188.7	193.3	188.6	0.68	0.65
Sugar (g)	92.1	87.5	92.3	87.4	0.35	0.40
Fibre (g)	15.6	16.2	15.6	16.2	0.96	0.99
Alcohol (g)	11.7	12.3	11.5	12.4	0.59	0.69
Vit A (μg)	1178	943	1192	932	0.66	0.57
Vit C (mg)	55.2	55.2	55.0	55.4	0.90	0.93
Vit E (mg)	5.0	4.9	4.9	5.0	0.95	0.95

* Analysis of variance adjusted for age and occupation
** Analysis of variance adjusted for age, occupation and cotinine

In both men and women, randomly recruited cigarette smokers consumed more vitamin A then the volunteers, and this was not affected by age, occupation group or cotinine measurement. Alcohol consumption appeared to differ by recruitment source in men with the random sample consuming more alcohol than the volunteers. The adjustment for age, occupation group and cotinine appeared to have little effect on the differences between recruitment groups in men or women.

If a dose response relationship exists between diet and smoking it may be expected that adjusting for cotinine would reduce the difference between the groups. However,

difference in cotinine measurements were small and so were sample sizes with complete data sets and therefore differences may have existed but could not be detected.

In summary, for most nutrients there was little difference in nutrient intake after 'correction' of the FFQ. However, differences were observed for vitamin A and alcohol in men and women, and for fibre in men and women and polyunsaturated fat in men.

6. CROSS-SECTIONAL STUDY-FOOD PATTERNS

The results of the cross-sectional study, comparing the dietary habits of current smokers, ex-cigarette smokers and never smokers are described in chapters six and seven. The overall differences in food intakes between smoking categories are discussed in chapter six whilst nutrient differences are discussed in chapter seven. The effect of occupation group on differences in food intakes between the smoking categories will be investigated in chapter six.

Chapter four showed that although the overall agreement between the WR and FFQ for food items was not affected by source of recruitment, there were differences for individual food groups which could lead to misleading results if the random sample and volunteers were analysed as a composite group. The 'correction' method was not reliable when applied to the food groups. Therefore, analysis has been carried out on the random sample only.

6.1 SUBJECT CHARACTERISTICS

To investigate whether there is a dose response relationship between nutrient intake and cigarette smoking the smokers were divided into two groups heavy smokers and light smokers. Smokers with a serum cotinine of at least 265ng/ml were regarded as heavy smokers and those with a values of less than 265ng/ml as light smokers (265 was the 50th percentile value when men and women were combined). Smokers with no cotinine estimate were excluded from these analyses. Table 6.1 shows the general characteristics of all subjects. Similar results were obtained when randomly recruited subjects were analysed separately. For men, shown in table 6.1i, there was a statistically significant difference for age across smoking groups, with ex-smokers on average two years older than smokers and one year older than never

smokers. There was no difference in height between smoking groups. For weight and body mass index there were statistically significant differences between smoking groups with heavy smokers having the lowest BMI and ex-smokers with the highest BMI. Never smokers and light smokers had a similar BMI. Occupation group and percentage of men taking dietary supplements did not differ by smoking category. Approximately 20% of all men were taking dietary supplements at the time of their appointment and slightly more never smokers than current smokers (24% compared with 19%) took supplements.

Table 6.1: Subject characteristics (random sample only)

i) Men

	Heavy smokers	Light smokers	Ex-smokers	Never smokers	p*
Number	79	62	105	76	
Age (years)	49.8 (48.6,51.0)	49.6 (48.1,51.0)	52.1 (50.9,53.3)	50.8 (49.4,52.2)	0.03
Height (m)	1.74 (1.72,1.75)	1.76 (1.74,1.77)	1.75 (1.74,1.76)	1.76 (1.74,1.78)	0.19
Weight (kg)	76.5 (73.6,79.4)	81.3 (78.5,84.1)	82.4 (79.9,84.8)	80.9 (78.1,83.8)	0.006
Body mass index (kg/m^2)	25.2 (24.5,26.0)	26.3 (25.5,27.0)	26.9 (26.2,27.6)	26.1 (25.4,26.9)	0.009
Occupation† % manual / % non-manual	44/49	58/39	48/51	46/54	0.36
% taking dietary supplements	19	13	20	24	0.43

ii) Women

	Heavy smokers	Light smokers	Ex-smokers	Never smokers	p*
Number	86	102	125	217	
Age (years)	49.7 (48.4,50.9)	49.8 (48.3,51.3)	51.2 (50.2,52.3)	52.0 (51.2,52.8)	0.09
Height (m)	1.63 (1.61,1.64)	1.63 (1.61,1.64)	1.63 (1.61,1.64)	1.62 (1.61,1.62)	0.31
Weight (kg)	64.4 (61.8,66.9)	67.9 (65.4,70.4)	70.2 (68.0,72.4)	68.5 (63.8,73.2)	0.001
Body mass index (kg/m^2)	24.4 (23.5,25.3)	25.7 (24.8,26.6)	26.5 (25.8,27.3)	25.4 (24.9,25.9)	0.001
Occupation† % manual / % non-manual	48/45	50/45	46/50	42/55	0.45
% taking dietary supplements	28	45	34	32	0.06

* Statistical tests, analysis of variance for age, height and weight; chi squared occupation group and dietary supplements.
† Numbers do not add up to 100% as some subjects were not able to be classified (eg armed forces, housewives.

The same results for women are shown in table 6.1ii. The results show that there was a similar trend to that found in men for age, with smokers appearing younger than non-smokers. Height did not appear to differ between smoking categories. Weight and body mass index varied by smoking category with heavy smokers having the lowest weight and BMI and the ex-smokers with the highest weight and BMI. Again as found in the men, the BMIs of never smokers and light smokers were similar. Occupation group differences were not statistically significant across smoking categories, although heavy smokers and light smokers were more likely to belong to manual occupations than non-smokers. The percent of ex-smoking and never smoking women who reported taking dietary supplements was similar (34% and 32%). However, light smokers appeared more likely to take dietary supplements than non-smokers, and heavy smokers less likely. More women than men took dietary supplements; 34% of women took dietary supplements compared to 20% of men.

The number of cigarettes reported as smoked daily by men was 23.2 (range 2 to 60) and for women was 19.3 (range 2 per week to 60 per day).

For ex-smokers, mean time since quitting for men was 13.8 years (range 0.1 to 39 years) and for women was 14.1 years (range 1 week to 40 years). Three men and six women had quit less than one year before their appointment, 12 men and 17 women had quit between one and four years previously, 19 men and 25 women between five and nine years earlier and 71 men and 77 women had quit for more than nine years.

In summary, ex-smokers had the highest body mass index and heavy smokers had the lowest BMI. A higher proportion of smokers had manual occupations than ex and never smokers. Smokers were younger than ex-smokers and in women more light smokers than the other groups reported taking dietary supplements.

6.2 FOOD CHOICES AND SMOKING STATUS

Food group data using the FFQ did not approximate a normal distribution even after transformation, and therefore non-parametric tests have been used. Table 6.2 shows median weights (with 5th and 95th centiles) of the food groups by smoking category. The composition of each food group is shown in appendix 3. The significance of the Kruskal-Wallis test (see chapter 2) is shown for all four smoking categories (P1) and for all smokers (heavy and light), ex-smokers and never smokers (P2).

Table 6.2: Median weights (5th, 95th centiles) of food groups (g/day) consumed by each smoking category

i) Men

	Heavy smokers	Light smokers	Ex-smokers	Never smokers	*P1	*P2
Number	39	29	105	76		
Fruit	86 (0,207)	69 (0,310)	117 (0,269)	116 (0,258)	0.003	0.008
Vegetables	58 (7,102)	44 (7,102)	58 (9,102)	44 (27,102)	0.32	0.43
Potatoes	173 (51,276)	154 (19,325)	171 (45,297)	168 (90,275)	0.36	0.52
Breakfast cereals	12 (0,47)	15 (0,76)	25 (0,70)	34 (0,63)	0.02	0.003
White breads	88 (0,266)	68 (0,251)	77 (0,208)	36 (0,245)	0.02	0.007
Brown breads	0 (0,180)	0 (0,162)	6 (0,102)	14 (0,127)	0.008	0.007
Cakes & biscuits	12 (0,50)	18 (0,74)	13 (0,79)	16 (0,79)	0.54	0.52
Milk	284 (284,568)	284 (142,568)	284 (0,568)	284 (284,568)	0.73	0.56
Dairy	40 (16,119)	41 (4,108)	41 (16,104)	40 (7,84)	0.67	0.70
Sfa fats	21 (0,88)	11 (0,53)	3 (0,43)	8 (0,43)	0.07	0.02
Pufa fats	6 (0,67)	5 (0,47)	7 (0,60)	7 (0,54)	0.90	0.68
Processed meat	40 (5,126)	36 (0,162)	35 (0,90)	37 (5,95)	0.22	0.47
Meat	42 (7,80)	47 (11,88)	44 (0,86)	40 (0,89)	0.49	0.37
Fish & chicken	39 (8,104)	36 (0,167)	54 (15,124)	49 (8,100)	0.02	0.01
Snacks	5 (0,28)	7 (0,39)	10 (0,47)	10 (0,38)	0.11	0.06
Tea & coffee	1260 (720,2700)	1260 (720,2880)	1260 (414,2160)	1080 (540,2520)	0.11	0.03
Soft drinks	36 (0,180)	52 (0,194)	36 (0,166)	36 (0,180)	0.75	0.49
Sugar	46 (0,140)	41 (0,160)	1 (0,97)	2 (0,72)	<.0001	<0.0001

ii) Women

	Heavy smokers	Light smokers	Ex-smokers	Never smokers	P1	P2
Number	30	51	125	217		
Fruit	68 (0,245)	114 (0,268)	146 (13,281)	129 (13,299)	0.001	0.001
Vegetables	80 (11,102)	73 (23,102)	73 (19,102)	73 (15,102)	0.76	0.36
Potatoes	162 (47,405)	149 (8,237)	150 (26,267)	166 (40,269)	0.09	0.08
Breakfast cereals	0 (0,58)	17 (0,60)	20 (0,68)	29 (0,81)	<.0001	<.0001
White breads	35 (0,176)	34 (0,148)	34 (0,166)	41 (0,154)	0.79	0.57
Brown breads	4 (0,81)	15 (0,114)	4 (0,72)	10 (0,101)	0.15	0.12
Cakes	13 (0,78)	7 (0,54)	11 (0,51)	14 (0,68)	0.02	0.02
Milk	426 (0,568)	284 (284,568)	284 (0,568)	284 (284,568)	0.46	0.43
Dairy	39 (4,114)	36 (8,91)	34 (9,790	36 (4,78)	0.96	0.84
Sfa fats	17 (0,72)	15 (0,49)	7 (0,37)	3 (0,36)	0.003	<.0001
Pufa fats	3 (0,41)	2 (0,24)	3 (0,28)	6 (0,32)	0.007	0.002
Processed meat	22 (0,72)	29 (0,74)	22 (0,64)	23 (0,68)	0.57	0.84
Meat	34 (0,91)	42 (4,103)	31 (0,77)	35 (0,86)	0.37	0.47
Fish & chicken	47 (22,189)	64 (8,137)	57 (16,124)	59 (15,137)	0.87	0.38
Snacks	7 (0,65)	7 (0,43)	7 (0,41)	7 (0,45)	0.87	0.87
Tea & coffee	1620 (369,3105)	1260 (540,2700)	1080 (594,1800)	1080 (540,1800)	0.0001	0.0001
Soft drinks	45 (0,180)	71 (0,186)	52 (0,166)	48 (0,166)	0.54	0.56
Sugar	0 (0,151)	1 (0,77)	0 (0,41)	0 (0,41)	0.10	0.05

* Kruskal-Wallis - P1 analysis of all 4 smoking groups
- P2 analysis of 3 smoking groups (data for heavy and light smokers have been combined)

Tables 6.2i and 6.2ii show that for men and women there were statistically significant differences between smokers (as one group), ex-smokers and never smokers for fruit, breakfast cereals, saturated fats, tea and coffee. In men only, there were differences for white and brown breads, fish and chicken and sugar; and in women only, for cakes and polyunsaturated fats. There were no statistically significant differences for vegetables, potatoes, milk, dairy foods, processed meat, meat, snacks or soft drinks in men or women between smoking categories. Further detailed information for milk was unavailable as although questions were asked on types of milk consumed, subjects were able to record an answer of more than one type of milk and therefore precise information on how much of each type is not known (appendix 2).

Men and women who smoked consumed the least fruit, whereas intakes were similar between never and ex-smokers. In women, heavy smokers and never smokers appeared to consume more potatoes than light and ex-smokers. In both men and women for breakfast cereals, never smokers had the highest intakes and heavy smokers the lowest intake.

Bread intake did not differ by smoking category in women but in men, smokers and ex-smokers ate more white bread but less brown bread than never smokers. In women heavy smokers and never smokers consumed the most cakes and biscuits with the lowest intake by light smokers.

Saturated fats differed by smoking category in men and women with heavy smokers with the highest intake and non-smokers with the lowest. Difference between smoking categories was also found for polyunsaturated fats in women with never smokers consuming the most but there was little difference detected between smokers and ex-smokers.

For fish and chicken in men, never and ex-smokers consumed more than smokers. For tea and coffee in men, intakes were

the same for smokers and ex-smokers but lowest for never smokers. In women highest intake of tea and coffee was in heavy smokers with light smokers intermediate and lowest intake in ex-smokers and never smokers. For sugar in men, smokers consumed much higher quantities than non-smokers.

Table 6.3: Median weight (5th, 95th centiles) for types of alcohol (g/day) consumed by each smoking category (random and volunteer smokers combined)

i) Men

	Heavy smokers	Light smokers	Ex-smokers	Never smokers	P1	P2
Number	79	62	105	76		
Wine	0 (0,141)	0 (0,186)	0 (0,213)	0 (0,142)	0.03	0.02
Beer	0 (0,1136)	0 (0,1215)	159 (0,1218)	40 (0,1210)	0.05	0.02
Spirits	0 (0,144)	0 (0,144)	0 (0,46)	0 (0,18)	0.007	0.003
Consumers only						
Number (%)	17 (22)	26 (55)	41 (39)	28 (37)		
Wine	107 (17,372)	72 (17,248)	88 (17,471)	71 (13,176)	0.24	0.29
Number (%)	43 (54)	39 (63)	68 (65)	39 (51)		
Beer	488 (80,1686)	488 (40,2272)	488 (80,1250)	329 (40,1465)	0.61	0.49
Number (%)	30 (38)	20 (32)	37 (35)	12 (16)		
Spirits	29 (3,192)	22 (2,190)	21 (3,77)	14 (2,27)	0.05	0.02

ii) Women

(Data for beer consumption is not shown as very few women consumed beer)

	Heavy smokers	Light smokers	Ex-smokers	Never smokers	P1	P2
Number	86	102	125	217		
Wine	0 (0,132)	0 (0,290)	0 (0,213)	0 (0,248)	0.16	0.03
Spirits	0 (0,27)	0 (0,45)	0 (0,31)	0 (0,21)	0.02	0.007
Consumers only						
Number (%)	27 (31)	38 (37)	59 (47)	93 (43)		
Wine	72 (17,351)	72 (9,372)	71 (17,248)	72 (9,253)	0.71	0.58
Number (%)	27 (31)	33 (32)	36 (29)	34 (16)		
Spirits	21 (2,96)	10 (2,98)	14 (3,52)	14 (2,84)	0.59	0.72

* Kruskal-Wallis - P1 analysis of all 4 smoking groups
- P2 analysis of 3 smoking groups (data for heavy and light smokers have been combined)

For types of alcoholic beverage consumed shown in table 6.3 the overall medians are difficult to interpret as not all subjects consumed alcohol; therefore analysis has also been carried out for consumers of each type of alcoholic drink only. No differences were detected in types of alcohol consumed between the smoking groups with the exception of spirits in men where the lowest intake was by never smokers and the highest in heavy smokers. The table also shows the percent of each category that consumed each alcoholic beverage. In both men and women, a higher percentage of ex-smokers and never smokers consumed wine than smokers. Approximately equal percentages of heavy, light and ex-smoking men and women consumed spirits but only half this proportion of never smoking men and women consumed spirits. Therefore the main difference between the smoking categories with respect to alcohol consumption was in consumption of spirits with a lower proportion of men and women who had

never smoked consuming spirits than the other groups. In addition, smokers were less likely to consume wine than non-smokers.

The ex-smokers appeared to have intakes more like never smokers with the exception of white bread in men and women, where intakes were similar between heavy smokers, light smokers and ex-smokers. For tea and coffee in men, ex-smokers consumed similar intakes to smokers. For alcoholic beverages ex-smokers had habits more like smokers than never smokers.

Therefore, there were differences in food choices between smoking categories with smokers eating more less 'healthy foods' and more 'unhealthy foods than never smokers. Ex-smokers appear to have diets between smokers and never smokers. However, the effects of confounding variables such as age and occupation group have not been taken into account and may affect the results. This point will be discussed further later in the chapter.

These differences in a wide range of food choices affect the overall diet and their effect on nutrient intakes will be discussed in chapter seven.

6.3 THE EFFECT OF OCCUPATION GROUP

Occupation group is adjusted for in most published studies as smoking is associated with manual occupations and non-smoking with non-manual occupations. Table 6.1 suggested that smoking was associated with a manual occupation. To determine whether within occupation groups the same relationships between smoking and food intakes were apparent the subjects were

Table 6.4: Analysis of selected foods by smoking status and occupation group

i) Men

	Smokers	Ex-smokers	Never smokers	*
NON-MANUAL				
Number	32	54	41	
Fruit	80 (0,324)	130 (0,282)	108 (13,262)	0.28
Potatoes	172 (74,286)	161 (16,296)	159 (87,269)	0.45
High fibre cereals	1 (0,49)	0 (0,47)	26 (0,51)	0.002
Saturated fats	15 (0,54)	1 (0,42)	6 (0,44)	0.39
Snacks	8 (0,36)	9 (0,49)	14 (0,35)	0.99
Tea & coffee	1260 (657,2412)	1080 (270,2025)	1080 (396,2502)	0.18
Sugar	46 (0,167)	0 (0,95)	1 (0,40)	<0.0001
MANUAL				
Number	51	50	35	
Fruit	68 (0,196)	112 (0,252)	132 (0,260)	0.003
Potatoes	166 (27,286)	200 (117,3100	175 (107,280)	0.03
High fibre cereals	0 (0,46)	0 (0,50)	0 (0,45)	0.38
Saturated fats	19 (0,76)	6 (0,48)	9 (0,47)	0.11
Snacks	4 (0,28)	11 (0,47)	7 (0,45)	0.03
Tea & coffee	1440 (720,2682)	1260 (540,2160)	1260 (540,2556)	0.08
Sugar	42 (0,159)	18 (0,119)	25 (0,116)	0.06

ii) Women

	Smokers	Ex-smokers	Never smokers	*
NON-MANUAL				
Number	39	62	116	
Fruit	108 (0,293)	142 (29,282)	121 (13,312)	0.03
Potatoes	147 (33,305)	132 (22,268)	158 (51,272)	0.06
High fibre cereals	0 (0,49)	11 (0,72)	23 (0,78)	0.01
Saturated fats	15 (0,38)	5 (0,37)	2 (0,32)	0.007
Snacks	11 (0,48)	11 (0,41)	10 (0,43)	0.89
Tea & coffee	1440 (540,2700)	1170 (567,1800)	1080 (540,1827)	0.04
MANUAL				
Number	54	58	90	
Fruit	93 (0,263)	149 (0,285)	144 (23,285)	0.001
Potatoes	156 (34,271)	166 (49,304)	172 (30,278)	0.39
High fibre cereals	0 (0,54)	16 (0,50)	7 (0,50)	0.02
Saturated fats	17 (0,56)	10 (0,37)	4 (0,36)	0.004
Snacks	7 (0,56)	7 (0,32)	7 (0,35)	0.44
Tea & coffee	1440 (540,2430)	1080 (540,2160)	1080 (459,1881)	0.002

* Kruskal-Wallis test

divided into manual and non-manual occupations and analysed separately. Because of small sample sizes, heavy and light smokers have been combined.

Table 6.4 shows that in men for fruit, the difference between smokers and never smokers was larger for manual occupations,

whereas the difference between ex-smokers and smokers was similar for both occupation groups. Differences for fruit achieved statistical significance in the manual occupation group but not in the non-manual occupation group.

Consumption of potatoes did not appear to differ by smoking category in the non-manual occupation group but in the manual occupation group smokers had the lowest consumption of potatoes and ex-smokers the highest. In the non-manual group only never smokers consumed the most high fibre cereals. Snacks were eaten more in the manual occupations by ex-smokers and never smokers than smokers.

For women, as in men the differences in fruit consumption between never smokers and smokers were larger in the non-manual occupations. Difference in high fibre cereal consumption was seen in both groups, although the difference was greater in the non-manual group.

The differences between the occupation groups were small and are difficult to interpret due to the small sample sizes. It is possible that differences in fruit consumption are more likely to be detected in manual occupations than non-manual occupations as there was a larger difference between the smoking categories.

To look at the overall dietary patterns for each smoking category and to adjust for the potentially confounding effects of age, occupation group and body weight and height, a discriminant analysis was carried out with the four smoking categories (heavy smokers, light smokers, ex-smokers and never smokers). To increase the sample size men and women were analysed together with gender included as a variable.

Table 6.5: Discriminant analysis, for smokers, ex-smokers and never smokers.

Rotated standardised canonical discriminant function coefficients
(Canonical discriminant functions evaluated at group means; heavy smokers -1.0, light smokers -0.3, ex-smokers 0.2 never smokers 0.6)

Foods	Standardised coefficient	Variables	Standardised coefficient
	Positive		Negative
Gender	0.36	Tea & coffee	-0.59
High fibre breakfast cereal	0.33	Saturated fats	-0.46
Cakes & biscuits	0.26	Spirits	-0.30
Brown breads	0.20	Polyunsaturated fats	-0.17
Body weight	0.17	Sugar	-0.12
Low fibre breakfast cereal	0.16	Soft drinks	-0.11
Age	0.15	Processed meat	-0.10
Meat	0.14	Occupation*	-0.10
Milk	0.13	Vegetables	-0.06
Beer	0.08	Potatoes	-0.02
Dairy	0.06	Height	-0.02
Fruit	0.05	Fish and chicken	-0.01
White bread	0.04		
Wine	0.02		
Snacks	0.004		

* coded 1 for non-manual and 2 for manual occupations

As four smoking categories were used, three uncorrelated discriminant functions were derived. Function 1 contributed 68% of the variation between the groups and function 2 contributed 14% of the variation and function 3 12%. As most of the variance was explained by function 1 the results are shown only for this function. The canonical discriminant functions at the group means (table 6.5) increased from heavy smokers through to never smokers, implying a trend of either

increasing or decreasing intake through the smoking categories. This analysis was able to correctly predict group membership as a smoker (to either heavy or light) for 68% of smokers and as a non-smoker (to either ex or never smokers) for 73% of non-smokers.

Table 6.5 lists the rotated standardised canonical discriminant function coefficients (variables are ordered by size of coefficient) and group means. The table shows that the main variables differentiating between smokers and non-smokers (denoted by size of standardised coefficient) were tea and coffee, saturated fats, gender and breakfast cereals. The overall pattern of a smoker's diet included a variety of beverages; tea and coffee (with sugar), soft drinks and spirits. Fats, both saturated and to a lesser extent polyunsaturated fats, which may be spread on bread or used in cooking were also associated with a smoker's diet. As bread appears to be more associated with a non-smokers diet it is likely that smokers use more fat by either or both spreading fat more thickly on bread or consuming more fried foods or both. Smokers also appear to be more likely to have manual occupations and to use more processed meats (meat pies, bacon, canned meats) than non-smokers.

Non-smokers appeared to consume a diet that was higher in carbohydrate containing foods such as breakfast cereal, cakes and biscuits, and bread. They were also more likely to be women, weigh more and be older than the smokers. Instead of consuming processed meats like smokers they ate unprocessed cuts of meat and were also more likely to consume milk.

These data appear to confirm the findings of Whichelow *et al*, (1988 & 1989) table 1.9 (see page 53). However, the Southampton study found a higher consumption of polyunsaturated fat spreads in the smokers than the non-smokers. This may reflect a change in types of fats consumed, as the Whichelow study was carried out in 1984-

1985, five or more years before the Southampton study. Alternatively, table 1.9 reflected frequency of choice only. It is possible that although fewer smokers used polyunsaturated fat, those that did may have spread it more thickly. This point was confirmed by Whichelow, (1989) who showed that smokers were more likely than non-smokers to spread fat thickly.

The Southampton study also shows that it was not only alcohol in total that was higher in smokers but that there were differences between the types of alcoholic drink consumed by the smoking categories.

In conclusion, after taking into account potentially confounding variables, smokers in comparison with non-smokers consumed more tea and coffee, sugar, fat (spreading and cooking), spirits and processed meats, whereas non-smokers consumed more breakfast cereals, cakes and biscuits, meat and milk. There were also differences between the gender groups in the food groups which differed. In men differences were observed for bread and in women for cakes and biscuits, and polyunsaturated fats. There were also differences in the trend found within occupation groups with the difference in fruit consumption between smokers and non-smokers greater in manual occupations.

7. CROSS-SECTIONAL STUDY-NUTRIENT INTAKES

Smokers have a different overall food pattern to never and ex-smokers. The effect of this difference in food pattern between smoking categories on nutrient intake is discussed in this chapter. Firstly, the methodological issues of using the food frequency questionnaire in its 'uncorrected' and 'corrected form', together with the effect of inclusion of the volunteers in the smoking group are discussed. The importance of taking into account use of dietary supplements will be commented on. The results of the cross-sectional study will follow and will include a section on whether the same relationships between nutrient intake and cigarette smoking are observed in manual and non-manual occupation groups.

7.1 THE METHODOLOGICAL ISSUES

The primary aim of this section is to look at the effect of correcting the FFQ to obtain similar absolute intakes to a weighed record and to detect differences between the groups. It also investigates the effect of the inclusion of volunteers with the random sample.

The mean 'uncorrected' nutrient intakes and 95% confidence intervals for the randomly recruited men are shown in table 7.1 and the respective corrected values are given in columns one, three and four in table 7.2. The results show that for randomly recruited men after 'correcting', the FFQ nutrient intakes in all smoking categories increased for energy, protein, fat and types of fat, carbohydrate, vitamin E and alcohol but decreased for sugar, fibre and, vitamins A and C.

The statistical significance using analysis of variance with no confounding variables included in the model for randomly recruited men is shown by P1 in table 7.1 for uncorrected values and by P2 for corrected values in table 7.2. The

Table 7.1: Mean nutrient intakes (95% confidence intervals) by smoking category in randomly recruited men using uncorrected values

	Smokers	Ex-smokers	Never smokers	Anova P1*
Number	78	105	76	
Energy (MJ)	9.2 (8.7,9.7)	9.0 (8.6,9.4)	8.9 (8.5,9.4)	0.80
Protein (g)	80.6 (76.2,85.1)	83.8 (80.2,87.5)	82.6 (78.9,86.4)	0.42
Fat (g)	84.6 (77.5,91.8)	80.0 (75.1,84.8)	78.4 (73.1,83.6)	0.54
Pufa (g)	14.7 (12.8,16.5)	15.5 (13.9,17.1)	15.2 (13.7,16.8)	0.51
Sfa (g)	35.3 (32.1,38.5)	32.5 (30.4,34.6)	31.7 (29.2,34.1)	0.26
Cho (g)	262.8 (247.3,278.3)	254.2 (240.3,268.0)	265.6 (249.9,281.2)	0.47
Sugar (g)	128.8 (116.7,141.0)	111.7 (102.8,120.6)	115.2 (104.9,125.5)	0.10
Fibre (g)	20.6 (19.2,22.1)	22.6 (21.1,24.1)	26.1 (24.1,28.0)	<0.001
Alcohol (g)	16.3 (12.1,20.5)	18.7 (14.9,22.6)	11.5 (8.2,14.8)	0.07
Vitamin A (μg)	2049 (1644,2453)	1606 (1362,1851)	1769 (1474,2065)	0.27
Vitamin C (mg)	65.9 (58.9,73.0)	71.9 (66.4,77.4)	71.9 (64.6,79.2)	0.15
Vitamin E (mg)	5.3 (4.8,5.8)	5.4 (5.0,5.9)	5.4 (5.0,5.9)	0.74

* Analysis of variance between smokers, ex-smokers and never smokers with no confounding variables included in the model

Table 7.2: Mean nutrient intakes (95% confidence intervals) using corrected values with and without inclusion of the volunteers

	Smokers (random only)	Smokers (all)	Ex-smokers	Never smokers	Anova P2*	Anova P3*
Number	78	159	105	76		
Energy (MJ)	10.1 (9.6,10.5)	10.1 (9.8,10.5)	9.9 (9.6,10.3)	9.8 (9.4,10.2)	0.77	0.44
Protein (g)	84.5 (80.3,88.8)	84.4 (81.7,87.0)	87.6 (84.1,91.1)	86.4 (82.8,89.9)	0.42	0.29
Fat (g)	96.6 (91.2,102.0)	97.1 (93.7,100.4)	92.9 (89.3,96.6)	92.0 (88.0,96.0)	0.48	0.14
Pufa (g)	16.7 (15.3,18.1)	16.5 (15.4,17.5)	17.1 (15.9,18.3)	17.0 (16.0,18.1)	0.66	0.18
Sfa (g)	38.9 (36.4,41.4)	39.0 (37.5,40.6)	37.0 (35.3,38.6)	36.3 (34.3,38.3)	0.31	0.07
Cho (g)	277.9 (263.3,292.5)	277.9 (267.4,288.4)	269.7 (256.7,282.6)	280.0 (265.3,294.6)	0.48	0.48
Sugar (g)	128.1 (116.0,140.3)	128.6 (120.3,136.9)	111.0 (102.1,119.9)	114.5 (104.2,124.8)	0.11	0.01
Fibre (g)	18.7 (17.7,19.8)	19.1 (18.2,20.0)	20.3 (19.2,21.4)	22.9 (21.3,24.5)	<.001	<.001
Alcohol (g)	20.3 (15.2,25.3)	21.3 (17.5,25.2)	23.3 (18.8,27.8)	14.7 (10.8,18.7)	0.07	0.10
Vit A (μg)	1472 (1067,1876)	1245 (1025,1465)	1029 (785,1274)	1192 (897,1488)	0.17	0.01
Vit C (mg)	57.2 (50.8,63.5)	57.9 (52.6,63.2)	62.2 (57.3,67.2)	62.6 (56.1,69.1)	0.15	0.03
Vit E (mg)	6.7 (6.0,7.5)	6.8 (6.4,7.2)	7.0 (6.3,7.6)	7.0 (6.3,7.7)	0.73	0.94

* Analysis of variance for random sample of smokers, ex-smokers and never smokers, P2; and all smokers, ex-smokers and never smokers P3.

level of significance appeared to be similar for the uncorrected and corrected values, with a statistically significant difference between the smoking groups for fibre ($P < 0.001$) and a marginally significant result for alcohol

(P = 0.07). The trends between the groups were not affected by the 'correction' method. For example, both 'uncorrected' and 'corrected' data showed that smokers consumed the highest intake of energy, fat, saturated fat, sugar and vitamin A.

Table 7.3: Differences in nutrient intake between smokers and never smokers (Smokers - Never smokers) the FFQ in its uncorrected and corrected form
(calculated from tables 7.1 and 7.2 for men and tables 7.4 and 7.5 for women)

	Men		Women	
	Uncorrected	Corrected	Uncorrected	Corrected
Energy (MJ)	0.3	0.3	-0.4	-0.4
Protein (g)	-2.0	-1.9	-5.3	-4.8
Fat (g)	6.2	4.6	1.4	1.4
Pufa (g)	-0.5	-0.3	-2.4	-2.2
Sfa (g)	3.6	2.6	2.8	3.0
CHO (g)	-2.8	-2.1	-22.2	-20.4
Sugar (g)	13.6	13.6	0.2	0.4
Fibre (g)	-5.5	-4.2	-4.3	-3.7
Alcohol (g)	4.8	5.6	-0.5	-0.6
Vitamin A (μg)	280	280	53	40
Vitamin C (mg)	-6.0	-5.4	-9.3	-9.3
Vitamin E (mg)	-0.1	-0.3	-0.7	-0.9

Table 7.3 shows the observed differences between smokers and never smokers using the corrected and uncorrected values for the random sample. In men, with the exception of energy, sugar, alcohol and vitamins A and E, correcting the values made the differences between the groups smaller.

Smaller differences are more difficult to detect than larger differences (assuming similar variances) for the same sample

size. The P values for the 'corrected' form of the FFQ could be expected to be larger than those for the 'uncorrected form'. That this does not appear to happen could be explained by a lower nutrient variance (95% confidence interval) after 'correction'. Thus, 'correction' of the FFQ tended to decrease both nutrient differences between the groups and nutrient variance of mean estimates.

Correcting the FFQ values appeared to alter the absolute values but have little effect on the trends between the groups when no other variables were taken into account.

Column two in table 7.2 shows the results for all smokers (random and volunteer). The inclusion of volunteers had no effect on the absolute intakes of energy, protein, saturated fat and carbohydrate but slightly increased the estimates of fat and sugar intake in smokers which increased the difference in fat and sugar intake between smokers and non-smoking groups. Addition of volunteers also decreased polyunsaturated fat intake of smokers which increased the difference from the other groups. For fibre and vitamins C and E, addition of volunteers increased values in smokers and thus made the difference between the groups smaller. For vitamin A and alcohol the addition of volunteers reduced values for smokers and also the difference between the groups for vitamin A.

Therefore, 'correcting' nutrient values appeared to change absolute intakes and decrease the difference between the groups, but did not appear to affect the trends between the groups. Addition of volunteers had a greater effect firstly by increasing the power and also by slightly altering the nutrient values so that differences between the groups were increased for fat and polyunsaturated fat and decreased for fibre and vitamins. The result of including volunteers lead to statistically significant differences being observed for sugar, vitamins A and E in addition to fibre.

Table 7.4: Mean nutrient intakes (95% confidence interval) by smoking category in randomly recruited women using uncorrected values

	Smokers	Ex-smokers	Never smokers	Anova P1
Number	102	125	217	
Energy (MJ)	7.0 (6.7,7.4)	6.8 (6.6,7.1)	7.4 (7.2,7.7)	0.006
Protein (g)	72.8 (69.2,76.4)	73.1 (70.2,76.0)	78.1 (75.5,80.6)	0.02
Fat (g)	67.0 (62.3,71.7)	59.5 (56.0,63.0)	65.6 (62.7,68.5)	0.01
Pufa (g)	10.5 (9.7,11.4)	11.0 (10.2,11.8)	12.9 (12.0,13.8)	<0.001
Sfa (g)	29.5 (26.9,32.1)	24.4 (22.7,26.1)	26.7 (25.4,28.0)	0.006
Cho (g)	196.7 (184.2,209.1)	199.8 (190.7,208.9)	218.9 (211.0,226.8)	<0.001
Sugar (g)	98.0 (88.9,107.1)	94.5 (89.1,100.0)	97.8 (93.4,102.1)	0.54
Fibre (g)	19.1 (17.8,20.4)	21.6 (20.4,22.9)	23.4 (22.4,24.5)	<0.001
Alcohol (g)	5.2 (3.5,6.9)	6.2 (4.7,7.8)	5.7 (4.6,6.9)	0.22
Vitamin A (μg)	1829 (1506,2153)	1672 (1404,1941)	1776 (1556,1996)	0.55
Vitamin C (mg)	67.6 (62.2,73.1)	78.8 (72.5,85.2)	76.9 (72.9,80.9)	0.02
Vitamin E (mg)	4.6 (4.2,4.9)	4.9 (4.5,5.2)	5.3 (5.1,5.6)	0.001

* Analysis of variance between smokers, ex-smokers and never smokers with no confounding variables included in the model

Table 7.5: Mean nutrient intakes (95% confidence interval) using corrected values with and without inclusion of the volunteers in women

	Smokers (random only)	Smokers (all)	Ex-smokers	Never smokers	Anova P2	Anova P3
Number	102	228	125	217		
Energy (MJ)	7.0 (6.7,7.4)	7.1 (6.8,7.3)	6.8 (6.6,7.1)	7.4 (7.2,7.7)	0.006	<.001
Protein (g)	62.9 (59.6,66.2)	62.8 (60.8,64.8)	63.1 (60.5,65.8)	67.7 (65.4,70.0)	0.02	0.006
Fat (g)	76.3 (71.0,81.7)	74.6 (71.5,77.7)	67.9 (63.8,72.0)	74.9 (71.6,78.2)	0.02	0.01
Pufa (g)	11.7 (10.9,12.5)	11.5 (11.0,12.1)	12.1 (11.3,12.8)	13.9 (13.1,14.7)	<.001	<.001
Sfa (g)	30.0 (27.3,32.6)	29.7 (28.1,31.2)	24.7 (22.9,26.4)	27.0 (25.7,28.4)	0.006	<.001
Cho (g)	188.8 (177.1,200.5)	189.0 (181.7,196.4)	191.4 (183.0,199.8)	209.2 (201.8,216.6)	0.001	<.001
Sugar (g)	90.2 (81.8,98.7)	89.5 (84.0,94.9)	86.8 (81.9,91.7)	89.8 (85.8,93.8)	0.54	0.29
Fibre (g)	15.1 (14.0,16.2)	15.7 (14.9,16.5)	17.2 (16.1,18.4)	18.8 (17.9,19.7)	<.001	<.001
Alcohol (g)	5.9 (4.0,7.8)	6.1 (4.8,7.4)	7.1 (5.3,8.8)	6.5 (6.2,7.8)	0.20	0.15
Vit A (μg)	1230 (961,1498)	1034 (885,1184)	1105 (881,1329)	1190 (1004,1377)	0.62	0.42
Vit C (mg)	54.8 (49.4,60.3)	53.9 (50.1,57.8)	66.0 (59.7,72.4)	64.1 (60.1,68.1)	0.05	<.001
Vit E (mg)	4.9 (4.4,5.3)	4.9 (4.6,5.2)	5.2 (4.8,5.6)	5.8 (5.5,6.1)	0.002	<.001

* Analysis of variance for random sample of smokers, ex-smokers and never smokers, P2; and all smokers, ex-smokers and never smokers P3.

Tables 7.4 and 7.5 show the same results for women. 'Correcting' the FFQ values did not alter energy intake. After 'correction' estimates for protein, carbohydrate, sugar, fibre, vitamin A and C were decreased and those for fat and type of fat, and vitamin E and alcohol increased. As

in men, the level of statistical significance was not affected by the 'correction', although for vitamin C the P value increased from 0.02 to 0.05. The 'correction' did not appear to alter the trends across the groups. Both 'uncorrected' and 'corrected' forms showed that smokers had the highest intake of fat, saturated fat, sugar and vitamin A. Table 7.3 shows that the difference between smokers and never smokers did not change for energy, fat and vitamin C. However, it was reduced for protein, polyunsaturated fat, carbohydrate, fibre and vitamin A after 'correction' of the FFQ.

As in men, the 'correction' of the FFQ values tended to alter the absolute values and reduce some nutrient differences, but did not affect the trends across the smoking categories.

In women inclusion of volunteers into the smoking category did not affect the results for energy, protein, saturated fat, carbohydrate, sugar and vitamin E.

For fats, inclusion of the volunteers decreased total fat and polyunsaturated fat estimates for smokers thus reducing the difference between the groups for total fat and increasing the difference between the groups for polyunsaturated fat. For fibre, inclusion of volunteers increased the smokers' value thus decreasing the difference. For vitamin A the smokers estimate was reduced so that instead of smokers consuming more vitamin A than the other groups, smokers appeared to consume less vitamin A than the other groups. Inclusion of volunteers reduced the vitamin C estimate for smokers and therefore increased the difference between the groups.

The effect on statistical significance was small although for vitamin C inclusion of the volunteers increased the significance from marginal to highly significant.

In summary, in both men and women 'correction' of the FFQ values to those of a WR did not greatly affect trends between the groups, but did give more reliable estimates of absolute intakes and of differences between the groups if a weighed record is considered a better estimate of true diet than the FFQ. Therefore the FFQ does appear reliable in detecting differences between the groups but not in estimating intakes, although by using this simple 'correction' technique values can be 'corrected' so that more realistic intakes can be obtained from the FFQ.

The 'correction' method also enables the randomly recruited subjects and the volunteers to be analysed as one group. The differences first observed between these groups appeared to be due to differences in agreement between the weighed record and food frequency questionnaire and so after 'correction' these differences were removed.

Inclusion of the volunteers has the benefit of increasing sample size and power thus making differences between the groups easier to detect. It also affects the nutrient values for some nutrients as follows:

Inclusion of the volunteers **increased** differences between the groups for:

Fat and polyunsaturated fat in men
Polyunsaturated fat and vitamin C in women

and **decreased** differences between the groups for:

Fibre, alcohol and vitamin A, C and E in men
Fat and fibre in women

It also completely changes the relation for vitamin A in women. In the random sample smokers consumed the highest intake of vitamin A and after inclusion of the volunteers the

smokers had the lowest intakes. However, the differences were not statistically significant before or after inclusion of volunteers.

7.2 THE EFFECT OF VITAMIN TAKERS ON THE ANALYSIS

Before the analysis of nutrient intakes, the effect of vitamin supplementation on the analysis must be addressed. In chapter 6, table 6.1 showed that there was no statistically significant difference between the smoking groups in the percent of subjects taking vitamin supplements at the time of their appointment. However, although questions were asked about which vitamins were taken, the dose of the vitamins was not recorded. This was because many subjects did not know the dose or the brand of vitamin supplements and often the supplements were taken irregularly. Therefore information on dose was likely to be inaccurate.

It is possible that subjects with low vitamin intakes from food increased their vitamin intake using supplements. If this is true it may seriously affect the results. To investigate the possibility, analysis was carried out on subjects reporting no vitamin supplements and the results compared with data from all subjects. For this analysis randomly recruited smokers and volunteers were combined as there was no difference in vitamin supplementation between the two sources. Subjects were classified into three groups; those not taking supplements; those taking vitamins and minerals, but no oils; and those taking oil of evening primrose and/or fish oil capsules (with or without additional vitamins and minerals).

Results are shown for polyunsaturated fat, vitamin A, vitamin C and vitamin E as these are the nutrients most likely to be affected by supplements (table 7.6).

In men, for pufa it appeared that after exclusion of the oil takers the difference between the groups decreased.

Table 7.6: The effect of inclusion of vitamin supplement users on the diet smoking relationship for polyunsaturated fat (pufa), vitamins A, C and E.

i) Men

	Smokers	Ex-smokers	Never smokers	†
Vitamin takers excluded *				
Pufa (g)	17.0 (15.8,18.3)	16.7 (15.6,17.8)	17.0 (15.8,18.2)	0.74
Vitamin A (μg)	1305 (1066,1545)	1051 (798,1304)	1174 (869,1479)	0.008
Vitamin C (mg)	58.2 (52.8,63.6)	62.2 (57.2,67.2)	63.7 (56.7,70.8)	0.04
Vitamin E (mg)	6.8 (6.4,7.3)	6.9 (6.3,7.5)	6.9 (6.2,7.7)	0.91
All subjects	159	105	76	
Pufa (g)	16.5 (15.4,17.5)	17.1 (15.9,18.3)	17.0 (16.0,18.1)	0.18
Vitamin A (μg)	1245 (1025,1465)	1029 (785,1274)	1192 (897,1488)	0.01
Vitamin C (mg)	57.9 (52.6,63.2)	62.2 (57.3,67.2)	62.6 (56.1,69.1)	0.03
Vitamin E (mg)	6.8 (6.4,7.2)	7.0 (6.3,7.6)	7.0 (6.3,7.7)	0.94

* Numbers included in the analysis were: for pufa, 130, 84, 58; for vitamins, 144, 101, 66; for smokers, ex-smokers, never smokers respectively

† Analysis of variance with no confounding variables

ii) Women

	Smokers	Ex-smokers	Never smokers	†
Vitamin takers excluded *				
Pufa (g)	11.4 (10.8,12.0)	12.2 (11.2,13.1)	14.0 (12.9,15.0)	<0.001
Vitamin A (μg)	1031 (865,1197)	1013 (832,1195)	1227 (1023,1431)	0.28
Vitamin C (mg)	53.5 (49.3,57.7)	64.1 (57.7,70.6)	64.2 (60.0,68.5)	0.001
Vitamin E (mg)	4.9 (4.6,5.2)	5.3 (4.9,5.7)	5.8 (5.4,6.1)	0.001
All subjects	228	125	217	
Pufa (g)	11.5 (11.0,12.1)	12.1 (11.3,12.8)	13.9 (13.1,14.7)	<0.001
Vitamin A (μg)	1034 (885,1184)	1105 (881,1329)	1190 (1004,1377)	0.42
Vitamin C (mg)	53.9 (50.1,57.8)	66.0 (59.7,72.4)	64.1 (60.1,68.1)	<0.001
Vitamin E (mg)	4.9 (4.6,5.2)	5.2 (4.8,5.6)	5.8 (5.5,6.1)	<0.001

* Numbers included in the analysis were: for pufa, 178, 97, 170; for vitamins, 193, 109, 195; for smokers, ex-smokers, never smokers respectively
† Analysis of variance adjusted for age, occupation group and energy

It is possible that in smokers, oil capsule takers consume less polyunsaturated fat from food than non-takers. As a result numbers of men taking oil capsules should be taken into account in the cross-sectional analysis. The differences for vitamins were small.

In women, nutrient intakes were similar for pufa when oil capsule takers were excluded and little difference was observed for vitamins A, C and E when vitamin takers were

excluded.

In summary, if dietary supplements are not taken into account the results for vitamins A, C and E do not appear to be affected. However, men smokers may supplement their dietary intake of polyunsaturated fat with oil capsules thus making the overall difference between the smoking categories smaller. The effect of this in the following analyses will be considered.

The aim of the cross-sectional analysis was to show differences between the groups and not to determine precise intakes so the analysis will be restricted to nutrient intake from food and alcohol only and not dietary supplements.

Effect of year of appointment was also investigated as ex-smokers and never smokers were recruited over the duration of the project and diets may have changed over the two year period. Therefore a comparison between ex-smokers and never smokers seen over the same time period as the smokers with those seen over the later time period has been made. The results are shown in table 7.7.

There were no statistically significant differences between ex and never smokers seen in the first part of the survey or in the second. A possible bias could occur if diets had changed over the period of the study. Thus if diets had improved (decreased in fat, increased in pufa and vitamin intakes) this would make the observed differences between smokers and non-smokers larger. There does not appear to be a consistent trend for this in the above table. As all randomly selected subjects were selected at the same time, it is possible that any differences that might have occurred may be due to differences in age and not dietary change. As age has been included in the model the possibility of this has been reduced.

Table 7.7: Mean energy and nutrient intakes adjusted for gender, occupation and age for ex-smokers and never smokers seen in the same time period or later than the smokers

	EX-SMOKERS			NEVER SMOKERS		
	SAME Before June 1991	LATER After June 1991		SAME Before June 1991	LATER After June 1991	
Number	72	153		70	217	
Energy (MJ)	8.2	8.3	0.31	8.2	8.0	0.81
Protein (g)	73.9	75.0	0.41	73.9	72.2	0.48
Fat (g)	78.4	80.1	0.27	81.1	78.6	0.88
Pufa (g)	15.1	14.1	0.49	14.8	14.7	0.85
Sugar (g)	93.9	99.9	0.36	96.4	96.2	0.92
Fibre (g)	18.1	19.4	0.65	19.9	19.9	0.75
Alcohol (g)	13.2	15.3	0.23	8.8	8.7	0.85
Vit C (mg)	67.0	62.9	0.42	61.7	64.4	0.72

Analysis of variance adjusting for gender, occupation and age

7.3 NUTRIENT INTAKE BY SMOKING CATEGORY

This section discusses the differences in nutrient intakes between the groups using the composite smoking group and taking into account the findings from sections 7.1 and 7.2.

Table 7.8 shows mean nutrient intakes (95% confidence interval) for men and women separately.

In men, (table 7.8i) there were statistically significant results for sugar, fibre and vitamin A, with marginally

Table 7.8: 'Corrected' mean nutrient intake (95 % confidence interval) by smoking category

i) Men

	Heavy smokers	Light smokers	Ex-smokers	Never smokers	Anova
Number	79*	62*	105	76	
Energy (MJ)	10.2 (9.7,10.6)	10.2 (9.7,10.7)	9.9 (9.6,10.3)	9.8 (9.4,10.2)	0.57
Protein (g)	83.9 (80.2,87.7)	85.3 (80.8,89.8)	87.6 (84.1,91.1)	86.4 (82.8,89.9)	0.52
Fat (g)	99.9 (95.2,104.7)	95.2 (89.8,100.6)	92.9 (89.3,96.6)	92.0 (88.0,96.0)	0.06
Pufa (g)	17.1 (15.3,18.9)	16.1 (14.6,17.5)	17.1 (15.9,18.3)	17.0 (16.0,18.1)	0.44
Sfa (g)	39.8 (37.9,41.8)	38.2 (35.5,40.8)	37.0 (35.3,38.6)	36.3 (34.3,38.3)	0.06
Cho (g)	276.2 (260.9,291.5)	279.6 (263.5,295.6)	269.7 (256.7,282.6)	280.0 (265.3,294.6)	0.64
Sugar (g)	124.3 (112.9,135.7)	131.2 (118.3,144.0)	111.0 (102.1,119.9)	114.5 (104.2,124.8)	<0.001
Fibre (g)	19.0 (17.7,20.3)	19.5 (18.1,20.9)	20.3 (19.2,21.4)	22.9 (21.3,24.5)	<0.001
Vit A (μg)	1302 (932,1672)	1297 (989,1604)	1029 (785,1274)	1192 (897,1488)	0.02
Vit C (mg)	58.5 (50.8,66.2)	58.1 (49.5,66.7)	62.2 (57.3,67.2)	62.6 (56.1,69.1)	0.09
Vit E (mg)	7.0 (6.4,7.6)	6.7 (6.0,7.3)	7.0 (6.3,7.6)	7.0 (6.3,7.7)	0.90
Alcohol (g)	20.5 (15.4,25.6)	22.9 (16.0,29.9)	23.3 (18.8,27.8)	14.7 (10.8,18.7)	0.21

* 14 subjects did not have serum cotinine estimates and were not included

ii) women

	Heavy smokers	Light smokers	Ex-smokers	Never smokers	Anova
Number	86*	102*	125	217	
Energy (MJ)	7.0 (6.0,7.4)	7.1 (6.8,7.4)	6.8 (6.6,7.1)	7.4 (7.2,7.7)	0.008
Protein (g)	61.2 (57.8,64.6)	65.9 (63.1,68.8)	63.1 (60.5,65.8)	67.7 (65.4,70.0)	0.005
Fat (g)	74.1 (68.5,79.6)	76.0 (71.5,80.5)	67.9 (63.8,72.0)	74.9 (71.6,78.2)	0.03
Pufa (g)	10.8 (10.0,11.5)	12.2 (11.3,13.2)	12.1 (11.3,12.8)	13.9 (13.1,14.7)	<.001
Sfa (g)	30.2 (27.2,33.2)	29.4 (27.3,31.5)	24.7 (22.9,26.4)	27.0 (25.7,28.4)	0.003
Cho (g)	189.4 (176.0,202.8)	189.2 (178.3,200.1)	191.4 (183.0,199.8)	209.2 (201.8,216.6)	0.001
Sugar (g)	89.4 (79.3,99.5)	88.7 (81.2,96.2)	86.8 (81.9,91.7)	89.8 (85.8,93.8)	0.35
Fibre (g)	15.6 (14.3,16.9)	16.0 (14.8,17.2)	17.2 (16.1,18.4)	18.8 (17.9,19.7)	<.001
Vit A (μg)	1145 (830,1459)	964 (789,1140)	1105 (881,1329)	1190 (1004,1377)	0.17
Vit C (mg)	52.7 (46.5,58.8)	55.8 (50.0,61.5)	66.0 (59.7,72.4)	64.1 (60.1,68.1)	0.002
Vit E (mg)	4.7 (4.3,5.1)	5.0 (4.6,5.5)	5.2 (4.8,5.6)	5.8 (5.5,6.1)	0.001
Alcohol (g)	5.9 (3.9,8.0)	7.1 (4.9,9.2)	7.1 (5.3,8.8)	6.5 (6.2,7.8)	0.35

* 40 subjects did not have a serum cotinine estimate and were excluded

significant results for fat, saturated fat and vitamin C. Smokers consumed more sugar and less fibre than never smokers and ex-smokers. For fibre there appeared to be a trend that fibre consumption increased from heavy to light smokers to ex-smokers to never smokers. For fat and saturated fat smokers had higher intakes than never and ex-smokers and

there was also a trend of increasing consumption from never smokers through to heavy smokers. Both light and heavy smokers consumed more vitamin A than non-smokers. Ex-smokers and never smokers consumed more vitamin C than smokers.

In women, (table 7.8ii) there were statistically significant differences for all nutrients except for sugar, vitamin A and alcohol. Never smokers consumed the most energy, with similar intakes between heavy and light smokers and lowest intake in the ex-smokers. If the results of ex-smokers were ignored, there appeared to be a trend of decreasing protein and polyunsaturated fat intakes from never smokers to heavy smokers and of increasing saturated fat from never smokers to heavy smokers. Ex-smokers had the lowest intakes of energy, protein, fat and saturated fat. For carbohydrate highest intake was in the never smokers with similar intakes between the other groups. For fibre and vitamin E there appeared to be a trend that intake increased from heavy smokers to never smokers. For vitamin C largest difference appeared to be between smokers and non-smokers, with non-smokers consuming more vitamin C. Table 7.9 shows the analysis of variance; adjustment for age and occupation only (not shown except for energy) affected the statistical significance of the nutrients only slightly. The main variable that affected the significance was energy. The values adjusted for age, occupation group and energy are shown in the table.

In men, after adjustment for age, occupation group and energy, smokers consumed the least protein, polyunsaturated fat, fibre and vitamin C. Smokers had an intermediate intake of carbohydrate and highest intakes of fat and sugar. There appeared to be a dose response relationship for protein, fat, and fibre. Heavy smokers consumed the least protein and fibre but had the highest intake of fat. For saturated fat although the trend did not reach statistical significance

Table 7.9: 'Corrected' adjusted mean nutrient intake by smoking category after inclusion of confounding variables

i) Men

	Heavy smokers	Light smokers	Ex-smokers	Never smokers	Anova
Number	74	60	104	76	
Analysis 1					**P1**
Energy (MJ)	10.2	10.2	10.0	9.8	0.63*
Protein (g)	82.9	84.3	88.5	87.7	0.006
Fat (g)	97.9	93.4	93.8	93.7	0.03
Pufa (g)	16.9	15.4	17.6	17.4	0.008
Sfa (g)	38.9	37.6	37.1	37.0	0.11
Cho (g)	274.0	274.6	271.2	286.0	0.05
Sugar (g)	125.7	129.2	111.5	117.7	0.01
Fibre (g)	18.7	19.1	20.5	23.1	<0.001
Alcohol (g)	20.2	23.3	23.7	15.1	0.11
Vitamin A (μg)	1298	1257	1046	1240	0.03
Vitamin C (mg)	58.9	58.1	62.2	62.9	0.08
Vitamin E (mg)	6.8	6.4	7.2	7.2	0.55
Analysis 2					**P2**
Energy (MJ)	10.1	10.2	9.9	9.9	0.69*
Protein (g)	83.0	84.2	88.6	87.6	0.01
Fat (g)	97.8	93.3	94.3	93.3	0.03
Pufa (g)	17.0	15.3	17.8	17.2	0.006
Sfa (g)	39.0	37.5	37.2	36.9	0.07
Cho (g)	271.5	274.2	275.8	282.7	0.19
Sugar (g)	123.8	129.2	113.7	116.5	0.04
Fibre (g)	18.7	19.0	20.9	22.7	<0.001
Alcohol (g)	20.5	23.3	23.5	15.1	0.10
Vitamin A (μg)	1312	1248	1048	1230	0.05
Vitamin C (mg)	59.3	57.7	62.7	62.0	0.09
Vitamin E (mg)	6.8	6.4	7.2	7.1	0.51

P1-analysis of variance adjusting for age, occupation group and energy intake
P2-analysis of variance adjusting for age, occupation group, energy intake, height, weight and alcohol intake
* Adjustment for age and occupation group only

ii) women

	Heavy smokers	Light smokers	Ex-smokers	Never smokers	ANOVA
Number	80	97	121	211	
Analysis 1					**P1**
Energy (MJ)	7.0	7.2	6.9	7.4	0.02*
Protein (g)	62.7	65.8	65.6	65.9	0.06
Fat (g)	77.5	75.7	72.0	71.6	0.001
Pufa (g)	11.3	12.3	12.6	13.4	0.001
Sfa (g)	31.7	29.2	26.2	26.0	<0.001
Cho (g)	196.5	189.8	200.8	201.9	<0.001
Sugar (g)	93.2	88.4	90.9	86.5	0.33
Fibre (g)	16.1	16.1	17.9	18.3	<0.001
Alcohol (g)	6.0	7.2	7.3	6.5	0.32
Vitamin A (μg)	1181	936	1176	1141	0.24
Vitamin C (mg)	54.6	56.4	67.6	63.1	0.01
Vitamin E (mg)	4.9	5.1	5.5	5.5	0.02
Analysis 2					**P2**
Energy (MJ)	7.0	7.1	6.9	7.4	0.02*
Protein (g)	62.9	65.8	65.5	65.8	0.10
Fat (g)	77.5	75.8	72.2	71.5	0.001
Pufa (g)	11.3	12.4	12.7	13.4	0.001
Sfa (g)	31.6	29.2	26.4	25.7	<0.001
Cho (g)	194.3	189.9	202.7	201.7	<0.001
Sugar (g)	91.7	88.2	91.8	86.7	0.16
Fibre (g)	16.0	16.1	18.0	18.3	<0.001
Alcohol (g)	5.8	7.2	7.4	6.4	0.19
Vitamin A (μg)	1170	946	1199	1127	0.24
Vitamin C (mg)	55.5	56.1	66.5	63.6	0.02
Vitamin E (mg)	4.9	5.1	5.6	5.5	0.01

P1-analysis of variance adjusting for age, occupation group and energy intake
P2-analysis of variance adjusting for age, occupation group, energy intake, height, weight and alcohol intake
* as for P1 and P2 without the inclusion of energy

heavy smokers consumed the highest intake and never smokers the lowest.

After the additional adjustment for alcohol, height and

weight the results were unchanged apart from those for saturated fat and carbohydrate. This additional adjustment increased the difference between heavy smokers and never smokers for saturated fat thus increasing the significance. For carbohydrate after the additional adjustment the result was no longer marginally significant.

Polyunsaturated fat differed by smoking category when the confounding variables were taken into account, but table 7.3 showed that the inclusion of the volunteers tended to increase the difference. Therefore to exclude the bias from the volunteers and the random smokers that took oil capsules the adjusted means for unsupplemented randomly recruited subjects were calculated and were 16.7, 16.9 and 17.1 for smokers, ex-smokers and never smokers (n = 130, 84, 158 respectively) for P1 and 16.6, 17.0, 16.9 for P2 and were not statistically significant. However, as the sample size is smaller, this is difficult to interpret.

Thus inclusion of volunteers and supplemented random recruits may lead to misleading results for polyunsaturated fat after adjusting for the confounding variables.

In women (table 7.9ii), after adjustment for age, occupation group and energy intake smokers had the lowest intakes of polyunsaturated fat, carbohydrate, fibre, vitamin C and vitamin E, and the highest intakes of fat and saturated fat. There appeared to be a dose response relationship for fat and saturated fat. Heavy smokers consumed the most fat and saturated fat and never smokers the least. However, never smokers consumed the most polyunsaturated fat and vitamin E and heavy smokers the least.

After additional adjustment for alcohol, height and weight the results were largely unchanged.

Inclusion of the volunteers increased differences for

polyunsaturated fat and vitamin C and therefore the analysis was repeated for randomly recruited subjects only and gave polyunsaturated fat estimates for P1 of 12.1, 12.6, 13.4 g for smokers, ex-smokers and never smokers (P = 0.03) and for P2 12.5, 12.2, 13.2 g (P = 0.13) respectively. For vitamin C (mg) the same results were P1 55.8, 67.5, 63.0 (P = 0.06) and 60.6, 69.2, 66.3 (P = 0.29) for smokers, ex-smokers and never smokers.

In summary, after adjusting for age, occupation group, energy intake, alcohol intake, height and weight, men smokers tended to consume a diet that was higher in fat and sugar, but lower in protein, fibre than non-smokers. In women, smokers consumed a diet that was higher in fat and saturated fat but lower in carbohydrate, polyunsaturated fat, fibre, vitamin C and vitamin E than non-smokers.

Table 7.10 shows the mean nutrient intakes as percent of both total energy and food energy for men and women. The results are similar to those shown in table 7.8 despite using different methods to adjust for energy and alcohol consumption. The table also shows that P:S ratio increases from smokers to never smokers in men and women. In women the heavy smokers had the lowest P:S ratio.

Table 7.10: Mean nutrient intake as percent of energy (total and food) (95% confidence interval)
i) men

	Heavy smokers	Light smokers	Ex-smokers	Never smokers	Anova P1*	Anova P2*
Total energy						
Protein	13.9 (13.5,14.1)	14.1 (13.6,14.6)	14.9 (14.4,15.3)	14.8 (14.4,15.2)	0.002	0.003
Fat	37.2 (36.2,38.1)	35.2 (34.2,36.3)	35.3 (34.6,36.1)	35.4 (34.4,36.5)	0.01	0.04
Pufa	6.3 (5.8,6.8)	5.9 (5.5,6.3)	6.5 (6.1,6.8)	6.6 (6.2,6.9)	0.04	0.008
Sfa	14.8 (14.3,15.3)	14.1 (13.4,14.7)	14.0 (13.6,14.5)	13.9 (13.3,14.5)	0.05	0.10
CHO	42.5 (41.2,43.8)	43.3 (41.6,44.9)	42.5 (41.3,43.7)	44.6 (43.4,45.8)	0.07	0.05
Sugar	18.9 (17.7,20.1)	20.3 (18.5,22.1)	17.4 (16.3,18.4)	18.1 (16.8,19.4)	0.03	0.008
Alcohol	5.8 (4.4,7.2)	6.2 (4.4,8.1)	6.9 (5.6,8.2)	4.5 (3.4,5.6)	0.17	0.09
P:S	0.44 (0.39,0.48)	0.44 (0.40,0.48)	0.48 (0.45,0.51)	0.50 (0.46,0.53)	0.02	0.009
Food energy						
Protein	14.9 (14.4,15.3)	15.1 (14.6,15.6)	16.1 (15.5,16.6)	15.5 (15.1,16.0)	0.004	0.004
Fat	39.5 (38.5,40.5)	37.7 (36.5,38.9)	38.0 (37.2,38.8)	37.1 (36.1,38.2)	0.007	0.02
Pufa	6.7 (6.1,7.2)	6.3 (5.9,6.8)	6.9 (6.6,7.3)	6.9 (6.5,7.2)	0.06	0.009
Sfa	15.8 (15.2,16.4)	15.1 (14.4,15.8)	15.1 (14.7,15.6)	14.6 (14.0,15.2)	0.02	0.05
Cho	45.1 (44.0,46.3)	46.2 (44.6,47.7)	45.6 (44.6,46.6)	46.7 (45.5,47.9)	0.28	0.34
Sugar	20.1 (18.8,21.4)	21.7 (19.8,23.6)	18.7 (17.5,19.8)	19.0 (17.6,20.4)	0.03	0.007

ii) Women

	Heavy smokers	Light smokers	Ex-smokers	Never smokers	P1	P2
Total energy						
Protein	15.0 (14.4,15.6)	15.7 (15.1,16.2)	15.6 (15.2,16.0)	15.4 (15.0,15.7)	0.19	0.10
Fat	39.7 (38.1,41.2)	39.7 (39.3,41.1)	36.8 (35.6,38.1)	37.5 (36.5,38.4)	0.003	0.002
Pufa	5.9 (5.5,6.3)	6.4 (6.1,6.8)	6.6 (6.3,7.0)	7.0 (6.7,7.2)	<0.001	0.001
Sfa	16.0 (14.9,17.0)	15.3 (4.5,16.2)	13.4 (12.7,14.0)	13.6 (13.1,14.0)	<0.001	<0.001
Cho	42.5 (41.0,44.0)	41.4 (39.9,42.8)	43.9 (43.0,44.9)	44.2 (43.4,44.9)	<0.001	<0.001
Sugar	19.7 (18.1,21.4)	19.3 (17.9,20.7)	19.9 (19.1,20.8)	19.1 (18.4,19.7)	0.31	0.35
Alcohol	2.5 (1.7,3.4)	3.0 (2.1,4.0)	3.2 (2.4,3.9)	2.6 (2.0,3.1)	0.34	0.34
P:S	0.43 (0.38,0.48)	0.46 (0.42,0.50)	0.54 (0.50,0.58)	0.56 (0.53,0.60)	<0.001	<0.001
Food energy						
Protein	15.4 (14.8,16.1)	16.2 (15.6,16.7)	16.1 (15.7,16.6)	15.8 (15.4,16.1)	0.11	0.05
Fat	40.7 (39.2,42.2)	41.1 (39.6,42.6)	38.0 (36.8,39.2)	38.5 (37.5,39.4)	0.003	0.002
Pufa	6.1 (5.7,6.5)	6.6 (6.3,7.0)	6.9 (6.5,7.2)	7.1 (6.9,7.4)	<0.001	<0.001
Sfa	16.4 (15.3,17.5)	15.9 (15.0,16.7)	13.8 (13.1,14.5)	13.9 (13.4,14.4)	<0.001	<0.001
Cho	43.5 (42.1,44.9)	42.6 (41.3,43.8)	45.4 (44.5,46.2)	45.3 (44.6,46.0)	<0.001	<0.001
Sugar	20.2 (18.6,21.8)	19.8 (18.5,21.2)	20.6 (19.7,21.4)	19.5 (18.9,20.2)	0.23	0.28

* Analysis of variance, P1, no confounding variables; P2, inclusion of age and occupation group.

7.4 NUTRIENT INTAKE, SMOKING AND OCCUPATION GROUP

Heavy smokers and light smokers have been combined to increase sample sizes. Table 7.11 for men shows that there was a marginally significant difference in energy and alcohol intakes in the non-manual group but not in the manual occupation group between smoking categories. For protein, there was a marginally significant difference in the manual group but not in the non-manual group between smoking categories. For absolute intakes (between smoking categories), statistically significant differences were observed for carbohydrate, sugar, fibre and vitamin A in non-manual occupations and for fibre and vitamin C in manual occupations.

When the nutrients were adjusted for energy the trends were unchanged except that protein and polyunsaturated fat became significant in the non-manual occupation group. This result for polyunsaturated fat in the non-manual group is probably due to the inclusion of the volunteers as there was a higher proportion of volunteers in the non-manual occupation group.

In women, statistically significant differences were found in the non-manual occupation group for energy, protein, fat, polyunsaturated fat, saturated fat, carbohydrate, fibre and vitamins C and E and in the manual occupation group for polyunsaturated fat, carbohydrate and fibre only.

Table 7.11: Mean nutrient intakes (se) between smokers and non-smokers by occupation group†

i) Men

	Non-manual occupations			Manual occupations		
	Smokers	Ex-smokers	Never smokers	Smokers	Ex-smokers	Never smokers
Number	72	54	41	78	50	35
Energy (MJ)	10.1 (0.2)	9.4 (0.2)	9.5^{ns} (0.2)	10.3 (0.2)	10.5 (0.3)	10.1 (0.3)
Protein (g)	85.0 (2.2)	84.2 (2.2)	86.9 (2.1)	84.4 (1.8)	91.6 (2.7)	85.7^{ns} (3.0)
Fat (g)	94.5 (2.5)	89.2 (2.3)	90.7 (2.7)	98.9 (2.3)	97.2 (2.8)	93.5 (3.0)
Pufa (g)	15.9 (0.9)	15.9 (0.9)	16.7 (0.7)	17.2 (0.7)	18.4 (1.1)	17.4 (0.8)
Sfa (g)	38.4 (1.2)	35.4 (1.2)	35.6 (1.3)	39.3 (1.0)	38.6 (1.2)	37.2 (1.6)
Cho (g)	273.6 (7.6)	244.2 (7.5)	269.9* (8.5)	286.0 (7.8)	295.9 (9.7)	291.7 (12.3)
Sugar (g)	127.1 (6.0)	98.1 (5.2)	104.9** (8.5)	134.1 (6.3)	124.7 (7.2)	125.8 (8.8)
Fibre (g)	19.1 (0.7)	19.2 (0.7)	22.9** (1.1)	19.3 (0.6)	21.5 (0.9)	22.8* (1.2)
Alcohol (g)	25.2 (2.9)	26.0 (3.6)	12.5^{ns} (2.0)	18.1 (2.7)	20.8 (2.8)	17.3 (3.6)
Vit A (μg)	1287 (167)	714 (146)	1374*** (230)	1251 (165)	1388 (194)	980 (174)
Vit C (mg)	64.4 (3.9)	60.1 (3.7)	67.7 (4.7)	54.0 (3.8)	63.4 (3.2)	56.6* (4.3)
Vit E (mg)	6.7 (0.3)	6.2 (0.4)	7.0 (0.5)	6.9 (0.3)	7.9 (0.5)	6.9 (0.5)

ii) Women

	Non-manual occupations			Manual occupations		
	Smokers	Ex-smokers	Never smokers	Smokers	Ex-smokers	Never smokers
Number	106	63	120	108	58	91
Energy (MJ)	7.1 (0.1)	6.8 (0.2)	7.5* (0.2)	7.0 (0.2)	6.9 (0.2)	7.4 (0.2)
Protein (g)	62.3 (1.3)	62.3 (1.8)	68.1* (1.5)	63.6 (1.6)	64.4 (2.1)	67.0 (1.9)
Fat (g)	76.4 (2.1)	67.4 (2.9)	74.8* (2.1)	73.9 (2.5)	68.7 (3.2)	74.4 (2.7)
Pufa (g)	11.4 (0.4)	12.0 (0.6)	13.7** (0.5)	11.9 (0.4)	12.1 (0.5)	14.2** (0.8)
Sfa (g)	31.1 (1.1)	24.8 (1.2)	27.2** (0.9)	28.6 (1.2)	24.6 (1.4)	26.4 (1.0)
Cho (g)	188.6 (5.1)	191.6 (6.0)	207.9* (5.0)	190.6 (5.7)	192.2 (6.3)	210.1* (5.8)
Sugar (g)	89.0 (3.9)	88.7 (3.4)	89.8 (2.9)	90.7 (4.1)	84.9 (3.8)	89.6 (2.8)
Fibre (g)	16.1 (0.6)	17.2 (0.8)	18.8* (0.7)	15.4 (0.6)	17.5 (0.8)	18.9*** (0.7)
Alcohol (g)	7.5 (1.1)	8.5 (1.3)	7.7 (0.9)	5.1 (0.7)	5.4 (1.2)	5.0 (1.0)
Vit A (μg)	948 (81)	860 (104)	1083 (96)	1136 (135)	1390 (210)	1300 (184)
Vit C (mg)	56.9 (3.0)	68.5 (4.0)	66.1* (2.9)	53.0 (2.7)	64.1 (5.2)	61.6ms (2.9)
Vit E (mg)	4.9 (0.2)	5.4 (0.3)	5.9* (0.2)	5.0 (0.2)	5.1 (0.3)	5.7 (0.3)

† Analysis of variance, adjusting for age ms $P < 0.1$, * $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$

In the same way as for food groups a discriminant analysis for nutrients was carried out using the four smoking categories. The canonical discriminant functions evaluated at the group means (table 7.12) showed a trend from heavy smokers to never smokers. The greatest variation between the groups was observed for smokers as compared with non-smokers.

Table 7.12: Rotated standardised canonical discriminant function coefficients (Canonical discriminant function evaluated at group means heavy smokers -0.7, light smokers -0.6, ex-smokers 0.0, never smokers 0.3)

Variables	Standardised coefficient	Variables	Standardised coefficient
	Positive		Negative
Cho	1.63	Sugar	-1.22
Gender	0.63	Fat	-1.20
Age	0.34	Saturated fat	-0.42
Pufa	0.27	Height	-0.24
Vitamin C	0.24	Vitamin A	-0.23
Fibre	0.21	Dietary supplements	-0.14
Weight	0.21	Energy	-0.12
Alcohol	0.15	Occupation group	-0.10
Protein	0.08		
Vitamin E	0.02		

The model was able to correctly predict non-smokers (ex-smokers and never smokers) for 66% of subjects and smokers (as either light or heavy smokers) for 69% of subjects. Function 1 accounted for 51% of the variance.

Table 7.12 shows the greatest discrimination between smokers and non-smokers was between carbohydrate (associated with non-smokers) and sugar and fat (associated with smokers). Smokers' diets appeared to be characterised by more sugar,

fat (especially saturated fat), vitamin A and energy. They were also more likely to take dietary supplements than non-smokers. Smokers were also more likely to have manual occupations. The non-smokers consumed more carbohydrate, polyunsaturated fats, fibre, alcohol and vitamins. The non-smokers were also more likely to be older, women and weigh more.

If a comparison is made between this table and table 7.4 on page 188 there is agreement for the anthropometric measurements and occupation group. The higher fat and sugar intakes observed in the smokers are explained by more added sugar and more fat as spread and in cooking. Although the smokers used more polyunsaturated fat spreads and oils than non-smokers the overall polyunsaturated fat intake was less. This could be explained by a higher intake of polyunsaturated fat from cereal foods such as bread and breakfast cereal which would also contribute to the higher fibre intake observed in the non-smokers. Although fruit intake was not a major discriminator between the groups, it was associated with a non-smokers diet in line with vitamin C. Alcohol consumption appears higher in the non-smokers. This may be confounded by high alcohol intakes in ex-smokers, therefore care is needed in the interpretation for this nutrient.

The study in Southampton appears to be in agreement with other cross-sectional dietary studies in finding a higher energy, fat (in particular saturated fat) intakes and lower intakes of vitamins, fibre and polyunsaturated fats in smokers compared with non-smokers, despite the different dietary methodologies and smoking classifications.

In conclusion, smokers appear to consume different nutrient intakes from ex- and never smokers and the differences do not appear to be greatly affected by non-dietary confounding variables exist that the differences between smokers and non-smoker are affected by occupation group for some nutrients.

There also appear to be dietary differences between heavy and light smokers with light smokers more like never smokers.

8. EXPERIMENTAL STUDY - FOOD INTAKES

The aim of this chapter is to report the findings from the experimental study of changes in food choices after quitting smoking. The results of changes in nutrient intake are discussed in chapter nine.

As response rates for completion of the weighed record were low it is possible that the non-responders behaved

Table 8.1: Comparison of baseline characteristics of subjects that completed one weighed record compared with those who also completed at least one at follow-up

	MEN			WOMEN		
	1 WR	> 1 WR	P*	1 WR	> 1 WR	P
Number	51	71		80	98	
Occupation (% non-manual/ % manual)	49/47	41/52	0.57	43/49	53/43	0.33
Attendance at cessation classes (%)	51	58	0.58	64	53	0.20
Source (% random)	27	49	0.03	33	43	0.21
Supplement takers (%)	16	14	0.61	36	35	0.98
Cigarettes / day	25.6 (22.5,28.8)	23.0 (20.2,25.8)	0.22	19.7 (17.8,21.6)	19.5 (17.8,21.2)	0.86
Cotinine (ng/ml)	305 (264,346)	280 (254,307)	0.29	257 (229,286)	252 (226,278)	0.79
Weight (kg)	80.3 (76.5,84.0)	77.0 (74.4,79.6)	0.16	63.6 (61.4,65.8)	66.8 (64.3,69.4)	0.07
BMI (kg/m^2)	26.2 (25.2,27.1)	25.3 (24.5,26.1)	0.14	24.4 (23.5,25.2)	25.3 (24.4,26.1)	0.13

* Statistical analysis - Chi-squared test for occupation, attendance, source, supplement takers; T-test for the remainder.

differently from those who attended. This is difficult to determine. However, a comparison between baseline measures of responders and non-responders has been made and is shown in table 8.1. The comparison was made for subjects completing a weighed record at baseline and those completing at least one at follow-up.

The table shows that randomly recruited subjects were more likely to return for follow-up weighed records. In men responders had a lower weight and BMI than non-responders but in women the reverse was true with responders weighing more and having a higher BMI. This, however, appears to reflect differences between sources of recruitment (see table 4.1 page 118) as randomly recruited men had a lower BMI than volunteer men and were more likely to attend. In women volunteers had a lower BMI than the randomly recruited subjects but as the random recruits were more likely to attend the responders had a higher BMI.

8.1 SUBJECT CHARACTERISTICS

Table 8.2 shows the baseline characteristics of those who continued to smoke (smokers) and those who were successful in stopping smoking (quitters). Fourteen (20%) men and sixteen (16%) women who completed baseline and follow-up weighed records were successful in stopping smoking. There were no significant differences in the age or occupation group of smokers and quitters at baseline. A greater proportion of volunteers were successful (as they volunteered to stop smoking this is not surprising). In fact 13% of smokers from the random sample and 21% of volunteers were successful.

There was also no significant difference in the proportion of subjects attending at least one cessation class. Although, any of the subjects may have attended other groups, undergone hypnosis or consulted a doctor, this was not recorded.

Table 8.2: Characteristics of smokers and quitters at baseline (total number 169)

	Baseline	
	Smokers	Quitters
Number (Men/women)	57/82	14/16
Age (se) (years)	50.5 (0.5)	50.9 (1.1)
Occupation* (% manual / % non-manual)	47/47	47/50
Source (R/V) (%)	49/51	30/70†
Cessation‡ classes (%)	42	57

* Do not add up to 100% as not all subjects could be classified
† Chi-squared test P = 0.009
‡ Attendance at one session or more

Table 8.3i shows the changes in weight, body mass index, cigarettes and cotinine between subjects at baseline and first follow-up. All subjects with at least two completed weighed records irrespective of the length of time between the weighed records were included. For subjects with three weighed records the first two were included in this analysis. At baseline no differences were detected between the smokers and quitters (analysis of variance). At follow-up (table 8.3ii) there were statistically significant increases in weight and BMI after cessation. The weight and BMI increases attributable to smoking cessation were 3.1kg in men and 3.7kg in women as shown in table 8.3ii. Adjustment was made for baseline measure to take into account small differences at baseline between smokers and quitters.

Table 8.3: Non-dietary variables at baseline and follow-up one

i) Absolute mean values (SE)

	Baseline		Follow- up	
	Smokers	Quitters	Smokers	Quitters
MEN				
Number	56	14		
Weight (kg)	77.4 (1.7)	75.2 (2.7)	78.0 (1.6)	78.9 (2.8)
BMI (kg/m^2)	25.4 (0.4)	24.8 (0.8)	25.6 (0.5)	26.0 (0.8)
Cigarettes/d	23.4 (1.5)	21.6 (3.3)	17.5 (1.6)	0
Cotinine (ng/ml)	278 (14)	293 (40)	268 (17)	23 (16)
WOMEN				
Number	81	16		
Weight (kg)	66.3 (1.3)	69.6 (4.5)	67.1 (1.3)	74.1 (4.8)
BMI (kg/m^2)	25.1 (0.4)	26.1 (1.6)	25.4 (0.4)	27.7 (1.7)
Cigarettes/d	19.3 (1.0)	20.4 (1.7)	14.7 (0.8)	0
Cotinine (ng/ml)	260 (14)	211 (36)	240 (14)	16 (14)

Subjects who continued to smoke reported reducing their cigarette consumption by four per day. However, there was only a minimal change in the cotinine concentration. This means that either the subjects had not reduced the number of cigarettes smoked daily or that they were giving a correct answer but were compensating for the reduction in cigarettes by smoking more of the cigarette or inhaling more etc. After smoking cessation the cotinine concentration should return to zero. However, five subjects reported taking nicorette chewing gum which produced the cotinine reading (the carbon monoxide readings for these subjects were those of non-smokers).

ii) Differences (SE) in weight and BMI between first follow-up and baseline by smoking status and gender

	Smokers	Quitters	Difference attributable to cessation
	MEN		
Weight	0.6 (0.3)	3.7 (0.8)***	3.1
BMI	0.2 (0.1)	1.2 (0.3)***	1.0
	WOMEN		
Weight	0.7 (0.2)	4.4 (1.1)	3.7
BMI	0.3 (0.1)	1.7 (0.4)	1.4

Analysis of variance with data from men and women combined adjusted for baseline measure, gender, occupation, age, cessation classes, source, time between appointments, *** $P < 0.001$.

The follow-up times for men were 21 weeks (range 10 to 68) for those who continued to smoke and 21 weeks (range 16 to 52) for those who quit. For women the times were 26 weeks (range 10 to 68 weeks) and 21 weeks (range 16 to 52 weeks)

The time since quitting for men was 10.7 weeks (range 1-22 weeks) and for women was 12.5 (2 to 26) weeks.

8.2 SHORT TERM EFFECT OF SMOKING CESSATION

Table 8.4 shows the intake (g) of the food groups at baseline and follow-up for the smokers and quitters. Only data for food groups showing statistically significant differences in either men or women are shown.

Table 8.4: Food consumption at baseline and follow-up in men

i) Absolute amounts at baseline and follow-up (SE)

	Baseline		Follow-up	
	Smokers	Quitters	Smokers	Quitters
Number	57	14	57	14
Fruit	54.3 (19.3)	47.7 (12.4)	43.2 (9.8)	46.5 (9.2)*
Bcereal	19.5 (3.9)	30.2 (7.4)	20.5 (4.4)	52.2 (12.9)**
Cakes	48.6 (6.1)	57.9 (11.6)	46.9 (5.9)	48.1 (9.8)
Milk	301 (21)	324 (40)	334 (25)	418 (45)
Dairy	47.6 (3.6)	46.1 (6.8)	45.9 (4.7)	43.1 (8.2)
Pufa fat	11.1 (1.5)	12.7 (3.2)	10.6 (1.5)	18.4 (3.2)**
Processed meat	56.5 (4.8)	44.9 (7.2)	59.5 (5.0)	81.0 (13.7)ms
Snacks	14.9 (2.5)	14.3 (3.1)	10.2 (1.9)	30.8 (8.6)**

ii) Difference in food consumption between appointments (SE)

	Difference (unadjusted)		Difference (adjusted)†		
	Smokers	Quitters	Smokers	Quitters	‡
Fruit	-11.2 (19.2)	-0.8 (10.8)	-18.7	19.4	38.1
Bcereal	1.0 (4.7)	22.0 (9.5)*	-1.0	25.5**	26.5
Cakes	-1.7 (4.5)	-9.8 (11.2)	-3.1	-6.7	-3.6
Milk	32.3 (15.8)	93.9 (53.4)	23.9	103.8*	79.9
Dairy	-1.7 (4.3)	-3.0 (8.1)	-4.2	-0.4	3.8
Pufa fat	-0.6 (1.2)	5.6 (1.8)**	-0.9	5.1**	6.0
Processed meat	3.0 (5.0)	36.1 (11.5)ms	-0.6	32.6*	33.2
Snacks	-4.8 (2.1)	16.5 (9.6)***	-3.9	15.8**	19.7

† Analysis of variance adjusting for age, occupation, attendance of cessation classes, recruitment source, baseline measure and length of time between appointments ms (marginal significance) $p < 0.1$, * $p < 0.05$, ** $p < 0.01$. ‡ Difference associated with smoking cessation (quitters - smokers)

Table 8.5: Food consumption at baseline and follow-up in women

i) Absolute amounts at baseline and follow-up (SE)

	Baseline		Follow-up	
	Smokers	Quitters	Smokers	Quitters
Number	82	16	82	16
Fruit	71.6 (14.0)	77.3 (10.8)*	64.4 (8.5)	81.4 (23.3)
Bcereal	17.6 (2.8)	13.2 (6.4)	24.4 (3.9)	15.6 (7.0)
Cakes	32.6 (3.9)	40.3 (8.6)	35.0 (3.9)	53.1 (7.5)**
Milk	347 (27)	332 (41)	349 (25)	329 (40)
Dairy	41.1 (5.9)	26.3 (3.8)	31.4 (3.0)	37.1 (5.3)
Pufa fat	9.3 (1.0)	7.6 (2.4)	7.5 (0.8)	9.3 (2.8)
Processed meat	32.2 (2.5)	24.4 (3.9)	30.8 (2.6)	38.0 (5.5)
Snacks	16.4 (2.2)	16.9 (6.6)	12.7 (2.0)	14.1 (14.7)

ii) Difference in food consumption between appointments (SE)

	Difference (unadjusted)		Difference (adjusted)†		
	Smokers	Quitters	Smokers	Quitters	‡
Fruit	-7.3 (9.9)	4.1 (20.2)	-11.5	21.9	33.4
Bcereal	6.8 (3.4)	2.4 (5.9)	7.4	2.5	-4.9
Cakes	3.2 (2.8)	12.8 (8.6)**	2.1	17.2**	15.1
Milk	1.2 (16.7)	-3.5 (20.2)	1.5	-0.7	-2.2
Dairy	-9.7 (5.2)	10.8 (5.1)*	-8.4	9.4*	17.8
Pufa fat	-1.8 (1.0)	1.8 (2.2)	-1.5	0.6	2.1
Processed meat	-1.4 (2.8)	13.6 (6.5)ms	-1.5	13.2ms	14.7
Snacks	-3.7 (1.9)	-2.9 (7.3)	-4.0	1.6	5.6

† Analysis of variance adjusting for age, occupation, attendance of cessation classes, recruitment source, baseline measure and length of time between appointments ms (marginal significance) $p < 0.1$, * $p < 0.05$, ** $p < 0.01$. ‡ Difference associated with smoking cessation (quitters - smokers)

Firstly for men in table 8.4, there were no differences between the food groups at baseline, but at follow-up the quitters were consuming more fruit, breakfast cereal, pufa fats, snacks and marginally more processed meats. After adjustment for the confounding variables (table 8.4ii) the quitters consumed more breakfast cereal, pufa fats, snacks, processed meats and milk than the smokers. The difference attributable to smoking cessation are shown in the table.

In men smoking cessation was associated with an increase in breakfast cereal, pufa fats, snacks, processed meat and milk.

In women in table 8.5i the quitters appeared to consume more fruit at baseline than the smokers but there were no differences for other groups. At follow-up the only statistically significant difference detected was for cakes with quitters consuming more than the smokers. Table 8.4ii shows the differences after adjustment for the confounding variables and shows that quitters significantly increased their consumption of cakes and dairy products with a marginally significant increase in processed meat. Therefore smoking cessation in women was associated with increases in cakes, dairy products and processed meats. However, the trends of increases in the other food groups except for breakfast cereal were also apparent but were not so large as in men.

8.3 LONG TERM EFFECT OF SMOKING CESSATION

Table 8.6 shows that as found in the previous section, cessation at the first follow up was associated with increases in weight and BMI. It also shows that weight and BMI were still increasing with the second follow-up. The times since quit were as follows 12.9 weeks (range 4-26 weeks) at one follow-up and 46.0 weeks (range 39-52 weeks) for two

Table 8.6: Differences (SE) in weight and BMI by follow-up appointment for smokers and quitters for subjects completing three weighed records and quitters if quit at both follow-up appointments.

(Numbers 86 smokers (31men) and 15 quitters (5 men)

	Baseline		2 Follow-ups	
	Smokers	Quitters	Smokers	Quitters
Weight (kg)	71.0 (1.5)	73.3 (4.8)	70.8 (1.7)	79.3 (4.8)*
BMI (kg/m²)	25.4 (0.4)	26.2 (1.7)	25.3 (0.5)	28.4 (1.7)*

ii) Differences (SE) in weight and BMI with one and two follow-ups

	Smokers	Quitters	†
Follow-up 1			
Weight (kg)	0.4 (0.2)	4.4 (1.2)***	4.0
BMI (kg/m²)	0.1 (0.1)	1.6 (0.5)***	1.5
Follow-up 2			
Weight (kg)	-0.2 (0.8)	6.0 (1.4)***	6.2
BMI (kg/m²)	-0.1 (0.3)	2.1 (0.5)***	2.2

† Difference attributable to smoking cessation
Analysis of variance adjusting for age, occupation, cessation classes, source, baseline measure, follow-up time * $P < 0.05$, *** $P < 0.001$

follow-ups. The mean time between baseline and follow-up one appointments was 21 weeks (range 10-31 weeks) for smokers and 21 weeks (range 16-26) for quitters. The time interval between baseline and follow-up two appointments was 54 weeks (47-73) for smokers and 53 (52-57) for quitters.

Table 8.7: Food intakes (differences) by appointment and smoking status for subjects completing three weighed records (men and women have been combined)

i) Absolute intakes in grammes (SE) at baseline and 2nd follow-up

	Baseline		2nd Follow-up	
	Smokers	Quitters	Smokers	Quitters
Number	86	15	86	15
Fruit	68.2 (13.5)	78.0 (13.0)*	60.4 (7.8)	53.1 (11.6)
Bcereal	17.7 (3.2)	27.7 (8.5)	17.4 (3.6)	32.6 (8.9)*
Cakes & biscuits	38.5 (4.9)	51.1 (11.7)	43.7 (5.5)	62.5 (13.9)
Milk	344 (26)	390 (47)	356 (29)	402 (31)
Dairy	44.9 (5.6)	21.7 (3.6)*	41.5 (4.5)	40.2 (6.0)
Sfa fat	13.8 (1.4)	16.5 (3.5)	12.4 (1.5)	10.4 (2.6)
Pufa fat	10.6 (1.1)	7.2 (2.3)ms	10.5 (1.2)	6.1 (2.2)
Processed meat	40.3 (3.5)	35.9 (6.6)	40.5 (3.1)	39.2 (5.6)
Snacks	16.7 (2.2)	20.3 (7.1)	9.8 (1.4)	12.9 (6.0)

ii) Gramme differences (SE) between 1st follow-up and baseline

	Difference (unadjusted)		Difference (adjusted)		†
	Smokers	Quitters	Smokers	Quitters	
Fruit	-7.7 (9.6)	-26.7 (11.5)	-10.1	-12.3	-2.2
Bcereal	1.7 (3.4)	7.9 (8.4)	1.5	11.1	9.6
Cakes & biscuits	1.3 (3.0)	6.5 (11.5)	0.9	13.2	12.3
Milk	12.3 (13.3)	21.3 (40.2)	10.0	25.5	15.5
Dairy	-0.4 (6.1)	17.5 (8.9)	3.0	1.7	-1.3
Sfa fat	-1.6 (0.9)	-2.5 (2.3)	-1.7	-2.4	-0.7
Pufa fat	-0.8 (1.0)	4.0 (1.7)	-1.1	3.0	4.1
Processed meat	-0.1 (3.1)	16.9 (10.3)ms	-1.1	16.1ms	17.2
Snacks	-5.8 (2.0)	-1.9 (7.5)*	-5.9	2.7ms	8.6

iii) Gramme differences(SE) between 2nd follow-up and baseline

	Difference (unadjusted)		Difference (adjusted)		
	Smokers	Quitters	Smokers	Quitters	†
Fruit[a]	-8.2 (10.0)	-24.9 (13.0)	-	-	-
Bcereal	-0.6 (4.2)	4.9 (10.6)*	-1.9	10.2*	12.1
Cakes & biscuits	5.6 (3.3)	11.5 (11.1)	6.9	13.4	6.5
Milk	11.8 (14.6)	12.5 (37.6)	12.7	10.5	-2.2
Dairy	-3.6 (5.8)	18.5 (6.2)	-0.4	4.3ms	4.7
Sfa fat[a]	-1.2 (1.1)	-6.1 (2.6)	-	-	-
Pufa fat	-0.04 (1.2)	-1.1 (2.6)	-0.4	-3.6	-3.2
Processed meat	1.0 (3.3)	3.3 (6.4)	-0.3	3.7	4.0
Snacks	-7.0 (1.9)	-7.5 (7.4)	-7.4	-2.0	5.4

† Analysis of variance adjusting for age, occupation, attendance of cessation classes, recruitment source, baseline measure and length of time between appointments ms (marginal significance) $p < 0.1$, * $p < 0.05$.
† Difference associated with smoking cessation (quitters - smokers)
[a] Results shown separately as there was a significant interaction between occupation and smoking status.

Table 8.7 shows the baseline and second follow-up results for men and women combined (there were no significant gender smoking interactions). As the sample of quitters contains only 4 men the results tend to reflect the smaller differences detected in women. At baseline there were significant differences between the smokers and quitters for fruit and dairy products and at 2nd follow-up for breakfast cereal. The results for differences at first follow-up are shown in table 8.6ii. These results do not achieve significance due to the small sample size and the greater proportion of women but show trends for increases in breakfast cereal, pufa fat, snacks, milk, processed meats and cakes. The differences between the second follow-up and baseline are shown in table 8.6iii and show a significant difference for breakfast cereal and marginal difference for dairy products. The difference attributable to smoking being

larger than at first follow-up for breakfast cereal and dairy products. However, for the other food groups differences attributable to smoking are smaller. For fruit and saturated fats there were significant interactions between occupation group and smoking status ($P = 0.04$ for saturated fats, $P = 0.01$ for fruit).

The adjusted mean differences between follow-up two and baseline for fruit between smokers and quitters were as follows: 2.0g and 11.8g for non-manual occupation groups, -23.6g and -5.0g for manual occupation groups. With differences attributable to smoking cessation of 9.8g for non-manual occupations (not significant) and -18.6g ($P < 0.05$) for manual occupations. The adjusted mean differences for saturated fats for non-manual occupation groups were -1.0g, and -11.3 for smokers and quitters respectively and for manual occupations -2.1g, and 0.04 respectively. The differences attributable to smoking cessation were 10.3g for non-manual occupations ($P < 0.10$) and -2.1g (not significant) for manual occupations. Therefore differences were observed in the non-manual occupations at second follow-up for saturated fats and manual groups for fruit.

In summary, in the short term smoking cessation was associated with increased weight and food intakes. The food groups that were affected differed by gender. In men they were breakfast cereals, polyunsaturated fat, snacks, processed meat and milk, and in women they were cakes and biscuits, and dairy foods. Longer periods of cessation were associated with a continued weight gain but the observed differences in food groups seen in the short term disappeared with the exception of those for breakfast cereals. It is possible that initially quitters replace cigarettes with food such as snacks and sweets (also shown by Stubbe *et al*, 1982) but as the withdrawal symptoms subside quitters revert back to their diet as smokers. However, this would not explain

the continued increase in body weight.

9. EXPERIMENTAL STUDY-NUTRIENT INTAKES

The effect of smoking cessation on nutrient intake in both the short-term and long-term is discussed in this chapter. The relationship between changes in energy intake and weight will also be addressed.

9.1 NON-RESPONDERS

Chapter eight showed that there were no statistically significant differences in occupation group, attendance at cessation classes, use of vitamin supplements, number of cigarettes smoked and serum cotinine concentrations, weight or body mass index at baseline between subjects who completed one weighed record and those who completed more than one. Table 9.1 shows the nutrient intakes of subjects who completed one weighed record compared with those who completed more than one. In men there were no differences in baseline nutrient intake between the non-responders and responders at follow up. However, in women the returners consumed higher intakes of all nutrients except for β carotene, eicosapentaenoic acid (EPA), mufa and alcohol where no difference was detected (not shown in table). After adjustment for energy, no significant differences remained. Therefore, women who completed more than one WR consumed a greater nutrient intake but the composition of the diet was not different.

Table 9.1: Comparison of mean nutrient intakes (95% CI) of subjects completing one weighed record with those who completed more than one.

	MEN		WOMEN	
	1 WR	> 1 WR	1 WR	> 1 WR
Number	51	80	71	98
Energy (MJ)	10.2 (9.5,10.8)	10.1 (9.7,10.5)	6.6 (6.3,6.9)	7.4** (7.1,7.7)
Protein (g)	86.8 (81.9,91.8)	82.4 (78.5,86.3)	60.3 (57.3,63.3)	66.7 (63.4,69.9)**
Fat (g)	98.6 (92.2,105.1)	98.9 (94.0,103.8)	68.9 (64.1,73.7)	76.3 (71.8,80.8)*
Pufa (g)	16.8 (15.0,18.6)	15.8 (14.5,17.1)	10.8 (9.8,11.7)	11.8ms (10.9,12.7)
Sfa (g)	39.0 (36.1,41.9)	40.0 (37.7,42.2)	28.4 (26.0,30.7)	31.7* (29.4,33.9)
Cho (g)	274.9 (252.2,297.6)	279.0 (203.3,294.6)	178.7 (167.2,190.3)	201.7** (190.8,212.6)
Sugar (g)	130.4 (114.5,146.4)	130.3 (118.2,142.4)	79.5 (70.7,88.2)	94.9* (86.0,103.9)
Fibre (g)	18.6 (16.9,20.3)	19.5 (18.1,20.9)	14.8 (13.8,15.9)	16.9ms (15.6,18.2)
Vit C (mg)	59.9 (49.1,70.7)	56.2 (49.3,63.2)	50.6 (43.8,57.4)	57.9* (50.9,64.9)
Vit E (mg)	6.6 (5.8,7.3)	6.6 (6.0,7.1)	4.4 (4.0,4.7)	5.3** (4.8,5.7)

Two tailed T-test, marginal significance ms $P < 0.10$, * $P < 0.05$, ** $P < 0.01$

9.2 SHORT TERM EFFECT OF SMOKING CESSATION

The mean nutrient intakes for continuing smokers and quitters at first follow-up are shown in table 9.2. No statistically significant differences were found for any nutrient in either men or women between baseline measure of those who continued to smoke and those who went on to stop smoking. At first follow-up, comparison between smokers and quitters not taking

into account any other variable showed in men that there were significant differences for energy, protein, fat, polyunsaturated fat, carbohydrate and fibre and marginally significant differences for monounsaturated fat and vitamin E. Values of all these nutrients increased after cessation. In women, only a marginal statistical difference in saturated fat was detected. However, the trends of increases in nutrient values after quitting as shown in men were apparent.

Table 9.2: Mean nutrient intakes (se) at baseline and first follow-up

i) Men

	Baseline		1st follow-up	
	Smokers	Quitters	Smokers	Quitters
Number	57	14	57	14
Energy (MJ)	10.2 (0.2)	9.9 (0.3)	9.6 (0.2)	11.1 (0.5)**
Protein (g)	82.2 (2.3)	83.3 (2.9)	80.6 (2.0)	96.4 (4.8)**
Fat (g)	100.3 (2.8)	92.9 (4.6)	93.7 (2.6)	110.4 (7.1)*
Pufa (g)	15.9 (0.7)	15.3 (1.2)	15.3 (0.8)	20.2 (1.5)**
Sfa (g)	40.4 (1.3)	38.1 (2.3)	37.2 (1.2)	42.6 (3.5)
Mufa (g)	35.7 (1.1)	32.2 (1.5)	32.9 (1.0)	38.1 (2.7)ms
EPA (g)	0.3 (0.02)	0.3 (0.1)	0.3 (0.03)	0.4 (0.06)
CHO (g)	278.4 (9.5)	281.2 (9.0)	264.2 (8.2)	303.6 (14.3)*
Sugar (g)	131.1 (7.4)	127.2 (6.5)	123.1 (6.9)	136.9 (10.2)
Fibre (g)	19.2 (0.8)	20.4 (1.3)	18.5 (0.8)	23.5 (2.0)*
Alcohol (g)	21.0 (3.2)	18.9 (6.8)	16.8 (2.9)	16.5 (6.2)
β carotene (μg)	1197 (112)	906 (140)	1124 (133)	1095 (242)
Vit C (mg)	54.9 (4.0)	61.6 (7.3)	57.2 (4.3)	61.1 (7.6)
Vit E (mg)	6.5 (0.3)	6.6 (0.5)	6.2 (0.4)	7.6 (0.7)ms

Analysis of variance, marginal significance ms $P < 0.10$, * $P < 0.05$, ** $P < 0.01$

ii) Women

	Baseline		1st follow-up	
	Smokers	Quitters	Smokers	Quitters
Number	82	16	82	16
Energy (MJ)	7.4 (0.2)	7.4 (0.4)	7.0 (0.2)	7.5 (0.5)
Protein (g)	67.0 (1.9)	65.0 (3.2)	66.3 (1.7)	67.3 (4.0)
Fat (g)	75.9 (2.5)	78.5 (5.6)	70.1 (2.3)	81.5 (6.2)
Pufa (g)	11.9 (0.5)	11.1 (1.0)	11.1 (0.4)	11.6 (1.2)
Sfa (g)	31.1 (1.2)	34.4 (3.0)	28.4 (1.1)	35.1 (3.1)^{ms}
Mufa (g)	26.4 (1.0)	26.8 (1.9)	24.1 (0.9)	27.5 (2.1)
EPA (g)	0.2 (0.02)	0.2 (0.04)	0.2 (0.02)	0.2 (0.04)
CHO (g)	202.1 (6.1)	199.9 (12.6)	196.0 (6.1)	201.8 (14.3)
Sugar (g)	94.9 (5.0)	94.9 (10.3)	90.4 (4.9)	89.6 (8.6)
Fibre (g)	17.1 (0.8)	15.9 (0.9)	16.3 (0.7)	16.9 (1.2)
Alcohol (g)	6.3 (1.0)	5.2 (2.2)	4.9 (0.9)	3.9 (1.4)
β carotene (μg)	964 (102)	1341 (160)	1214 (132)	1008 (145)
Vit C (mg)	58.3 (4.2)	55.7 (3.6)	57.1 (3.8)	48.1 (4.7)
Vit E (mg)	5.3 (0.3)	5.1 (0.4)	4.8 (0.2)	5.2 (0.4)

Analysis of variance, marginal significance ^{ms} $P < 0.10$, * $P < 0.05$, ** $P < 0.01$.

Table 9.3: Differences in nutrient intakes (se) between appointments (data for men and women have been combined)

	Difference (unadjusted)		Difference (adjusted)		
	Smokers	Quitters	Smokers	Quitters	Attributable to cessation
Energy (MJ)	-0.5 (0.1)	0.6 (0.3)**	-0.5	0.6**	1.1
Protein (g)	-1.1 (1.1)	7.3 (2.7)*	-1.4	6.9*	8.3
Fat (g)	-6.1 (1.6)	9.8 (4.5)**	-5.9	8.0**	13.9
Pufa (g)	-0.7 (0.3)	2.5 (0.9)**	-0.7	2.4**	3.1
Sfa (g)	-2.9 (0.7)	2.5 (1.9)**	-2.9	1.9*	4.8
Mufa (g)	-2.5 (0.6)	3.1 (1.6)**	-2.3	2.3*	4.6
EPA (g)	-0.03 (0.02)	0.03 (0.05)	-0.03	0.02ms	0.05
Cho (g)	-9.4 (3.3)	11.5 (8.1)*	-10.4	14.5*	24.9
Sugar (g)	-5.9 (2.2)	1.7 (5.3)	-6.7	5.0ms	11.7
Fibre (g)	-0.8 (0.3)	2.0 (0.8)**	-0.8	2.3**	3.1
Vit E (mg)	-0.4 (0.2)	0.5 (0.4)*	-0.4	0.6*	1.0

Analysis of variance adjusting for age, occupation, attendance at cessation classes, recruitment source, baseline measure and length of time between appointments ms $P < 0.10$, * $P < 0.05$, ** $P < 0.01$.

The effect of smoking cessation was larger in men than women but otherwise did not appear to be affected by gender. The mean nutrient differences between follow-up and baseline with data for men and women combined are shown in table 9.3. The mean difference adjusted for age, occupation, gender, baseline measure and length of time between appointments is also shown. The final column shows the difference attributable to smoking cessation when the confounding variables were taken into account. Taking the confounding variables into account did not change the overall results. Smoking cessation was associated with increases in energy, protein, fat, and types of fat, carbohydrate and sugar, fibre and vitamin E. Alcohol, β carotene, and vitamin C tended to decrease after cessation but these results were not

statistically significant (not shown in the table). After the additional adjustment for energy, no nutrient showed statistical significance but fibre (P = 0.08) and polyunsaturated fat (P = 0.05) showed marginally significant increases after cessation. Other studies that have measured change in nutrient intake within weeks of smoking cessation have reported increases in energy, fat, carbohydrate and sugar (Stubbe *et al*, 1982; Rodin, 1987; Hall *et al*, 1989; Moffat & Owens, 1991). Stamford *et al*, (1986) like the Southampton study found an increase in energy but the overall macronutrient composition of the diet did not change. The Southampton study showed increases in all nutrients studied apart from alcohol, β carotene and vitamin C.

In summary, there appeared to be an increase in the total diet but the composition of the diet did not vary substantially.

9.3 LONG TERM EFFECT OF SMOKING CESSATION

The longer term effect of smoking cessation in subjects completing three weighed records has been investigated. Data for men and women have been combined as before. There was no difference between quitters and smokers in the number of subjects starting or stopping dietary supplements. The number of subjects taking dietary supplements at baseline was 21 smokers and 6 quitters, and at both follow-ups 23 smokers and 4 quitters were taking dietary supplements. The analysis of variance showed that there was no statistically significant interaction between smoking status and gender. The results are shown in table 9.3. These again show that there were no differences in baseline measures of those who quit and those who continued to smoke except for alcohol in which the quitters had a lower consumption at baseline than the smokers. There were also no differences detected in the results from the third weighed record between quitters and

smokers. The actual differences between first follow-up and baseline and second follow-up and baseline are shown in 9.4ii and 9.4iii. As long term quitters may differ from

Table 9.4: Nutrient differences (SE) by appointment and smoking status for subjects completing three weighed records (data for men and women have been combined)

	Baseline		1st follow-up	
	Smokers	Quitters	Smokers	Quitters
Number	86	15	86	15
Energy (MJ)	8.5 (0.2)	8.2 (0.3)	8.2 (0.2)	8.3 (0.6)
Protein (g)	73.4 (2.0)	73.4 (4.4)	72.7 (1.9)	80.3 (5.4)
Fat (g)	86.4 (2.8)	83.9 (6.3)	81.3 (2.9)	83.7 (7.0)
Pufa (g)	13.6 (0.6)	11.8 (1.1)	13.1 (0.6)	12.0 (1.5)
Sfa (g)	35.1 (1.2)	36.9 (3.5)	32.9 (1.3)	34.9 (3.0)
Mufa (g)	30.4 (1.1)	28.7 (2.1)	28.1 (1.1)	29.0 (2.4)
EPA (g)	0.3 (0.02)	0.2 (0.04)	0.2 (0.02)	0.2 (0.04)
Cho (g)	230.0 (7.3)	235.6 (17.8)	225.8 (9.0)	234.4 (17.7)
Sugar (g)	107.9 (5.5)	110.0 (11.7)	106.9 (7.4)	98.1 (10.9)
Fibre (g)	18.0 (0.8)	18.8 (1.6)	17.6 (0.7)	18.7 (1.8)
Alcohol (g)	12.7 (2.1)	2.2 (0.8)*	11.1 (1.9)	3.6 (1.4)
β carotene (μg)	1000 (85)	1159 (167)	1174 (99)	1036 (211)
Vit C (mg)	57.0 (4.1)	65.5 (5.9)	56.2 (3.6)	57.0 (4.8)
Vit E (mg)	6.0 (0.3)	5.4 (0.4)	5.7 (0.3)	5.1 (0.6)

Analysis of variance * $P < 0.05$.

ii) Mean differences (SE) between 1st follow-up and baseline

	Difference (unadjusted)		Difference (adjusted)		
	Smokers	Quitters	Smokers	Quitters	†
Energy (MJ)	-0.5 (0.1)	0.5 (0.4)*	-0.6	0.5*	1.1
Protein (g)	-1.3 (1.4)	3.8 (3.4)	-2.0	3.2	5.2
Fat (g)	-7.6 (2.0)	6.9 (4.9)*	-8.1	4.9*	13.0
Pufa (g)	-0.9 (0.4)	2.1 (1.0)*	-1.1	2.0**	3.1
Sfa (g)	-3.3 (0.9)	1.6 (2.2)ms	-3.5	0.7	4.2
Mufa (g)	-3.0 (0.8)	1.9 (1.8)*	-3.1	1.1	4.2
EPA (g)	-0.05 (0.02)	0.08 (0.05)*	-0.05	0.08**	0.1
Cho (g)	-8.6 (4.2)	9.0 (11.0)	-10.5	16.0ms	26.5
Sugar (g)	-4.7 (2.8)	-1.7 (7.6)	-6.3	4.7	11.0
Fibre (g)	-0.7 (0.4)	0.4 (1.1)	-1.0	0.7	1.7
Alcohol (g)	-2.5 (0.7)	2.0 (1.2)**	-2.4	0.5*	2.9
β carotene (μg)	175 (1240	3 (305)	183	-73	-256
Vit C (mg)	0.8 (3.1)	-4.4 (6.5)	-2.7	3.2	5.9
Vit E (mg)	-0.5 (0.2)	0.2 (0.3)	-0.6	0.3ms	0.9

† Difference attributable to smoking cessation
Analysis of variance adjusting for age, occupation, attendance at cessation classes, recruitment source, baseline measure and length between appointments, marginal significance ms $P < 0.10$, * $P < 0.05$, ** $P < 0.01$.

iii) Mean differences (SE) between 2nd follow-up and baseline

	Difference (unadjusted)		Difference (adjusted)		
	Smokers	Quitters	Smokers	Quitters	†
Energy (MJ)	-0.3 (0.2)	0.1 (0.3)	-0.4	0.04	0.4
Protein (g)	-0.7 (1.5)	6.9 (3.2)*	-0.9	6.3ms	7.2
Fat (g)	-5.2 (2.3)	-0.2 (5.2)	-5.9	-2.4	3.5
Pufa (g)	-0.5 (0.5)	0.2 (1.5)	-0.7	-0.7	0
Sfa (g)	-2.2 (1.0)	-2.0 (2.2)	-2.5	-2.4	0.1
Mufa (g)	-2.3 (0.9)	0.3 (1.7)	-2.5	-0.5	2.0
EPA (g)	-0.06 (0.02)	0.01 (0.04)	-0.07	-0.02	0.05
Cho (g)	-4.2 (6.5)	-1.2 (7.8)	-4.9	-2.7	2.2
Sugar (g)	-1.1 (5.2)	-11.9 (7.0)	-0.8	-11.4	-10.6
Fibre (g)	-0.4 (0.5)	-0.1 (1.1)	-0.6	-0.3	0.3
Alcohol (g)	-1.6 (0.8)	1.4 (1.2)	-1.5	-0.2	1.3
β carotene (μg)	175 (91)	-123 (269)ms	166	-228*	-394
Vit C (mg)	-0.7 (3.2)	-8.5 (5.6)	-2.0	-4.7	-2.7
Vit E (mg)	-0.3 (0.2)	-0.3 (0.6)	-0.4	-0.7	-0.3

† Difference attributable to smoking cessation
Analysis of variance adjusting for age, occupation, attendance at cessation classes, recruitment source, baseline measure and length between appointments ms $P < 0.10$, * $P < 0.05$, ** $P < 0.01$.

intermittent quitters data are again shown for the first follow up (table 9.4ii). The difference attributable to smoking cessation was similar to that in table 9.3 except that the difference for protein was smaller in the longer term quitters. After adjustment for energy (not shown) only alcohol ($P = 0.03$) was significant and EPA ($P = 0.06$) was marginally significant. The same results for the second follow-up are shown in table 9.4iii. After adjustment for the variables only β carotene was statistically significant and remained so after energy adjustment. β carotene appeared to decrease after smoking cessation. If the differences

attributable to smoking cessation are compared from first and second follow-ups, it appears that for energy, fat, types of fat, carbohydrate, fibre, alcohol differences observed at first follow-up are reduced by the second follow-up. However for protein the difference at second follow-up was greater than at first follow-up. For sugar, β carotene, vitamins C and E intakes were reduced to below baseline level by the second follow-up. There appeared to be occupation group smoking group interactions after energy adjustment implying that the relationship between smoking cessation and nutrient intake differed by occupation group. This was observed for sugar, carbohydrate and monounsaturated fat and can be seen in table 9.4iv.

Table 9.4iv: The effect of occupation group on mufa, cho and sugar

	Non-manual occupations			Manual occupations		
	Smokers	Quitters	Attributable to cessation	Smokers	Quitters	Attributable to cessation
Mufa (g)	-1.8	-3.9	-2.1	-2.7	0.1	2.8^{ms}
Cho (g)	-22.6	4.1	26.7	12.6	-26.3	-38.9^{ms}
Sugar (g)	-14.6	2.4	17.0	11.5	-30.2	-41.7^{**}

Analysis of variance adjusting for age, attendance at cessation classes, recruitment source, baseline measure and length between appointments marginal significance ^{ms} $P < 0.10$, * $P < 0.05$, ** $P < 0.01$.

The table shows that for manual occupations there was a significant increase in mufa after cessation in the longer term. There were also marginally significant decreases for carbohydrate and sugar.

9.4 CHANGES IN WEIGHT, ENERGY INTAKE AND SMOKING

The effect of smoking cessation on weight and energy differences was investigated using the quitters at first follow-up so that the short term effect of increases in energy could be investigated. Figure 9.1 shows the relationship between changes in energy intake and time since quitting and figure 9.2 the relationship between changes in weight and time since quitting. Figure 9.2 shows that as time since quitting increases so does the weight difference. Three subjects in fact lost weight after smoking cessation and one subject increased her weight by 16kg. Figure 9.1 shows that energy intake appears to increase initially after cessation but thereafter tends to decrease to baseline by 21 weeks. There was a large variation in energy intake changes between subjects. For example at 13 weeks 8 subjects had quit and all showed increases in weight. However, energy intakes increased by over 5MJ in one subject and 0.5MJ in another, whereas the remainder reported decreases in energy intake. This may reflect a decline in the quality of the weighed record in this group. Alternatively weight reflects longer term energy intake and expenditure whereas the dietary assessment may only reflect the period of measurement.

It is possible that subjects returning for their appointment discovered they had increased their weight and thus in the weighed record either consciously or subconsciously reduced their intake. There appears to be an increase in energy intake immediately after stopping smoking as suggested by the increases food group consumption in chapter eight, and this subsides after cessation. If smoking does increase metabolic demand it is possible that the effect of smoking cessation on weight takes longer to stabilise after cessation. If smoking does increase the requirement for energy then cessation should be accompanied by a decline in energy intake. Although energy intake had reduced from the short term effect it was not below baseline and hence intake may be greater

Figure 9.1: Graph of energy difference against time quit

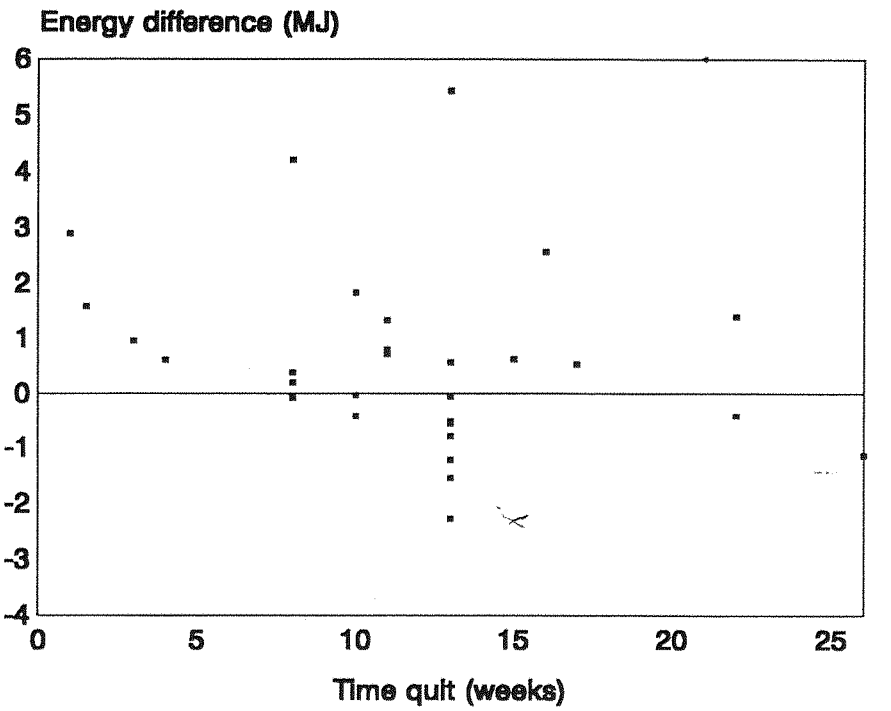
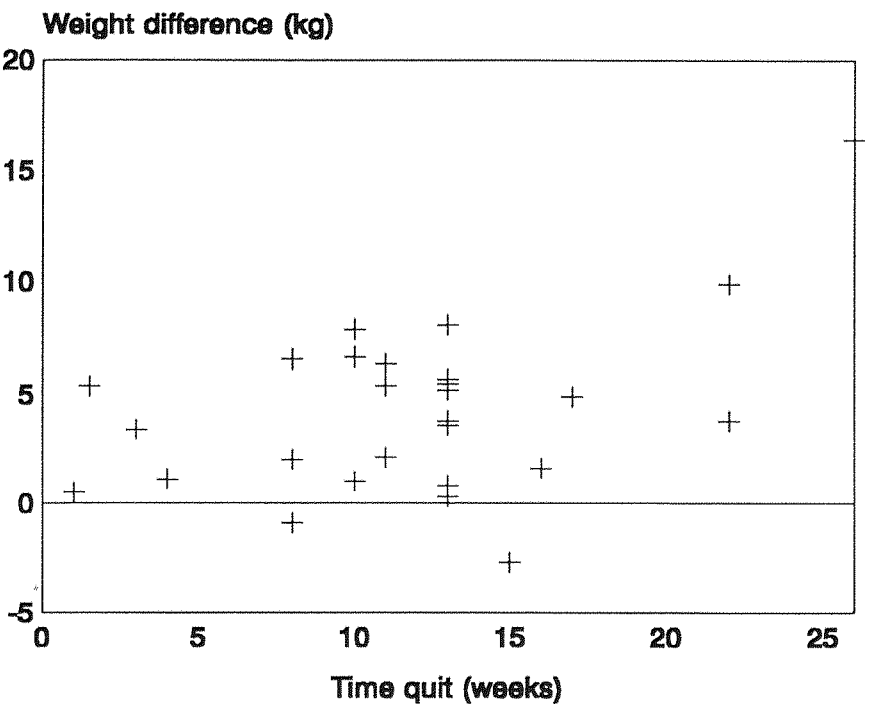


Figure 9.2: Graph of weight difference against time quit



than expenditure hence leading to further increases in weight.

In summary, initial increases in energy intake were accompanied by increases in weight. There does not appear to be a change in the composition of the diet immediately after stopping smoking. Within 46 weeks energy intake had decreased to near baseline despite further increases in weight and there was no change in the overall composition of the diet except for protein. However, differences between occupation groups were observed for carbohydrate and monounsaturated fat.

10. FINAL DISCUSSION AND FUTURE WORK

The primary aim of this work was to explore the methodological issues of using an FFQ in place of a WR in an epidemiological study. The FFQ was calibrated against a 10 day WR in a group of smokers using conventional statistical analyses and showed a good agreement between the methods. The largest differences between the methods were observed for vitamins and fibre and these appeared to result from overestimates of fruit, vegetables, and bread. A graphical technique which shows the agreement between the methods over the range of intakes was also used and was able to detect differential misclassification across the range of intake for some nutrients such as energy, fat and vitamin C. The graphical technique was then employed to produce a 'correction' factor which was subtracted from the FFQ values so that absolute nutrient intakes were similar to those derived from weighed records.

Using randomly recruited subjects and volunteers the effect of different sources of recruitment on the agreement between the methods was investigated. This showed that there were differences in agreement between the recruitment groups for vegetables, processed meat, potatoes and beer; and for vitamin C and alcohol in men. After correcting the FFQ values there were few differences between the recruitment sources implying that the observed differences using the FFQ were a result of differences in agreement between the methods for each recruitment source and not real differences between the sources. This has implications for studies in which the dietary method is calibrated in a sample of subjects who are recruited by different methods to the study population.

Using the dietary differences between smokers, ex-smokers and never smokers as a model, the FFQ was used to compare the nutrient intakes of the groups both with uncorrected and corrected values. The result of the correction was to alter

the absolute differences between the smoking categories but it did not affect the trends between the groups. Thus in its 'uncorrected' form the FFQ was able to detect differences between the groups, but after 'correction' the actual differences were more like those that would have been detected with a WR (and thus more reliable if the WR is a better estimate of the truth). Weighed records are much more arduous for both subject and observer and therefore with the 'correction' technique applied to FFQ data, results of the same quality as a WR can be collected. As a calibration study should be carried out before use of a FFQ the 'correction' method does not require any extra data collection (for large populations a random sample could be taken). Although the 'correction' method was reliable when applied for nutrients it did not appear to be so for food groups. To improve the food group information particular areas of concern such as fruit intake need to be identified. The FFQ may then be improved by looking at the actual question on the FFQ to see if it is ambiguous and checking the portion size.

The results of the cross-sectional study confirm the findings from other cross-sectional studies that show different food patterns and nutrient intakes in smokers compared with non-smokers. The main observed differences between the four smoking categories (heavy smokers, light smokers, ex-smokers and never smokers) were between smokers and non-smokers. The smokers consumed more beverages of all kinds, in particular tea and coffee; and also more saturated fat sources of spreading and cooking fats, whereas the non-smokers consumed more breakfast cereals. The main nutrient differences between smokers and non-smokers were more sugar and fat (especially saturated fat) in smokers and more carbohydrate and polyunsaturated fat in non-smokers. This study, however, has used validation of reported smoking habit and clearly defined smoking groups to avoid bias from smoking misclassification. It has included potential confounders in

the analysis and suggests that these confounders with the exception of energy do not have a large effect on the results. This then makes comparison between different studies including different confounders much easier. The study has also shown differences between heavy and light smokers that appear to suggest a dose response relationship between cigarette smoking and dietary habits. Although restricted by smaller sample sizes, occupation groups were analysed separately to determine if the same relationships were observed in both occupation groups. There did appear to be some differences, in particular for vitamin C. This point needs further attention to determine whether the effects of smoking on diet differ between occupation groups. If differences do exist the cause of the dietary differences between smoking categories may be part non-physiological and relate to other lifestyle differences.

To produce some evidence that cigarette smoke itself does cause a change in diet, a prospective study comparing smokers who quit with those who continue to smoke was carried out. There did not appear to be any overall differences in baseline dietary habits between smokers who went on to stop smoking and those who continued to smoke. The experimental study in the short-term showed increases in food groups and nutrients especially fat, but that after a longer period of cessation these differences disappeared. Other studies have suggested that up to one year or more quitters have diets more like smokers than ex-smokers (Whichelow *et al*, 1988; Bolton-Smith *et al*, 1993). There were changes that occurred immediately after stopping smoking that do not appear to be related to the longer term changes observed in cross-sectional studies. These changes may reflect the effect of withdrawal of smoking and substitution of cigarettes with food, and also contribute to the initial weight gain observed in smoking cessation studies. It is possible that smoking increases metabolic demand which leads to increases in weight in the longer term if energy intakes are not decreased to

below baseline levels. The reasons for dietary differences between smoking habits were not an objective of inquiry in this study but may result from effects of smoking on appetite or different health attitudes between smokers and non-smokers. It is possible that cigarette smokers are more resistant to health messages and therefore take longer before they take steps to improve their diets.

It appears that smokers' diets upon quitting do not immediately become similar to ex-smokers in cross-sectional studies but may take some time to achieve this change. To obtain more information about the changes in diet after stopping smoking longer term prospective studies need to be carried out. There are problems with prospective smoking cessation studies such as non-response, compliance with smoking cessation methods and dietary assessment, and recidivism. There may be bias because of changes that might occur due to the intervention method and taking part in a study. A better suggestion if the long term changes are of interest would be a large cohort study which collects validated data on smoking habit and dietary assessment and could even be a sub-study of another epidemiological study. The subjects would need to be followed up at regular intervals over a number of years and those who quit would be compared with those who continued to smoke and obviously the problem of non-response would still remain, but might be reduced by employing less demanding assessment methods such as the FFQ. One advantage is that the subjects need not know the study was about smoking cessation. The differences that were observed in the smoking cessation study between occupation groups warrant further investigation. Once the changes in dietary habits have been fully investigated effort should then be put into studying the causes of the changes.

Appendix 1

GENERAL HEALTH SURVEY

YOUR HELP WITH THIS HEALTH SURVEY WILL BE OF GREAT VALUE TO THE MEDICAL PROFESSION.

PLEASE ANSWER ALL THE QUESTIONS BY PLACING A TICK IN THE APPROPRIATE BOX. ALL THE INFORMATION RECORDED IN THIS QUESTIONNAIRE WILL BE TREATED AS STRICTLY CONFIDENTIAL.

GENERAL HEALTH SURVEY

STUDY NO. ¦__¦__¦__¦__¦

1. What is your date of birth?

.....

2. What do you think of your present state of health? (Tick one box only)

Very good	¦__¦	Not very good	¦__¦
Reasonably good	¦__¦	Very bad	¦__¦
Medium	¦__¦		

3. Have you been told by your doctor that you have had any of the following? (Tick more than one box if necessary)

Liver disease	¦__¦	Heart attack	¦__¦
Kidney disease	¦__¦	High blood pressure	¦__¦
Angina	¦__¦	None of these	¦__¦

4. What do you usually drink? (Tick more than one box if necessary)

Coffee	¦__¦	Tea	¦__¦
Decaffinated coffee	¦__¦	Fruit or herbal tea	¦__¦
		Other	¦__¦

5. What kind of cooking fat do you usually use at home?

Liquid oil	¦__¦
Hard fat	¦__¦
Sometimes one, sometimes the other	¦__¦

6. Do you smoke?

Yes ¦__¦ No ¦__¦

If no, please go to question 8.

7. What do you smoke? (Tick more than one box if necessary)

Cigarettes ¦__¦

Pipe ¦__¦

Cigars ¦__¦

Please go to question 10.

8. Have you ever smoked in the past?

Yes ¦__¦ No ¦__¦

If no, please go to question 10.

9. What do you smoke? (Tick more than one box if necessary)

Cigarettes ¦__¦

Pipe ¦__¦

Cigars ¦__¦

10. Do you regularly take part in any of the following?

Walking ¦__¦ Football ¦__¦

Swimming ¦__¦ Jogging ¦__¦

Badminton ¦__¦ Squash ¦__¦

Tennis ¦__¦ Cycling ¦__¦

Other ¦__¦

11. How would you rate your general level of physical activity? (Tick one box only)

Very active	¦__¦	Fairly inactive	¦__¦
Fairly active	¦__¦	Very inactive	¦__¦
Average	¦__¦		

PLEASE CHECK THAT YOU HAVE ANSWERED ALL THE QUESTIONS. RETURN THIS QUESTIONNAIRE IN THE STAMPED ADDRESSED ENVELOPE AS SOON AS YOU CAN.

THANK YOU FOR YOUR HELP

Appendix 2

FOOD INTAKE & SMOKING HABIT QUESTIONNAIRE

FOR OFFICE USE ONI

Surname..... Study no. 1-2

First Name(s)..... Subject no. 3-6

Address..... Male/Female 7

..... Questionnaire no. 8

Phone no.....

Date of Birth..... Date of survey..... 9-10 11-12 13-14 15-16 17-18 19-20

The following questions are about the foods you USUALLY eat.

Please indicate the number of days per week that you eat each item on average. Ring the answer as in these examples:

If you eat the food every day, ring 7 (7) 6 5 4 3 2 1 F R

If you eat the food 3 days/week, ring 3 7 6 5 4 (3) 2 1 F R

If you eat the food once a fortnight, ring F 7 6 5 4 3 2 1 (F) R

If you rarely or NEVER eat the food, ring R 7 6 5 4 3 2 1 R (R)

PLEASE ANSWER EVERY QUESTION.

BREAD

How often do you eat the following breads and how many slices do you have per day?

	No. days/week	*No. slices rolls/day*	*Size of slices/rolls*	
White or high fibre	7 6 5 4 3 2 1 F R	.....	Thick/med/thin Large/small	21-23
Brown or wheatgerm	7 6 5 4 3 2 1 F R	.....	Thick/med/thin Large/small	24-26
Wholemeal/chapatis	7 6 5 4 3 2 1 F R	.....	Thick/med/thin Large/small Chapatis	27-29
Bread rolls	7 6 5 4 3 2 1 F R	.....	White/brown/ wholemeal	30-32
Crispbread, ryvita or cream crackers	7 6 5 4 3 2 1 F R	.....		33-34

FOR OFFICE USE ONL

BREAKFAST CEREALS

How often do you eat the following cereals?

1. Cornflakes or Frosties	7 6 5 4 3 2 1 F R	
2. Sugar Puffs, Special K, Ricicles or Rice Krispies	7 6 5 4 3 2 1 F R	
3. Muesli or Fruit n'Fibre	7 6 5 4 3 2 1 F R	
4. Weetabix, Weetaflakes or Shredded Wheat	7 6 5 4 3 2 1 F R	35-36
5. Bran Flakes or Sultana Bran	7 6 5 4 3 2 1 F R	
6. Porridge or Ready Brek	7 6 5 4 3 2 1 F R	37-38
7. All Bran	7 6 5 4 3 2 1 F R	

How many teaspoons of sugar/honey do you add ?	.....	39
How often do you have wheat bran?	7 6 5 4 3 2 1 F R	40
How many dessertspoons of wheat bran per day?	.....	41

MEATS

How often do you have the following meats?

Beef (all forms including mince)	7 6 5 4 3 2 1 F R	42
Lamb	7 6 5 4 3 2 1 F R	43
Pork	7 6 5 4 3 2 1 F R	44
Bacon	7 6 5 4 3 2 1 F R	45
Ham	7 6 5 4 3 2 1 F R	46
Chicken or other poultry	7 6 5 4 3 2 1 F R	47
Canned meat (eg. corned beef)	7 6 5 4 3 2 1 F R	48
Sausages	7 6 5 4 3 2 1 F R	49
What type of sausages do you have?	1 Pork	
	2 Beef	
	3 Pork & beef	50
	4 Turkey	
	5 Low fat	51
Meat pies/pasties - shopbought	7 6 5 4 3 2 1 F R	52
Meat pies/pasties - homemade	7 6 5 4 3 2 1 F R	53
Liver/kidney/heart	7 6 5 4 3 2 1 F R	
Do you usually eat the fat on meat?	Yes/No	54

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FISH

How often do you eat the following fish?

White fish (cod/haddock/plaice/fish fingers)	7 6 5 4 3 2 1 F R	55
Kipper/herring/mackerel/trout (including canned)	7 6 5 4 3 2 1 F R	56
Pilchards/sardines/salmon (including canned)	7 6 5 4 3 2 1 F R	57
Tuna (including canned)	7 6 5 4 3 2 1 F R	58

How many fish oil capsules do you take/day? 59

Please specify brand .....

VEGETABLES

How often do you have the following vegetables?

Potatoes - boiled or mashed	7 6 5 4 3 2 1 F R	60
Potatoes - jacket	7 6 5 4 3 2 1 F R	61
Chips - shopbought or 'oven chips'	7 6 5 4 3 2 1 F R	62
Chips - homecooked	7 6 5 4 3 2 1 F R	63
Potatoes - roast	7 6 5 4 3 2 1 F R	64
Peas	7 6 5 4 3 2 1 F R	65
Other green vegetables/salads	7 6 5 4 3 2 1 F R	66
Carrots	7 6 5 4 3 2 1 F R	67
Parsnips/swedes/turnips	7 6 5 4 3 2 1 F R	68
Baked beans/lentils/butterbeans	7 6 5 4 3 2 1 F R	69
Onions (cooked/raw/pickled)	7 6 5 4 3 2 1 F R	70
Spaghetti/other pasta	7 6 5 4 3 2 1 F R	71
Rice (NOT pudding rice)	7 6 5 4 3 2 1 F R	72

BISCUITS CAKES & PUDDINGS

How often do you eat the following items?

Digestive biscuits/plain biscuits	7 6 5 4 3 2 1 F R	73
Other sweet biscuits	7 6 5 4 3 2 1 F R	74
Chocolate	7 6 5 4 3 2 1 F R	75
Sweets	7 6 5 4 3 2 1 F R	76
Crisps	7 6 5 4 3 2 1 F R	77
Icecream	7 6 5 4 3 2 1 F R	78

Page

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Yogurt	7 6 5 4 3 2 1 F R	79
Fruitcake/sponge cake - shopbought	7 6 5 4 3 2 1 F R	80
Fruitcake/sponge cake - homemade	7 6 5 4 3 2 1 F R	81
Fruit tart/jam tart - shopbought	7 6 5 4 3 2 1 F R	82
Fruit tart/jam tart - homemade	7 6 5 4 3 2 1 F R	83
Milk pudding (eg. rice/tapioca/macaroni)	7 6 5 4 3 2 1 F R	84

What type of milk do you use for milk pudding? 85

1 Ordinary/whole
2 Semiskimmed
3 Skimmed
4 Canned milk pudding - ordinary
5 Canned milk pudding - low fat

FRUIT

How often do you have canned fruit?	7 6 5 4 3 2 1 F R	86
How many apples do you have per week?	.....	87
How many pears do you have per week?	.....	88
How many oranges/grapefruit do you have per week?	.....	89
How many bananas do you have per week?	.....	90

EGGS & MILK PRODUCTS

How many eggs do you usually eat per week? 91-92

Roughly how much milk do you drink in a day in tea/coffee/milky drinks/with cereals? 93

1 None
2 Half a pint or less
3 Between half a pint and one pint
4 One pint or more

What type of milk do you have? 94

1 Ordinary/whole
2 Semiskimmed
3 Skimmed
4 More than one type

How much cream do you use per week?
(1 tablespoon=20g; small carton=150g; large carton=300g) .....g 95-97

How much cheese (excluding cottage cheese) do you usually eat per week? .....g 98-100

(Suggestion: divide amount bought for household by number of people in house)

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FATS

What do you usually spread on bread? 1 Butter

2 Margarine - polyunsaturated

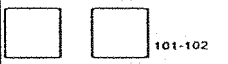
3 Margarine - other soft (tub)

4 Margarine - hard (block)

5 Low fat spread - polyunsaturated

6 Low fat spread - other

0 Bread eaten dry

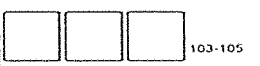


Brand name & description on packet/tub .....

How much butter/margarine do you usually eat per week?

(One block or small tub = 250g. Spread on one slice of bread:

Thinly=5g; Medium=8g; Thickly=13g.) .....g



How often do you have food which is shallow-fried?

(eg. fish/onions/mushrooms/tomatoes/eggs) 7 6 5 4 3 2 1 F R

What BRANDS of fats do you use in cooking?

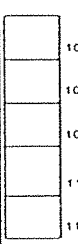
Shallow-frying ..... solid/liquid

Chips ..... solid/liquid

Roast potatoes ..... solid/liquid/eaten out

Homemade cake .....

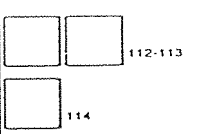
Homemade pastry .....



DRINKS

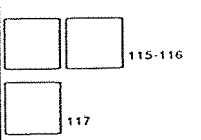
How many cups of tea do you have per day? .....

How many teaspoons of sugar/honey per cup? .....



How many cups of coffee do you have per day? .....

How many teaspoons of sugar/honey per cup? .....



How often do you have fruit juice/squash/fizzy drinks

(NOT low calorie)? 7 6 5 4 3 2 1 F R

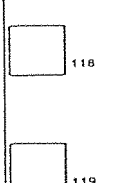
Which of these drinks do you usually have?

1 Natural juice

2 Squash

3 Fizzy drink

4 More than one



How often do you have drinks containing alcohol? 7 6 5 4 3 2 1 F R

When you drink, how many do you have on ONE occasion?

Beer/stout/cider Number of pints.....

Wine Number of glasses.....

Sherry/port/vermouth Number of glasses.....

Spirits No. of single measures.....

What is the total number of drinks per occasion? .....

SMOKING HABIT

Do you smoke? Yes/No

IF YES, which of the following do you smoke?

1 Cigarettes

2 Cigars

3 Pipe

4 More than one

How many cigarettes do you smoke per day? .....

IF NO, have you ever been a regular smoker? Yes/No

How long ago did you give up smoking?

1 Less than a year

2 1-4 yrs ago

3 5-9 yrs ago

4 10 yrs or more

HEIGHT & WEIGHT

What is your height? .....ft .....ins OR .....cm

What is your weight? .....st .....lbs OR .....kg

THANK YOU VERY MUCH FOR YOUR HELP

Diet code

FOR OFFICE USE ONLY

120

121-122

123

124

125

126

127-128

129

130-133

134-137

138

Appendix 3

Food groups	Fresh fruit: apples, pears, oranges, bananas
Fruit	Green vegetables including salad
Vegetables	Includes chips, boiled, mashed, roast and jacket
Potatoes	Cornflakes & Rice Krispies
Low fibre breakfast cereals	Weetabix, branflakes, all bran, shredded wheat, muesli
High fibre breakfast cereals	(other bran type cereals)
White bread	White bread and rolls (includes high fibre white breads
Brown bread	Wholemeal and brown breads and rolls
Cakes & biscuits	All types of cakes & biscuits
Milk	All type of milk
Dairy	Cheese, cream & eggs
Sfa fats	Butter, ordinary margarines including low fat spreads, lard
Pufa fats	Sunflower & soya margarines (including low fat varieties, vegetable oils (sunflower, soya, vegetable, olive etc)
Processed meat	meat pies, sausage rolls, tinned meats, ham & bacon
Meat	Beef, lamb & pork
Fish & chicken	White and oily fish, and chicken
Snacks	Crisps, chocolates (nuts using WR)
Tea & coffee	Tea & coffee (as made up)
Soft drinks	Fruit juices, squashes (made up), fizzy drinks
Sugar	Added to drinks and breakfast cereal
Wine	
Beer	All types Includes lager and cider
Spirits	All types

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