SOURCES OF ERROR AND BIAS IN THE ASSESSMENT OF DIETARY INTAKE: 24-HOUR RECALLS AND FOOD RECORDS

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by

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"Just because a great many people believe in something

is no guarantee of its' truth"

(Gandhi)

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DECLARATION

I, Shelly Tracy Meltzer (nee Friedman), hereby declare that the work on which this thesis is based is my original work (except where acknowledgments indicate otherwise), and that neither the whole work nor any part of it has been, is being, or is to be submitted for another degree in this or any other University.

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ABSTRACT

The first aim of this dissertation was to validate the 24-hour recall method of dietary assessment and to identify possible sources of error and bias in a cross-cultural sample of South African women. The second aim of this dissertation was determine the source and extent of inter-researcher variability associated with the interpretation of food intake records.

The first study was designed to consider whether reporting error is dependent on individual subject characteristics such as ethnicity, body mass, body fatness, age and education, or whether it is due to the dietary assessment tool (i.e., the 24-hour recall). In this study 118 women (25-55 years old) representing different ethnic and language groups (51 Xhosa-speaking, 31 Afrikaans-speaking, 36 English-speaking), different job types (25 unemployed, 25 general assistants, 52 medics and para-medics and 16 administrative personnel) and different levels of education (5 with 6-7 years of schooling, 35 with 8-10 years of formal schooling, 43 with 11-12 years of formal schooling and 35 with post high school diploma or degree) consumed a meal that was based on what they reported to habitually eat. All food and beverages consumed were covertly weighed and this was compared to a 24-hour dietary recall performed on the following day.

Results of this study showed that the overall variance in reporting error was low. The error was, however, nutrient specific and was related to certain subject characteristics. Under-reporting was greater for subjects with a higher percentage body fat mass and a greater body mass index. Subjects with a lower level of education were more likely to under-report absolute carbohydrate (g) intake, whereas subjects with a higher level of education tended to under-report dietary fat. Subjects with a greater knowledge of food and nutrition were more likely to under-estimate protein intake and over-estimate carbohydrate intake. 'Seasonality' (fluctuations in food purchases due to income) affected body mass, socio-economic status and dietary reporting error. Under-reporting of fat intake (g) was greatest in subjects that experienced the most fluctuations in income.

In the second study of this dissertation, three post graduate students in dietetics independently assessed and analyzed ten, 3-day food records. The specific areas of variability that were studied related to (i) the selecting of food names/codes on the computer dietary analysis program, (ii) the keying of data from the written dietary records (clerical errors) to the data storage file and, (iii) the conversion of food consumption quantities to gram weights (judgment errors).

There were no systematic differences in the variability amongst dietitians in interpreting and analyzing dietary data in this study. The mean coefficient of

variation for added sugar was 14.8 ± 12.6 (g) and for fat 7.1± 5.2 (g). In one subject, the range of difference in fat (kJ) intake assessed by the dietitians was as high as 1313 kJ.

Conclusions: 1) Adiposity is a universal predictor for under-reporting of dietary intake. 2) Inaccuracies in dietary reporting are nutrient specific and may be influenced by social desirability bias (through education or knowledge of food), language, familiarity with certain foods and 'seasonality' in food purchases. 3) These same factors influence the choices of food and beverages that subjects make in a 'test meal' that is used to validate dietary intake 4) The variations in interpretation of the quality and quantity of reported food intake by the measurer is a source of experimental error that cannot be ignored and which may account, at least partially, for the difference between true and reported intake.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

CHAPTER 1: INTRODUCTION

"A very serious limitation at present is not the errors in dietary data but rather our failure to appreciate the nature of these errors" (Beaton, 1994)

Food intake data influences the development of nutrition policy and programs leading to improved health world-wide. Epidemiological studies that examine the relationship between nutrition and health rely on food intake data to reflect nutritional status and consumer behavior. Yet, a major limitation of research using dietary assessment is the uncertainty about the validity of assessment methods and the consequent uncertainty about the results obtained with them.

It has been well documented that the validity of dietary assessment measures is often poor and that there is little or no correlation between a dietary measure and biochemical, clinical or anthropometric measurement of nutritional status (Mertz et al.,1991; Schoeller, 1990). Delegates from the World Health Organization (WHO) and the Food and Agriculture Organization of the United Nations (FAO) met in 1992 formulated a mandate for the future research directions of dietary assessment methodology. These research priorities included the development of techniques for assessing food intake that were culturally sensitive and for persons of different ages and communication styles. Furthermore, they called for the validation of dietary assessment methodology by calibration studies to quantify the bias in reporting food intake (Buzzard and Siebert, 1994).

Internationally there has been an attempt in recent years to develop tools and methods to overcome literacy barriers and allow multilingual interviews for food intake assessment. These have included questionnaires, audio systems, videotapes (Brown et al., 1990), and portable electronic scales with tape recorders (PETRA) to automatically record the cumulative weight of foods saving the description into a 'black box' (Bingham et al., 1985). Pictures and photographs have been developed to assess portion sizes (Elwood PC, Bird G, 1983; Howat et al., 1994). Local members of communities have been trained in observational techniques to observe and record intakes (Gittelsohn et al., 1994).

Mixed results have been obtained in studies using these approaches. For example, in the study by Gittelsohn et al. (1994) it was found that the accuracy of the observers' estimates varied by food type and portion size. The cost and availability of equipment such as the PETRA scales and computerized technology are a limitation in many areas. Furthermore, the use of *a priori* coding in computer assisted data collection may result in the loss of detail of food choice and preparation, particularly in field studies (Thompson and Byers, 1994).

Thus, in many situations the 'traditional' 24-hour recall is still the method of choice for assessing dietary intake. In fact, the consensus from the working group discussions held at the 1993 Workshop on Dietary Assessment (sponsored by the National Center for Health Statistics, Centers for Disease Control in collaboration with other Federal Agencies) was that multiple 24-hour recalls are the best tool for most nutrition monitoring needs. However, it was recommended that more research be conducted on cognitive issues in dietary recall and portion size estimation (Thompson and Byers, 1994). Accuracy of recall, may for example, be affected by the subject's gender, age, socio-economic factors, or level of education and occupation (Dwyer, 1988).

It is not clear whether there are cultural factors that may also affect reporting bias. Furthermore, it is unclear whether individuals from cultures that find a greater body weight and higher food intake acceptable or desirable tend to over-report intake. Moreover, reporting bias may be reflected in the under- or over-reporting of a specific nutrient, and may differ depending on the population under study. Complicating matters further is the impact of "nutrition transition" whereby populations through the process of acculturation, adjust their diets (Popkin,1994) and/or alter their perceptions. This may in turn impact on reporting error and bias.

Epidemiological research in South Africa that made use of the 24-hour recall method to assess dietary intake on three different ethnic groups in the Coronary Risk Factor Study (CORIS), the Coronary Risk Factor Study among Coloureds in the Cape Peninsula (CRISIC) and the Coronary Heart Disease Risk Factor Study in the African Population of the Cape Peninsula (BRISK), raised some interesting questions in this regard. In all studies, reported energy intakes of adult females was low compared to the Recommended Dietary Allowances (RDA) (Bourne et al., 1993). Respondents of the BRISK cohort, that consisted of Black South Africans living in the Cape Town metropolitan area, reported the lowest energy intakes. Fifty-three percent of this cohort reported energy intakes below 67% of the RDAs. In the same sample, 44% of the women had a body mass index (BMI) ≥ 30. There was thus a paradoxical relationship in this cohort between the low reported energy intakes and the high prevalence of obesity (and associated adverse metabolic sequelae).

The investigators of the BRISK study assumed that the under-reporting was systematic, that it manifested equally across all food groups and that the data reflected the true dietary pattern of the study population (Bourne et al., 1993). This conclusion was based on the fact that the macro-nutrient profile was similar to other local studies done on urban Africans using different methodologies (Manning et al., 1974). They gave two possible reasons for the under-reporting in this cohort. Firstly, they proposed that the under-reporting may be due to the high prevalence of obesity in the sample (which is in agreement with studies that have shown that the greatest reporting error occurs in individuals with the lowest reported energy intakes) (Briefel et al., 1995; Fricker et al, 1992; Lichtman et al., 1992; Livingstone et al., 1990; Mertz et al., 1991; Prentice et al., 1986). Secondly, they also mention the 'thrifty genotype hypothesis' which holds that populations exposed to inadequate or fluctuating food supplies are genetically selected, resulting in an increased fuel utilization or fat storage and therefore require fewer calories. This increased metabolic efficiency may predispose "thrifty" individuals to obesity and/or diabetes as food supplies increase (Neel JV, 1962, Knowler et al., 1983).

A further potential source of variance and error is the experimental error associated with interpreting and analyzing the food intake reported by the subject. Experimental error can arise from observer and instrument error. Both observer and instrument error may result from recording and transcription errors and errors in analysis of diets. It has been suggested that measurers of diet probably vary more in their skill in obtaining dietary information then they do in obtaining biochemical information (Dwyer, 1988). This is especially important where reported food intake data are analyzed by different dietitians or scientists.

This study was then based on the premise that by reliably validating both the energy and macro-nutrient content of the urban South African women, insight may be provided into the causes of adverse metabolic sequelae seen in both obese and non-obese women. Furthermore, if possible sources of error or reporting bias in a specific population are understood, then appropriate nutrition recommendations can be developed.

Accordingly, this thesis was designed with two major aims. The first aim was to validate the 24-hour recall method of dietary assessment and to identify possible sources of error and bias in a cross-cultural sample of South African women. This trial was designed to consider whether reporting error is dependent on individual subject characteristics such as ethnicity, body weight, body fatness, level of urbanization /acculturation, and age, or whether it is due to the instrument (i.e. the 24-hour recall).

The second aim of the thesis was to assess the variability associated with the interpreting and analyzing of reported food intake by different measurers. In this trial the measurers were postgraduate students in dietetics and the dietary assessment tool that was used were 3-day dietary records.

CHAPTER 2: A REVIEW OF THE LITERATURE

2.1 INTRODUCTION

In 1992, over 300 delegates representing 25 countries from the World Health Organization (WHO), and the Food and Agricultural Organization of the United Nations (FAO), met in St. Paul, Minnesota, to reach consensus on research priorities in dietary assessment methodology for the future. The main recommendation from the meeting was for the development of dietary assessment methodology that was sensitive to different cultures, age groups, communication styles and cognitive abilities. Moreover, the delegates felt that research priorities should include, 1) identification and minimization of bias in reporting and assessing food intake, 2) improvement in the methodology for estimating portion sizes, 3) the development of tools which are sensitive to a change in habitual diet, and 4) the validation of dietary assessment methods by some external standard (Buzzard and Sievert, 1994).

The consensus from the National Center for Health Statistics (NCHS) and Centers for Disease Control and Prevention (CDC) Workshop in 1993 was that multiple 24-hour dietary recalls was the most efficacious method to assess nutritional intake. This together with the mandate of the WHO and the FAO clearly highlights the importance of understanding more about the errors that are involved in collecting dietary data and computing nutrient intakes, in particular those pertaining to the 24-hour recall.

In this literature review the focus is therefore on research that has considered the efficacy of the 24-hour dietary recall. Studies that have been designed to determine sources of error in dietary research (e.g., physiological and non-physiological characteristics of individuals that may impact on reporting error) are reviewed and the different validation and calibration techniques are described. In addition, studies that have considered dietary research in different cultural contexts are reviewed. This is relevant since the South African population from which the subjects were selected, is comprised of diverse ethnic groups.

2.1.1 TERMINOLOGY AND DEFINITIONS

2.1.1.1 Ethnicity versus race versus culture

"Diversity adds richness and color to the tapestry of human experience" (Villa, 1994)

Assumptions that are made when 'pigeon-holing' subjects according to certain criteria can lead to making Type II statistical errors, i.e., accepting as true a hypothesis that is false. For example, race, ethnicity, or geographic residence are often inaccurately viewed as synonymous with culture and this leads to stereotypical "lumping" (Terry, 1994).

Race has a different meaning from ethnicity. Race refers to three major categories of human beings: Asian, Black and Caucasian and so fails to account for the considerable variation within a single group or mixtures of groups. Ethnicity, on the other hand, reflects a groups' diversity and confers more specificity than race. Ethnicity as defined by Pollitzer and Anderson (1989) "*refers to the distinction of a group by identifiable differences but makes no statement as to whether these differences are due to genetic or environmental causes. Ethnicity goes beyond race to include all the layers of cultural complexity that both delight and confuse the onlooker*".

Ethnicity was used as the classification schema for this study. Subjects were asked as which ethnic group they belonged to and this was then collapsed into three groups (Black African, Caucasian, or Mixed Ancestry). This classification was chosen to allow for comparisons to be made with previous South African research. As a separate question, in the present study, subjects were asked to which language group they belonged. Since the distinction that the subjects made was the same as that for ethnicity, it appears that in this study, language was a surrogate for ethnicity.

2.1.1.2 Acculturation

Acculturation refers to loss of traditional values (Villa, 1994). According to Redfield and Linton (1935), "*acculturation comprehends those phenomena which result when groups of individuals having different cultures come into continuous first-hand contact, with subsequent changes in original cultural patterns of either or both groups*".

Acculturation can therefore be a 2-way process with a migration of society to urban areas and at the same time there may be a shift of so-called Westernized patterns to rural areas. The effects of acculturation on diet have been studied in various countries world-wide (Popkin, 1994). There is evidence that in countries like Thailand, China, Brazil and South Africa, a situation of under- and over- nutrition often coexists. This reflects the trend in which an increasing proportion of people consume the types of diets associated with a number of chronic diseases (Popkin, 1994). In South Africa, for example, the mean reported dietary fat intake of the urban African women was 26-27% of total energy (fat intake assessed by Bourne et al. 1993) which was higher than that reported for rural African women (fat intake was 21% of total energy (Walker et al., 1989, Walker et al., 1990).

2.1.1.3 Validity versus reliability versus calibration

Validity is another term for the absence of bias and is the degree to which the measurement actually assesses the usual dietary intake of subjects. Bias is the systematic error that occurs regardless of the number of observations in a study.

Validity refers to the appropriateness of the test in measuring what it is designed to measure. Validation studies involve a comparison to a test known to be valid or true (i.e. unobtrusive observational techniques, laboratory measures).

Reliability, or reproducibility refers to the consistency of data obtained on more than one administration of the same instrument to the same subjects (van Staveren et al., 1985; Willett, 1990). Instruments may be reliable, but not valid.

<u>**Calibration**</u> is a comparison of one method of dietary assessment with a reference method (often another dietary assessment method).

In Trial 1, a validation study was conducted using the 24-hour recall method as the instrument to be tested and compared to unobtrusive observation. In Trial 2, dietary data (from the same food records) that had been assessed and analyzed by different measurers, was compared.

2.2 DIETARY ASSESSMENT AND HEALTH

2.2.1 INTRODUCTION

Dietary assessment for research purposes is -

"- to provide optimal scientific foundations for the primary prevention of mass diseases -"

(Stamler, 1994)

Nutritional problems are at the root of major diseases world wide and there is growing consensus that relationships exist between diet-disease, not only for diseases of under-nutrition (e.g., anemia and goiter), but also for many of the chronic diseases of industrialized society, such as cardiovascular diseases, many types of cancers, diabetes, obesity, osteoporosis, and gallbladder and liver diseases.

The formulation of nutrition policies to reduce health risks, the prediction of the adequacy of the food supply, and the monitoring of trends in food use, exposure to contaminants, and compliance with dietary guidelines, requires efficient and valid dietary assessment (Buzzard, 1994). The National Health and Nutrition examination survey (NHANES) dietary intake data are, for example, used to track national progress in the United States in achieving health and nutrition objectives, provide reference data on nutrient intakes, and provide insight into the relationship between health and disease (Briefel et al., 1995).

Furthermore, testing diet-disease hypotheses requires methods that provide adequate specificity for describing foods and quantifying nutrient intakes; while simultaneously minimizing systematic error and thereby providing reasonably accurate estimates of the variability between individuals and/or groups. Whereas high-quality dietary assessment provides a sound scientific foundation for the primary prevention of mass diseases, inadequate assessment can produce false-negative or misleading results contributing to the confusion about the impact of diet on disease (Stamler, 1994; Livingstone et al., 1990).

For example, the etiology of obesity and the role of dietary intake in obesity is an issue that is still constantly debated in the literature. Obesity is one of the most common health problems world-wide and in South Africa is of particular concern in adult Black African women (Kruger et al., 1996). There is some evidence that the differences of obesity prevalence between populations may be attributed to differences in physical activity (Al-Rehamani, Bjorntorp,1992; Seidell et al.,1989) and dietary intake (Hankin and Wilkens, 1994; Seidell et al., 1991). However, some studies suggest that there may be ethnic differences in metabolism (Fontvielle et al., 1992; McGarvey, 1991; Aluli, 1991). Considering that small metabolic differences can result over a long period in a large cumulative effect, studies require great precision and accuracy to identify significant causal factors.

Since it was against a background of ethnic diversity that various epidemiological studies were conducted in South Africa, this chapter focuses on the dietary assessment methods used in these studies, the implications of the results, and importance of culturally-sensitive nutrition assessment in a broader context.

2.2.2 CULTURALLY SENSITIVE DIETARY ASSESSMENT

"Culturally sensitive research recognizes differing values and the primacy of the respondent and works to establish strong lines of communication between researcher and respondent" (Cassidy, 1994)

Cultural aspects of eating make dietary assessment unusually difficult and in the literature there is general consensus that for individuals with strong ethnic identification, special consideration must be given to the type of dietary assessment that is required (Cassidy, 1994; Hankin and Wilkens, 1994; Stallones, 1982; Terry, 1994).

Culture determines what food is, how it is prepared and "who does what and how" to the food supply. Culture defines a meal, the unit of food consumption, complementary foods and the distribution of foods in a meal, the timing and order of eating and eating techniques. For many, eating is not simply an act of nourishment and therefore the symbolic or ritual role of food in different cultures may vary. In addition, individual differences may occur within cultures.

A common predicament is "I know what I ate but I don't know how to tell you". Therefore there is some criticism of the use of standard questionnaires and lists such as food frequency lists, particularly in multi-ethnic populations, as these tools may not have the same level of accuracy in different cohorts, thus biasing the estimation of relative risk of disease associated with diet (Hankin and Wilkens, 1994).

There are several examples cited in the literature that illustrate the implications and the magnitude of cultural bias in dietary assessment. Researchers involved with the San Antonio Heart Study, a population-based follow-up study of diabetes and cardiovascular disease in Mexican Americans and non-Hispanic whites were unable to confirm an effect of dietary variables or level of physical exercise in predicting future obesity in the Mexican Americans (Haffner et al., 1991). The authors of this study attributed the lack of an association between weight gain and ethnicity in their sample, to a lack of cultural specificity in their study methods. Firstly, they mention the imprecision of the 24-hour dietary recall technique and the dietary-behavior and exercise questionnaire. Response patterns, (according to Cassidy, 1994) may be affected by the order of presentation, terminology, breadth of food categories, and gender of the respondent. Secondly, the cut-off points to define overweight that Haffner et al. (1991) used in their study were based on values for a Caucasian population (BMI $\geq$27).

A multi-ethnic study in which the issue of terminology was demonstrated, was the Hawaii-California cohort study which included more than 300 000 participants from 5 different ethnic groups. The study was designed to focus on diet and cancer. The results showed that the reason that some participants omitted food sources of fat from their diets was because they did not understand the terminology used on the diet history questionnaire. For example, some participants were unfamiliar with the word "sausage" that had been used several times in the food frequency questionnaire. For these participants the word "hot links" would have been more appropriate (Hankin and Wilkens, 1994).

The quantification of ingredients (e.g., salt, sugar and fat) added to food either in the kitchen at home or out, or at the table, complicates dietary assessment. This is especially difficult in certain populations who practice "one-pot cooking" or who share food by eating out of the same pot. Because of the issue of quantifying "hidden" and "added" salt, in the INTERSALT study the researchers collected and analyzed urine-samples for sodium and potassium concentrations, rather than using dietary salt assessments (Stamler, 1994). Use of this biochemical validation, however, assumes that all individuals are healthy and not suffering from diseases where sodium or potassium is either excreted or retained excessively. The quantification of fat added to the food preparation process or to food before it is eaten, remains a problem.

Stallones (1982) questions the appropriateness of quantitative dietary assessment and believes that qualitative differences in food preference and food use are very delicate indicators of social class and acculturation. Stallones' (1982) concern about quantitative assessment is based on the premise that measurement error (respondent error, observer error and instrument error) is confounded with real differences in the usual diets of individuals. In addition real differences between current diets of individuals versus what is measured in a study reduce the accuracy of quantitative dietary assessment. These factors create "*noise in the information system*" (Stallones, 1982) and obscure the message. In contrast, qualitative data (e.g., information on differences in food preference and food use) is more easily determined (Stallones, 1982). Cassidy (1994), on the other hand, suggests that many cultural communication issues can be resolved by awareness, attention and the judicious combination of culturally sensitive qualitative and quantitative research techniques.

One assessment method that combines a qualitative and quantitative approach is the 24-hour recall. When it is properly administered it is respondent-driven and the researcher does not pre-guess what is eaten. Cassidy (1994) and others (Wright et al., 1994) suggest that the 24-hour recall technique can be used successfully in different populations and in different settings provided that the format is manipulated to suit the exigencies of the specific situation.

Some researchers suggest using the combination of a food frequency or food list method with multiple 24-hour recalls (Liu, 1992; Sempos et al., 1992). However, this approach is questioned by others who believe that the combination or averaging of data from different dietary methods in a single survey may in fact produce new errors (Wright et al., 1993). The dietary history method, for example, is a combination of various assessment methods and a number of studies have found that the dietary history method when compared to food records or 24-hour recalls, overestimates nutrient estimates (Young et al., 1952; Jain et al., 1980). Use of a combination approach over-exposes individuals to different dietary methods within one study or analysis (Bingham, 1987). For example, in situations where a 24-hour recall plus two days of food records are collected, information about dietary intake may be acquired incidentally and intentionally, respectively. Furthermore, each dietary assessment method may rely on a different learning style and the type of errors produced may be different from each other.

2.2.3 DIETARY ASSESSMENT CHALLENGES IN SOUTH AFRICA

"the epidemiologic transition describes the shift from a pattern in which pestilence, famine, and poor sanitation lead to a high prevalence of infectious diseases and malnutrition to a pattern in which the prevalence of chronic and degenerative diseases is high" - Omran's epidemiological stages described in a paper by Popkin (1994)

In South Africa the diversity of ethnic groups, the transient nature of the urbanizing population and the changing peri-urban environment, as well as the high level of illiteracy make nutrition research particularly challenging.

Furthermore, the rate of urbanization has been exceptionally rapid. In 1911 only 12.9% of the total Black African population was urbanized. By 1960 this figure had risen to 28% and it has been predicted to reach 75% - 80% by the year 2000 (O'Keefe et al., 1982; Levitt et al., 1993). With this increase in urbanization, qualitative and quantitative changes in diet occur (Bourne et al.,1993; Walker et al., 1989), as well as changes in physical activity and stress-related phenomena (Levitt et al.,1993). Moreover, situations of growth retardation and wasting, coexisting with obesity among preschoolers have been observed (Steyn et al., 1991).

"Teasing out" factors that impact on health status becomes increasingly challenging as the effects of acculturation influenced by changes in income and/or exposures to urban influences are not clearly understood. The change in perceptions of ideal body size for example is not clear. Although obesity is well accepted in Black African culture (O'Keefe et al., 1982), there is some evidence to indicate that a significant percentage of obese Black African women may want to lose weight (Kruger et al., 1994).

In addition to these challenges, problems relating to dietary research in multi-ethnic groups as discussed in Chapter 2.2.2 apply. For example, in some families, in some cultures, food is shared out of a common pot and the proportion of ingredients in the pot may vary. This makes quantification of portion sizes eaten by individuals difficult.

Furthermore, practical problems like the lack of telephones in some areas and the frequent shifting of persons to different homes in the peri-urban areas means that accessibility and follow-up of subjects is often difficult.

Given these limitations, the 'traditional' 24-hour dietary recall remains the most suitable dietary assessment method for large-scale nutrition research in South Africa.

2.3 THE 24-HOUR DIETARY ASSESSMENT METHOD

2.3.1 Introduction

"The measurement of the habitual food intake of an individual must be among the most difficult tasks a physiologist can undertake" (Garrow, 1974)

The 24-hour dietary recall falls into one of the main four categories of methods used to assess dietary intake: specifically; food records, diet histories, 24-hour recalls, and food frequency questionnaires.

The principal use of a single 24-hour recall is to describe the average dietary intake of a group (Thompson and Byers, 1994). For epidemiological studies involving multi-ethnic groups and illiterate subjects it is often the instrument of choice. To characterize an individual's intake, multiple 24-hour recalls need to be used to account for the day-to-day variation in the intake of individuals (Liu et al., 1978; Sempos et al., 1985).

There are several advantages of using the 24-hour recall method. Firstly, the respondents are not required to be literate and the tool places little burden on the respondent. Secondly, it usually only takes about 20-30 minutes to complete a 24-hour recall. Using automated computer software (as in NHANES III) that specifies the details needed to code each response, greater standardization is achieved. However, this is at the risk of losing the respondent's descriptions of food for later review (Block, 1982). Finally, in contrast to the diary methods of recording food intake, dietary recalls occur after the food has been consumed, so there is less potential for the assessment method to interfere with dietary behavior.

Disadvantages of the 24-hour recall method include cognitive issues and individual characteristics that may influence the reliability of recall such as age, economic status or health status (Freudenheim, 1993; Krall et al., 1988). This is discussed in Chapter 2.4. The time and effort required to code questionnaires may also be a disadvantage. However, if automated computer programs are used, direct coding is possible and much time is saved (Feskanich et al., 1988).

In essence, there are two issues regarding the use of the 24 hour-recall method in individuals:

1) is it valid in reflecting dietary intake in the last 24 hours?

2) does the intake in the last 24 hours adequately represent usual intake over an extended period of time (Block; 1982)?

There seems to be agreement in the answer to the second question. It has been documented that since intra-individual variation on a day-to-day basis is high, in order to have 95% probability of being within ± 20% of a person's true year-long mean for calories, it would be necessary to obtain between four and nine 24-hour recalls per person (Balogh et al., 1971; Liu et al., 1978).

It is really the first question that this study attempts to address and subsequently the literature reviewed in this chapter focuses on techniques used in various validation and calibration studies in the search for an answer to this question.

2.3.2 Description of the 24-hour recall method

For the 24-hour recall, subjects are asked to remember and report all the foods and beverages consumed in the preceding 24 hours or in the preceding day. The recall typically is conducted by personal interview, either computer-assisted or using a paper-and-pencil form. Much of the dietary information is collected by asking probing questions to help the respondent remember all food and beverages consumed in the 24 hour period. Probing questions should be standardized and neutral. Interviewers should be trained and knowledgeable about foods available in the marketplace and about preparation practices, including prevalent regional or ethnic foods.

A quality control system to minimize error and increase reliability of interviewing and coding 24-hour recalls is essential. This should include a detailed protocol for administration, training and retraining sessions for interviewers, duplicate collection and coding of some recalls throughout the study period, and the use of a computerized database system for nutrient analysis (Thompson and Byers, 1994).

2.3.3 Validation/Calibration studies

2.3.3.1 Introduction

"In comparing results of validation studies of questionnaires, one must take into consideration not only the adequacy of the questionnaire, the study population, and the

method of administration, but also the adequacy of the reference data used as the gold standard" (Potosky, 1990).

Researchers, in their attempts to assess the worth of the various dietary assessment methods, have used various reference methods to represent the truth. In many cases the techniques used for validation have been extremely expensive (such as doubly-labeled water or duplicate plates (refer to sections 2.3.3.4 and 2.3.3.8)) and therefore prohibitive for local use.

In this chapter the various methods that have been used to validate the 24-hour recall are described and the suitability of each validation method for population based studies is discussed.

2.3.3.2 Agreement with food records

Estimates of group mean nutrient intakes from 24-hour dietary recalls have been compared with those from diet records for the same individuals with mixed results (Bingham, 1987). Whereas some studies show similar estimates, others show one method giving substantially higher estimates than the other:

- Young et al. (1952) compared intakes from 24-hour recalls with dietary histories and seven-day food records. All assessment procedures were conducted on 166 subjects (the sub-groups were: 51 school children, 87 high school and college students and 28 pregnant women). Subjects kept estimated rather than weighed food records. They found that the means for each sub-group (for energy) given by the dietary records and the 24-hour recalls were ‘interchangeable’(less than 10% difference) if there were more than 50 subjects. In comparison, there was up to a 23% difference between means for each sub-group (for energy) assessed by the dietary histories when compared to means for each sub-group assessed by the 24-hour recall. Individuals’ dietary intakes as assessed by the 24-hour recall were not ‘interchangeable’ with individuals’ dietary intakes as assessed by the seven-day food records. The order of testing procedures in this study may have influenced the results. The first interview was the 24-hour recall, followed by the dietary history and then the 7-day record.

- Bransby et al. (1948) looked at 3 day weighed records versus recalled intakes of 49 children and found an error of 10% for fat and an error of 7% for energy, protein and carbohydrate. It should be noted though that in this study the children had all taken a “lively interest in the proceedings and familiarized themselves with their food more than usual” (Bingham, 1987)
- A 10% error (for energy) between the 24-hour dietary recall method and weighed food records was found by Acheson et al. (1980). In this study 12 men first kept weighed food records followed by a 24-hour dietary recall the next day.
- In a study by Todd et al., (1983) 18 male students recorded their food intake for a minimum of 5 days (maximum 10 days) before a 24-hour dietary recall was obtained. The 24-hour recall was compared to data from records kept the day beforehand for which they had measured all food consumed using household measures. In this study coefficients of variation between the 24-hour recall and food records were far greater

than those of Acheson et al. (1980) and Bransby et al. (1948) i.e. 24% for energy and 33% for protein.

- Beer-Borst S & Amando (1995) used an estimated 3-day dietary record as the reference method against which a 24-hour recall was compared in 41 men. Median % differences in nutrient intakes between the two assessment techniques ranged from -9% to 22% and daily food intake differed significantly in only 3 out of the 10 food groups.

These studies have all been criticized for the following reasons:

1. Self-recording dietary intake prior to the recall may influence results (Block, 1982) and therefore the coefficients of variation reported in these studies may be under-estimated (Bingham, 1987).
2. In these studies (except for the study by Todd et al. (1983)) comparisons were made on the basis of averages for three or more days of recorded intakes and compared to the intake of 24-hour period.

Therefore, use of food-records to establish error in the 24-hour dietary recall method is unsatisfactory.

2.3.3.3 Agreement with dietary history

The original Burke diet history (Burke, 1947) included three elements: a detailed interview about the usual pattern of eating, a food list asking for amount and frequency usually eaten, and a 3-day record (Thompson and Byers, 1994). There are several variations of the Burke diet history with some interviews more detailed than others. However, a common feature of the dietary history assessment is that it includes cross-checks. Therefore, to convert the information (qualitative and quantitative) from the different sections of the dietary history to nutrients involves a decision-making process that includes the weighting and the interpretation of the data collected. This detail is often not cited in the literature.

As with the comparison of the 24-hour recall with food records, using the dietary history method as the reference method involves the use of one unvalidated method as the reference method for another. Results from calibration studies using this method are conflicting:

Stevens et al. (1963) found the mean values given by history and recall to be similar for most nutrients. For energy the mean difference was from 2% for young men to 6% for older men and older women. In this study a total of two hundred and twenty-five 24-hour recalls and ninety-seven dietary histories were conducted on 74 subjects.

In the study by Young et al. (1952) the percentage difference in mean values of energy given by the history method and the 24-hour recall were higher for school children and pregnant women (21-23%) when compared to the high school and college students (-10%). For an individual, in any of the 3 population groups studied, the 24-hour recall did not give the same estimate of intake as the dietary record or the dietary history. The protocol of this study is discussed in chapter 2.3.3.2. A limitation of this study was the over-exposure of individuals to different assessment methods (and thus subjects were possibly sensitized). This effect differed according to the different population groups studied.

Morgan et al. (1978) obtained a dietary history and the 24-hour recall at the same sitting for 400 persons and they found the mean values for calories and fat to be significantly different (higher values were obtained from the dietary history) and correlations, though significant, were low. In this study the 24-hour recall was administered after the dietary history.

Balogh et al. (1971) showed correlations for calories, fat and protein and carbohydrate in the range of 0.6 to 0.8 in a study where the average of results from several (an average of 8) 24-hour recalls obtained over a 12-month period were compared to a shortened version of the dietary history.

The study of Balogh et al. (1971) achieved the closest correlations between estimates from the 24-hour recall and a shorter version of the dietary history, but the method of averaging several recalls over a year and comparing this to a dietary history may in certain cases be impractical.

Thus a major limitation using the dietary history as the gold standard to validate 24-hour recalls, is the interpretation and the conversion of the data collected in the different sections of the questionnaire to nutrients and energy. Furthermore, results may be influenced by the order of exposure to each questionnaire. It has also been demonstrated that results vary in different population groups. In addition, as in the case of diet records, it is difficult to identify the source of the bias since both the "gold standard" and the 24-hour recall are subjective measures. Unless food intakes have actually been observed, interpretation of the bias is difficult.

2.3.3.4 Agreement with energy expenditure - doubly-labeled water

The doubly-labeled water technique was developed by Lifson et al. (1974) to measure free-living energy expenditure (Prentice et al., 1986). This method has been used to test the accuracy of dietary assessments with respect to energy intake working on the principle of energy balance, i.e., metabolizable energy intake equals energy expenditure plus the change in body energy stores. In a weight-stable individual, body energy stores change very little and thus metabolizable energy intake is virtually the same as energy expenditure.

The principle of the method is that after a loading dose of water labeled with deuterium and ^{18}O, the deuterium is eliminated from the body as water and the ^{18}O is eliminated as water and carbon dioxide. The elimination rate of deuterium therefore provides a measure of water flux, and the elimination of ^{18}O provides a measure of the sum of water and carbon dioxide flux. The difference then is equal to the carbon dioxide flux. Because carbon dioxide is the end product of substrate oxidation for energy production, standard indirect calorimetric techniques can be used for the calculation of energy expenditure (Schoeller, 1990).

This method, compared to calorimetry, is accurate to within 1%, with a relative precision or coefficient of variation of 3-6% (Schoeller and Taylor, 1987) even in free-living individuals. The error will be larger if the subject obtains more than 5-10% of energy intake from alcohol (Black et al., 1986). A further advantage of this method is that it interferes minimally with the daily routine of free-living individuals. However, it is expensive and until recently, the method of analysis was very time-consuming (Bingham, 1987).

Most of the studies that have used doubly-labeled water to validate self-reported dietary intakes have had limited sample numbers (Lichtman et al., 1992 (total n = 90, doubly-labeled water was used to validate a sub-group of 16 subjects' intakes); Livingstone et al., 1990 (n = 31); Prentice et al., (1986) (n=22)). Moreover, most of these studies have considered dietary intake determined by food records as opposed to dietary recall. Even in the study by Bandini et al. (1990) where the sample number was large (n=55), food records were used to determine energy intake.

In the study by Lichtman et al., (1992) a sub-group of twenty subjects was fed a lunch comprising a variety of foods and were instructed to eat until they felt "80 percent full", with a time limit of 45 minutes. Ten subjects (Group 1) had a history of diet resistance and reported eating less than 1200 kcal for 7 days without weight loss, 10 subjects (Group 2) had no history of diet resistance. The following day, subjects were contacted telephonically for a 24-hour dietary recall. The results of the subject's attempt to recall the test meal were compared with the weight of the actual foods eaten (for all of Group 1 subjects and for 6 of Group 2 subjects) and this was related to their energy expenditure (determined by doubly labeled-water), energy intake (determined by 14 day food records) and their scores on behavioral and psychological evaluations (which included the Beck Depression Inventory (Beck and Beamesvorter, 1974) and the Eating Inventory (Stunkard and Messick, 1985)). The use of the 24-hour recall in this study was merely to assess the subjects' accuracy of estimates of portion size of various standard foods (see Chapter 2.4.5). Results from the food records, physical activity records and energy expenditure measurements showed that subjects from Group 1 under-reported their actual intake by an average of 47 ± 16% (mean ± standard deviation) ($P < 0.05$) and over-estimated their physical activity by an average of 51 ± 75% ($P < 0.05$). The extent to which Group 2 subjects under-reported their energy intakes (19 ± 38%) and over-estimated their physical activity (30 ± 43%) was smaller than that of Group 1 subjects. This difference was however not significant, possibly due to the small number of subjects included in this part of the study.

2.3.3.5 Agreement with Energy Expenditure - Calorimetry

Direct and indirect calorimetry have also been used to measure energy expenditure and this has been related to energy intake. Direct calorimetry is the measurement of energy released as heat, of an individual enclosed in a sealed chamber. Indirect calorimetry is the procedure in which oxygen consumption, carbon dioxide, and respiratory gas exchange are measured for the calculation of energy expenditure (using the Weir equation: Weir, 1949). The relationship between carbon dioxide production and oxygen consumption can also provide information about the relative contribution of nutritional substrates utilized for metabolic energy. Techniques used for both direct and indirect calorimetry have been combined in a single room-sized chamber.

Although it has been demonstrated that energy derived from direct and indirect calorimetry measurements is equivalent, it does not necessarily reflect free-living energy requirements. Seale et al. (1990) measured energy expenditure (EE) in 9 subjects (5 males and 4 females) with room calorimetry and doubly-labeled water. These subjects spent 7 consecutive days within a room calorimeter while EE was measured using both methods. There was no significant difference between indirect and direct calorimetry (1.6 ± 2.6%) but free-living EE measured by doubly-labeled water was greater (13.2 ± 7.1%) due to greater physical activity.

Therefore, application of this method is suitable for metabolic studies but is limited for population-based studies.

2.3.3.6 Agreement with Energy Expenditure - prediction equations

Another technique that has been used to validate energy intakes in 24-hour dietary recalls in free-living persons is to predict energy expenditures (using estimated basal metabolic rate) based on the formulae of Schofield et al. (1985). This approach has been used to interpret the 24-hour recall data in two major population studies (NHANES II (Klesges et al., 1995) and NHANES III (Briefel et al., 1995)).

The Schofield regression equations incorporate individual height, weight, gender and age in the prediction of energy expenditure. In a sample of 4 814 adults, Schofield et al. (1985) found correlations between these equations and measured basal metabolic rate to range from r = 0.60 to r = 0.74.

It has been suggested that for a sedentary population energy intake should be 1.50-1.55 times the calculated basal metabolic rate (Briefel et al., 1995). Energy intakes that are less than 1.20 times the calculated basal metabolic rates, are almost certainly invalid (Bingham, 1984), unless they are accompanied by weight loss or a severe reduction in physical activity. If the basal metabolic rate has actually been measured, the limits of precision for predicting EE are smaller so that a higher cutoff of 1.35 times the basal metabolic rate is possible (Goldberg et al., 1991).

The studies of Briefel et al. (1995) and Klesges et al. (1995) provide the most detailed information on under- and over-reporting of dietary intake in population studies using 24-hour recalls. Estimated basal metabolic rates were compared to recalled energy intakes of 14 801 NHANES III participants (Briefel et al., 1995) and 11 663 NHANES II participants (Klesges et al. (1995)). In the study by Briefel et al. (1995) the ratio of energy intake to estimated basal metabolic rate was 1.47 for adult males, 1.26 for non-pregnant adult females, 1.09 for overweight females and 1.28 for overweight males. In the study by Klesges et al. (1995) the criterion used to determine under-reporting was energy intakes less than 0.92 times calculated basal metabolic rates. They found that up to 31% of their subjects under-reported their dietary intake.

Although Briefel et al. (1995) related weight, gender and age to reporting error and Klesges et al. (1995) related gender, race, age, level of completed education and body mass index to reporting error (see Chapter 2.4.2.1), analysis of nutrient specific error was not calculated. Furthermore, the results of both these studies apply to the American population.

2.3.3.7 24-hour urine nitrogen

The 24-hour urine nitrogen method has been considered by many as the most practical independent check on dietary survey methods (Bingham, 1995; Isaksson, 1980) in that it does not interfere with the habitual diet. This method compares the reported nitrogen (protein) intake with 24-hour urine nitrogen output assuming that subjects are in nitrogen balance, and that there is no accumulation due to growth or repair of lost muscle tissue, or loss due to starvation or injury. Measurements are valid only if the completeness of the urine collections is verified (Bingham, 1987).

In individuals in nitrogen balance, urine nitrogen should not exceed dietary intake and should be within the range of 81 ± 5% of nitrogen intake estimated from any method that aims to assess habitual intake (e.g., dietary history, 14 days of food records, 24-hour recalls) (Bingham & Cummings, 1985). If total urine N is unavailable, urine urea N plus creatinine N should be 73 ± 5% of the dietary intake (Bingham & Cummings, 1985). Completeness must be assured by using the para-amino benzoic acid (PABA) check method where subjects are given an oral dose of PABA by mouth and the amount recovered in the urine is an index of the completeness of the urine collection (Bingham et al., 1995). The average recovery of PABA in the urine of a healthy subject is 93% of the administered dose in single 24-hour urinary collections and 100% in sequential urinary collections. Thus single collections that contain less than 85% of the PABA marker, are classified as unsatisfactory (Bingham, 1987).

Studies carried out by Isaksson's group using this technique confirmed the under-estimation of protein intake that is likely to occur with the 24-hour recall (Isaksson, 1980). These studies did show however, that protein intake assessed from both records and diet histories agreed with that estimated from the 24-hour urinary N (Isaksson, 1980).

A recent study by Bingham (1995) to validate different dietary methods using the 24-hour nitrogen technique as an independent biological marker, found that the correlations between dietary N intake and urine N were in the range of r = 0.78-0.87 for weighed records, r = 0.27 - 0.50 for the Oxford Food Frequency questionnaire, r = 0.15 - 0.19 for the Cambridge Food Frequency questionnaire, r = -0.31 - 0.26 for the unstructured 24 hour recall, r = 0.01 - 0.25 for the structured 24-hour recall.

In this study Bingham et al. (1995) also considered the correlation between nitrogen from a 7 day checklist and a 7 day checklist with portions. In other words, the 24-hour urine nitrogen technique was used to validate 7 different dietary methods on the same 156 individuals. All participants were exposed to the different dietary methodologies over the course of a year. Two different versions of the 24-hour recall were used. The unstructured 24-hour recall consisted of a blank piece of paper with a written example, whereas the structured recall contained 10 pages subdivided into seven meal time periods with detailed questions on the amount and type of food eaten. The structured recalls had photographs for portion size assessments. Both recalls were given to the subjects to be completed by themselves (Bingham et al., 1994). The correlations between dietary and urinary N were higher for the structured ($r = 0.21$) as compared to the unstructured 24-hour dietary recalls ($r = 0.10$) (Bingham et al., 1995). It is important to note that the unstructured 24-hour recall was given to subjects at the start of season 1, and the structured 24-hour dietary recall was given to subjects at the start of season 2.

Due to multiple exposures of subjects over time to different dietary assessment tools, it is difficult to interpret the utility of urinary nitrogen as a means of validating 24-hour dietary recalls. Furthermore, the 24-hour urinary nitrogen method is really only an assessment of protein intake and cannot be extrapolated to assess other nutrients, particularly foods such as sugar, fats and oils, soft drinks and alcohol (van Staveren et al., 1985).

2.3.3.8 FEEDING TRIALS

Supervised feeding trials have been used to validate dietary records and generally results from these trials have shown that dietary records under-estimate energy requirements and have poor reliability. In the Beltsville re-feeding studies (Mertz, 1991) 266 subjects (203 males, 63 females) first kept 7-day diet records and were then fed diets adjusted to maintain their body weight for more than 45 days. Results from this study indicated that subjects under-estimated their intake by 18-20%.

It is interesting that the results from the Beltsville re-feeding studies (Mertz, 1991) compare favorably to a study on 31 “free-living” individuals who had their energy expenditure estimated by doubly-labeled water and compared to their energy intake (measured concurrently by seven day weighed dietary records) (Livingstone et al., 1990). However, anecdotally Livingstone et al. (1990) found that subjects altered their eating and/or failed to report all food eaten during the 7-day weighed record period.

In a controlled feeding trial with 269 free-living healthy subjects by De Vries et al. (1994), self-reported energy intakes from 3-day records were compared with actual intakes needed to maintain body weight during controlled trials lasting 6-9 weeks. Each subject was supplied with a diet that met his/her energy requirement, as judged by stable body weight during the trial. On weekdays subjects consumed their hot meals at the Department. All other food was supplied daily as a package and consumed at home. In addition, each participant received a list of “free-choice items” worked out to provide an amount of energy fixed for each energy level. Subjects kept a daily diary in which they logged their compliance. The energy reported was 277 ± 378 kcal/d lower than actual energy expenditure. This represented an under-estimation of energy intake by 10% The relative bias was significantly smaller for men (-8 ± 13.7%) than for women (-12.2 ± 13.7%). The mean body weights of the subjects were close to ideal values (BMI =22.1± 2.4). This study was well designed. However, since it was based on the principle of energy balance, the same design could not be applied to validate a single days’ dietary intake.

In a study by Lissner et al. (1989) body composition, weight change and energy intake of 63 women were measured in a metabolic unit for an average of 36 days. Food records were used to determine the energy requirement of 58 subjects and 24-hour recalls were used to determine the energy requirements for 5 subjects. These subjects were then fed experimental diets equal to their reported energy intakes for a period of 14 to 47 days. Reporting error was calculated by determining the difference between observed energy intake and initial reported energy intake, taking into account each subject's deviation from energy balance. An assumption of this study was that subjects were in energy balance during the pre-study interval.

Results of the study by Lissner et al. (1989) showed that self-reported energy intake before the experiments was not correlated with lean body mass and was under-estimated by lean subjects at least as much as by obese subjects.

Controlled feeding trials have been criticized in that the daily visits to the clinical research facility and the control of eating habits are restrictions which may interfere with subjects' normal routines and activities and may therefore confound results (Seale, 1995).

Duplicate plate collections

The limitations of using duplicate plate collections as the 'gold standard' against which energy intake can be compared were highlighted in the Beltsville One-Year Dietary Intake Study (1984). For one week periods, on four different occasions in a year, twenty-nine participants ate their self-selected diets and collected duplicate plate portions for analysis. In this time there was a 12.9% decline in daily energy intake of the subjects, as compared with their whole year's mean intake. Thus, duplicate plate collections are not necessarily representative of true dietary intake. Furthermore, since the 24-hour dietary recall is a retrospective method, it is not practical to use duplicate plate collections as a validation method.

2.3.3.9 Observation studies

Although the literature frequently cites the importance of observation studies to validate dietary intakes (Bingham.,1987; Block., 1982; Mertz, 1992) few observation studies have been done. Certainly, no observation studies to validate dietary intakes have been done in South Africa on multi-ethnic populations.

Results from the studies that have compared respondents' reports of dietary intakes with dietary intakes unobtrusively recorded or weighed by trained observers have shown that the group mean nutrient estimates from 24-hour recalls were similar to observed intakes (Gersowitz et al., 1978; Madden et al., 1976), although respondents with lower observed intakes tended to over-report their past intakes and under-report large quantities (Madden et al., 1976). This has been referred to as the "flat-slope syndrome".

The study by Madden et al. (1976) compared 24-hour recalls with observed and weighed duplicate meals for 76 elderly persons who consumed an institutional lunch. In this study the greatest range of the coefficient of variation was 42% for energy to 400% for Vitamin C (Bingham, 1987). In a further study by Linusson et al. (1974) on pregnant women who were not aware that their food consumption was being observed before questioning the next day, the percentage error between observed and reported intakes ranged from 48% for breakfast cereals to 92% for salads.

There are two observation studies cited in the literature that have been designed to address questions similar to those questions raised in this thesis. The first was a Finnish study on 84 male subjects and 56 female subjects (15-67 years of age) who were studied in groups of 8-10 (Karvetti and Knuts, 1985). These subjects (who at the time were living in a dormitory) had 4 meals that they had self-selected and ate in a cafeteria while the food was unobtrusively recorded. The dishes that were served had been pre-weighed and standardized. The following day 24-hour recalls were obtained. In this study, omissions (foods not recalled), additions (recall of foods not consumed) and misidentifications (erroneously recalled foods) were the major sources of error. Omissions were greatest for cooked vegetables (50% of times vegetables were eaten they were omitted) and least for fish (4% of times fish was eaten, it was omitted). Two percent of the time bread was recalled, it was not actually eaten and 29% of the time sugar was recalled it was not actually eaten. The highest variance in nutrient error was for sucrose (mean under-reporting for the group was 20%). The correlation coefficient between observed and recalled nutrient intake was in the range of $r = 0.43$ ($P = 0.003$) (niacin) to $r = 0.74$ (not significant) (cholesterol). Although, the authors of this study concluded that validity for the whole group was satisfactory, they acknowledged that at the individual level, validity was unsatisfactory. An explanation given for the better group validity was the "flat-slope syndrome" whereby the effects of under-reporting and over-reporting largely cancel each other out.

It is not possible to apply the results of the study by Karvetti and Knuts (1985) to the South African population. Firstly, although the authors comment on the heterogeneity of their sample population, all subjects studied had a basic level of formal education (6-9 years) and ate a 'typically Finnish diet'. Secondly, no information is given on the relationship between subject characteristics (other than age and gender) and reporting error. Furthermore, standard portion sizes of the foods served at the test meal were determined by the researchers, rather than by the subjects. Although this eased the logistics of the study, it is debatable if subjects would have eaten the same 'standard' quantities if they were free to portion their own meal.

The relationship between the amount of food eaten at a test meal and reporting error was demonstrated in the study by Lichtman et al. (1992). Lichtman (1992) showed that subjects who ate less food (676 $\pm$ 327 kcal) at a test meal under-reported their intake (546 $\pm$ 419 kcal) when compared to the subjects who ate more food at the test meal (807 $\pm$ 569 kcal). The latter group over-reported their energy intake at the recall (913 $\pm$ 635 kcal). This is in contrast to the "flat-slope syndrome" that was evident in the study of Karvetti and Knuts (1985) and Gersovitz et al. (1978) who found that subjects tend to over-report their dietary intakes when they were observed to have eaten small quantities, but to under-report large intakes. Although Lichtman et al. (1992) found that the under-reporters scored higher on the cognitive restraint scale and reported less disinhibition and less hunger than the subjects that ate more at the test meal, the fact that the amount of food eaten at the test meal influenced reporting error, should not be ignored.

An observation study by Myers et al. (1988) was designed to consider the effects of obesity on self-reports (24-hour recalls) of dietary intake in adult females. Twenty one overweight female college students (mean weight 76 ± 10 kg) and 19 normal weight female college students (59 ± 5 kg) consumed a lunch meal at the university cafeteria while being unobtrusively observed. As in the study by Karvetti and Knuts (1985), foods served at the test meal were portion-controlled and weighed before being served and plate-waste was calculated after the meal. Subjects returned to the laboratory within 24 hours of their cafeteria lunch when a 24-hour recall was administered. In contrast to the results of Karvetti and Knuts (1985) Myers et al. (1988) showed little difference between the types and numbers of food items eaten and recalled. However, Myers et al. (1988) did show nutrient differences with subjects' significantly over-reporting fat and total calories and under-reporting of sugar ($P < 0.01$). They attributed the nutrient differences to quantitative errors (portion size errors) in the subjects' assessment of foods consumed. Results showed that 50% of the subjects over-reported the food consumed at the test meal by more than 10%, and 25% of the subjects under-reported food consumed at the test meal by more than 10%. There was no significant effect of body weight on the accuracy of reporting intake.

As in the study by Karvetti and Knuts (1985) subjects were unobtrusively observed and the study relied on observers documenting foods eaten. No indication is given whether the foods served at the test meal in these studies were eaten typically by the subjects. In addition, the studies do not cite the number of food items that were served. The population studied by Myers et al. (1988) were all tertiary level psychology students (18-38 years old) and as an incentive to participate in the study subjects were offered extra credit points. This places doubt on the interpretation and application of these results in a more heterogeneous population.

2.3.4 Conclusions regarding the 24-hour recall

The value of the 24-hour recall as a tool to examine the average intake of groups is well established. However, validation and calibration studies done to date in a variety of conditions and populations suggest that the 24-hour recall method is associated with systematic under-estimation of food intake that may range from 4 to 400% for specific nutrients. It is surprising that only a few studies have used various techniques of direct observation and measurement of intake to validate this assessment method especially since the time period covered in the 24-hour recall method is relatively short.

2.4 SOURCES OF ERROR IN DIETARY RESEARCH

2.4.1 Introduction

"many researchers incorrectly assume that quantifiable data are more accurate than qualitative data, or that quantifiable data are explanatory, when, in fact, they are descriptive" (Cassidy, 1994).

Dietary research frequently focuses on precise measures and amounts. However, in performing this type of research there are certain limitations and difficulties.
These limitations can be considered in three main categories: precision, random inaccuracy, and non-random error. Non-random errors, or bias are the most serious limitations in dietary research. These systematic errors remain regardless of the number of observations made in a study (Bingham, 1987) and can lead to invalid conclusions. Study design should minimize bias, and where this is not possible, it is important to understand the magnitude and direction of bias (Livingstone et al., 1990).

Stallones (1992) categorized the variance in measuring food intake data as follows:

1) Real differences in the usual diet of individuals.

2) Real differences between the usual diet of a person and the diet that is being measured in the study.

3) Differences between the current diet and the measurement of current diet. These differences can be subdivided into respondent error and observer error, and sometimes, instrument error (Stallones, 1992).

This chapter will expand on the studies described in Chapter 2.3 that have focused on factors primarily affecting respondent error, with a brief look at observer and instrument error.

2.4.2 Factors affecting respondent error:

Respondent error can arise when there is:

1) under-reporting or over-reporting of the food ingested by the respondent/subject, or
2) if eating patterns are altered during the period of reporting food intakes. This is especially important in situations where intake is measured over time or where the task of recording food intake is prospective and demanding. This was the case in the collection of duplicate food portions in the Beltsville One-Year Dietary Intake (1984) which resulted in reducing the intake estimates of the subjects by 13%.

It is not entirely clear why people under-report or over-report dietary intake. According to studies done, more people are likely to under-report intake than over-report intake. Mertz et al. (1992) found that in a sample of 266 subjects, over 80% of the sample under-reported food intake by a mean of 2.8 MJ per day, and only 8% over-estimated food intake. Similar results have been found in other studies (Livingstone et al., 1990), and in large scale studies using the 24-hour recall method such as in NHANES II (1976-1980). In this study a discrepancy of 700 kcal/day remained between reported dietary intakes (1900 kcal/day) and food energy available at retail level (3500 kcal/day), taking into account losses and waste occurring between the purchase and the consumption of food (Schoeller, 1990). It was estimated that food waste amounted to 600kcal/day in the food marketing system and 300 kcal/day in household waste (Swan, 1983).

It is interesting that energy intake values from NHANES III (1989-1994) are 100-300 kcal/day higher than the same-age respondents in NHANES II (Briefel et al., 1995). One of the reasons given for the difference is the more sophisticated methodology used for the dietary recalls in NHANES III (improved 24-hour recall protocol, a computer-based interview with an automated data collection system, the use of a quick list with additional interviewer probes for forgotten foods and standardized probes to elicit detail) (Briefel et al., 1995).

Many researchers have shown that under-reporting of food consumption occurs more often in women, overweight persons and some weight conscious people (Bingham, 1987; Black et al., 1991; Black et al., 1993; Schoeller, 1990). However, the differential effect of this under-reporting on specific food components and on specific sub-groups is not well understood (Briefel et al., 1995). In addition, little is known regarding the influences of non-physiological factors such as knowledge, attitudes, education, socio-economic status, acculturation and social desirability on reporting error.

2.4.2.1 Physical characteristics relating to reporting error: gender, body composition, age and ethnicity.

Results from phase 1 (1988-1991) of the NHANES III survey showed that overweight adults, particularly women, were more likely to under-report intakes. The mean ratio of energy intake (assessed from 24-hour recalls) to estimated basal metabolic rate (calculated from the Schofield equations) was 1.47 for adult males and 1.26 for non-pregnant adult females. For overweight adults this ratio was lower; with a mean of 1.28 for males and 1.09 for females. A mean ratio of 1.50-1.55 is expected for a sedentary population (Briefel et al., 1995). Thus the results of the NHANES III suggest under-reporting particularly in females and overweight persons.

More is known on the presence and degree of apparent under-reporting in the NHANES II participants. A comprehensive study designed by Klesges et al. (1995) included 11 663 men and women participants of NHANES II (age 18-74). Self-reported dietary intake (assessed by 24-hour recalls) was compared with estimated basal energy expenditure (calculated from the equations of Schofield et al., 1985). The cut-off limit for under-reporting in this study was conservatively set at 0.92 (ratio of energy intake to calculated metabolic rate). This value was the lowest cut-off suggested by Goldberg et al. (1991) for energy intake compared to calculated basal metabolic rate at 95% confidence. The major variables of interest in this study included race, level of education, gender, body mass index, reported total energy intake and estimated basal energy expenditure.

Results of the study by Klesges et al. (1995) indicated that 31% of adults in the sample may have under-reported intakes, using the cut-off value of 0.92. The odds for under-reporting were higher for females than males at all ages (female participants were 5 times as likely as male participants to under-report their intake; this effect was more pronounced in younger women and men), higher for persons with a higher body mass index (for every 1 unit increase in BMI, there was a 16% increase in the odds of under-reporting), higher for persons with less formal education (under-reporting decreased 6% with every 4-year increase in education) and higher for persons that were not Caucasian (participants who were not Caucasian were 2.26 times more likely to apparently under-report intake relative to Caucasians).

When Sex x Race interactions in the Klesges et al. study (1995) were considered, female participants of both races were more likely to under-report than male participants, but the difference between male and female participants was greater among Caucasians. For female participants, both Caucasian and non-Caucasian participants apparently under-reported (relative to Caucasian male participants). The likelihood of female non-Caucasian participants under-reporting more than female Caucasian participants was slightly higher (odds ratio: 1.21, $P < 0.04$).

Several other validation studies (metabolic, doubly-labeled water studies, re-feeding studies and studies that have predicted energy expenditure and compared it to reported energy intake) have confirmed that gender and adiposity are two physiological variables that are associated with under-reporting, but the results are not consistent. Moreover, most of these studies used food records as opposed to 24-hour recalls (except for the 5 subjects included by Lissner et al. (1989)) to determine energy intake. The magnitude of under-reporting in males and females documented in these studies ranges from 12 % (Johnson et al., 1994) to 19% (Livingstone et al., 1990) for men and from 18% (Livingstone et al., 1990) to 24% (Lissner et al., 1989; Johnson et al., 1994) for women. The study of Johnson et al. (1994) was conducted on an older population (66 ± 6 years) and in this study under-reporting was calculated using the difference between predicted energy expenditure (RMR calculated by indirect calorimetry) and self-reported food records; Livingstone et al. (1990) used the doubly-labeled water technique to measure energy expenditure, and Lissner (1989) measured actual energy intake in a metabolic unit, correcting for deviations from energy balance. Both Bandini et al. (1990) and Prentice et al. (1986) using doubly-labeled water confirmed that obese subjects under-reported energy intake by 20-30% compared to their non-obese counterparts. Prentice et al. (1986) studied 22 adult women and Bandini et al. (1990) studied a total of 55 male and female adolescents. The definition of under-reporting in these studies differed. For example, in the study of Johnson et al. (1994) under-reporters were those subjects whose self-reported energy intakes subtracted from their predicted energy expenditure, resulted in a negative value. However, in the study of Livingstone et al. (1990) under-reporters were those subjects whose reported energy intakes were less than 1 times their measured total energy expenditure.

In the study by Livingstone (1990) the subjects' (n = 31) weights ranged from 46.8 kg (a female) - 111.4 kg (a male). The authors noted that women in the upper third of energy intake had a mean ratio of intake to expenditure of 0.96 as compared to women in the middle and lower thirds, whose ratios were 0.70 and 0.61 respectively. The authors concluded that these low values were physiologically impossible and could not be fully explained by the existence of metabolic adaptations that save energy or increase the efficiency of absorption or retention of nutrients to maintain homeostasis. Furthermore, the error could not be attributed to a systematic error in the doubly-labeled water technique which at most is unlikely to be biased by more than 5% (Schoeller, 1990). The observed discrepancies in this study were ascribed to inaccurate estimates of habitual energy intake due to conscious or sub-conscious changes in normal dietary patterns or both.

The same trend (i.e., men being less apt to under-estimate their intake) was found in 37 published studies reviewed by Black et al. (1991) focusing on younger men and women. Hallfrisch et al. (1982) in metabolic studies calculated that the actual energy requirements to maintain body weight was 19% greater in men and 37% greater in women than estimated by self-recorded food records.

The gap between reported energy intake and expenditure is not restricted to obese subjects. For example, large discrepancies between intake and expenditure have been reported for male and female athletes (Westerterp et al., 1986). When lean subjects were studied in Gambia (Singh et al., 1989) their energy intake averaged only 40% of their measured energy expenditure. Similarly, Lissner et al. (1989) (their data reflects a combination of six trials between 1981 and 1986) found that self reported energy intake was under-estimated by lean subjects, at least as much as by obese subjects. In these trials components of body composition were measured and there was a significant association between fat-free mass and the degree of under-reporting ($P < 0.0001$). One possible explanation is that persons with higher fat-free mass have the largest energy expenditure, thereby increasing the likelihood of the magnitude of reporting error. The 24-hour dietary recall was used in only 1 of the 6 trials (this trial included 5 subjects) by Lissner et al. (1989) to determine dietary intake. In the 5 other trials (total of 58 subjects) 3-5 day food journals were used to determine dietary intake. No explanation is provided for the difference in design in these trials.

Taken collectively, the results of these studies show that some degree of under-reporting occurs in both obese and non-obese persons, although it appears that the degree of under-reporting among obese participants is greater than that of participants of normal weight.

The effect of age on dietary reporting is unclear. Sawaya et al. (1996) studied differences in older (74 ± 1.4 years) versus younger (25.2 ± 1.14 years) women. They found that in the younger women the 24-hour recall energy intakes gave mean energy intakes that were closest to free-living energy expenditure, whereas in the older women, no energy intake data correlated significantly with energy expenditure. However, subject numbers in this study were limited (10 subjects per age group) and the researchers exposed these subjects to 3 different dietary assessment methods (weighed food records, food frequency questionnaires and duplicate 24-hour recalls).

Observation studies have shown different results. It is interesting to note that in the observation study to validate the 24-hour dietary recall by Karvetti and Knuts (1985) it was found that women in the 35 to 44 year age group achieved more accurate results than men in the same age group, although men tended to over-estimate the food amounts and women often under-estimated the amounts. In this particular study no details on subjects' physical characteristics such as body mass index or weight were described. The authors do, however, suggest that overweight, which is common in the 35-44 year age group, may have been a reason for under-estimation of food amounts by the women subjects. Bias in dietary reporting resulting from "social desirability" has been studied and is discussed in Chapter 2.4.2.2.

The observation study on 40 females by Myers et al. (1988) (described in further detail in Chapter 2.3.3.9) showed that the degree of inaccuracy ranged from under-reporting by 50% to over-reporting by 257%. Myers et al. (1988) do not indicate whether this error relates to energy or to specific nutrients. They mention that items recalled were similar to items eaten, but no further detail regarding items eaten or recalled is given. Their study showed that there was no difference between the reporting error of the "overweight group" when compared to the "normal weight group." However, in this study an inclusion criterion for subjects in the "normal-weight" group was to be within the scales of normal eating. To ensure this, the Revised Restraint Scale was administered to the subjects in the normal weight group. Results of this study therefore provide no information on the reporting error for subjects with "normal-weight" who have restraint scores outside the range of normal limits. In this study the mean weight of the "normal-weight" participants was 59.0 ± 4.5 (n=19) and the mean weight of the "overweight participants" was 75.6 ± 9.9 (n=21).

In summary, the current literature suggests that the following characteristics of subjects are related to dietary under-reporting:

1) gender: women are more likely to under-report dietary intakes across all age groups
2) ethnicity: the gap between women and men in dietary reporting is greater in Caucasians and there is a slightly greater likelihood of non-Caucasian women under-reporting when compared to Caucasian women. This applies to populations studied in America.
3) age: older adults are more likely to under-report than younger adults.
4) body mass: there is a positive correlation between body mass and reporting error.

2.4.2.2 Non-physiological characteristics relating to reporting error: knowledge/attitudes/beliefs/education/socio-economic status/acculturation

Factors that influence eating behavior include knowledge, attitudes and beliefs about diet (Thompson and Byers, 1994). Coupled with education, occupation (Dwyer, 1988; Klesges et al., 1995) and possibly socio-economic status (Livingstone and Prentice, 1990), these factors can influence the accuracy of reporting food intake. Certainly in areas where public awareness is heightened, changes in self-reporting and/or diet can occur (Rathje, 1984; Cote, 1984). It is possible that when people are exposed to different value systems and lose their traditional values (i.e., through the process of acculturation) this may influence how they report their food intake.

Studies that have addressed these factors have shown the following:

- individuals such as nutritionists, graduate students or bank clerks may be better respondents in diet recall than others (Dwyer, 1988). In the observation study by Myers et al. (1988) all subjects were tertiary level psychology students and their results showed that 25% of the sample population (n=40) was within 10% accuracy of actual observed intake. Yet, in the metabolic study by Lissner et al. (1989) female university staff and students were still found to under-estimate true energy requirements by 23% or 2.27 MJ/day.
- registered dietitians under-estimated their energy intake by only 0.5% when compared to their energy expenditure that was determined using 24-hour room calorimetry

measurements. Other subjects in the study under-estimated their intake by 7% (Drouas et al., 1992).

- subjects in lower socio-economic brackets when compared to those subjects in higher socio-economic brackets were shown to be more prone to under-report in a study by Livingstone et al. (1990) although this did not reach statistical significance. This study included only 15 women and 16 men.
- a study in which self-reported intake was compared with the actual disposal of packaging materials in home garbage showed that frozen dinners and alcoholic beverages were under-reported, whereas fresh meats were over-reported by 10% (Rathje, 1984).
- "lower-status foods" such as frozen dinners and beer have been shown to be under-reported by middle-class Americans (Cote, 1984).
- the most comprehensive study that reports the influences of education on reporting error is the study by Klesges et al. (1995) on NHANES II participants. As discussed earlier, their findings showed that under-reporting decreased as the level of education increased.

The way in which questions are asked affects responses. Subjects "talking a good diet" and depending on the social desirability for foods seen as "good" or "bad", may over-estimate low intakes and under-estimate high intakes (Dwyer and Coleman, 1994). A social desirability scale (the Marlow-Crowne Social Desirability Scale) and a social approval scale (the Martin-Larsen Social Approval Scale) was used to assess bias in reported food intake in 27 females and 14 males in a study by Herbert et al. (1995). The study was comprised of two phases. In the first phase multiple 24-hour dietary recalls and two 7-day diet recalls were used to determine nutrient intakes (one 7-day diet recall (7DDR) was administered at the beginning of the test period and one at the end). In the second phase of the study (two years later) subjects were posted the Social Desirability and Social Approval Questionnaires. The time that the subjects took to return the forms was also noted as an estimate of compliance, which the authors related to social desirability.

Results from this study showed that social approval (the tendency for an individual to seek a positive response in the testing situation) was not related to any nutritional variables. However, social desirability and body mass index were related to under-reporting of nutrients, specifically fat and total energy. This under-reporting of nutrient intake due to social desirability was greater for women than for men. Under-reporting was less in the post measures than in the pre-measures suggesting a decrease in reactivity with increased exposure to dietary assessment.

It therefore seems that reported dietary intake is associated with greater error in persons with lower socio-economic status and persons with a lower level of education. Furthermore, social desirability, which has been defined as the tendency of an individual to convey an image in keeping with social norms and to avoid criticism in a 'testing' situation (Herbert et al., 1995), results in bias. This bias is greater in women possibly due to the incidence of dieting, guilt about eating, restrained eating, stress-induced eating, binge eating and obesity (Herbert et al., 1995).

The study by Bingham et al. (1995) demonstrated the effects of dietary restraint on reporting error. This study is described in detail in Chapter 2.3.3.7. When the sample was sorted into quintiles according to their urine nitrogen: dietary nitrogen ratio, it was found that for the unstructured 24-hour recall, there was a negative correlation (r = -0.31) between urine N and dietary N in the top quintile. The top quintile incidentally represented heavier subjects with significantly greater body mass indices. Furthermore, these subjects were reportedly more restrained eaters and had significantly lower energy intake: basal metabolic rate ratios.

Thus it seems that social desirability, education, and dietary restraint together with body weight are markers for under-reporting of dietary intake.

2.4.3 Cognitive research relating to dietary assessment

Errors of memory in dietary recall methods have been discussed and researched by several investigators (Dwyer et al., 1987; Freudenheim, 1993; Friedenreich, 1994; Smith et al., 1991). Memory differentially affects the accuracy of responses for 24-hour recalls and food frequency questionnaires (Dwyer and Coleman, 1994). Whereas the 24-hour recall calls on episodic memory of all actual events in the very recent past, a food frequency questionnaire relies primarily on non-specific memory and the respondent is asked to report the usual frequency of food eaten over the previous year. As the time between the behavior and the report increases, respondents may rely more on non-specific memory and less on episodic memory (this refers to stimuli pertaining to experiences of a distinct time or place) (Smith et al., 1991).

Cognitive tasks involved in dietary recall go beyond memory tasks and involve inference and many other skills such as computational ability (Bradburn et al., 1987). The following observations have been documented in studies that have focused on the 24-hour recall method:

- Interviewer probing and memory cues affects responses. One study found that respondents with interviewer probing reported 25% higher dietary intakes than did respondents without interviewer probing (Campbell and Dodds, 1967).
- The frequency with which a food is consumed may determine the response to questions. Dwyer and Coleman (1994) comment that reports are most accurate for those food items that are never eaten and for those that are eaten frequently. The remaining food items probably merge into an average. In the study by Karvetti and Knuts (1988) results showed that there was less omission of foods such as fish, potatoes, bread and coffee, and more omission of cooked vegetables, eggs and cakes. A reason cited for the difference was that the first group of items were more commonly eaten by their subjects.
- Age may influence cognitive abilities to recall food intake. Results from studies however, are conflicting. For example in studies on children's diets, response bias, recall bias and difficulties in assessing portion sizes have all been noted (Karvetti and Knuts, 1985; Guthrie, 1983). Interestingly, a study by Livingstone et al. (1992) demonstrated that children less than 12 years old estimated their energy expenditure correctly by weighed dietary records and that under-reporting increased with increasing age. This study comprised 78 subjects aged 3-18 years. Results from a study on older persons by Campbell and Dodds (1966) (300 hospital patients between the ages of 20-

40 years and over 65 years) showed that there was a significant difference between younger and older subjects in the energy omitted from the 24-hour dietary recall, with the older group forgetting up to 35% of calories. In the study by Klesges et al. (1995) on 11 663 NHANES II participants (20-70 years of age), younger female participants were more likely to under-report than older participants.

- Habitual intake patterns may be disrupted by illness or spells of illness (e.g., in the case of bulimia or an eating binge) and make it difficult to retain or recall intake patterns (Dwyer, 1988; Dwyer and Coleman, 1994). This notion is supported by Hadigan et al. (1992) who in a study on the reporting error in patients with bulimia nervosa found that as the amount of food eaten at the test meal increased, the tendency to over-estimate food consumed increased ("steep-slope syndrome"). In this study 15 patients who had had bulimia nervosa for 7.3 ± 4.8 years were served a test meal comprising a variety of foods (ranging from snack type foods to foods commonly served at meals), and the following day a 24-hour recall was administered.
- Terminology may affect responses. If food names cannot be recalled (young children or adults who have cognitive impairments), related information on food frequency and portion size may be lost. In addition, terminology may affect responses in certain ethnic subgroups if foods are called by other names, or if food names fail to be retained or retrieved (Cassidy, 1994).

The cognitive working group of the 1993 Workshop on Dietary Assessment (NCHS/CDC) suggested that more research needs to be done on strategies that may impact on memory for foods. More needs to be known about the following:

1) the effects of prior notification of the 24-hour recall;

2) the use of cueing strategies like lists of foods, time periods in the day as cues, moving chronologically forward in time as opposed to backwards;

3) the effects of a single interview repeating the recall process and verifying the probing strategy each time (using activities in the day, categories of foods and food lists as probing strategies).

2.4.4 Observer and instrument error

An additional problem of accuracy of the 24-hour dietary recall method may be a result of imprecision on the part of the observers. The extent to which different interviewers are able to elicit the same information over the same period from individuals is an important basic check on the 24-hour recall method (Bingham, 1987). It has been suggested that measurers of diet probably vary more in their skill in obtaining dietary information than they do in obtaining biochemical measurements (Dwyer, 1988).

Frank et al. (1977) found that the coefficient of variation in children's diets (interviewed by different interviewers using the 24-hour recall method) ranged from 9% for protein to 27% for cholesterol. Moreover, evidence from this laboratory suggests that the interpretation of a food record for total energy by individual dietitians and final year post-graduate dietetics students has a coefficient of variation as high as 10% (Meltzer et al., 1994) (Chapter 4).

Observer and instrument error can arise from recording and transcription errors and errors in analysis. Beaton et al. (1979) compared coding results from 60 dietary records. Coefficients of variation ranged from 3% for protein to 8% for fat and 17% for P:S ratio between those that were coded at one location versus those coded at a centralized coding station. The same computer databases were used at both locations. The use of standardized food tables and well-designed protocols with default values for particular foods is a requisite in any dietary survey (Bingham, 1987).

Finally, the calibration of tools that are used for assessing portion sizes (e.g., household measures, scales), is important. The capacity of different spoons for example, varies by 20 to 28% (Nettleton et al., 1980).

2.4.5 Quantification - Estimation of portion sizes

The recall of portion size probably involves tasks and abilities such as spatial comparisons and orientation, and size estimation (Dwyer and Coleman, 1994). From the limited data in the literature dealing with dietary assessment it seems that the errors associated with the estimation of weights of food are regularly around 50%, and 20% for nutrients (Bingham, 1987). In some instances where mixed foods such as casseroles have been tested, errors up to 90% have been reported (Bingham, 1987).

Dwyer and Coleman (1994) suggest that familiarity with the unit of serving or measurement may improve a person's ability to estimate amounts accurately and that items that come in standard units such as milk in cartons, brands of candy bars and pre-packaged foods are subject to less error in estimation than foods such as meat, chicken, fish, poultry and snack foods.

Additional factors that influence the estimation of portion sizes have been demonstrated in several studies (Howat et al., 1994; Gittelsohn et al., 1994; Lichtman et al., 1992). In these studies the portion tests have either been performed by observers trained to assess dietary intake (Gittelsohn et al., 1994) or by participants of energy balance studies (Howat et al., 1994; Lichtman et al., 1992). In all three studies, the subjects did not actually consume the food that was tested.

In the study on 10 local Nepalis trained for 3 months in observational techniques (Gittelsohn et al., 1994) a total of 6902 observations were completed on 150 different foods. The correlation for observed food weight and actual weight was high for all food (r=0.96). However, they found that the visual appearance of food may affect estimation error. Foods of high volume, but low weight e.g., puffed rice, corn and white bread were less accurately estimated than foods of low weight but high volume. Moreover, smaller portions (less than 30g), regardless of the food type were estimated less accurately.

In the study of Howat et al. (1994) subjects (n = 44) were also trained on portion size estimations. Life-sized food photographs and models of eleven common foods were used for the tests. They found that the subjects over-estimated portion sizes using both the food models and the photographs. These over-estimations, however, decreased over time from 92% for test 1, to 84% for test 2 to 81% for test 3. The time gap between the 1st and the 3rd test was 11 days. They found that the error was greatest in amorphous and liquid foods (e.g., gelatin, broccoli, french fries and milk), and least in solid foods like ground meat patties and chicken breasts. All subjects in this study were within the restrained eating and disinhibitor sub-scales for the 3 Factor Eating Questionnaire (Stunkard and Messick, 1985).

Lichtman et al. (1992) considered portion size estimates in both restrained (n = 10) and unrestrained eaters (n = 10). They found that subjects in both groups were able to accurately estimate portion sizes. However, when the same subjects were fed a test meal that they recalled the next day (24-hour recalls were administered telephonically), the restrained eaters under-reported by 20% and the unrestrained eaters over-reported by 12% the energy eaten at the test meal. No information is given in the study on the amounts or types of foods that were used for the portion size tests. In addition, no information is given about the types of foods served at the test meal.

The results of these three studies combined suggests that portion size estimations are similar in subjects when the food tested is not eaten by the subjects. In addition, when the food tested is not eaten by the subjects, estimations are not affected by the subjects' mass or dietary restraint/disinhibition.

Judgment may be influenced by the tools used to determine portion size. For example, greater accuracy is achieved using measuring scales or household utensils than using other size standards (Dwyer and Coleman, 1994). Rustihauser (1982) showed that when nutrition students were asked to estimate portion size the coefficients of variation of differences between actual and estimated weights were from 16 to 53%, with household measures and 10 to 27% with models and photographs.

Results on the estimation of food sizes using models are conflicting. Whereas Moore et al. (1967) found that models seem to increase estimates, Rustihauser (1982) found that a 4% underestimation resulted when using models to assess weights of food.

Studies comparing portion size estimates from food models versus photographs or pictures have shown varying results. Posner et al. (1992) examined the comparability of portion size reports for the same foods using food models and equivalent two-dimensional pictures of those same models and found that although some respondents reported differently depending on whether they were using food models or pictures, no apparent bias in the direction of reporting was evident. This was in contrast to the study of Howat et al. (1994) who found that food portion estimates were improved when using life-sized photographs as compared to models.

The definitions used to describe portion sizes are not always understood. When Smith (1991) increased or decreased the definitions of a "large", "medium" and "small" serving size of a food, the subjects he tested did not alter their descriptions of typical portion sizes accordingly. This is of relevance since these descriptions/definitions may be used in a 24-hour recall.

Training in recall methods has been shown to improve the accuracy of food portion estimates (Howat et al., 1994). However, it should be noted that in this study foods were not eaten. Moreover, it appears that the effects of training may be temporary and may be lost in less than one month (Bolland et al., 1990). In the study by

Bolland et al. (1990) subjects received training by food models that were labeled with their respective quantities. Four weeks later subjects were re-tested. The mean absolute percentage error for all foods combined was 59 ± 72% when subjects were tested the same day, 62 ± 60% a week later and increased to 77 ± 105%, four weeks later. The training/time factor was significant ($P < 0.05$) for four of the six food items tested (meat loaf, fish, soup and spaghetti).

2.4.6 CONCLUSIONS REGARDING SOURCES OF ERROR IN DIETARY RESEARCH

Errors in estimating dietary intake are not uniform from food to food . Furthermore, the use of tools (e.g., photographs, models) to determine portion size may influence the results. Whereas some foods and beverages may be over-estimated when dietary intake is assessed, other foods and beverages may be under-estimated. In situations where foods are in non-standard forms (e.g., the situation of one-pot cooking in South Africa) the judgment of portion size may be particularly difficult.

Training may influence the subjects' ability to accurately determine portion size of foods and may sensitize subjects in energy intake studies. Characteristics of subjects, such as body weight and dietary restraint/disinhibition that are associated with under-reporting food intake and reducing the accuracy of dietary recall, do not influence the subjects' ability to estimate portion sizes.

Reported dietary intake data are thus influenced by subject characteristics and the methods used to estimate portion sizes of foods. The potential error in epidemiological dietary studies using 24-hour recalls may be as much as 31%.

2.5 SUMMARY: CHAPTER 2

High quality dietary assessment is a prerequisite for improved nutrition and for the formulation of nutrition recommendations to reduce health risks. To be of high quality, dietary research should be culturally sensitive and should recognize the influences of acculturation.

Although the 24-hour dietary recall instrument is considered a culturally sensitive technique (Cassidy, 1994), use of this method in research has consistently been associated with under-reporting.

The motivation for the under-reporting is not entirely understood. Moreover, the differential effect of this under-reporting on specific food components is not clear. Studies have shown that adult women are more likely to under-report dietary intakes than adult men. In America, non-Caucasian women are more likely to under-report dietary intakes than Caucasian women. Physical characteristics that have been associated with this under-reporting are the degree of overweight and % lean body mass. Non-physiological characteristics such as level of education and socio-economic status have also been shown to influence reporting error. Certainly in situations where there is heightened "social desirability", reporting error is greater.

Memory and portion size assessment are cognitive tasks that have been shown to affect reporting error. Estimations of portion size errors are not uniform from food to food. The training of subjects and the use of tools to determine portion size may influence subjects' responses. In tests where subjects have not actually eaten the food, they seem to be equally accurate in estimating portion sizes.

Further considerations regarding error in dietary assessment involve observer error and instrument error. The variation amongst measurers of diet can introduce observer error. This error can arise from recording and transcription errors and errors in analysis. Instrument error can arise unless tools (i.e., scales) used in studies are calibrated. Computer data packages used in dietary studies need to be standardized.

Finally, one cannot assume that instruments designed to measure dietary intakes are valid simply because they give reproducible data when measures are repeated under similar conditions. Tests of validity must include a measure of accuracy (Schoeller, 1990).

2.6 AREAS FOR FURTHER STUDY

This literature review has shown that the use of the 24-hour dietary recall method as a dietary assessment tool may result in error in the assessment. The nature and magnitude of this error depends on both the dietary collection methodology and the subjects studied. The impact of this error depends on the research questions being asked. If there is systematic bias in a study on the relationship between diet and disease, the bias will lead to an erroneous description of the diet-disease relationship (Beaton, 1994). This has implications in understanding the absence or presence of a relationship of diet and disease, especially where the disease may be related to certain nutrients (e.g., heart disease and saturated fatty acids).

In addition, if subject characteristics are related to reporting error, this too may impact on the diet-disease relationship. For example, if the gap between expected energy intake and reported energy intake is in fact due to error in the assessment of dietary intakes of Black South African women, the anomaly of obesity in the presence of apparently low energy intakes will be explained. This will of course have implications for other population groups for whom a similar anomaly has been described.

Therefore, the extent to which individual subject characteristics, both physiological and non-physiological, and their impact on error need to be rationalized. The causes of the large gender differences in reporting error need to be understood. If the cause is attributable to the effects of dieting, this needs to be realized. If in fact there are patterns in reporting error whereby certain individuals leave out or add in specific nutrients, these need to be identified at the same time grasping the motivation for the under- or over-reporting.

It is possible to determine nutrient specific reporting error in an observation study to validate reported/recalled dietary intake. However, it is evident that observation studies to validate dietary intakes are lacking. Accordingly, the first study in this thesis was designed to validate the 24-hour recall method of dietary assessment, using observed intakes as the "gold standard." The study was designed to identify possible sources of error and bias in a cross-cultural sample of South African women. In addition, a second study was designed to assess the variability associated with the interpreting and analyzing of reported food intake by different researchers.

CHAPTER 3: TRIAL 1: SOURCES OF ERROR AND BIAS IN THE ASSESSMENT OF DIETARY INTAKE USING 24-HOUR RECALLS

3.1 INTRODUCTION

This study was designed to validate the 24-hour recall method of dietary assessment and to identify possible sources of error and bias. Specifically, the relationship of reporting error to ethnicity, body weight, body fatness, age, and education, was examined. A test meal eaten by the subjects was used as the "gold standard" against which a 24-hour dietary recall was performed for reproducibility. This meal was weighed covertly before it was eaten.

3.2 METHODS

Study design

To draw comparisons with other dietary studies on South African population groups, viz. the CORIS (Rossouw et al., 1983), the CRISIC (Langenhoven et al., 1988) and the BRISK (Bourne et al., 1993) studies, this study required a representative sample of women from different ethnic and socio-economic groups in South Africa. The study population comprised of a total of 131 subjects opportunistically selected from Groote

Schuur Hospital staff and including 25 unemployed subjects who were recruited from the Department of Manpower.

Subjects were recruited through advertisements placed in the internal hospital newsletter and posters placed in the wards and cafeterias. Due to the nature of the trial it was advertised as a study to "understand differences in food choices and physical activity for persons with different lifestyles" (Appendix A).

The experimental protocol was approved by the Ethics and Research Committee of the Faculty of Medicine of the University of Cape Town. Permission to recruit staff from Groote Schuur Hospital as subjects was obtained from the Hospital Medical Superintendent. The Department of Manpower approved the recruitment of unemployed subjects at their premises. The Department of Medicine authorized the use of the kitchen and dining room area for the plating and recall trials.

Subject Selection

Inclusion Criteria

The following inclusion criteria were applied:

a) Subjects included healthy women between the ages of 25 and 55 years.

b) All subjects had to be reportedly weight-stable for a minimum of 3 months prior to entry into the trial. This meant that their weight change in this time had to be less than 5% of total body weight.

c) All subjects had to have been living in Cape Town for at least 1 month.

Exclusion Criteria

The following exclusion criteria were applied:

a) Persons who were pregnant were excluded.

b) Persons were excluded if they were on special diets (e.g., halaal or kosher).

c) Persons were excluded if they had previously participated in any formal group, or individual dietary program or if they had participated in a research project that included a dietary component.

d) Persons were excluded if they knew details of the study from other subjects who had participated in the trial.

One hundred and eighteen subjects successfully completed the trial. Fifty-three were Black Africans, 33 were from Mixed Ancestry and 32 were Caucasian. The employed subjects represented a range of job types: 25 were employed as general assistants, linenor house-keepers or supervisors; 16 were employed in administrative portfolios ranging from clerical to human resources and training; and 52 were working in the medical or paramedical field. A total of thirteen subjects dropped out of the study (ten subjects dropped out before having eaten the test meal and three subjects dropped out after having eaten the test meal).

All subjects gave written informed consent to participate in the study after the procedures were explained to them. In addition to transportation expenses, each subject received a small honorarium for completing the trial.

The questionnaires used in the study were translated into Xhosa and Afrikaans. However, since all subjects (with the exception of three Xhosa-speaking unemployed subjects) were comfortable with English, only the English version was used. A subject who was conversant in Xhosa and in English who had completed the trial assisted with translation and the responses of these three subjects. Their responses were back-translated and checked.

Two qualified dietitians assisted with the study. They were trained and standardized on their interviewing techniques, anthropometric procedures, food weighing and 24- hour dietary recall methods (APPENDIX B).

Visit Schedules

Subjects were required to attend 3 visits over the trial period. To keep disruption of the work day (particularly for the employed subjects) to a minimum, appointments were set up in advance and small numbers of subjects were interviewed and recruited at a time. These subjects were then divided into smaller groups for the 2nd and 3rd visit making the workload for the dietitians manageable and limiting the time between visits. This also minimized subject drop-out. The time gap between the 2nd and 3rd visit was 7-10 days. This process of recruitment and intervention was then repeated until the desired number of subjects was achieved. The sample size was statistically determined for 80% power and an alpha level for Type I error of 5%. The study took 6 months to complete.

FLOWCHART OF VISITS

recruitment

⇓

1st VISIT

anthropometry

dietary history

socio-demographic and urbanization information

⇓

2nd VISIT

test meal

⇓

3rd VISIT

24-hour recall

attitudes/knowledge test

weight, perception of weight and dieting history

alcohol/smoking/contraception practices

SOCIO-DEMOGRAPHIC AND URBANISATION INFORMATION

The urbanization profile included questions used in the BRISK study (Bourne et al., 1993) for information on age (taken to time of study), gender, socio-economic status and living environment. Urban exposure and some migratory data were provided by questions on place of birth, age of arrival in the city and proportion of life spent in the city. Participants were categorized into 4 levels of education. These levels were; Primary School (6-7 years formal schooling), 1st half High School (8-10 years of formal schooling), 2nd half High School (11-12 years formal schooling) and Post High School (tertiary training, diploma or degree or post graduate diploma or degree). Job classification was determined after asking open-ended questions regarding occupation. Four job categories were used; unemployed, general assistants, paramedical or medical, and administrative. Housing density was also recorded.

THE MEASUREMENT OF KNOWLEDGE, ATTITUDES AND BELIEFS

Questions adapted from the Diet and Health Knowledge Survey 1994-1996 USDA (DHKS) on self-perceptions of relative nutrient intake, perceived importance of following the dietary guidelines, awareness of diet-health relationships and food sources of nutrients were customized for this study population and tested for clarity in the pilot study before being included in the final interview. Eight questions to test knowledge were used and a score was assigned for each correctly answered question. Seven questions focused on subjects' self-perceptions of relative nutrient intake. In addition, categorical questions were included on subjects' desire to lose weight, their own opinion on their weight, and their partner's opinion on their body shape. Their personal ideal weight was recorded. Subjects were also questioned on their method of contraception, their smoking habits and alcohol use.

ANTHROPOMETRY/BODY COMPOSITION ANALYSIS

Each subject's body mass was measured on a Seca beam balance to the nearest 0.1 kg. Subjects were weighed without shoes and wearing as little clothing as possible. Stature was measured to the nearest 0.1 cm by using a stadiometer. For subjects interviewed and assessed at the Department of Manpower a stationary inflexible measuring tape and flat headboard at right angles to the wall was used to measure stature. Body mass was measured to the nearest 0.1 kg using a calibrated portable Phillips digital scale. Body mass index (BMI) was calculated as mass (in kg) divided by stature^2 (in m).

Subjects' waist-to-hip circumference ratio was determined to estimate upper and lower body fat distribution. Waist measurements were recorded at the minimal circumference of the abdomen, and the hip circumference was measured at the maximal gluteal protuberance of the buttocks. Subjects stood upright and relaxed with their mass distributed evenly on both legs.

Body composition was measured using bioelectrical impedance (Lipocare hand-held monitor). This process measures the overall resistivity of a body from which fat and lean body mass can be calculated. The method is based upon the principle that when a constant, low-level alternating current is applied to a biological structure, the structure produces an impedance to the spread of the current that is dependent on the frequency of the signal and the water and electrolyte distribution in the biological conductor. Because water and conducting electrolytes are found only in fat free mass, conductivity of this mass is greater than fat mass. The low frequency current associated with bioelectrical impedance correlates highly with total body water measures.

Body composition was measured in the post-absorptive state with the subject lying in a supine position with legs and arms slightly abducted. Subjects' jewelry was removed. Electrodes were positioned on the right side of the body at the following sites: the distal portion of the second metacarpal, between the distal portions of the ulna and radius, distal portion of the second metatarsal and between the two malleoli. Subject's stature, body mass and age were then entered into the manufacturer-generated equations for body composition.

Dietary Assessment Instruments

1. Dietary History - qualitative information

The dietary history was structured to:

1) obtain information on each subject's usual diet, and

2) to understand what constituted a typical meal so that this could then be reproduced for the test meal.

The following was included in the dietary history:

1) a food frequency with a time reference of one month. The food frequency list was based on foods commonly eaten in South Africa (Bourne et al., 1994; Langenhoven et al., 1988; Rossouw et al., 1983).

Only 26% of the subjects completed the food frequency section at home. Forms were generally poorly completed and/or forgotten at home. It was therefore decided that the food frequency questionnaire would be administered by the dietitian and completed together with the subject during the 1st visit.

2) open-ended questions to determine characteristics of foods eaten as well as foods not captured on the food frequency list. Questions with information on meal and snack patterns were asked.

Subjects were asked to describe their typical main meals and were questioned on methods of food preparation, added fats and sugars and combinations or mixtures of foods at meals. This was for the purpose of creating the test meal with similar nutrient composition and taste to the subject's actual intakes. Standard interviewing probes were used during the session. Questions on constituents and combinations of foods at main meals were also asked. For example, subjects were questioned on the number and type of salads, vegetables and desserts they ate. The proportion of carbohydrate- and protein-rich foods and vegetables contributing to the habitual diet was determined by a forced response question. Added fat (APPENDIX E, Questionnaire 2, no 2 and

Questionnaire 3, no 2) and hidden fat (APPENDIX E, Questionnaire 2 (food frequency choices), Questionnaire 3, no 2 and no 5) was 'qualitatively' assessed.

'Seasonality' (changes of diet over a month or during a year due to fluctuations in income or food availability) was assessed by a question on dietary changes in a month or in a year (APPENDIX E, questionnaire 3, no 4) and further probing on reasons for dietary fluctuations. If subjects indicated that their diet fluctuated, and if they ascribed this fluctuation in intake to income, this was regarded as 'seasonality' in intake.

3) cross-checks to detect inconsistencies in subject's reported intakes. The frequency of fruit intake was questioned in the food frequency and again when asking the subjects to describe a typical meal. Fat added to vegetables was probed for in the food frequency and again when asking about food preparation methods. A separate question on the types of fat and the use of fat was included.

2. The Test Meal - quantitative information and use as the "gold standard"

Information from the food frequency questionnaire was summarized on to spreadsheets. Subjects who ate similar types and combinations of foods were placed into groups for the test meal/plating exercise. Meals were planned according to the subject's responses and attempts to approximate recipes were made. Recipes were researched for authenticity, standardized (e.g., the samp and beans recipe that had been researched and standardized by the University of the Western Cape, was used) and analyzed using a computer program based on the Medical Research Council's Food Composition Tables (Langenhoven et al., 1991).

Calculating standardized portions

At each test meal a variety of foods and beverages matching the descriptions from the subject's dietary history, were presented. For every group of subjects, between 19 and 21 food and beverage items were displayed. For every food and beverage item a standardized portion weight was determined. Calibrated measuring utensils and a Sartorius GMBH laboratory scale, accurate to 0.1g, were used to weigh the food and beverages. The dietitians weighed the individual and reconstituted foods (e.g., lasagna) and the mean of at least 3 weighings per measure of food item was recorded. Thus weights for "typical" portions, i.e. "small", "medium", "large", and "thinly", "medium" and "thickly" spread were determined. These weights and descriptions of portion sizes were recorded and used to develop the protocol (APPENDIX C).

Measurement of food eaten

Individuals in a group were given appointments (times staggered with 5 minute intervals) to come for the test meal. Crockery and trays were labeled and coded for each subject. Subjects were instructed individually to select and to serve themselves a meal. They were requested to plate quantities that they would consider as satisfying and adequate for themselves as a main meal. To ensure the food eaten was typical and unmodified, subjects were instructed to choose foods that they would normally include at least twice a week in their diet. To control for subjects eating more or less than usual and to avoid being tempted by other options available, subjects were told that what they ate would be checked against their dietary histories from the 1st visit and that should they desire anything else at the end of the session they would be offered "left-overs" on the following day.

Every subject was instructed to dish-up one food and beverage item at a time. This gave the dietitian the opportunity to weigh and record every item on the plate. The weighing was done covertly using the Sartorius GMBH laboratory scale that was concealed. Each item was weighed to the nearest 0.1g. The scale had a total capacity of 1620 g and had the added advantage of being able to "zero/ tare" between additions of food.

Subjects that questioned the dishing-up procedure were told that as part of the study the food plated was being analyzed for nutrient composition i.e. a macro- and micro-nutrient analysis was being performed.

The subjects then warmed the food in a microwave and ate in an adjoining room. The dietitian checked to see that no food was being shared or exchanged between subjects.

The same procedure was followed for second servings. After the meal subjects were asked if they ate more, less or the same as usual. Plate waste was weighed and recorded. Appointments were made for each subject for the following day (ensuring a 24 hour gap) and each subject was told that a few final questions would be asked after which they would receive their payment.

The original design of the study was to serve subjects the test meal at a time that matched their usual main meal. In many cases this would have been in the evening. This was impractical in terms of transport costs and respondent burden and from the pilot study it was evident that subjects were not prepared to travel at night. It was therefore decided to serve the test meal at lunch time.

3. The 24-hour recall

The protocol and kit developed for the 24-hour recall was based on that used in the BRISK study (Appendix B). Respondents were asked to report all food and beverages consumed in the preceding day. First they were asked to recall all food items in an uninterrupted manner (i.e., the "quick list"). Then for each item mentioned on the "quick list" specific detail on the types of foods, preparation, ingredients and quantities were questioned. After all foods and beverages were specified, the interviewer reviewed the entire recall with the respondent for completeness and accuracy. With the help of another trained dietitian, two subjects were interviewed at a time with the recall taking on average, 20 minutes to complete. A kit was developed for each interviewer and subjects were instructed on portion sizes using standardized household measures and common utensils as well as food models.

CALCULATIONS OF THE ERROR AND BIAS IN THE RECALL

The 24-hour recalls were checked and transcribed by one dietitian using the protocol described in detail in Appendix C. Only the meal (food and beverages) described in the 24-hour recall that coincided with the time that the test meal was eaten, was compared to the test meal. Data were entered into the computer by the main investigator thus eliminating inter-dietitian bias and effects. The computer program FoodFundi Dietary Analysis Software designed by the South African Medical Research Council's National Research Program for Nutritional Intervention (1992) was used to analyze macro-nutrients (absolute grams and percentages) and energy of each subject's test meal and their 24-hour recalled meal to determine validity and reliability.

To determine foods or beverages omitted or added in the 24-hour recall the number of choices/items eaten in the test meal was compared to those recalled.

3.3 STATISTICAL ANALYSIS

The data were expressed as mean ± the standard error of the mean (X ± SEM). The data were first analyzed to describe subject and group differences using a Kruskal-Wallis analysis of variance (ANOVA) test. When F-ratios were significant ($P < 0.05$), a multiple range test (LSD) was performed. The Chi-squared test was used to determine differences in frequencies of subjects in specific sub-groups (education, job and language). Bivariate correlations were determined for physical characteristics (e.g., height, body mass index, weight) and recall error and bias. To determine the relationship between non-physical characteristics (e.g., food purchasing, education and language) and reporting error and bias a Kruskal-Wallis ANOVA test (plus *post-hoc* multiple LSD range test) was performed. Spearman's rank order correlation was used to determine the relationship between knowledge and reporting error and bias and between the number of items served and reporting error and bias.

3.4 RESULTS

3.4.1. SUBJECT CHARACTERISTICS

Subject characteristics for the entire group, and by language, educational experience and job classification, are presented in Tables 3.1- 3.4. Age and anthropometric variables for the entire group are given in Table 3.1.

TABLE 3.1. Characteristics of the 118 subjects who completed the study (mean ± SEM)

n = 118	Mean	SEM
AGE (years)	36.3	0.8
STATURE (meters)	1.61	0.01
BODY MASS (kg)	70.0	1.5
BMI (kg/m^2)	26.9	0.6
% BODY FAT	36.0	0.8
WAIST/HIP RATIO	0.80	0.01

BMI: body mass index

In Table 3.2, anthropometric variables and level of acculturation, represented by % of life spent in the city, are presented by language group. The English first-language speakers were significantly taller ($P < 0.01$) than either the Afrikaans-speaking or Xhosa-speaking women. Xhosa-speaking women were also significantly heavier than the English speaking women ($P < 0.05$) and had a higher percentage body fat ($P < 0.0001$) and higher body mass index ($P < 0.001$) than both the Afrikaans and English speaking women.

The Xhosa-speaking group had spent significantly fewer years residing in the city than either the English or Afrikaans first-language speakers ($P < 0.0001$). Thus, in women for whom Xhosa was a first language, percentage body fat was significantly higher, weight and body mass index were significantly higher. Furthermore these women had spent significantly less of their lifetime living in the city.

TABLE 3.2. Characteristics of the subjects according to language (mean ± SEM)

Group	AGE (years)	STATURE (m)	B.MASS (kg)	BMI (kg/m^2)	%B.FAT	WAIST/HIP	%TIME IN CITY
XHOSA (n=51)	36.5 ± 1.24	1.60^a ± 0.01	74.1^a ± 2.2	29.1^a ± 0.8	39.6^a ± 1.1	0.80 ± 0.01	64.3^a ± 5.3
AFRIK (n=31)	35.1 ± 1.5	1.61^a ± 0.01	67.5 ± 3.0	26.1^c ± 1.1	34.3^d ± 1.5	0.77 ± 0.01	86.9^d ± 4.3
ENG (n=36)	36.9 ± 1.5	1.65^c ± 0.01	66.1^b ± 2.2	24.3^c ± 0.8	32.4^d ± 1.2	0.83 ± 0.04	95.6^d ± 2.2

BMI: body mass index; B.MASS: body mass; %B.FAT: % body fat; WAIST/HIP: waist to hip ratio; Afrik: Afrikaans; Eng: English

(a vs b $P< 0.05$; a vs c $P < 0.001$; a vs d $P < 0.0001$)

In Table 3.3, anthropometric variables and level of acculturation, are presented by educational experience. Early school leavers tended to be older ($P < 0.05$). Individuals who were more highly educated had significantly lower body weight ($P < 0.05$), body mass index ($P < 0.001$) and percent fat mass ($P < 0.001$). Persons with post-school education experience were also significantly taller ($P < 0.05$). Lower segment fat distribution measured by waist-hip ratio was lowest in women who had completed at least 11-12 years of school. This difference was only significant compared to those with tertiary training ($P < 0.05$).

The proportion of life spent residing in the city was not significantly different between groups on the basis of educational experience.

There were differences in the relationship between language and education in the Xhosa- and English-speaking women (Chi-squared analyses; $p < 0.0001$). Whereas 69% of the English-speaking women had a tertiary level education and 14% had completed 8-10 years of formal school, only 14% of the Xhosa-speaking women had a tertiary level education with 50% having completed 8-10 years of formal schooling. Of the Afrikaans-speaking group, 64% had completed 10-12 years of school and 10% had a tertiary level education.

TABLE 3.3 Characteristics of the subjects according to education (mean ± SEM)

Group	AGE (years)	STATURE (m)	B.MASS (kg)	BMI (kg/m^2)	%B.FAT	WAIST/HIP	%TIME IN CITY
PRIMARY SCHOOL (n=5)	40.1 ± 5.0	1.58^a ± 0.03	91.1^a ± 12.7	36.0^a ± 4.2	47.5^a ± 4.8	0.86 ± 0.02	63.7 ± 10.1
1st HALF HIGH SCHOOL (n=35)	39.8^a ± 1.5	1.59^a ± 0.01	74.2^b ± 2.8	29.2^d ± 1.1	40.0^d ± 1.4	0.80 ± 0.01	81.1 ± 5.7
2nd HALF HIGH SCHOOL (n=43)	34.0^b ± 1.3	1.61^a ± 0.01	67.7^{bc} ± 2.1	26.1^e ± 0.8	35.6^e ± 1.0	0.77^a ± 0.01	75.5 ± 5.3
POST HIGH SCHOOL (n=35)	35.0^b ± 1.4	1.65^c ± 0.01	65.4^c ± 1.9	24.1^e ± 0.7	30.9^f ± 1.0	0.83^b ± 0.04	86.0 ± 4.5

B.MASS: body mass; %B.FAT: % body fat; BMI : body mass index; WAIST/HIP: waist to hip ratio; Primary school : 6-7 years formal schooling; 1st Half High School: 8 -10 years formal schooling;
2nd Half High School: 11-12 years formal schooling; Post High School: tertiary training, diploma or degree or post graduate degree or diploma (a vs b, a vs c $P< 0.05$; a vs d, a vs e, d vs e, e vs f $P< 0.001$)

In Table 3.4, anthropometric variables and level of acculturation, are presented by job type. The unemployed group were significantly younger (when compared to the employed persons)($P < 0.001$). There was also a significant difference in age between the general assistants (mean age of 41.4 ± 1.5 years) and the paramedics and medical group (mean age of 36.0 ± 1.2 years).

There were significant differences ($P < 0.001$) in body mass, body mass index and percentage body fat between all job groups. General assistants had the highest body mass, body mass index and percentage body fat, followed by unemployed women, then the paramedics and medics and women in administrative jobs.

General assistants had the highest waist/hip ratios (0.85 ± 0.01) and this was significantly different from the unemployed group (0.76 ± 0.01) and women in administrative work (0.76 ± 0.01) ($P < 0.001$).

In both the English- and Afrikaans-speaking groups, over 60% of the women were working in the paramedical/medical or nursing field. Proportionately more English-speaking women worked in administrative jobs than either Afrikaans- or Xhosa-speaking women ($P < 0.0001$). Proportionately more Xhosa-speaking women worked as general assistants. Forty-seven % of the Xhosa-speaking group were unemployed.

TABLE 3.4. Characteristics of the subjects according to job (mean ± SEM)

Group	AGE (years)	STATURE (m)	B.MASS (kg)	BMI (kg/m^2)	%B.FAT	WAIST/HIP	%TIME IN CITY
UNEMP (n=25)	31.5[a] ± 1.5	1.60 ± 0.01	69.5[a] ± 2.7	27.1[a] ± 1.0	37.3[a] ± 1.5	0.76[a] ± 0.01	49.9[a] ± 8.0
GEN ASS (n=25)	41.4[b] ± 1.5	1.60 ± 0.01	83.5[b] ± 3.5	32.8[b] ± 1.3	44.1[b] ± 1.5	0.85[b] ± 0.01	88.6[b] ± 4.4
PARA-MED/MED (n=52)	36.0[c] ± 1.2	1.63 ± 0.01	66.7[c] ± 1.7	25.2[ac] ± 0.6	32.9[c] ± 0.9	0.81 ± 0.03	86.4[b] ± 3.6
ADMIN (n=16)	36.9[bc] ± 2.2	1.60 ± 0.02	60.0[c] ± 3.2	22.6[c] ± 1.3	31.3[c] ± 1.6	0.76[a] ± 0.01	91.0[b] ± 5.0

B.MASS: body mass; BMI: body mass index; %B.FAT: % body fat; WAIST/HIP: waist to hip ratio; Unemp: unemployed; Gen Ass: general assistant; Para-med/med: paramedical and medical;
Admin: administrative
(a vs b, b vs c, a vs c P < 0.001)

3.4.2 RELATIONSHIP BETWEEN THE FOOD EATEN AT THE TEST MEAL AND LANGUAGE, JOB AND EDUCATION

Table 3.5 shows that subjects in the different language, job and education groups ate a similar amount of items at the test meal. However, there were significant differences in the total energy (kJs) and nutrients (fat in g and %, carbohydrate in %, protein in g and %) consumed in these groups.

TABLE 3.5 Number of food items eaten at the test meal according to language, job and education (mean ± SEM)

GROUP	ITEMS EATEN	ENERGY (kJ)	FAT (g)	FAT (%)	CHO (g)	CHO (%)	PRO (g)	PRO (%)
LANG;								
XHOSA	8.0	2648[a]	28.6[a]	39.9[a]	56.7	36.4[a]	39.5[a]	25.0
(n= 51)	± 0.2	± 86	± 1.6	± 1.4	± 2.8	± 1.6	± 1.5	± 0.6
AFRIK	7.8	2194[d]	20.6[d]	34.3[d]	56.3	43.9[d]	30.4[d]	23.1
(n = 31)	± 0.4	± 134	± 1.8	± 1.4	± 3.9	± 2.2	± 2.4	± 1.1
ENG	7.9	2054[d]	17.8[d]	31.8[d]	57.8	47.8[d]	27.8[d]	22.6
(n = 36)	± 0.4	± 140	± 1.6	± 1.5	± 4.6	± 2.8	± 2.1	± 1.2
JOB:								
UNEMP	7.8	2830[a]	34.3[a]	45.2[a]	55.4	33.2[a]	39.7[a]	23.5
(n = 25)	± 0.2	± 129	± 2.4	± 1.7	± 4.0	± 2.3	± 2.1	± 0.8
G. ASS	7.8	2255[c]	20.4[d]	32.9[d]	54.4	41.8[d]	35.0	25.6
(n = 25)	± 0.3	± 121	± 1.8	± 1.6	± 3.0	± 2.3	± 2.7	± 1.2
P/MED	8.0	2254[c]	20.1[d]	32.6[d]	61.8	47.1[ed]	30.7[b]	22.5
(n = 52)	± 0.3	± 114	± 1.4	± 1.2	± 3.5	± 2.1	± 1.9	± 0.9
ADMIN	7.8	2045[c]	20.2[d]	37.7[de]	47.5	38.1[a]	30.9[b]	25.4
(n = 16)	± 0.7	± 175	± 1.9	± 2.1	± 6.4	± 3.6	± 3.0	± 1.6
EDUC:								
PRIM	7.4	2197	19.2	30.5[a]	55.4	43.7	33.3	25.9
(n=5)	± 0.9	± 436	± 6.0	± 3.7	± 10.9	± 5.7	± 8.5	± 4.0
1[st] H. Sc	8.2	2459	25.2[a]	38.0[a]	55.4	38.2[a]	36.9	25.0
(n= 43)	± 0.3	± 110	± 1.6	± 1.5	± 3.4	± 1.9	± 1.9	± 0.8
2[nd] H.Sc	7.9	2397	26.3[a]	40.0[d]	51.7	38.2[a]	34.7	23.9
(n=32)	± 0.3	± 122	± 2.0	± 1.5	± 2.9	± 2.1	± 2.1	± 0.9
POST	7.8	2197	18.0[c]	30.4[e]	65.0	49.7[d]	28.8	22.1
(n=35)	± 0.4	± 137	± 1.5	± 1.5	± 4.7	± 2.6	± 2.1	± 1.1

CHO: carbohydrate; PRO: protein; AFRIK: Afrikaans; ENG: English; UNEMP: unemployed; G.ASS: general assistant; P/MED: paramedical and medical; ADMIN: administrative; PRIM: 6-7 years formal schooling; 1[st] H.Sc: 8-10 years formal schooling; 2[nd] H.Sc,:11-12 years formal schooling; POST: tertiary training degree or diploma
(a vs b $P < 0.05$; a vs c $P < 0.007$; a vs d, a vs e, e vs d $P < 0.0009$)

The Xhosa-speaking subjects ate a significantly higher fat (g and %) and protein (g) but lower carbohydrate (%) meal when compared to both the Afrikaans- and English-speaking subjects ($P < 0.0009$).

The unemployed subjects ate the highest fat (g and %) meal when compared to the other occupational groups ($P < 0.0009$). Furthermore, the unemployed subjects ate significantly less carbohydrate (%) compared to the general assistants and paramedical staff ($P < 0.0009$). Protein intake (g) of the unemployed group was significantly higher than that of the paramedical and administrative group ($P < 0.05$).

The fat content (g) of the meal eaten was significantly higher in the two groups that had achieved some level of high school education (8-10 years and 11-12 years) when compared to the group that had tertiary training ($P < 0.007$). In addition, these subjects ate significantly less carbohydrate (%) then the subjects with tertiary level training ($P < 0.0009$). There was no relationship between protein eaten (g and %) and level of education.

3.4.3. PHYSIOLOGICAL CHARACTERISTICS AND RECALL BIAS AND ERROR

In Tables 3.6 to 3.9, subjects' physiological characteristics (age, stature, body mass, percentage body fat) were correlated to reporting error in energy and nutrient intake. There was a positive correlation between the subjects' stature and differences in reported versus actual total energy (in kJ) and carbohydrate (in grams), and a negative correlation between subjects' stature and the differences in reported versus actual protein (%) ($P < 0.05$) (Table 3.7).

There were no systematic correlations between the degree and direction of reporting error in energy or nutrient intake and age, body fatness or waist/hip ratio. There was, however, a significant negative correlation between the difference in the number of items recalled compared to actual items consumed. Individuals with a higher % body fat (and body mass index) tended to be more likely to omit items in the recall ($r = -0.2$, $P < 0.05$).

TABLE 3.6 Correlations (r) , standard error of estimates (SEE), and significance (P) for regression of error vs age (n=118)

DIETARY COMPONENT	r	SEE	P
Delta Energy (kJ)	- 0.01	2444.1	0.88
Delta CHO (g)	- 0.02	14.9	0.87
Delta CHO (% of energy)	0.02	8.14	0.84
Delta PRO (g)	- 0.05	9.65	0.57
Delta PRO (% of energy)	- 0.03	4.44	0.71
Delta Fat (g)	0.06	8.40	0.52
Delta Fat (% of energy)	-0.01	6.06	0.99
Delta Items	-0.16	1.18	0.09

Delta values = reported - actual intakes; CHO = carbohydrate; PRO = Protein
Items = no of foods and beverages

TABLE 3.7 Correlations (r) , standard error of estimate (SEE), and significance (P) for regression of error vs stature (n=118)

DIETARY COMPONENT	r	SEE	P
Delta Energy (kJ)	0.19	2400.5	0.04 *
Delta CHO (g)	0.21	14.66	0.02*
Delta CHO (% of energy)	0.03	8.14	0.75
Delta PRO (g)	0.03	9.66	0.72
Delta PRO (% of energy)	-0.19	4.37	0.04*
Delta Fat (g)	0.17	8.33	0.06
Delta Fat (% of energy)	0.10	6.03	0.26
Delta Items	0.16	1.19	0.09

Delta values = reported - actual intakes; CHO = carbohydrate; PRO = Protein ;
Items = no of foods and beverages

TABLE 3.8 Correlations (r) , standard error of estimate (SEE), and significance (P) for regression of error vs weight (n=118)

DIETARY COMPONENT	r	SEE	P
Delta Energy (kJ)	- 0.04	2441.7	0.64
Delta CHO (g)	- 0.05	15.0	0.59
Delta CHO (% of energy)	- 0.10	8.10	0.29
Delta PRO (g)	- 0.08	9.64	0.38
Delta PRO (% of energy)	0.03	4.45	0.71
Delta Fat (g)	0.01	8.45	0.92
Delta Fat (% of energy)	0.10	6.04	0.28
Delta Items	- 0.15	1.18	0.11

Delta values = reported - actual intakes ; CHO = carbohydrate PRO = Protein
Items = no of foods and beverages

TABLE 3.9 Correlations (r) , standard error of estimate (SEE), and significance (P) for regression of error vs percentage body fat (%FM) (n=118)

DIETARY COMPONENT	r	SEE	P
Delta Energy (kJ)	- 0.09	2432.8	0.34
Delta CHO (g)	- 0.13	14.8	0.15
Delta CHO (% of energy)	- 0.10	8.09	0.27
Delta PRO (g)	- 0.03	9.66	0.76
Delta PRO (% of energy)	0.15	4.39	0.09
Delta Fat (g)	- 0.05	8.44	0.62
Delta Fat (% of energy)	0.01	6.06	0.87
Delta Items	- 0.20	8.01	0.02*

Delta values = reported - actual intakes ; CHO = carbohydrate PRO = Protein
Items = no of foods and beverages

3.4.4 EDUCATION AND RECALL BIAS AND ERROR

There were significant differences in the accuracy of recall for persons of different educational experiences ((P < 0.02) (Figure 3.1) as determined by Kruskal-Wallis analysis of variance. Omissions were significantly greater in the group with 8-10 years of formal schooling (mean difference between food items reported and items consumed = -1.37 ± 0.28) when compared to both the group with 11-12 years of formal schooling (mean delta items = -0.65 ± 0.12), and the group with tertiary level education (mean delta items = -0.46 ± 0.15). The mean difference between reported food items and actual food items eaten was lowest for women with the lowest level of education (delta items = -0.4 ± 0.24).

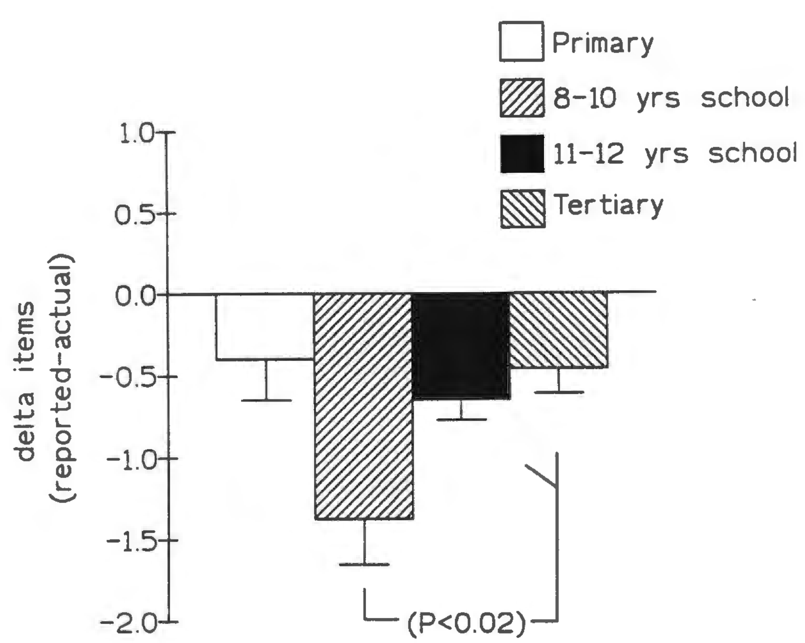


Figure 3.1. Difference between items reported and items eaten (Delta Items) between educational groups. Women with 8-10 yrs schooling significantly under-reported items compared to those with higher levels of eduation (P < 0.02)

There were no significant differences in recall error for total energy content, absolute and relative protein (g or %), fat (g or %) and carbohydrate (g or %) according to level of education.

However, there were significant differences in absolute carbohydrate (g) and relative fat (%) recall error between persons who completed 10 years of formal schooling versus those who had matriculated or left school just prior to matriculation (11-12 years formal schooling) (Figure 3.2 and 3.3). The group with a lower level of education tended to under-report total carbohydrate (g) intake ($P < 0.03$). Conversely, fat (%) was under-estimated more in the group with the higher level of education (11-12 years formal schooling). The group with 11-12 years of school education under-estimated fat % by nearly 4%. This group also tended to under-estimate fat % more ($P < 0.06$) than the group with tertiary level education.

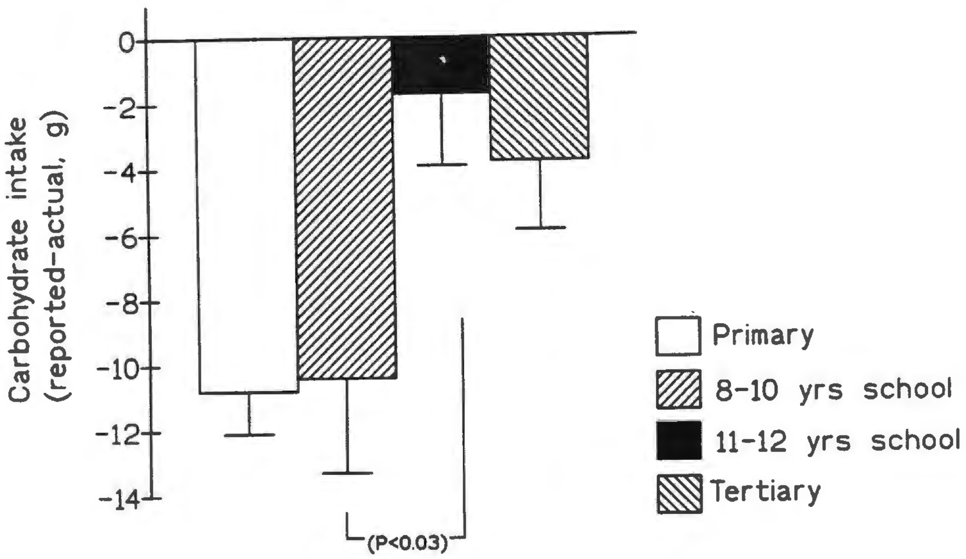


Figure 3.2. Differences in reported vs actual carbohydrate intake (g) in women with lower levels of education. Those with 8-10 yrs schooling significantly under-reported compared to women with 11-12 yrs schooling (P < 0.03).

3.4.5 OCCUPATION AND URBANIZATION AND RECALL BIAS AND ERROR

There were no significant differences in energy or nutrient recall between the various occupation levels. Furthermore, there were no differences between groups in the number of food items omitted or added. There were also no significant relationships between the extent and direction of recall error and the degree of urbanization as measured by % time spent in the city.

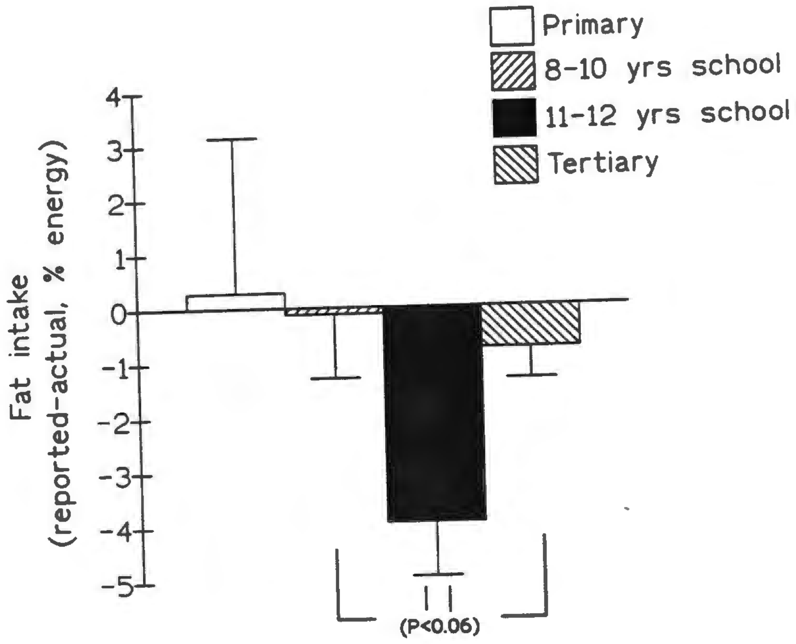


***Figure 3.3.** Women with 11-12 yrs formal schooling under-reported fat intake (% by energy) when compared to those women with both tertiary education and those with 8-10 yrs formal schooling (P < 0.06).*

3.4.6 LANGUAGE GROUP AND RECALL BIAS AND ERROR

There were no systematic differences in recall of nutrients or energy, however, there was a significant difference ($P < 0.02$) between the number of items actually eaten and items reported in the English-speaking group (mean delta items = -0.47 ± 0.15) when compared to the Xhosa-speaking group (mean delta items = -1.12 ± 0.21) (Figure 3.4).

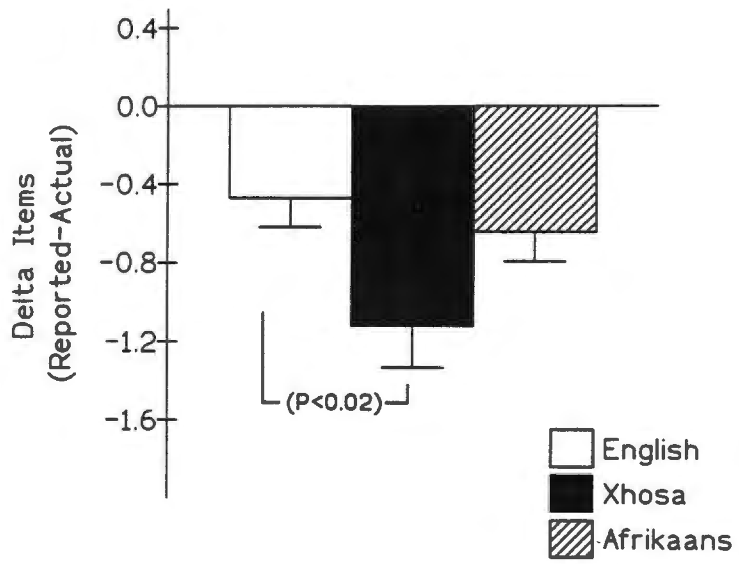


Figure 3.4. Xhosa-speaking women significantly under-reported the number of items eaten compared to both the English and Afrikaans first-language speakers (P < 0.02).

3.4.7 FOOD PURCHASING AND PREPARATION PRACTISES AND FAMILIARITY WITH THE TIME OF EATING THE TEST MEAL, AND RECALL BIAS AND ERROR

The relationships between subject's involvement with food purchasing, preparation and serving of food, usual time of eating the main meal and recall error and bias are represented in Tables 3.10 -3.13.

The only factors which were significantly associated with under-reporting of absolute carbohydrate (g), were shopping and food preparation. Persons who did not prepare their own food, compared to persons who did prepare their own food under-estimated their absolute carbohydrate (g) intake (- 12.56 ± 3.15 g versus - 4.33 g ± 1.48 g ; $p < 0.05$) (Table 3.10). Persons who did not purchase their own food, compared to persons who did purchase their own food also under-estimated their carbohydrate (g) intake ($- 12.27 \pm 2.92$ g versus $- 4.05 \pm 1.50$ g ; $p < 0.05$) (Table 3.12). However, persons who served themselves food were more likely to under-report total energy intake ($- 853.1 \pm 237.4$ kJ versus $- 606.1 \pm 626.1$ kJ ;$P < 0.05$) (Table 3.11). 'Seasonality' in food intake due to fluctuations in income was significantly associated with under-reporting of fat intake (in g). Specifically, persons whose food purchases were influenced by changes in monthly income, compared to persons whose food purchases were not influenced by changes in monthly income under-estimated their fat (g) intake ($- 7.05 \pm 2.63$ g versus $- 2.24 \pm 0.80$ g; $p < 0.05$).

There was a significant difference in reporting error of total energy ($P < 0.05$), grams of carbohydrate ($P < 0.01$) and grams of protein ($P < 0.05$) between persons who ate their main meal in the evening, versus those who ate their main meal at midday (Table 3.13). The difference between reported intake and actual intake was greatest in persons who usually ate their main meal at midday when compared to those who usually ate their main meal in the evening.

TABLE 3.10 Food preparation and recall error (mean ± SEM)

Group	Delta Energy (kJ)	Delta CHO (g)	Delta.PRO (g)	Delta.FAT (g)	Delta CHO (%)	Delta PRO (%)	Delta FAT (%)
PREP1 (n=104)	-813.0 ± 244.1	-4.33[a] ± 1.48	-0.51 ± 0.97	-3.15 ± 0.83	-0.1 ± 0.8	1.9 ± 0.4	-1.9 ± 0.6
PREP2 (n=14)	-990.6 ± 540.1	-12.56[b] ± 3.15	1.46 ± 2.10	-1.94 ± 2.16	-3.4 ± 1.9	3.1 ± 1.0	-0.2 ± 1.9

PREP 1 = self preparation; PREP 2 = other prepare Delta values = reported - actual
(a vs b $P < 0.05$) (to convert kJ to kcal, 1 kcal = 4.18 kJ)

TABLE 3.11 Serving food and recall error (mean ± SEM)

Group	Delta Energy (kJ)	Delta CHO (g)	Delta PRO (g)	Delta FAT (g)	Delta CHO (%)	Delta PRO (%)	Delta FAT (%)
SERVE1 (n=109)	-853.1[a] ± 237.4	-4.93 ± 1.45	-0.38 ± 0.92	-3.24 ± 0.83	-0.2 ± 0.8	2.0 ± 0.4	- 2.0 ± 0.6
SERVE2 (n=9)	-606.1[b] ±626.2	-9.86 ± 4.09	0.96 ± 3.37	-0.19 ± 1.28	-4.1 ± 1.6	2.2 ± 1.2	1.5 ± 1.1

SERVE 1 = serves food for self ; SERVE 2 = others serve the food Delta values = reported - actual
(a vs b, $P < 0.05$) (to convert kJ to kcal, 1 kcal = 4.18 kJ)

TABLE 3.12 Shopping for food and recall error (mean ± SEM)

Group	Delta Energy (kJ)	Delta CHO (g)	Delta PRO (g)	Delta FAT (g)	Delta CHO (%)	Delta PRO (%)	Delta FAT (%)
SHOP1 (n=100)	-744.62 ± 247.83	-4.05[a] ± 1.50	-0.44 ± 0.99	-2.89 ± 0.85	-0.1 ± 0.8	1.8 ± 0.4	-1.9 ± 0.6
SHOP2 (n=18)	-1331.79 ± 509.67	-12.27[b] ± 2.92	0.61 ± 1.97	-3.68 ± 1.91	-3.2 ± 1.3	3.5 ± 0.8	-0.6 ± 1.4

SHOP 1 = shops self for food ; SHOP 2 = others shop for food Delta values = reported - actual
(a vs b $P < 0.05$) (to convert kJ to kcal, 1 kcal = 4.18 kJ)

TABLE 3.13 Main meal time and recall error (mean ±SEM)

Group	Delta Energy (kJ)	Delta CHO (g)	Delta PRO (g)	Delta FAT (g)	Delta CHO (%)	Delta PRO (%)	Delta FAT (%)
EVE (n=90)	-533.08[a] ± 249.25	-2.86[a] ± 1.48	0.98[a] ± 1.02	-2.69 ± 0.89	-0.1 ± 0.9	2.3 ± 0.5	-2.3 ± 0.7
MID (n=26)	-1794.01[b] ± 497.29	-12.88[c] ±3.11	-4.45[b] ±1.69	-4.04 ±1.69	-1.4 ±1.3	1.2 ±0.7	0.1 ±1.1
MORN (n=2)	-1906.08 ± 129.58	-16.75 ± 0.25	-2.50 ± 4.00	-3.80 ± 1.50	-3.8 ± 0.9	2.9 ± 2.0	0.7 ± 2.3

EVE=main meal in the evening; MID = main meal midday; MORN = main meal in the morning;
Delta values = reported - actual (a vs b $P < 0.05$; a vs c $P < 0.01$)
(to convert kJ to kcal, 1 kcal = 4.18 kJ)

3.4.8 KNOWLEDGE, ATTITUDES AND PERCEPTION OF SELF AND RECALL BIAS AND ERROR

There were no significant differences in reporting error between subjects who reportedly wanted to change their body mass (n = 74) when compared to those subjects who were satisfied with their body mass (n = 44).

Spearman ranked correlation coefficients were determined to assess the influence of knowledge on reporting error and bias (Table 3.14). There was a significant correlation (r = 0.2, P< 0.05) for both absolute and relative carbohydrate intake and broad nutrition knowledge and for relative protein (r = -0.3, P < 0.007) and knowledge indicating that as knowledge increased, carbohydrate was over-reported and protein was under-reported.

TABLE 3.14 Spearman ranked correlations (r) and significance (P) for regression of error vs knowledge (n=118)

DIETARY COMPONENT	r	P
Delta Energy	0.15	0.10
Delta CHO (g)	0.21	0.02*
Delta CHO (%)	0.28	0.03*
Delta PRO (g)	- 0.01	0.87
Delta PRO (%)	- 0.31	0.007**
Delta Fat (g)	- 0.13	0.15
Delta Fat (%)	- 0.04	0.68
Delta Items	- 0.09	0.35

Delta values = reported - actual intakes ; CHO = carbohydrate PRO = Protein

3.5 DISCUSSION

This validation study, the first of its kind in South Africa, was designed to characterize potential sources of error and bias in 24-hour dietary recall in sub-groups of South African women. By using a convenience sample incorporating a broad cross-section of socio-demographic, anthropomorphic, education/occupational and ethnic/language groups, it was possible to evaluate the sub-groups and identify possible causes of under- and over-reporting. It must, however, be noted that the recall error is quantified for a single-observed meal, and not an entire day's intake. Significant efforts were made to create a test meal environment that closely resembled subjects' habitual intake and main meal food choices.

The decision to focus solely on women was based on the findings of previous studies that have demonstrated that women are more likely to under-report dietary intakes than men (Black et al., 1991; Briefel et al., 1995; Johnson et al., 1984; Karvetti and Knuts, 1985; Klesges et al., 1995). In addition, there is concern world-wide on the increasing prevalence of obesity (and its related negative health consequences) particularly in women who are exposed to modern settings (Jeffrey 1991;McGarvey 1991). This is a major problem in South Africa as evidenced by results of the BRISK Study where it was shown that 44% of the women had a BMI > 30 (Bourne et al., 1993) .

Furthermore, a recent survey (Mazur and Qangule, 1997) has shown that women comprise 57 percent of the population that has migrated to the peri-urban and urban areas of Cape Town. Nearly 40 percent of urban households are headed by women without partners. This further demonstrates the importance of focusing dietary intervention programs on women.

The hypothesis that overweight women are more likely to under-report dietary intakes is based on validation studies that have been done overseas using methods that are either financially prohibitive for local use (e.g., the doubly labeled water technique) or impractical to use in South Africa (e.g., reliant on adequate postal and tele-communication infrastructures or subject literacy). Studies which measure or estimate total energy expenditure may provide insight into the magnitude of reporting error, but do not provide insight into nutrient-specific reporting error.

Observation studies can provide information on nutrient specific reporting error. The observation studies most similar to the present study are the studies of Myers et al. (1988) and Karvetti and Knuts (1985). Whereas Karvetti and Knuts (1985) observed dietary intake over a whole day (but ignored in-between meal snacks and drinks), both the present study and the study of Myers et al. (1988) based the observation on one meal. There were fewer women subjects in both the Karvetti and Knuts (1985) and Myers et al. (1988) studies (Karvetti and Knuts (1985) included men (84 males, 56 females) and Myers et al. (1988) included 40 female psychology students). Although Karvetti and Knuts (1985) did strive to include wide ranges of age and socio-economic status, it is unlikely that they had the same cultural and language diversity of the present study. Moreover, as they pointed out, all their subjects were accustomed to eating in a similar style and a typical "Finnish" diet . In their results they did not relate individual characteristics (other than sex and age) to reporting error. Application of the results of the study by Karvetti and Knuts may therefore be somewhat limited in the South African context. Likewise, the results of Myers et al. (1988) cannot be applied to a heterogeneous South African population.

3.5.1 INFLUENCES OF SUBJECT CHARACTERISTICS ON REPORTING ERROR AND BIAS

The first finding of this study was that percent fat mass and body mass index were associated with reporting error, and this error was in the "expected" direction as found in the studies by Bandini et al. (1990), Bingham (1995), Livingstone (1990), Prentice et al. (1986), Schoeller (1990). These findings are in line with those of the NHANES II (Klesges et al.,1995) and NHANES III Surveys (Briefel et al., 1995) where under-reporting in overweight adults was identified by comparing energy intake (as assessed by 24-hour dietary recalls) to estimated basal metabolic rate requirements. This may explain, in part, the large differences which have previously been found in reported dietary intake and expected energy requirements in urban South African Xhosa-speaking women. Bourne et al. (1993) found that 52% of females in this population group reported energy intakes of less than 67% of the expected energy intakes .

To understand reasons for the strong association between adiposity and reporting error found in the present study, results were further examined for collinear relationships and for other significant factors that could provide explanations for these findings. Three main issues were raised:

1) What was the influence of education on reporting error? 2) How did familiarity with certain food types influence reporting error? 3) How did knowledge of nutrition influence reporting error?

In considering each of these issues the potential influence of social desirability is discussed. In addition, possible confounding due to limitations of experimental design, is considered. The question on whether or not the food that the subjects chose to eat at the test meal was the same as their habitual diet, and how this may have impacted on the results, is also addressed. In addition, the relationship between nutrient-specific error and errors in the items recalled (items omitted, items added and items erroneously recalled) is discussed.

The influence of education on reporting bias

There was an association between education and items omitted and reporting error. Whereas subjects with a lower level of formal education were more likely to under-report absolute carbohydrate intake, the opposite was true for dietary fat. The greatest error in reporting relative (%) dietary fat was made by subjects with a higher level of formal education (11-12 years of school). In fact, it was at this stage (11-12 years formal schooling) of education that the least error in carbohydrate (g) reporting occurred. This relationship could possibly be attributed to a form of social desirability bias, which is supported by the significantly higher ($p < 0.007$) intake of fat (in g and % Energy) of these subjects compared to subjects from all other education groups at the test meal.

Thus this study provides additional insight to the findings of Klesges et al. (1995). Whereas they showed that subjects with less education were more at risk for under-reporting, the present study shows that this under-reporting is not systematic, but is nutrient specific. Moreover, the present study suggests that social bias, in response to education, influences nutrient-specific reporting error.

Familiarity with certain food types and reporting error

The difference between reported carbohydrate (g) (derived from foods the subjects reported to eat at the test meal) and actual carbohydrate (g) was less for subjects who were involved with food purchasing and preparation when compared to subjects who were not involved with these chores. Furthermore, findings from the present study suggest that the effects of 'seasonality' (i.e., fluctuations in food purchases due to monthly income) were significantly associated with body mass, socio-economic status and dietary reporting error.

Greater fluctuations in income and food purchases were associated with greater error in under-reporting of dietary fat (g). It is possible that 'seasonality' due to income may be a proxy for socio-economic status. This is further supported by an association found in the present study between body mass and 'seasonality' by income ($P < 0.05$) and similar findings in other studies (Kahn and Williamson 1991; McGarvey 1991) showing that overweight is more prevalent in persons with a lower income.

It is thus surprising that the same relationship between familiarity of foods eaten and reporting error was not evident in this study for subjects that reported to eat a habitual diet high in carbohydrate but low in fat. In the present study the Xhosa-speaking subjects ate a significantly ($P < 0.0009$) lower carbohydrate (%) meal when compared to both the English-speaking subjects and the Afrikaans-speaking subjects. Furthermore, the fat (g and %) intake of the test meal was significantly higher ($P < 0.0009$) for the Xhosa-speaking subjects when compared to both the Afrikaans speaking subjects and the English-speaking subjects. For the Xhosa- and Afrikaans-speaking subjects, the relative contributions (% of energy) of carbohydrate and fat of the test meal was contrary to what was expected on the basis of previous studies in these groups. Previous studies using 24-hour recalls have reported that the relative carbohydrate and fat (% of energy) intakes for Black South Africans was 62% carbohydrate, 27% fat (Bourne et al., 1993); for South Africans of Mixed Ancestry 46% carbohydrate and 37% fat (Langenhoven et al., 1988); and for White South Africans (mainly rural Afrikaans-speaking communities) 44-51% carbohydrate and 35-36% fat (Vorster et al., 1995; Wolmarans et al., 1988).

There are two possible explanations for the contrasting composition of the diet eaten by the subjects in this study compared to the habitual diets cited in the literature:

1) The diet eaten by the subjects at the test meal was not typical of their habitual diet, and was influenced by the fact that it was a "free meal" and therefore subjects ate differently to their usual diet. Although foods had been prepared to closely resemble that which had been described by the subjects as habitual in the first interview, due to practical constraints it was not possible to eliminate potential variety of food choices at the test meal. At each test meal between 19-21 food (including beverage) options were displayed. In support of the argument that subjects ate differently at the test meal is the fact the Xhosa-speaking subjects also ate significantly ($P < 0.0009$) more protein (g)

than either the Afrikaans-speaking subjects and the English-speaking subjects. Furthermore, the Xhosa-speaking group was the only group that included unemployed persons which suggests that this group may have been more vulnerable to eating differently and may have viewed the test meal as a "treat" (APPENDIX F).

2) The Xhosa-speaking subjects included in this study ate a habitual diet that was more "Westernized" than the diet eaten by the subjects included in the BRISK study (Bourne et al., 1993). There is the possibility that this sample included subjects that through the process of "acculturation" followed a diet higher in fat and lower in carbohydrate than the described traditional diet. This is, however, difficult to evaluate.

Thus, although the present study confirms that familiarity with food purchasing and preparation affects reporting error it does not show that familiar food types are more accurately recalled This is in contrast to the findings of Krantzler et al. (1982) and Karvetti and Knuts (1985) who suggested that foods eaten regularly were most accurately recalled, while foods less frequently consumed were more often omitted in the recall. The most likely reason for the anomaly in the present study is that subjects ate differently at the test meal as compared to their habitual diet. This is despite efforts to prepare food (a meal) which closely resembled the habitual diet.

Knowledge of nutrition and reporting error

The fact that reporting error can be attributed to knowledge of nutrition cannot be ruled out. Collinear relationships were found between knowledge of food and error in reported protein (%) intake and subject's stature and error in reported protein (%) intake. Subjects who scored high on the knowledge questionnaire, under-reported their protein (%) intakes.

Similarly, taller subjects under-reported protein (%) intake. Since the subjects who had English as their first language were significantly taller than either the Afrikaans-speaking or Xhosa-speaking subjects, it is conceivable that height is a proxy for language in this study.

Interestingly, the direction of the error was the same for carbohydrate (g) estimates and stature and nutrition knowledge and carbohydrate (g) error estimates. This was however, in the opposite direction to the protein/knowledge correlation with subjects who scored high on the knowledge questionnaire, more likely to over-estimate their carbohydrate (g) and carbohydrate (%) intake.

Thus accepting language as a proxy for stature means that English-speaking subjects are more likely to under-estimate protein intakes and over-estimate carbohydrate intakes, the reverse being true for Xhosa-speaking subjects. Another reason for the Xhosa-speaking people to “over-estimate” their protein-rich foods and “under-estimate” their carbohydrate-rich foods may be due to the foods selected and eaten in the test meal. In the test meal it was the Xhosa-speaking subjects that ate significantly more ($P < 0.0009$) protein (g) but less carbohydrate (%) ($P < 0.0009$) than the English-speaking subjects.

Perhaps the relationship between food eaten at the test meal and reporting error can be explained by the effects of “social desirability” (in this case in response to knowledge of nutrition) on reporting error. Knowledge of nutrition in this study was tested by questions relating either to the fat content of food or the potential of food to cause weight gain. Thus persons who scored high on the knowledge questions were more likely to understand that fat, as opposed to carbohydrate, had a greater potential to cause weight gain. These persons were then less prone to under-report carbohydrate as opposed to the subjects that still viewed carbohydrates as "fattening". The majority of the subjects (n = 74) indicated that they wanted to lose weight.

Following this argument, subjects with a poorer knowledge of nutrition were more likely to over-report protein intakes. The idea that certain subjects may over-report protein in response to public awareness is supported by Rathje (1984) who in a comparison of self-reported intakes with actual disposal of packaging materials found that meat was over-reported by 10%.

In contrast to the findings of Klesges et al. (1995) and Sawaya et al. (1996) results of this study could not confirm that age had any influence on reporting error. However, the results of the study by Sawaya et al. (1996) may have been confounded by the exposure of the same subjects (n = 20) to 3 different dietary assessment methods.

SUMMARY

Thus, this study confirmed that adiposity is a universal predictor for under-reporting dietary intakes in women. Even in a diverse population representing different ages, education levels, language and ethnic groups, socio-economic levels and at various stages in the process of acculturation, adiposity remained a determinant of reporting error.

Furthermore, this study helped to identify sources of the inaccuracies in self-reported food data in women. These inaccuracies are nutrient-specific and may be influenced by social desirability bias (via education or knowledge of food), language, or familiarity with certain foods.

3.5.2 INFLUENCE OF TESTING PROCEDURES ON REPORTING ERROR

It may be argued that the study design and testing procedures introduced bias or error into the recall. These issues are addressed in the following discussion:

Study design and subject compliance

The methodology was carefully developed and designed over a long time period and then piloted, with special consideration to confounding variables and practical limitations. Unlike other validation studies that experienced a large subject drop out rate or were reliant on highly motivated subjects (Bingham et al., 1994; Livingstone et al., 1990), in the present study 90% of participants successfully completed the trial.

Study population

The sample size (n = 118) for the present study included women only. Although the focus of the study was on women, the ethnic composition and age of the study population was representative of other epidemiological studies done in South Africa. However, it should be noted that the Xhosa-speaking group was the only sub-group that included unemployed persons.

The definitions, composition, and characteristics of the various sub-groups of this study deserve some comment. The possibility that bias was created by the definition of the sub-groups (i.e. ethnicity, language, education, occupation) used in this study needs to be considered. Furthermore, where proxy relationships or collinear relationships were evident it must still be considered that there may be flaws in the adoption of the proxy variable and that important characteristics of the original information gathered may be lost (Beaton, 1994). For example, in this sample population, the majority of women who were Afrikaans speaking were also of Mixed Ancestry. The distribution of educational experience and job-type may have in some way been influenced by socio-political policies of South Africa. Because there is, in many cases, a lack of heterogeneity in job types in this example, we cannot evaluate the influence of ethnicity on reporting error within certain educational or occupational sub-groups.

Analyses of results showed that in this sample, language was a proxy for culture or ethnicity. Secondly, the only true physical differences in the language sub-groups used in the current study were % body fat, body mass, body mass index and height. The other differences (education, job, time spent in the city) were more likely incidental, resulting from past political policies practiced in South Africa.

Language

The possibility that the language that was used in the interviews was a barrier and so influenced results was only evidenced in the recall error of items consumed. Xhosa-speaking subjects omitted the most items in the recall, followed by Afrikaans-speaking subjects and then the English-speaking subjects. However, speaking Xhosa was not systematically associated with under-reporting and in certain instances, Xhosa-speaking subjects were less likely to under-report intakes (e.g., for protein (%)) when compared to the English- or Afrikaans-speaking subjects.

Serving time of test meal

The fact that the test meal was served at lunch time when the majority of subjects indicated that they usually eat their main meal at night may have influenced results, but this was not in the expected direction. The difference between nutrients (carbohydrate (g), protein (g) and total energy (kJ)) derived from the foods reported and actual nutrients consumed was less for persons who usually ate their main meal at night when compared to persons who usually ate their main meal at midday. The difference in routine for those persons that would usually eat their main meal at night may account for their more accurate reporting.

Single meal vs. whole day

Due to financial constraints and practical problems a decision was taken to only serve one meal. However, this still allowed for the researchers to focus on the error involved with recalling a single meal over a 24-hour period. It is likely that the error found in a single meal recall is the minimum error expected from such a study. Furthermore, using a single meal as a "gold standard", allowed for careful control and eliminated other problems that arise in 24-hour observation studies that incorporate more meals. For example, in the observation study by Karvetti and Knuts (1985) subjects were served 3-4 meals in the cafeteria, but the investigators were not able to observe in-between meals and snacks. Snacks have been shown to be under-erode accuracy and act as powerful incentive to dietary restraint and/or under-estimation (Livingstone et al., 1992).

Composition of the test meal : items served and plated

In this study there was a significant inverse correlation between the error of reporting carbohydrate (g) and the number of items eaten at the test meal ($r = -0.2$; $p < 0.05$). There was no association between reporting error of fat and protein and the number of items served. There are three likely explanations for the lack of association between items eaten and reporting error of protein and fat:

1) In all the test meals, most of the items served were carbohydrates or were based on carbohydrate-rich foods. In terms of "food groups" at least 10 items that were on display at the test meal were from the "carbohydrate/bread group", on average 3 items were from the "protein group" and 3 items from the "fat group" (this excludes items with "hidden or added fat").

2) There were fewer overt fat and protein food choices and there were more foods containing “hidden sugars” than “hidden fats”.
3) The “gold standard” for the assessment was based on 1 test meal. Had snacks been included in the “observation” study it is likely that there would have been greater error in the reporting of fat intake.

The test meal was a free meal

It is important to consider that subjects did not have to pay for the lunch and that this may have affected their dietary intake. There was no significant difference in the number of items eaten by the different language, job and education groups. However, confounding error is suggested by the inverse relationship evidenced in the nutrient composition of the test meal when compared to that cited as being typical for the different language (ethnic) groups.

Database and dietitians

In the present study chemical analyses of food was not done. In studies that have used this method, slight differences have been found between calculated and measured energy content. For example, de Vries et al. (1994) found that the energy content of the diet was on average only 200.6 kJ (48 kcal) (lower per day when duplicate portions were chemically analyzed compared to when the energy content of these portions were calculated using food tables.

To eliminate inter-measurer effects (which are addressed in Chapter 4) dietitians were trained on weighing techniques and the 24-hour recall method, according to a standardized protocol. All data were entered into the computer and analyzed by the main investigator to eliminate any inter-measurer effects. The fact that the same dietitian who weighed the food was involved with the recall, may have favorably enhanced the accuracy of the findings.

Portion size issues

The same kit to describe portion sizes was used throughout the study. This kit had been well researched and included foam models and aids such as popcorn and oats and household measures that had been used in previous dietary studies in South Africa (Steyn et al., 1991). There is the possibility that subjects may have assumed that the food models or household measures represented standard serving sizes and therefore reported consumption in those particular amounts. Given the fact that this is a universal problem, the dietitians who were involved with the recall in the present study were trained to ask open-ended questions allowing the subjects to specify portion sizes (rather than the dietitian prompting or dictating).

3.6 SUMMARY

Results of the current study showed that the overall variance in reporting error is low, and suggest that this error is nutrient-specific.

The design of the study may have influenced results. Specifically, (i) the fact that the study was based on one meal (as opposed to a full day's intake), (ii) that subjects may have reported portion sizes close to the standards (i.e. the standardized household measures, common utensils and the food models) used in the recall, and (iii) that the same dietitian who weighed the food was involved with the recall, all may have influenced results.

Examination of the nutrient specific error suggests very strong evidence for social desirability bias. There were several indirect markers for social desirability bias in the present study: level of education, knowledge of food, involvement with food buying and preparation, and adiposity.

Factors unrelated to social desirability, but nevertheless important in terms of their direct impact of error in the current study were: (i) the language of the interviews, (ii) the fact that subjects may have eaten a meal that was different in composition to their usual diet, and (iii) subjects' familiarity with certain food types as evidenced by 'seasonality' in dietary intake in response to cycles in monetary income.

3.7 CONCLUSIONS

It can be concluded from this study that there is systematic under-reporting of dietary intake in women in relation to adiposity. Furthermore, this study showed that the dietary reporting error is nutrient-specific and may be influenced by specific subject characteristics.

It is likely that socio-economic factors, social desirability and knowledge of nutrition impact on the accuracy of the dietary recall. Furthermore, there is the possibility that these same factors may affect the validity of the tool chosen as the "gold standard" to validate dietary intakes. In the present validation study these factors may have confounded results by influencing the foods and beverages chosen by the subjects at the test meal.

Thus, the dietary intake of individuals, as assessed by the 24-hour dietary recall method, must be treated with great caution. Perhaps the answer to accurate dietary intake assessment lies in the suggestion by Beaton (1994) that the interpretation of dietary assessment information requires a blending of biological, environmental and statistical approaches.

CHAPTER 4: TRIAL 2: THE INTER-RESEARCHER VARIABILITY ASSOCIATED WITH THE INTERPRETATION OF FOOD INTAKE RECORDS

4.1 INTRODUCTION

There are up to three tasks involved in the reduction process of dietary intake data for nutrient calculation systems. Depending on the computerized dietary analysis system used, these tasks are: the assignment of food table codes to each food of the intake, the conversion of food consumption quantities to gram weights or other food units used by the nutrient calculation system, and the keying in of the data from written dietary intake documents to a data storage file (Feskanich et al., 1988).

Although potential error resulting from these tasks is often described in the literature, it is rarely quantified (Bingham, 1987). This error is relevant for calculating the total experimental error associated with reported food intake. Furthermore, this information is important where reported food intake data, analyzed by different dietitians or scientists, need to be compared.

The aim of this study was to determine the source and extent of inter-researcher variability associated with the interpretation of food intake records. Accordingly, three post graduate students in dietetics independently interpreted 3 day food records of the same 10 subjects. The variability associated with the calculation of energy and macro-nutrient content of the reported food intake by each dietitian was then calculated.

The computer dietary analysis program used for this study (FoodFinder Dietary Analysis Software, Medtech and Medical Research Council, Cape Town, 1991) was not designed to convert food volumes into gram weights. However, the program was able to identify foods by name or code. Thus, the potential sources of variability related to the selection of food codes or names, the keying of the data from written dietary records (clerical errors) to the data storage file, and the conversion of food consumption quantities to gram weights (judgment errors).

4.2 METHODS

Design and study population

This study was designed to compare the interpretation and analysis of food intake records by different researchers. Ten participants (5 males, 5 females) were asked to complete a 3-day dietary record (2 weekdays and 1 weekend day) on joining the University of Cape Town Weight Management Program. In a workshop, all subjects were given clear instructions by a single interviewer on how to record portion sizes and ingredients of prepared dishes for all food and drink consumed during these 3 days. A summary of the instructions were handed out to each subject with the record forms to complete (APPENDIX G). Amounts consumed could be weighed using a scale or using household measures and/or indicating dimensions (e.g., cups, tablespoons, size (length, breadth, width)).

The 3 researchers participated in a 2 hour training session in order to standardize the editing, coding and analyzing of the dietary records, before any diets were analyzed. Then the 10 completed food records were randomly rotated amongst the three researchers (one of whom was the investigator) who independently interpreted and analyzed the data using a computer program based on the South African Food Composition Tables (FoodFinder Dietary Analysis Software, Medtech and Medical Research Council, Cape Town, 1991).

The following values were calculated by each dietitian for each subject for the 3 day period that records were kept: intake of energy (kJ), protein (g), fat (g), carbohydrate (g), added sugar (g), alcohol (g), and percentages of total energy intake for protein, carbohydrate, fat and alcohol. These 3 day values were then divided by 3 to arrive at an average daily intake for each subject.

4.3 STATISTICAL ANALYSIS

For each subject, the mean and standard deviation for total daily energy and nutrient-specific intake were determined, based on the analysis by the 3 researchers. From these data, the coefficient of variation for each subject was determined, for total energy and nutrient-specific intake.

In order to provide an indicator of the precision of measurement or consistency in analyzing the food records, the overall mean coefficients of variation (plus standard deviation and 95% confidence intervals) for both energy and nutrients were calculated. In addition, a simple linear regression was performed relating the degree of error as measured by the coefficient of variation to the actual intake in kJ or g. In other words, to determine if an individual with the highest intake is also more subject to error in interpretation and data reduction.

Repeated measures analyses of variance (ANOVA) were performed to determine if there were systematic differences between researchers in the interpretation of energy and nutrient intake. Between-subject and between-researcher variability were determined. Significant between-researcher variability would be indicative of systematic error or bias.

Finally, intraclass reliability coefficients were calculated to determine the consistency in measurement (of magnitude and order) between researchers. The intraclass reliability coefficient (R1)is calculated as follows:

$R_1 = MS_{subjects} - ((SS_{researchers} + SS_{error}./df_{researchers} + df_{error}))/MS_{subjects}$

where: MS= mean square

SS= sums of squares

df = degrees of freedom

(Vincent, 1995)

Vincent (1995) states that "an intraclass reliability of > 0.90 is considered to be high, from 0.80-0.89 moderate, and < 0.80 to be questionable for physiological data".

4.4 RESULTS

The mean energy and nutrient intakes (and standard deviation) of each individual subject for the three researchers are presented in Table 4.1.

TABLE 4.1 Mean nutrient intakes of the subjects (X ± SD)

Subjects	Energy (kJ)	Protein (g)	Fat (g)	CHO (g)	Alcohol (g)	Sugar (g)
1	10536 ± 807	87.1 ± 5.6	110.0 ± 9.0	284.0 ± 28.0	5.3 ± 0	74.5 ± 8.8
2	6127 ± 601	48.1 ± 3.2	62.3 ± 9.2	179.0 ± 20.0	0	47.2 ± 3.6
3	11922 ± 643	132.1 ± 10.1	98.7 ± 6.5	345.5 ± 26.3	0	92.5 ± 7.6
4	7869 ± 279	63.7 ± 4.6	99.4 ± 6.6	180.5 ± 14.4	0	53.7 ± 4.4
5	7137 ± 105	66.4 ± 0.4	91.9 ± 0.3	109.1 ± 5.9	24.6 ± 0.1	18.3 ± 0.1
6	8239 ± 426	75.5 ± 3.2	101.9 ± 4.9	159.1 ± 15.5	16.5 ± 2.7	26.4 ± 9.4
7	12399 ± 636	76.8 ± 8.3	123.1 ± 6.3	366.7 ± 15.6	12.9 ± 2.2	67.2 ± 7.5
8	9140 ± 314	82.8 ± 3.4	94.9 ± 1.3	238.5 ± 20.8	4.0 ± 0.6	26.4 ± 3.0
9	6792 ± 562	74.2 ± 11.2	51.9 ± 3.3	204.2 ± 13.8	1.6 ± 0.3	12.2 ± 4.9
10	12442 ± 514	92.6 ± 9.0	116.5 ± 19.6	309.1 ± 19.9	47.3 ± 1.7	87.9 ±11.9

CHO, carbohydrate ; Sugar, added sugar

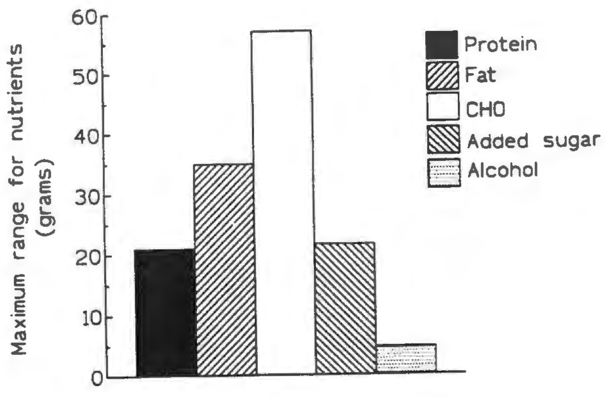
These data provide some indication of the subject heterogeneity with regard to food intake, with a range of individual total energy intake from a low of ~6200 kJ to a high of ~12500kJ.

Table 4.2 shows the mean inter-researcher coefficients of variation (standard deviations and 95% confidence intervals) for energy and nutrient intake for the 10 subjects. The coefficient of variation is calculated as the standard deviation divided by the mean and expressed as a percentage. The highest mean percentage error or coefficient of variation was for added sugar (14.8% (95% C.I.: 7.0-22.6)). There were, however, no significant relationships, using simple linear regression analysis, between the absolute intake (either kJ or g) and the degree of inter-measurer variability in estimating nutrient or energy intake.

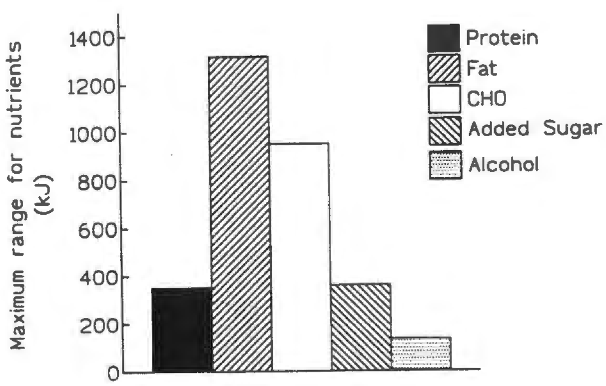
TABLE 4.2: Mean coefficient of variation of nutrients and 95% confidence intervals determined in 10 subjects by 3 dietitians.

NUTRIENT	MEAN COEFFICIENT OF VARIATION (± SD)	95% CI
Total energy (kJ)	5.4 ± 2.4	(3.9 ; 6.9)
Total carbohydrate (g)	7.8 ± 2.2	(6.4 ; 9.2)
Total protein (g)	7.3 ± 4.0	(4.8 ; 9.8)
Total fat (g)	7.1 ± 5.2	(3.9 ; 10.3)
Added sugar (g)	14.8 ± 12.6	(7.0 ; 22.6)
Alcohol (g)	6.9 ± 8.2	(1.8 ; 12.0)

Figure 4.1 (A) shows the maximum range which represents the most extreme differences in nutrient intake (in g) amongst the 10 individual diets as analyzed by the three researchers. In one subject, the range between the lowest and highest estimated carbohydrate intake was 58 g. However, when these values are expressed as kJ (Figure 4.1 (B)), dietary fat has the largest range between researchers (1313 kJ).



(A)



(B)

Figure 4.1 (A) The maximum range represents the most extreme difference in nutrient intake (g) amongst 10 individual diets analyzed by 3 dietitians. (B) Maximum range converted to kJ.

The results of the ANOVA for between-subject and between-researcher variability are given in Tables 4.3 and 4.4. The between-subjects variability was significant ($P < 0.001$) for all nutrients reflecting a heterogeneous population. The variability between researchers was not significant, suggesting that there was no systematic variation in interpretation of nutrients and energy by the dietitians.

TABLE 4.3: Results of ANOVA for between-subject variability

NUTRIENT	F
Energy (kJ)	60.3
Carbohydrate (g)	61.7
Protein (g)	33.4
Fat (g)	20.8
Added sugar (g)	55.5
Alcohol (g)	468.9

TABLE 4.4: Results of the ANOVA for between-measurer variability

NUTRIENT	F
Energy (kJ)	2.0
Carbohydrate (g)	1.3
Protein (g)	1.4
Fat (g)	1.0
Added sugar (g)	1.5
Alcohol (g)	1.4

The intraclass reliability coefficients for energy and nutrients are shown in Table 4.5. Since intraclass coefficients were greater than 0.90 for all variables measured, and were associated with a low between-researcher variability, there was a high degree of consistency (see definition by Vincent, 1995) in the researchers calculations of energy (kJ), macronutrients (in g), added sugar (g) and alcohol (g).

Table 4.5 Intraclass reliability for Energy and Nutrients

NUTRIENT	INTRACLASS RELIABILITY (R1)
Energy (kJ)	0.98
Carbohydrate (g)	0.98
Protein (g)	0.97
Fat (g)	0.95
Added sugar (g)	0.95
Alcohol (g)	0.99

4.5 DISCUSSION

The present study was designed to quantify the potential error attributable to coding and interpretation of weighed and unweighed dietary records by multiple researchers. The population was a sub-sample of participants of a Weight Management program. Results of this study highlight the random variability that may be introduced into the interpretation of weighed and unweighed dietary records by involving multiple trained dietitians (using the same computerized dietary analysis program) in a single survey. This is an issue of practical importance, as many epidemiological studies involving dietary assessment have multiple interviewers.

Inter-researcher variability

In the present study, the differences between dietitians in interpreting and analyzing the food records were not systematic, and therefore cannot be considered to be biased. The coefficients of variation in this study ranged from 5.4 ± 2.4% (for total energy in kJ) and 7.1 ± 5.2% (for fat in g) to 14.8 ± 12.6% (for added sugar in g).

In a comprehensive review on dietary assessment by Bingham (1987) it has been suggested that error greater than 10% in the dietary method is unacceptable since this may exceed actual differences in the study population's dietary intakes. Using 10% as the cut-off for the coefficient of variation in the present study, it is only for added sugar (in g) that the inter-researcher variability is of concern.

Another finding of the present study was that the quantities determined for alcohol were the most similar. There are two possible explanations for this finding. Firstly, alcohol is more easily quantified than fat or sugar and does not appear hidden in food as does fat and sugar intake. Secondly, the fact that 3 of the subjects did not report any alcohol consumption may have contributed to the consistency in interpretation and analysis of alcohol.

Although several studies in the literature mention the importance of inter-researcher error, few studies have directly assessed the error that is specifically associated with different researchers in interpreting and analyzing the same diets using the same database (i.e. food composition tables or computer program). Table 4.6 cites the results from the studies that considered this error:

In terms of design, the studies most similar to the present study are those by Eagles et al. (1966) and the unpublished study by Brewer cited by Whiting and Leverton (1960). Comparison of results with the latter study are however limited to energy and protein, as no further information is given in the literature. Interestingly, the inter-researcher coefficient of variation for energy was 5% in both the Brewer study and the present study. The coefficient of variation for protein differed in the 2 studies; whereas Brewer found an inter-researcher error of 12%, the error for protein was lower in the present study (7.3 $\pm$ 4.0%). No standard deviations were given in the Brewer study.

TABLE 4.6 Inter-researcher variance in analyzing and coding dietary intake

Reference	Number of researchers (dietitians)	Number and type of diets analyzed	Measure and magnitude of the error of variance
Brewer study cited by Whiting et al. (1960)	8	21 weighed food records	***Range of means (between researchers)*** kJ range:7541-8268 pro range (g):57-71 ***CV (between researchers)*** CV for kJ: 5% CV for pro (g): 12%
Eagles et al. (1966)	10	3 (1 day) un-weighed food records	***CV (between researchers)*** *(using SEM):* CV for kJ: 4% CV for pro (g): 3% CV for fat (g): 3% CV for SFA (g):12% ***Greatest range of variance (between researchers) :*** kJ range: 8644—11039 pro range (g) :79 -112 fat range (g): 74-149
Beaton et al. (1979)	? 2 locations with 2 researchers at one location; no information is given on the no of researchers at the 2nd location	60 24 hour recalls	***CV (between 2 locations)*** CV for kJ: *4%* CV for pro (g):3% CV for CHO (g): 5% CV for fat (g): 8% CV for P:S ratio: 17%

CV = coefficient of variation; PRO = protein CHO = carbohydrate
P:S = polyunsaturated:saturated fatty acid ratio

The results of the study by Eagles et al. (1966) cited in Table 4.6 are based on the analysis of 3 diets by 10 dietitians (who used the same food composition tables to analyze the diets). Although the authors mention that the dietitians had at least 2 years clinical experience and then received additional training, no information is given on this training. Their findings were similar to that of the present study in that there was no significant difference in the inter-dietitian variance in calculating energy, protein (g) and fat (g) despite the fact that the sample was heterogeneous ($P < 0.01$). However, the differences between dietitians within a single diet were as much as 2395 kJ, 33 g protein and 75 g fat, compared to the present study where the greatest range found for a particular subject was 1018 kJ, 18 g protein and 34.9 g fat (for subject 10). The reason for the lower range found in the present study may be due to the similar tertiary level training and subsequent standardization training of the 3 postgraduate dietetic students. Another reason for the difference may be the ratio of the number of diets analyzed to the number of measurers. In the present study 3 measurers analyzed 10 x 3 day records as compared to the study by Eagles et al. (1966) where 10 measurers analyzed 3 x 1 day records.

Included in Table 4.6 is a study by Beaton et al. (1979). Although this study was designed to assess interviewer, training and sequence effects in assessing diets using the 24 hour recall method, it included a comparison of the same 60 food records that were at coded at 2 different locations using the same food composition database. The weight of the food was known, so it was solely a comparison of inter-location errors that arise during coding and unfortunately no information is given on the nutrient differences found between the dietitians who analyzed the data. Their results showed that the inter-location coefficients of variation from errors due to inadequate description of foods, even when the weight of the food is known or established (and the same database was used), were 3% for protein, 8% for fat and 5% for carbohydrate and 17% for the polyunsaturated:saturated fatty acid ratio. As in the present study, these differences were not statistically significant. However, because the Beaton study included more than 2 researchers at one location, and an unknown number of researchers at the second location, it is difficult from the results of their study to ascertain how much error could be ascribed to inter-dietitian variance and how much to a coding rule change that was introduced during the course of their study. This coding rule change had by mistake only been applied to the one location and affected the coding for fat of french fried potatoes.

The present study, although conducted with fewer measurers than the studies cited in Table 4.6 confirms that trained dietitians are consistent in their interpretation and analysis of food records even when information in the food records was described in household measures and/or dimensions. Even for sugar which had the greatest variance of 14.8 ± 12.6% amongst the researchers, the error was not significant.

Inter-subject variabilty

In the present study the dietary intakes of the subjects were significantly different, reflecting a heterogeneous sample. The difference in mean nutrient intakes between Subject 10 and Subject 5 for example, was 5275 kJ, 26 g protein, 200 g carbohydrate, 25 g fat and 23 g alcohol. The average number of items consumed by Subject 10 per day was 20, compared to Subject 5 who consumed on average 10 different items per day, with Subject 10 consistently consuming the greater volumes. Moreover, Subject 5 (for whom low differences in nutrient ranges were found) consumed a diet comprising "simple" easily quantifiable foods, whereas Subject 10 (for whom high ranges of differences in nutrients were found) ate a diet rich in hidden and added fats (e.g., pies and sauces) and sugars. Furthermore, Subject 10 ate composite foods (e.g., spaghetti bolognaise). Dishes such as spaghetti bolognaise contain mixtures in unknown ratios or proportion. Thus, the dietary analysis of Subject 10's diet required a greater degree of interpretation from the dietitian.

However, even with significant between-subject variability and the greater amount of interpretation required in the interpretation and analysis of some of the subject's diets, the inter-researcher error was not significant and this was consistent for all the nutrients that were analyzed. One cannot however rule out the possibility of Type II errors because the inter-researcher measurement error was based on 3 researchers, one of whom was the investigator.

Other potential sources of experimental error

The present study did not examine all the potential sources of error in data handling. For example, it provided no estimate of any error inherent in the food composition table, nor did it provide any assessment of error that is associated with the subjects' ability (e.g., education) to accurately recall the food consumed (see results of Chapter 3 of this Thesis). It has been documented that the composition of the food supply changes more rapidly than the nutrient data in the food tables (Marshall and Judd, 1982) and therefore is a potential source for variation that needs to be considered. Different conditions in geography, seasons, storage of food, transportation of food, manufacturing processes and different recipes for composite dishes influence nutrient composition (Langenhoven et al., 1996; Marshall and Judd, 1982). Dwyer and Suitor (1984) suggest that the size of the database may influence results especially if multiple entries are available for similar foods. The larger the database, the more decisions need to be made and this may affect the reliability of nutrient content. This issue deserves attention.

The results of the present study suggest that the nutrient values calculated by the computer depend on the dietitians' interpretation of the descriptive terms and approximate measurements reported in the diet records (judgment errors) and clerical errors. Other potential sources of error in data handling include the food tables or food composition database.

4.6 SUMMARY

The variability amongst dietitians in the present study was not systematic, and as a result, not biased. Although this was a very positive finding, it is important to acknowledge that the design of the present study may have contributed to this finding. Certainly, the lower variation found in the present study, when compared to the findings of the other studies, may be explained by a variety of factors. Firstly, the similar background and training of the postgraduate dietitians may have reduced variability. Secondly, the study was conducted using only 3 dietitians (one of whom was the investigator), and finally, the database had approximately 1530 foods and beverages, thus limiting options.

The variability that arose in the present study may have arisen from errors in:

1) The assignment of codes or names to descriptions of the food noted in the food records.
2) Interpretation of the portion sizes described in the food records by the dietitian. To analyze the information from the food records, gram values of all foods and beverages needed to be ascertained. Since most subjects described their intakes in terms of household measures and dimensions rather than weighed their intakes, the dietitians needed to allocate gram values to many foods and beverages. The task of assigning

gram values to those foods and beverages that were unweighed by the subjects was thus a potential source of error.

This study highlights the importance of attention to detail that is necessary to minimize experimental error in dietary studies. The following 3 areas need specific consideration to reduce clerical errors and judgmental differences which may result in coding or entering data:

1) Training and standardization of the dietitians or measurers. The amount of time necessary for training will depend on the dietary analysis system used as well as the dietitians' familiarity with the foods used in the region under study. The training program should include decisions on using defaults in the computer program and how to handle unknowns. To minimize variability from portion size estimations, the diet records should be checked before and during translation to resolve any ambiguities. From the findings of Howat et al. (1994) it is suggested that more emphasis be placed on amorphous and liquid forms of food in training and from the findings of Frank et al. (1984), emphasis should be placed on judging portion sizes of sweets, meats and vegetables.
2) The instructions given to subjects on how to complete the food records must be clear. In the case of 24-hour recalls probing subjects for additional information is important. In one study of fat intakes, 15% of total fat intakes were of an unknown type and about half of this amount could be identified with further probing (Dwyer, 1988). In a verification study of the BRISK study on 50 adult men and women from the same population, in-depth probes on snacking and nibbling habits showed a further 7.4% increase in the estimation of energy intake over that recorded in the original study (Bourne et al., 1993)

3) It should be ensured that every data management program used throughout the study is consistent and that if any upgrades or changes are made during the study that these are applied to every system involved. The more widely used nutrition database program used in South Africa would be strengthened by adding more descriptive food names, additional nutrients, data quality indicators, reference sources for each nutrient and South African values for foods eaten by South Africans (Langenhoven et al., 1996).

4.7 CONCLUSIONS

The major component of variance in the present study was inter-individual differences between subjects and not inter-researcher differences in analysis. The relatively small variance attributable to data reduction, although not systematic, cannot be ignored since random error, reduces the reliability of the mean (Beaton et al., 1979). For example, the variance in fat for one subject was 1313 kJ, which is considerable if one were interested in the differences in fat (and/or) energy intake of different persons. Furthermore, it is likely that the error found in the present study represents the minimum variation expected from such an exercise, considering the few dietitians included in the study and their training.

To prevent inaccuracies in the interpretation of dietary data, not only should the questionnaire be optimal, the study population appropriate and the method of administration well controlled, but researchers/measurers, particularly in multi-center studies, need to be standardized. This standardization process should be included in the study design and should involve the replicate examination of a sub-sample of the population's diets by all the researchers involved in the dietary interpretation and analyses.

CHAPTER 5: RECOMMENDATIONS

Findings from the first study presented in this thesis showed that in a cross-cultural sample of South African women, respondent error in the 24-hour dietary recall method was related to adiposity, social desirability bias (on the basis of level of education or knowledge of food), language, familiarity with certain foods and 'seasonality' in food purchases. The second study presented in this thesis showed that the variations in interpretation of the quality and quantity of reported food intake by the measurer is a source of experimental error and even though it is random, it may account, at least partially, for the differences between true and reported intake. This inter-researcher error can be minimized through training.

Based on these research findings, the following recommendations are made. These recommendations apply specifically to the use of the 24-hour recall assessment method, with the exception of the first point, which applies to all dietary assessment methods;

1. Measurers should be well trained and standardized and the inter-measurer coefficient of variation should be determined for each study application.
2. Sampling procedures should minimize bias such as the "seasonal effects" of eating. Noting how diet may change in response to changes in income may be useful.
3. The language used in conducting the interview should be the same as that of the subject.
4. Anthropometric measurements of subjects should be noted as overweight individuals tend to under-report their dietary intake.

5. A measure of social desirability such as the Marlow-Crowne Social Desirability Scale, a measure of dietary restraint (as in the study by Bingham et al., 1995) or an attitude scale suitable for assessment of body image in the South African context (Kruger et al., 1996) should be used to validate the 24-hour recall.

Additional areas that warrant further research, but which are beyond the scope of this thesis include portion size issues, measurement of individual's intake from a common pot, and strategies that may improve the 24-hour recall such as prior notification of a recall, cueing strategies and multiple recall probes in a comprehensive interview.

APPENDIX A: ADVERTISEMENT AND INFORMED CONSENT

A study which is being conducted at GSH has been designed by a Masters Dietetics student to help understand differences in food choices and physical activity for persons with different lifestyles. She is looking for **women** participants between 25-55 years of age, who have been living in Cape Town for at least 1 month and whose weight has not changed much. Pregnant women and women on special diets (eg halaal or kosher) cannot be accepted for this trial.

100 Participants will be selected and will be requested to:

1) attend an initial interview (30 minutes: this includes taking basic measurements (weight, % body fat)
2) attend visit 2 which is a free meal (during lunch time)
3) attend visit 3 which is a 30 minute interview.

Participants who are selected will also receive R30 on successful completion of the trial and at the end of the study will receive feedback on their results and results from the study.

PARTICIPANT'S CONSENT FORM

I agree to participate in this study to understand differences in food choices and physical activity for persons with different lifestyles.

I understand that I will be asked questions relating to my diet and exercise, that my weight, height and body composition will be measured using standard anthropometric techniques that have no risk and that I will be requested to eat a meal with no risks additional to those in normal food preparation.

I understand that my records will remain entirely confidential.

PARTICIPANT'S NAME:______________________

PARTICIPANT'S SIGNATURE_________________

DATE:______________________

WITNESSES NAME ________________________

WITNESSES SIGNATURE____________________

DATE______________________

INVESTIGATOR'S NAME:_______________________

INVESTIGATOR'S SIGNATURE___________________

DATE:__________________________

APPENDIX B: PROTOCOL FOR 24-HOUR DIETARY RECALL

Ask the respondent to remember and report all the foods and beverages consumed in the 24 hours preceding the interview (i.e. the day of the 'test meal") mentioning that you are interested in the TIME THE FOOD WAS EATEN, THE TYPE OF FOOD EATEN, THE QUANTITY OF FOOD EATEN (not served), HOW THE FOOD WAS PREPARED and WHERE IT WAS EATEN. Everything consumed from on rising in the morning until going to bed (including anything eaten or drunk after supper and during the night), at mealtimes and in between must be considered . Do not interrupt the respondent whilst they are reporting their intake. Record everything using the form provided.

When the respondent stops, ask: "AnYthing else?" Then run through the record with them specifically probing for the following:

1. *TIME OF MEAL AND OCCASION*

From waking up till +- 9am

Midmorning: everything eaten or drunk between 9 am and 12 noon

LUNCH: meal between 12noon -2 p.m. (i.e. TEST MEAL)

Afternoon: after this and before the evening meal

Evening Meal: (i.e. supper) the meal after 5 p.m. in the afternoon, irrespective of how late it was eaten

After the evening meal and during the night: anything consumed after supper and during the night.

Extras- anything not mentioned, or that did not fit into any specific period.

2. *FOOD PROBES*

Check for sauces, fillings, gravy on everything

Where possible record **brand names** e.g. sunshine D, cardin or floro extra light.

At the end run through again and check for any left out items.

3. *AMOUNT SPECIFICATIONS AND PROBES:*

RECORD PORTION SIZES USING ANY OF THE FOLLOWING UNITS (USING THE STANDARDISED KIT):

Weight in grams.

Volume in ml, cups, tablespoons or teaspoons.

Relative to the standardized model from the kit.

Dimensions for the full shape of the food should be measured and noted.

If more than one person shared food from one communal basin, guide the respondent to describe their own consumption in terms of spoonfuls or in ml.

Record cooked portion sizes.

A. <u>BEVERAGES:</u>

TEA/COFFEE/COCOA or FLAVOURED MILK

Allow the respondent indicate quantity of beverages consumed using the cup/mug/glass that best resembles their own. Request them to pour water into the utensil and measure the "tea/coffee/milk" separately.

The type of milk (full cream, low fat, fat free or condensed milk or creamer) must be noted.

The amount of sugar added in teaspoons, sugar spoons, dessert spoons or tablespoons must be noted.

The amount of flavoring: Nesquick, Milo, Cocoa, Horlicks, Ovaltine must be noted.

COLDDRINK/FRUITJUICES/CORDIALS

Determine the quantity consumed in ml or record the size of the can or bottle. Work out the amount of cordial (using water as above) or concentrate or powder. Note the brand name of the drink or powder (e.g. Oros, Kool Aid, Trix, Quin, etc.) Question whether the drink was artificially sweetened. Note the proportion of ice to liquid. Record brand names of fruit juices (e.g. Liquifruit, Appletizer etc.) or dairy mixes (Frulati, Fiesta, Tropica).

ALCOHOLIC BEVERAGES.

The type of drink (give brand names), the mix (fruit juice, water or other non-alcoholic beverages), the quantity and the proportion of ice must be determined.

1 tot = 25 ml. 1 bottle = 750 ml.

If beer was home-brewed, find out what the mixture was and how much was consumed.

PROPORTION OF ICE.

TYPES OF MILK AND MILK SUBSTITUTES:

Fresh full cream milk, low fat milk (2%) or fat free milk (skim milk), powdered WHOLE milk (e.g. Nespray, Klim, Everyday) or powdered skim milk (Protea, Elite, Farmers Pride) or Milk Blends (Carnation blend, Molico, Sunset, Make-a-litre) or Creamers (cremora, Ellis Brown, Coffee Mate, Kreemee, Weigh Less); condensed milk - full cream (Gold Cross 325 g); condensed milk - skim (Gold Medal); evaporated milk - full cream (Carnation, Ideal); evaporated milk - skim (Slender); amasi/maas (bought or homemade) or drinking yogurt sweetened (Yogi-sip, yo-flo, Jolly Jo, Yog nog) or drinking yogurt - unsweetened; buttermilk.

B. BREAD

a) Type of bread (white, brown or mealie bread). Homemade or commercial.

b) Size slice.....shop sliced? If homemade or homesliced...cut 1 slice and weigh. Or use ruler. Or use model.

c) Spread? What? (Brick margarine, tub margarine, cooking fat, dripping). On how many slices of bread? How much? scraping (you can see the bread through the spread), medium (the spread just covers the bread) , thick (toothmarks)

d) Anything else on bread?(e.g. peanut butter/jam) How much (as definitions above) and on how many slices?

e) Vetkoek...brown or white flour? Size? Type of filling?

f) Bunny chow - quantify and specify type of bread

C. CHEESE

Type (Cheddar, sweet milk, cheese wedges or spread); if low fat mention type; if cottage or cream cheese give brand name and % fat.

Quantity: grated or sliced. If grated, was it spread thin/medium/thick; on how many slices of bread or how many spoonfuls (level or heaped). If sliced, what were the dimensions?

Spoonfuls: size of spoon and heaped or level.

No of cheese wedges.

D. <u>EGGS</u>

How many? Method of preparation: type of milk and fat if scrambled and determine type and quantity of any additions (e.g. cheese or vegetables) in preparation.

E. <u>MAIZE AND OTHER PORRIDGE</u>

RESPONDENT TO USE MEASURING CUP AND POCORN/OATS TO DEMONSTRATE VOLUME EATEN.

USE POPCORN to measure volume (ml) FOR STIFF PORRIDGE (umqa), CRUMBLY PORRIDGE (umphokoqo) AND SAMP and RICE.

Note kind.

USE OATS FOR SOFT PORRIDGE and allow the respondent to demonstrate volume consumed. Use measuring cup to determine volume.

Note (type and quantity) any additions e.g. milk,sugar,fat.

For SAMP and BEANS: was it a bought mixture (which has la lot of samp but ittle beans i.e. 5: 1) or, was it self mixed in which case, how much samp to how much beans? Brownish = lots of beans vs. whitish = less beans (unless white beans were used)

What else was served with the samp? (gravy: was this made with stock cubes and/or fat, vegetables and meat?) Determine the ratio of samp/beans/other additions.

F. MEAT AND MEAT DISHES

Specify beef, mutton or pork. Specify the cut. Note whether the meat was fat-trimmed or untrimmed. Record the method of preparation (fried, roasted, grilled, stewed, breaded or battered) and what sauces or gravies were added.

SOLID MEATS:

with bone or without bone.

sausage: measure size with ruler.

mutton chop: measure length, width and thickness.

or piece of beef : foam model/food model and measure length, width and thickness.

chicken: cut : wing, drumstick, thigh, breast (models). Skin or skinless.

meatballs: measure diameter and height

FLUID MEATS:

use oats or popcorn and measuring cup or ladle-spoon and let respondent demonstrate how much. Write down quantity in ml. If vegetables and potatoes were cooked with the meat, please quantify the meat, potato, vegetables and gravy separately.

Please state if there was bone in the meat. If minced meat and vegetables, state whether there were more vegetables than meat or visa versa.

Note amount and type of fat that was added in preparation.

COLD CUTS, POLONY, VIENNA SAUSAGES, BRAWN

give diameter (3cm,6cm,10cm) of polony and no of slices. Slices cut in shop, or homecut? If homecut, how thick? Short or long viennas, how many?

G. FISH:

a) FRESH FISH: kind, method of preparation.

QUANTITY: ruler or foam model/or modelof haddock.

b) TINNED FISH: kind (minced in tomato sauce, pickled)...brand name, method of preparation

QUANTITY: ladlespoon, tablespoon, or oats or foam or food models.

H. SOUP:

a) main ingredients

b) thick or watery

c) measuring cup and water for quantity.

I. VEGETABLES

POTATOES: preparation. For quantity compare to std potato model. For mashed use spoonfuls.

CHOPPED VEGTABLES: no of level or heaped table- or ladle-spoons, platefuls, or use popcorn or oats to determine in ml.

STIR-FRIED: fat added (type and amount)?

J. FRUIT

no and size (compare to real fruit stds)

preparation: additions of sugar and fat (note type)

canned fruit: platefuls or spoonfuls.

K. CAKE, BISCUITS, PUDDING

What (homemade or bought), how much, how prepared...type of milk, type of ice cream or custard etc.

Brand names where possible.

Compare to models, foam models or use the ruler or oats/popcorn to determine quantity.

For ice cream: mellorine, sorbet, real ice cream, frozen yogurt, etc.

L. SWEETS/CHOCOLATE/CRISPS/NUTS/POPCORN

Brand name. Size of packet or of individual sweets.

Note type of bubblegum, brand name of chocolate (size of bar), dried fruit sticks, ice suckers, marshmellows, brand name of crisps or popcorn or pretzels and if any flavourings (e.g. fat) was added.

APPENDIX C: WEIGHTS FOR HOUSEHOLD MEASURES AND MODELS

Standard references were determined to translate the described portions from the 24-hour recall into grams. Where food models or foam models were used, the equivalent volume of food was weighed on the Sartorius GMBH electronic scale. For some food items (e.g. mixed dishes like tuna lasagne, the actual food served was weighed, following the same procedure. For most food items weighings was done by one person only. At least three weighings per measure of food were recorded and the mean weights were calculated. Ordinal rankings were established by following the same procedures weighing out little or plenty according to the dimensions described. For quantifying spreads on bread the brown bread sandwich loaf slice (dimensions 93x93mm) was used as the standard slice of bread.

For the household measures, a "level" measure was defined as lightly leveled off by shaking or pushing. A "heaped" measure was defined as a rounded spoonful measure, such as would result from dishing up without leveling off. Where indicated in the table, weights for household measures were established. Household measures were used that were equivalent to the following volume measurements:
5 ml = metric measuring teaspoon
TSP = 3 ml average ordinary household teaspoon
DSP = 7 ml average ordinary household dessertspoon
TBS = 12 ml average ordinary household tablespoon
LS = 30 ml ladle (large spoon with long handle, also basting spoon)
125 ml = half a measuring cup

L = level measure
H = heaped measure
mm = millimetre
Where dimensions are given, volumes were calculated for length x width x height.

FOOD ITEM	SIZE/DESCRIPTION	ONE UNIT	1 L	1 H	LITTLE	MED	PLENTY
VEGETABLE SOUP	SOUP LADLE	148					
BREAD, WHOLEWHEAT	SLICE 95X90X10mm	35					
BREAD, BROWN	SLICE 93X93X10mm	30					
BREAD, WHITE	SLICE 93X93X10 mm	30					
SOFT MARGARINE	ON BREAD SLICE 93X93mm		tsp = 5	tsp = 10	5	7	10
HARD MARGARINE	ON BREAD SLICE 93X93mm		tsp = 5	tsp = 10	5	7	10
BUTTER	ON BREAD SLICE 93X93 mm		tsp = 5	tsp = 10	5	10	15
CHICKEN BREAST, +SKIN	AS NASCO MODEL: (100X60X28mm)	85 95 (+ batter)					125 124x86x 36
CHICKEN BREAST, - SKIN	AS NASCO MODEL: (100x60x28mm)	75					110 124x86x 36
CHICKEN LEG, + SKIN	AS NASCO MODEL: 125X57x35mm	85 95 (+ batter)			65 110x55x 35		
CHICKEN LEG, - SKIN	AS NASCO MODEL: 125x57x35mm	75			55 110x55x 35		

FOOD ITEM	SIZE/DESCRIPTION	ONE UNIT	1 L	1 H	LITTLE	MED	PLENTY
CHICKEN THIGH, + SKIN	AS NASCO MODEL: 90X60X34mm	85 95 (+ batter)			80 75x80x 30		
CHICKEN THIGH, - SKIN	AS NASCO MODEL: 90x60x 34mm	75			70 75x80x 30		
CHICKEN WING, + SKIN	AS NASCO MODEL: 90X 70X30mm	85 95 (+ batter)			40 85X48X 27		
TUNA LASAGNE	60x50x35mm	50	SS = 92	SS = 110			
SAVOURY MINCE			SS = 42	SS = 67			
COTTAGE PIE	60x50x35mm	65	SS = 101	SS = 192			
SAMP + BEANS	PROPORTION OF SAMP:BEANS..2:1		SS = 60	SS= 123			
RICE, WHITE			SS = 30 TBS=10	SS = 78 TBS=25			
STYWEPAP			SS = 71	SS= 100			
BABY POTATOES, BOILED + SKIN	36X37X25mm	22			16		26 (50mm)
ROAST POTATOES	60x45x33mm	70					
BAKED BEANS IN TOMATO SAUCE			SS=57 TBS=25	SS=99	TBS=25		
CABBAGE, FRIED			SS=44	SS=75			
CARROTS, BOILED RINGS			SS=48	SS=87			
GEM SQUASH, HALF	85mm diameter	96					
GREEN BEANS,BOILED	1 bean	5.58	SS=44	SS=98			
MIXED VEGETABLES, FROZEN , COOKED			SS= 49	SS=101			
PEAS, FROZEN, COOKED			SS=40 TBS=15	SS=81 TBS=30			
PUMPKIN COOKED WITH SUGAR AND PU MARGARINE			SS=71 1/4 CUP = 52.5	SS=129			
COLESLAW + MAYONNAISE			SS=44 TBS=20	SS=93			
FRENCH SALAD, NO DRESSING			SS=45 1/2 CUP=70	SS=85			
TOMATO/ONION SALAD	1 TOMATO SLICE 55mmx5mm (Diam)	10					

FOOD ITEM	SIZE/DESCRIPTION	ONE UNIT	1 L	1 H	LITTLE	MED	PLENTY
GRAVY			TBS=15 SOUP S= 10				
TOMATO/ONION SAUCE			DSP=25 SS=72	DSP=43			
SALAD DRESSING, FRENCH AND LOW OIL			TSP=3 DSP=7 TBS=15				
APPLE	52x66mm(Diam)	147			80	100 Diam=711 3 Diam=8	220
BANANA, , peeled	120x27mm(Diam)	75 (unpeeled= 120)			50		100
GUAVA,	60x55mm (Diam)	95			50		130
NAARTJIE, peeled	55x44mm (Diam)	75 (unpeeled=90)			50		120
ORANGE, peeled	65x70mm (Diam)	180 (unpeeled=25 5)			120 (174) 55mm		280 (395) 80mm
PEAR	80x68mm (Diam)	165			100		(220
CANNED PEACHES, SLICES, MEDIUM SYRUP	1 peach segment	10	1/2 CUP=125	SS=70			
IDEAL MILK			SS=30 TBS=14 1/2 CUP=130				
SUGAR			TSP=4	TSP=6			

APPENDIX D: KIT INCLUDING THE FOOD MODELS USED AS REFERENCES:

NASCO models:
1 cup stew (240 ml)
85 g roast beef sliced
85g hamburger patty
28g pork sausage
42g vienna sausage
113g lamb chop
48g pork chop fried
57g ham
85g sirloin steak
28g broiled bacon
10 g bacon slice
85g haddock
85g fried chicken breast
85g fried chicken wing
85g chicken drumstick
85g fried chicken thigh
canned tuna (60 ml)
cheese pizza
bran muffin
bread (25g)
cottage cheese (60 ml)
mashed potato (1/2 cup)
60g chips
3 oz candy bar
cup cake
15 ml peanut butter
1 c chocolate pudding
240 ml skim milk

FOAM MODELS, REAL FOOD AND HOUSEHOLD MEASURES
pizza
sausage roll
tart
meatball
30g cubes
20 sliced cheese
patty
pie 17mm
polony
mug 340 ml
glass
spoons and ladles
ruler
popcorn
oats

actual bread
margarine
knife
water jug
actual fresh fruit

APPENDIX E

QUESTIONNAIRE TO BE COMPLETED AT INTERVIEW | **FOR OFFICE USE**

INTERVIEWER:____________________ DATE:____________________

Participant Name:____________________ ____________________
First name and middel name Last name

Participant address:____________________ ____________________ __________
Street Suburd Code

Tel no: (h)____________________ (w)____________________

Main meal (when do you eat the most): (1) or (2) or (3) or (4)................

(1) Evening (after 5pm) (2) Midday (12-2 pm) (3) Breakfast (up until 9am)

(4) in between

Special Diet: (1) Halaal (2) Kosher (3) Vegetarian

SOCIO-DEMOGRAPHIC AND URBANIZATION INFORMATION:

1. Age :
Date of birth ☐☐ ☐☐ ☐☐
Day Month Year

2. Place of birth

____________________ ____________________
(Village/Town) (District)

3. Where did you spend most of your childhood (up to 10 years)? 1) 2) 3)4)
(1) = rural village (2) = a farm (3) = small town (4)= large town/city

4. When did you first begin to live in a city or a large town?
☐☐ ☐☐ ☐☐
Day Month Year

5. Have you spent any time periods away from the city, for at least a full year without a break, since you first arrived? (1) = Yes (2) = No

If yes, : Place Length of time (Yrs)
1 . ____________________
2. ____________________
3. ____________________
4. ____________________
5. ____________________
Total: ____________

INTERVIEW QUESTIONNAIRE CONTINUED.........

FOR OFFICE USE

6. What is your home language? ______________________________

7. Cultural ethnic group? ______________________________

8. What is the highest standard you passed at school?
(1) = no educational qualifications
(2) = Sub A - Std 1
(3) = Std 1- Std 4
(4) = Std 5
(5) = Std 6 or Form I
(6) = Std 7 or Form II
(7) = Std 8 or Form III or NTC I
(8) = Std 9 or Form IV or NTC II
(9) = Std 10 or Form V or NTC III

9. Do you have any other training or education?
(1) = Yes (2) = No

IF YES, indicate the highest qualification:
(1) = Formal training after school (eg NTC Dipl, IV or V nursing) - specify______________________________
(2) = Graduate training specify ______________________________
(3) = Postgraduate training or education specify ______________________________
(4) = Informal training specify______________________________
(5) = Other specify ______________________________

10. Job Classifaction Mark 1 or 2 or 3
(1) = if employed, Specify job______________________________
work hours/week ______________________________
(2) = casually employed ______________________________
work hours/week ______________________________
(3) = if unemployed
for how long □□ □□
mm yy
are you looking for work (1) = Yes (2) = No

11. How do you get paid?
(1) = weekly (2) = monthly (3) = ad hoc (4) = not applicable

12. How many people currently live in your household?

1 2 3 4 5 6 7 8 9 10 +10

INTERVIEW QUESTIONNAIRE CONTINUED........................

FOR OFFICE USE

13. With whom do you live? (Mark all that apply) (1) (2) (3) (4) (5) (6)
(1) alone (2)with husband/partner (3) with 1 or more children (4)with 1 or more parents (5) with other family (6)with 1 or more friends

14. Do you do the food shopping? (1) = Yes (2) = No

15. Do you do the food preparation? (1) = Yes (2) = No

16. What type of dwelling do you live in? (1) or (2) or (3) or (4) or (5)
(1) Formal housing (2) Informal shack-shelter (3) Hostel
(4) other.......specify ______________________________

....

PARTICIPANT NAME..

ANTHROPOMETRY

17. Weight.............Height .... BMI ....

18. Waist....... Hip.......... Ratio: ....

19. Bioelectrical impedence: LBM .... FM ....

NAME OF PARTICIPANT:__________________________________

QUESTIONNAIRE 2. FOOD FREQUENCY TO BE COMPLETED AT HOME AND TO BE RETURNED AT 2ND APPOINTMENT.................
DATE OF APPOINTMENT: ___________________________

In the last week (or if you have not had the item inthe last week) then in the last month, how many times have you eaten a serving of the following at your MAIN MEAL?:

		OR	OR
FOOD	NO OF TIMES/WEEK	NO OF TIMES/MONTH	NEVER
eggs			
yellow or hard cheese eg cheddar/edam			
cheese (on/in food eg pizza, pasta, quiche)			
camembert, feta			
low fat yellow cheese eg mozzarella			
low fat cottage cheese or ricotta			
fried fish			
other fish: (fresh and canned)			
fried chicken (eg Kentucky)			
other chicken (excluding chicken feet)			
chicken skin			
beef, mutton, pork (incls. mince,sausages)			
offal (including tripe, pootjies)			
cold meats (polony, viennas)			
the fat on meat			
pie (eg meat/chicken)			
vegetarian pie			
nuts (eg peanuts/peanut butter)			
dried beans, peas, lentils			
potato/ mashed potato/sweetpotato			
hot chips/roast potato			
rice			
spaghetti, pasta/noodles			
bread			
samp			
soup			
fresh fruit			
canned fruit			
pudding/dessert			
gravy (from drippings)			
cream (in food preparation)			
regular salad dressing			
low oil salad dressing			
added fat to to your vegetables (marg,oil)			
TIMES THAT YOU HAD MILK/DAY:	**********************	************************	******************
full cream milk			
low fat milk			
skim milk			

FOR OFFICE USE

QUESTIONNAIRE 2, CONTINUED.....

2. Which of the following do you mostly use on bread and in food preparation?

	on bread	in food preparation	never use
butter			
hard margarine (brick)			
soft margarine (tub)			
white margarine (holsum)			
oil			
lard/ dripping			

3. Do you drink anything with your main meals?
IF YES, What____________________________________

4. Who plates/dishes up the food?

____

5. How often do you eat 2 or more vegetables at a main meal (not including potatoes and salad?)________________________________

PARTICIPANT NAME: ________________ **DATE:** ________________ | **FOR OFFICE USE**

QUESTIONNAIRE 3. TO BE COMPLETED AT 2nd APPOINTMENT BY INTERVIEWER......INTERVIEWER..................................

1. What constitutes/describe a typical main meal?

____

____

____

2. What about, fruit?______________________________

dessert?______________________________

salad?______________________________

recipes/food preparation?______________________________

ANYTHING ELSE?______________________________

3. Which option (1 or 2 or 3 or 4 or 5) best describes your plate of food at a main meal...(ie what is there more of on your plate)?

	(1) =	or (2)
MOST OF	vegetables	..................ditto.....................
LESS OF	meat/chicken/fish	rice/potato/pasta/samp/bread
LEAST OF	rice/potato/pasta/samp/bread	meat/chicken/fish
	or (3) =	or (4) =
MOST OF	rice/potato/pasta/samp/bread	...............ditto..................................
LESS OF	vegetables	meat/chicken/fish
LEAST OF	meat/chicken/fish	vegetables
	or (5) =	or (6) =
MOST OF	meat/chicken/fish	....
LESS OF	rice/potato/pasta/samp/bread	vegetables
LEAST OF	vegetables	rice

4. Does your diet change during the month? (eg beginning of month, end of month, during the month/ or during winter/summer?)

Explain..

....

5. What do you snack on between meals? (cues for : crisps/biscuits/sweets/chocs/fruit/dried fruit/bread/crackers....)

____

____

24 HOUR RECALL PARTICIPANT NAME______________________DATE_______________
INTERVIEWER:________________________________

TIME	FOOD ITEM	AMOUNT	PREPARATION	PLACE

QUESTIONNAIRE 5... PARTICIPANT NAME :.. FOR OFFICE USE

INTERVIEWER DATE ....

ATTITUDES/KNOWLEDGE/WEIGHT HISTORY

1. Do you agree with the following statements:

1. Starchy food, like bread, potatoes and rice, make people fat. (1) =Yes (2) =No
2. What you eat can make a big difference in your chance if getting a disease, like heart disease or cancer. (1) = Yes (2) = No
3. The things I eat and drink now are healthy so there is no reason for me to make changes. (1) = Yes (2) = No

2. Compared to what is healthy, do you think your diet is (1) =too low, (2) =too high, or (3) = about right in:

1) Energy (calories/kilojoules) (1) or (2) or (3)
2) Protein (eg meat/chicken/fish/legumes..) (1) or (2) or (3)
3) Fat (eg butter/margarine/oil) (1) or (2) or (3)
4) Sugar and sweets (1) or (2) or (3)
5) Fruit (1) or (2) or (3)
6) Vegetables (1) or (2) or (3)
7) breads, cereals, rice and pasta (1) or (2) or (3)

3.Based on your knowledge, circle which has more fat:

	(1)		(2)
1.	peanuts	or	popcorn
2.	yoghurt	or	sour cream
3	skim milk	or	whole milk
4	coke	or	whole milk
5	1 small bran muffin	or	1 slice of wholewheat bread
6	a piece of toffee	or	a boiled sweet

4. **Do you consider yourself :**
(1) = overweight or (2) = underweight (3) = ideal

5.Would you like to change your weight? (1) = Yes (2) = No

6. What do you consider your ideal weight to be? ....

7.What does your boyfriend/husband think of your shape?
(1) = Just right (2)= Too large (3) = too lean

8.Do you smoke? (pipe/snuff?)
(1) = Yes (2) = No
If yes, how many...................

9.. Do you drink alcohol?
(1) = Yes (2) = No
How much during week............
How much on weekends..............

11.Method of contraception..................................
How long..

12.Currently lactating/breastfeeding
(1) = Yes (2) = No

APPENDIX - F

Quantities of foods selected & recalled by the subjects

GROUP 1

#	FOOD	EATEN WT (g)	RECALL WT (g)
1	veg soup	152	130
	chicken	133	85
	rice	122	90
	mixed veg	61	65
	cnd peaches	117	110
	ideal milk	23	50
	tea	125	125
	milk	70	65
	sugar	10	10
	tom/onion sauce	50	40
2	chicken	139	160
	rice	63	93
	mixed veg	66	100
	cand peaches	91	90
	ideal milk	41	15
	coke	226	200
3	veg soup	144	100
	mince	83	67
	rice	61	30
	potatoes	48	48
	mixed veg	52	101
	cand peaches	106	60
	ideal milk	34	50
	tom/onion sauce	23	0
	coke	164	160
	coffee	133	140
	milk	23.79	50
	sugar	13.65	10
4	veg soup	190	200
	chicken	136	85
	rice	102	60
	potatoes	53	0
	mixed veg	56	49
	cnd peaches	117	125
	ideal milk	21	0
	coke	255	240
	tom/onion sauce	55	0
5	chicken	95	85
	rice	33	22
	potatoes	22	32
	mixed veg	67	0
	cand peaches	98	50
	ideal milk	34	16
	tea	181	250
	milk	46	0
	sugar	12	0
6	chicken	59	21
	rice	100	45
	potatoes	42	32
	mixed veg	66	49
	apple	118	110
	water	254	160
7	veg soup	179	180
	chicken	87	95
	potatoes	79	80
	mixed veg	71	49
	salad	103	100
	sal dressing	5	7
	cand peaches	140	120
	tab	197	200
8	veg soup	87	80
	mince	69	42
	rice	66	30
	mixed veg	72	49
	salad	82	70
	sal dressing	10	15
	cand peaches	81	60
	coke	188	180
9	veg soup	205	250
	chicken	131	146
	potatoes	34	32
	mixed veg	55	101
	cand peaches	93	85
	ideal milk	26	15
	orange	179	0
	coke	277	0
10	veg soup	111	125
	chicken	92	128
	rice	47	117
	potatoes	33	32
	mixed veg	36	49
	salad	31	80
	sal dressing	8	5
	cand peaches	113	160
	ideal milk	13	15

Chicken = roast chicken

Mince = savoury mince

APPENDIX - F
Quantities of foods selected & recalled by the subjects
GROUP 2

#	FOOD	EATEN WT (g)	RECALL WT (g)	#	FOOD	EATEN WT (g)	RECALL WT (g)	#	FOOD	EATEN WT (g)	RECALL WT (g)
1	tuna lasagne	219	221	5	roast chicken	79	85	9	chicken	125	128
	french salad	68	90		potatoes	54	38		potatoes	48	40
	lite salad dressing	20	7		mixed veg	46	49		mixed veg	83	98
	coffee	162	180		french salad	56	45		french salad	73	90
2	veg soup	141	190		lite dressing	4	4		lite dressing	10	5
	roast chicken	98	85		coffee	178	180		coffee	170	190
	potatoes	48	0		sugar	3	2		sweetener	1	1
	mixed veg	59	0		lf milk	38	30		lf milk	33	50
	french salad	45	45		grape juice	85	120	10	veg soup	241	200
	lite salad dressing	7	7	6	tuna lasagne	247	165		tuna lasagne	108	110
	apple	153	147		mixed veg	111	152		potatoes	57	38
	tea	101	130		french salad	69	140		mixed veg	47	76
	sugar	8	8		lite dressing	14	8		french salad	42	43
	milk	27	30		apple	141	147		coffee	150	120
3	tuna lasagne	142	184		orange juice	325	400		lf milk	36	100
	potatoes	75	57	7	veg soup	162	148	11	brown bread	32	34
	french salad	64	90		tuna lasagne	144	184		hard marg	6	6
	lite dressing	14	8		mixed veg	57	49		tuna lasagne	201	184
	tea	169	200		french salad	71	140		mixed veg	60	49
	low fat milk	30	12		naartjie	109	104		banana	50	75
4	tuna lasagne	242	261		orange juice	375	190		coffee	147	180
	french salad	50	90	8	chicken	50	45		sugar	4	4
	french dressing	19	18		tuna lasagne	104	110		skim milk	31	30
	tea	157	250		potatoes	30	20		orange juice	89	100
	sugar	5	5		mixed veg	57	0	12	mixed veg	50	0
	full cream milk	25	50		french salad	41	45		french salad	131	140
					lite dressing	8	10		naartjie	243	207
									water	113	0

Chicken = roast chicken **Potatoes = baby potatoes**

APPENDIX - F
Quantities of foods selected & recalled by the subjects
GROUP 3

#	FOOD	EATEN WT (g)	RECALL WT (g)	#	FOOD	EATEN WT (g)	RECALL WT (g)	#	FOOD	EATEN WT (g)	RECALL WT (g)
1	chicken	123	95	4	chicken	74	70	7	chicken	102	95
	roast potatoes	76	97		roast potatoes	29	29		roast potatoes	55	85
	rice	39	18		rice	64	20		rice	29	78
	pumpkin	57	53		peas	36	30		pumpkin	34	30
	peas	35	82	5	veg soup	124	0		peas	51	40
	banana peeled	77	75		chicken	121	85		orange juice	216	180
	oros	50	30		roast potatoes	42	45	8	chicken	68	70
2	chicken	95	95		rice	55	45		roast potatoes	45	60
	roast potatoes	50	25		pumpkin	48	60		rice	46	30
	rice	40	38		peas	29	20		pumpkin	25	71
	pumpkin	67	0		apple	107	80		peas	38	40
	peas	19	68		oros	39	0		apple	108	113
	coffee	143	230		water	301	350		orange juice	175	200
	sugar	12	10	6	veg soup	102	80	9	veg soup	145	130
	low fat milk	48	0		chicken	82	85		br bread	29	34
	full cream milk	0	55		roast potatoes	53	50		soft marg	5	3
3	chicken	114	95		rice	51	30		chicken	134	120
	roast potatoes	25	35		pumpkin	49	71		rice	71	45
	rice	24	25		peas	35	40		peas	87	79
	pumpkin	35	53		apple	118	113		grape juice	168	215
	peas	20	15		coffee	137	150				
	apple	108	80		sugar	15	12				
	tea	113	160		lf milk	53	45				
	sugar	10	5								
	lf milk	58	80								
	orange juice	148	170								

Chicken = battered, fried chicken

APPENDIX - F
Quantities of foods selected & recalled by the subjects
GROUP 4

#	FOOD	EATEN WT (g)	RECALL WT (g)
1	white bread	33	0
	soft marg	9	0
	chicken	163	170
	baby potatoes	63	52
	rice	104	60
	gem squash	65	0
	baked beans	36	25
	coleslaw	105	88
	tomato/onion s	28	0
	gravy	20	30
	pear	175	165
	oros	96	50
	water	243	130
2	chicken	183	170
	baby potatoes	45	32
	coleslaw	78	44
	tomato/onion s	30	20
	pear	174	165
	oros	64	90
	water	123	90
3	white bread	33	30
	soft marg	9	5
	chicken	163	85
	baby potatoes	57	44
	gem squash	79	96
	baked beans	60	0
	coleslaw	81	93
	tomato/onion s	47	40
	gravy	12	0
	naartjie	59	75
	tea	132	110
	sugar	5	4
	lf milk	50	70
4	hard marg	4	0
	chicken	50	60
	baby potatoes	43	22
	gem squash	84	96
	coleslaw	27	40
	tea	153	150
	sugar	14	12
	low fat milk	33	0
	full cream milk	0	60

#	FOOD	EATEN WT (g)	RECALL WT (g)
5	chicken	133	133
	baby potatoes	5	0
	baked beans	43	29
	coleslaw	46	44
	tomato/onion s	21	15
	oros	66	40
	water	110	120
6	chicken	127	85
	baby potatoes	45	79
	baked beans	112	99
	coleslaw	87	66
	apple	111	100
7	chicken	70	85
	baby potatoes	18	16
	rice	34	15
	coleslaw	37	40
	water	117	150
	oros	33	50
8	chicken	69	43
	rice	49	78
	gem squash	109	96
	gravy	7	0
	naartjie	75	75
	water	147	130
	oros	26	50
9	chicken	145	110
	baked beans	70	98
	coleslaw	54	93
	tomato/onion s	34	35
	naartjie	69	75
10	chicken	97	128
	baby potatoes	63	66
	rice	68	60
	gem squash	99	96
	coleslaw	42	44
	tomato/onion s	17	15
	gravy	14	0
	pear	171	165
	water	124	130
	oros	43	50

#	FOOD	EATEN WT (g)	RECALL WT (g)
11	chicken	58	85
	baby potatoes	32	52
	rice	29	30
	coleslaw	37	44
	tomato/onion s	23	35
	gravy	3	0
	apple	116	113
	water	80	110
	oros	51	40
12	chicken	40	57
	baby potatoes	54	66
	rice	58	50
	gem squash	87	96
	coleslaw	62	60
	tomato/onion s	18	15
	gravy	5	14
	naartjie	59	75
	water	116	0
	oros	73	0
13	ww bread	40	37
	soft marg	4	5
	chicken	140	85
	baby potatoes	37	66
	gem squash	72	96
	tomato/onion s	28	35
	apple	114	120
	coffee	145	180
	sugar	15	12
	lf milk	36	20
	water	128	183
	oros	48	17
14	chicken	117	110
	rice	63	78
	baked beans	56	0
	coleslaw	70	66
	tomato/onion s	31	0
	gravy	12	30
	water	113	110
	oros	42	40

Chicken = roast chicken

APPENDIX - F
Quantities of foods selected & recalled by the subjects
GROUP 5

#	FOOD	EATEN WT (g)	RECALL WT (g)
1	chicken	62	60
	roast potatoes	56	35
	rice	65	0
	cabbage	31	44
	green beans	28	33
	carrots	32	48
	tom/onion sal	44	65
	gravy	7	0
	water	162	180
2	chicken	91	128
	roast potatoes	74	98
3	chicken	133	100
	roast potatoes	15	13
	cabbage	11	44
	carrots	36	35
	tom/onion sal	42	35
	water	127	120
	oros	26	40
4	chicken	67	70
	roast potatoes	38	0
	rice	33	25
	green beans	8	33
	carrots	55	48
	tom/onion sal	38	35
	gravy	5	10
	orange	246	280
	coffee	124	160
	sugar	10	6
	lf milk	66	40
5	chicken	171	170
	roast potatoes	81	79
	rice	61	78
	carrots	40	0
	tom/onion sal	80	55
	water	151	150
	oros	42	30

#	FOOD	EATEN WT (g)	RECALL WT (g)
6	ww bread	42	39
	soft marg	3	0
	chicken	136	170
	roast potatoes	50	39
	rice	25	0
	carrots	39	48
	tom/onion sal	42	45
	gravy	18	20
	orange	211	174
	water	122	90
	oros	58	80
7	chicken	181	170
	roast potato/rice	55	39
	rice	50	30
	carrots	17	24
	tom/onion sal	68	65
	gravy	9	15
	orange	250	280
	water	134	230
	oros	54	40
8	chicken	142	110
	roast potatoes	81	40
	rice	91	60
	cabbage	33	22
	carrots	7	24
	gravy	18	20
	orange	214	227
	water	152	155
	oros	30	35
9	chicken	133	125
	roast potatoes	49	0
	rice	57	30
	green beans	34	33
	carrots	53	48
	gravy	5	0
	apple	108	150
	water	141	150

#	FOOD	EATEN WT (g)	RECALL WT (g)
10	chicken	63	45
	rice	95	60
	cabbage	38	44
	carrots	55	48
	gravy	13	20
	apple	115	113
	tea	132	170
	sugar	10	8
	low fat milk	24	0
	full cream milk	0	30
11	chicken	185	175
	roast potatoes	80	50
	rice	97	156
	cabbage	47	74
	carrots	44	87
	tom/onion sal	80	45
	gravy	32	30
	apple	114	113
	water	145	160
	oros	27	40
12	chicken	115	85
	roast potatoes	37	0
	green beans	17	33
	carrots	30	48
	tom/onion sal	58	45
	naartjie	91	104
13	chicken	176	170
	roast potatoes	40	0
	cabbage	47	44
	carrots	55	48
	tom/onion sal	67	45
	orange	197	174
	water	256	130
	oros	66	80
14	chicken	159	142
	roast potatoes	51	50
	cabbage	38	22
	carrots	52	24
	orange	229	103
	water	161	150
	oros	15	30

Chicken = roast chicken

APPENDIX - F
Quantities of foods selected & recalled by the subjects
GROUP 6

#	FOOD	EATEN WT (g)	RECALL WT (g)	#	FOOD	EATEN WT (g)	RECALL WT (g)	#	FOOD	EATEN WT (g)	RECALL WT (g)
1	ww bread	40	39	5	cottage pie	238	273	9	cottage pie	124	102
	soft marg	6	5		rice	44	30		peas	34	40
	cottage pie	205	178		peas	46	48		carrots	48	48
	rice	37	20		carrots	38	40		mixed salad	47	140
	peas	30	26		mixed salad	18	20		tom/onion sal	45	35
	carrots	44	47		tom/onion sal	45	40		naartjie	101	104
	mixed salad	18	21		tea	149	150		mango juice	120	110
	tom/onion sal	17	15		sugar	10	8	10	tuna lasagne	153	110
	orange juice	106	100		lf milk	42	30		peas	40	20
2	ww bread	35	34		orange juice	145	150		mixed salad	26	70
	soft marg	6	8	6	ww bread	43	39		tom/onion sal	34	25
	tuna lasagne	196	221		soft marg	7	8		water	133	140
	peas	98	81		tuna lasagne	144	170	11	ww bread	43	39
	carrots	34	48		rice	28	15		tuna lasagne	200	138
	mixed salad	26	10		peas	27	40		peas	49	40
	tom/onion sal	97	45		carrots	44	48		carrots	51	48
	lite dressing	15	15		mixed salad	16	0		mixed salad	28	20
	tea	151	160		tom/onion sal	46	0		tom/onion	50	55
	lf milk	39	50		lite sal dress	6	0		water	169	165
	water	166	160		naartjie	91	104		orange juice	119	120
	oros	45	30		coffee	176	170	12	tuna lasagne	117	110
3	ww bread	40	39		sugar	4	4		rice	56	30
	soft marg	9	10		milk	39	40		peas	34	40
	cottage pie	307	300		mango juice	164	160		carrots	33	48
	mixed salad	30	70	7	tuna lasagne	116	110		mixed salad	29	20
	tom/onion sal	41	20		peas	43	40		tom/onion sal	26	25
	naartjie	100	104		carrots	26	48		mango juice	161	150
	tea	160	190		mixed salad	23	70	13	tuna lasagne	163	110
	sugar	12	10		lite sal dress	5	5		rice	23	30
	lf milk	23	20		apple	116	113		peas	39	40
	orange juice	225	200		orange juice	101	140		carrots	40	48
4	cottage pie	165	192	8	tuna lasagne	202	110		mixed salad	11	10
	carrots	51	48		peas	59	81		tom/onion sal	25	15
	mixed salad	27	45		carrots	47	48		coffee	141	180
	tom/onion sal	42	30		tom/onion sal	68	45		sugar	2	0
	orange juice	145	160		orange juice	114	100		low fat milk	44	30

APPENDIX - F
Quantities of foods selected & recalled by the subjects
GROUP 6

#	FOOD	EATEN WT (g)	RECALL WT (g)
14	cottage pie	89	152
	peas	35	40
	carrots	39	48
	tom/onion sal	65	45
	mango juice	163	160
15	tuna lasagne	173	192
	cottage pie	105	110
	peas	53	40
	carrots	51	48
	mixed salad	44	70
	tom/onion sal	85	55
	lite salad dress	15	30
	mango juice	178	180
16	cottage pie	136	240
	peas	33	40
	mixed salad	21	30
	tom/onion sal	49	35
	lite salad dress	4	5
	naartjie	92	104
	mango juice	167	170
17	cottage pie	156	101
	peas	34	40
	tom/onion sal	57	35
	apple	112	100
	mango juice	142	150
18	tuna lasagne	134	92
	peas	36	40
	carrots	29	48
	mixed sal	28	30
	tom/onion sal	39	35
	mango juice	180	200
19	cottage pie	19	20
	peas	39	81
	carrots	2	0
	mixed salad	6	6
	tom/onion sal	37	25
	salad dressing	4	10
	pear	161	0
20	tuna lasagne	114	74
	rice	32	15
	carrots	34	24
	naartjie	97	104
	coffee	117	150
	sugar	14	10
	low fat milk	45	40

APPENDIX - F
Quantities of foods selected & recalled by the subjects
GROUP 7

#	FOOD	EATEN WT (g)	RECALL WT (g)
1	ww bread	40	39
	soft marg	5	5
	chicken (no skin)	119	170
	peas	47	40
	carrots	45	48
	tom/onion sal	73	0
	pear	178	165
	orange	213	174
	water	204	180
2	chicken	110	85
	peas	58	19
	carrots	43	22
	cabbage	31	0
	tom/onion sal	64	35
	orange	150	120
	water	197	140
	oros	40	20
3	samp and beans	54	62
	chicken	200	175
	rice	34	20
	peas	41	9
	tom/onion sal	81	65
	orange	189	174
	rooibos	177	190
	sugar	12	8
4	chicken	157	130
	peas	43	40
	carrots	20	0
	cabbage	37	0
	tom/onion sal	68	25
	pear	167	0
	water	178	170
5	chicken	104	130
	rice	63	60
	peas	47	81
	carrots	39	87
	cabbage	41	43
	gravy	20	0
	apple	146	113
	water	181	180
6	chicken	145	130
	rice	79	60
	peas	44	81
	carrots	45	87
	cabbage	30	44
	tom/onion sal	30	35
	gravy	18	0
	orange	206	177
	water	135	140
	oros	52	40
7	chicken	64	45
	rice	94	45
	peas	37	40
	carrots	20	11
	gravy	19	0
	water	171	150
	oros	48	40
8	chicken(no skin)	170	173
	rice	32	37
	carrots	9	24
	cabbage	19	22
	tom/onion sal	33	0
	gravy	21	0
	orange	231	0
	water	159	150
	oros	71	70
9	ww bread	37	39
	soft marg	2	3
	chicken	92	100
	rice	59	30
	peas	79	40
	carrots	44	48
	tom/onion sal	41	35
	gravy	6	10
	water	168	159
	oros	41	21
10	chicken (no skin)	95	95
	rice	57	30
	peas	45	40
	carrots	12	48
	gravy	13	0
	coffee	157	170
	sugar	11	8
	lf milk	47	30
11	chicken	70	82.5
	rice	59	30.24
	peas	51	39.69
	tom/onion sal	14	0
	water	98	110
	oros	82	50
12	samp and beans	86	0
	chicken	94	0
	peas	18	0
	carrots	2	0
	tom/onion sal	22	0
	orange	190	0
	water	116	0
	oros	48	0
	bread	0	78
	hard marg	0	10
	cheese	0	100
	tea	0	250
	fc milk	0	80
	sugar	0	10
13	chicken	92	85
	rice	87	162.58
	peas	32	81.29
	cabbage	42	0
	tom/onion sal	50	45
	gravy	28	0
	water	135	120
	oros	58	40
14	chicken	101	90
	rice	80	81.29
	peas	60	39.69
	carrots	63	0
	apple	122	113
	water	149	150
	oros	33	50
15	chicken	96	85
	rice	100	30.24
	carrots	60	47.91
	cabbage	43	43.82
	tom/onion sal	66	0
	gravy	26	15
	water	169	190

Chicken = roast chicken

APPENDIX - F
Quantities of foods selected & recalled by the subjects
GROUP 8

#	FOOD	EATEN WT (g)	RECALL WT (g)
1	br bread	33	0
	soft marg	9	0
	samp&bean stew	105	60
	chicken	83	85
	carrots	30	24
	cabbage	30	22
	tom/onion gravy	35	0
	apple	114	113
	water	137	130
	oros	89	50
2	chicken	102	85
	stywepap	235	100
	carrots	72	87
	cabbage	51	44
	tom/onion gravy	62	0
	guava	97	95
	water	183	150
3	chicken	98	95
	stywepap	179	142
	carrots	44	43
	cabbage	39	74
	tom/onion gravy	49	30
	guava	92	950
	water	156	100
4	samp&bean stew	199	123
	chicken	64	48
	cabbage	62	44
	apple	113	0
	water	183	185
	oros	48	25
5	chicken	143	95
	stywepap	93	71
	cabbage	18	22
	tom/onion gravy	20	36
	water	81	50
	oros	34	30
6	chicken	96	128
	stywepap	104	142
	carrots	38	48
	cabbage	40	22
	tom/onion gravy	30	30
	apple	116	0
	coffee	140	120
	sugar	16	0
7	chicken	106	45
	stywepap	130	100
	carrots	81	87
	tom/onion gravy	55	72
	guava	101	0
	coffee	147	150
	sugar	17	15
	fc milk	35	70
	cabbage	0	74
8	chicken	110	95
	stywepap	108	150
	carrots	46	45
	cabbage	43	37
	tom/onion gravy	50	72
	apple	105	113
	water	214	250
9	samp&bean stew	140	123
	chicken	100	68
	stywepap	102	107
	carrots	37	24
	cabbage	44	0
	tom/onion gravy	59	72
	apple	114	113
	coffee	116	100
	sugar	14	10
	fc milk	69	90
10	chicken	122	45
	stywepap	138	200
	carrots	83	48
	cabbage	53	88
	tom/onion gravy	67	0
	apple	120	0
	water	210	0
11	samp&bean stew	27	246
	chicken	70	85
	stywepap	93	142
	carrots	2	48
	cabbage	45	44
	tom/onion gravy	33	36
	water	151	165
	oros	62	25
	apple	0	113
12	samp&bean stew	103	123
	chicken	74	67
	carrots	48	43
	cabbage	59	74
	apple	88	113
	coffee	132	160
	sugar	9	8
	fc milk	43	0
13	white bread	34	30
	soft marg	4	3
	samp & bean stew	215	123
	chicken	79	85
	carrots	67	87
	cabbage	79	74
	tom/onion gravy	72	72
	apple	111	113
	water	172	160
	oros	60	70
14	samp & bean	303	369
	chicken	114	130
	cabbage	11	0
	tom/onion gravy	64	144
	guava	92	95
	apple	98	113
	water	169	190
	oros	43	30
15	samp & beans	156	123
	chicken	91	0
	carrots	49	87
	cabbage	48	74
	tom/onion gravy	33	0
	water	167	180
	oros	68	50
16	br bread	61	60
	chicken	88	106
	carrots	45	96
	cabbage	64	88
	tom/onion gravy	43	72
	tea	100	110
	sugar	10	8
	fc milk	27	40
17	samp & beans	143	123
	chicken	88	85
	cabbage	48	74
	apple	108	113
	coffee	123	120
	sugar	16	12
	fc milk	68	70

Chicken = fried chicken

APPENDIX - F
Quantities of foods selected & recalled by the subjects
GROUP 8

#	FOOD	EATEN WT (g)	RECALL WT (g)	#	FOOD	EATEN WT (g)	RECALL WT (g)	#	FOOD	EATEN WT (g)	RECALL WT (g)
18	samp & beans	138	246	**21**	br bread	65	68	**23**	w bread	32	64
	chicken	50	85		hard marg	9	10		soft marg	4	10
	carrots	18	24		chicken	58	68		chicken	145	180
	cabbage	48	74		carrots	60	87		carrots	8	72
	rooibos	139	150		cabbage	49	112		cabbage	20	149
	sugar	10	8		tom/onion gravy	36	72		tom/onion gravy	15	150
19	samp & beans	123	0		guava	98	95		apple	110	113
	chicken	174	0		water	181	200		water	153	170
	carrots	33	0		oros	33	30		oros	86	80
	cabbage	61	0	**22**	chicken	84	85	**24**	samp & beans	22	30
	tom/onion gravy	41	0		stywepap	170	200		chicken	108	170
	water	154	190		carrots	79	48		stywepap	111	100
	oros	65	0		cabbage	80	66		carrots	42	24
	fish	0	170		tom/onion gravy	74	72		cabbage	41	22
	chips	0	60		apple	116	113		tom/onion gravy	46	72
	colddrink	0	340		water	119	180		apple	120	113
20	samp & beans	180	123		oros	50	40		water	124	140
	chicken	115	170						oros	60	15
	carrots	51	0								
	cabbage	5	0								
	tom/onion gravy	25	0								
	guava	102	95								
	tea	119	160								
	sugar	16	12								
	fc milk	18	40								

Chicken = fried chicken

APPENDIX G: 3 DAY FOOD RECORD

Please keep a record of all that you eat and drink for 3 days (2 weekdays and 1 weekend day). This should be done on the sheets provided in the following way. Record the foods as they are being eaten or as close as possible to the time that food is eaten.
NOTE: EAT THE WAY YOU USUALLY DO, PLEASE TRY NOT TO LET THE FACT THAT YOU ARE KEEPING A FOOD DIARY INTERFERE WITH YOUR USUAL EATING HABITS.

- Use a new page for each day.
- Write down the DAY, DATE and your NAME on each page.
- State what type of meal it is in the first column. Please use the following codes to determine what type of meal it is
  - MM = a main meal
  - LM = a light meal
  - S = a snack
  - UM = an unstructured meal
- In the second column, record the TIME and PLACE at which the food or drink was consumed.
- In the third column record the FOOD or DRINK item.
- A very detailed DESCRIPTION of the food consumed must be recorded in the fourth column.
- In the fifth column, the AMOUNT of food consumed must be recorded. This can be in WEIGHT (ounces or grams), VOLUME (eg 300ml coke), HOUSEHOLD MEASURE (eg 1 teaspoon), DIMENSIONS (eg 10cm boerewors or 1 small pizza 8cm diameter). If you are at a loss for words, DRAW the size of the food item on the back of the page.
- At the bottom of the page note any PHYSICAL ACTIVITY for the day.
- At the bottom of the page indicate whether or not this was REPRESENTATIVE OF YOUR NORMAL INTAKE.

PLEASE PAY VERY SPECIAL ATTENTION TO THE FOLLOWING:

- the type of milk consumed
  eg full cream, low fat (2%), skim, powdered (including brand name) or fresh
- the type of cheese consumed
  eg Cheddar, feta, creamed cottage or low fat cottage cheese or low fat edam
- the type of margarine consumed
  eg hard, soft or medium spread and whether it was spread thickly, medium or thinly
- whether the meat eaten was:
  - LEAN = no visible fat
  - MEDIUM FAT = prepared with visible fat removed
  - FATTY = prepared and eaten with visible fat
- whether fish eaten was canned in water or oil
- additions to foods, creams, sugar, etc.
  eg 70g spinach with cream added
  1 cup tea with 2 heaped teaspoons of brown sugar
- record commercial names where possible
  eg TRIM mayonnaise, CREMORA coffee creamer
- indicate whether amounts recorded are for the raw or cooked product

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