CHAPTER 2:

GENERAL METHODOLOGY

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AIM OF SURVEY

The aim of this survey was to collect baseline information on the food consumption patterns in children for the formulation of appropriate policy guidelines for food fortification, as well as for the development of appropriate nutrition education material for children in South Africa. The objectives of the survey were:

A. Primary Objectives:

- To determine usual food consumption of children aged 1 – 9 years (12 – 108 months) in South Africa
- To assess the usual nutrient intake of children aged 1 - 9 years in South Africa
- To identify factors impacting on food consumption
- To determine anthropometric status

B. Secondary Objectives:

Using the baseline data obtained from the primary objectives, propose/recommend:

- Appropriate food(s) for fortification
- Appropriate nutrition education material

Survey Design

A cross-sectional survey of a nationally representative sample of children aged 1 – 9 years in South Africa (see also Appendix: Protocol).

Survey population

The survey population comprised of all the children aged 1 - 9 years in South Africa. For this purpose, a nationally representative sample with provincial representation was selected using the Census 1996 information[1]. This implied that each child in the country had a known probability of being selected (self-weighting for the strata selected). This initial sample was adapted by means of 50% oversampling to accommodate for children that would not be at home at the time of the survey (approximately 25%), and for allowing an

overrepresentation of the children living in high-risk areas (approximately 25%) (low socioeconomic status) as well as the requirements of the 24-H-RQ in terms of the minimum recommended number of subjects.

Sample size

The stipulated number of children to be studied was originally 2200. However, in order to have a minimum of 50 observations per province and per urban/rural strata for the 24-H-R questionnaire, the number of children to be studied was increased to 2440 children. The sample was further increased to 3050 children (i.e. an increase of approximately 25%) to over represent children from high-risk areas. In order to ensure that this number of children (i.e. 3050) would be studied, the total number of children to be included in the sample was further increased to 3120 children to allow for children that would not be at home at the time of the survey.

Sampling strategy

First Stage: Selection of Clusters

An Enumerator Area (EA) was defined as the EA as drawn up for the 1996 Census. For financial and practical reasons, in formal/informal urban and tribal areas only EAs with at least 16 qualifying households were considered for inclusion in the sample, whereas in commercial farms only EAs with at least 6 qualifying households were considered for inclusion in the sample. EAs with hostels and special institutions as well as EAs classified as “other rural” in the 1996 Census were excluded from the sample. A qualifying household was defined as any household with at least one child aged between 1 to 9 years in it. All other qualifying EAs for the survey were randomly selected. A total of 156 EAs were included in the survey, 82 of which were urban and 74 non-urban. The distribution of EAs per province was determined proportionately to the distribution of the total population and the urban/non-urban distribution in each province (Table 2.1).

Table 2.1 Number of random EA's selected per province

	Number of EA's for Urban areas	Number of EA's for Non-Urban areas
KwaZulu/Natal	13	16
Gauteng	25	4
Eastern Cape	8	14
Northern Prov	4	14
Western Cape	14	4
North West Prov	4	8
Mpumalanga	4	6
Free State	6	4
Northern Cape	4	4
Total	82	74
Grand Total	156	

Second Stage: Selection of Households

After the maps of the relevant EA's were obtained, they were passed on to the respective fieldwork teams. An estimate was made of the total number of households (HHs) in each EA required in order to determine the approximate number of qualifying HHs with children within the prescribed age interval in the EA. An adapted version of "Snowball Sampling" was used to set up a partial sampling frame (see also Appendix: Training Manual). The "Snowball Sampling" method entailed the random selection of a number of HHs in each EA in which it was asked whether there were other HHs in the vicinity with children in the prescribed age range of the survey. These HHs were then recorded on the EA map. Ultimately, a list of qualifying HHs in the EA with children in the prescribed age range was drawn. From this list, the required number of households for the survey was randomly selected. Consequently, the following steps were followed:

A. For urban and peri-urban EAs:

Step One

A random starting point within each EA was selected. If this randomly selected HH had no children in the desired age range, then the fieldworker moved on to the next nearest household that had children in the prescribed age range. All the occupants of the HH were listed. If there was more than one child in the age range of 1-9 years, a "Random Numbers Table" (see also Appendix: Training Manual) was used to select ONE child in a given HH to be included in the survey. All the required questionnaires were filled in and all the required anthropometric measurements were taken. This HH was then considered as completed.

Once the survey in this given HH was completed, the occupants of the HH were asked whether they knew of other suitable HHs with children in the prescribed age range in the vicinity. There were now two possible options:

Option I: The occupants of the HH in which the fieldworker had just finished the survey might not know any other qualifying HHs in the vicinity. In such a case, the fieldworker proceeded to the next randomly selected HH in the EA and decided whether it qualified for the survey. The fieldworker continued doing so until he/she found the next qualifying HH in the EA and included it in the survey.

Option II: The occupants of the first randomly selected HH in the EA, in which the fieldworker completed the survey, did know of other qualifying HHs in the vicinity. These new HHs with children in the prescribed age range in them were recorded on the EA map. The fieldworker then went to these new HHs that qualified for the survey and ensured that they did have children in the prescribed age range.

Step Two:

The fieldworker then moved to another randomly selected HH in the EA and repeated step one above.

Step Three:

The first two steps in this process provided the fieldworker with a given number of randomly selected HHs in which the survey had already been

completed, as well as a list of qualifying HHs in the EA. The fieldworker made sure that the list of qualifying HHs he/she had created together with the completed HHs exceeded a total of 30 HHs and that the HHs selected were evenly spread throughout the EA. In the event that the fieldworker had not succeeded in obtaining a minimum total of 30 HHs after he/she had selected enough random points in the EA, an adjacent EA was selected. This was in order to fulfil the criterion of a cluster size of a minimum total of 30 HHs.

Step Four:

The listed HHs in which the fieldworker had not completed the questionnaires were numbered (i.e. if the fieldworker had already completed the questionnaires, say in 6 HHs, then he/she had to have at least 24 more HHs listed), from which 24 HHs a simple random sample was drawn. The survey in these randomly selected HHs was completed until the fieldworker had 20 completed HHs for which the questionnaires and anthropometric measurements had been completed (in the example above, the fieldworker only had to study 14 extra HHs from the ones that were randomly drawn for the list). The reason more than the required number of HHs was selected was to allow for:

- non-participation or for not finding anybody at home at the time of the visit, and subsequent SINGLE revisit
- a randomly selected child not being available at the time of the visit, and subsequent SINGLE revisit
- the HH selected not meeting the inclusion criteria for the survey.

A “Random Number Table” (see appendix; Training Manual) was provided for the random selection of the households, which contained random numbers between 1 and 30. If the fieldworker selected a number larger than the listed maximum (i.e. in the example above, 24), then this larger number was skipped and the following one on the “Random Number Table” was accepted that was equal to or smaller than 24.

B. For commercial farms and other rural EAs:

In the case of commercial farms (and sparsely populated rural or tribal areas), a small number of farms with equal probability was drawn using a Random Number Table. From these farms, all qualifying HHs were listed, and from these HHs a simple random sample of a total minimum of 30 HHs was drawn so as to ensure that 20 HHs were included in the survey.

Third Stage: Selection of Children within Households:

One child only in each randomly selected HH was included in the survey. If there was more than one child present in the prescribed age interval in a HH, then all children in the HH in age order were numbered, so that a single child could be selected at random. This list was then used to randomly select one child for inclusion in the survey using a specially designed “Random Number Table”.

Implementation of the Survey

The survey was implemented nationally between February and July 1999. The same procedure was followed at every HH included in the survey by each fieldworker. Essentially, a fieldworker visited each randomly selected HH and the mother or caregiver of the subject was interviewed according to the following procedure:

- The fieldworker introduced herself/himself and explained the purpose of the survey
- The interviewee was reassured regarding the confidentiality of the data and requested to answer the questions truthfully
- An informed consent was obtained
- The socio-demographic questionnaire was completed
- The anthropometric assessment of the child was undertaken
- The 24-H-R Questionnaire was completed
- The Food Frequency Questionnaire was completed
- The Food Procurement and Household Inventory Questionnaire (in every high-risk HH as well as one randomly selected HH in other EAs) was completed

- The Hunger Scale Questionnaire was completed.

All questionnaires were completed by the fieldworkers with the exception of the hunger scale, which was filled in by the mother/caregiver. Fieldworkers had master copies of questionnaires in the local languages.

Pilot study

All provinces in the first instance carried out a pilot in one urban and one non-urban EA. The pilot study also incorporated the exercise for the validation of the questionnaires. Once the pilot had been completed, the director, the coordinator, the team leader and the fieldworkers jointly addressed any points that needed to be attended to before the survey proper began. If no problem areas were identified during the pilot phase of the survey, then the survey proper could be started immediately.

Training

A set of questionnaires (see also Appendix: Questionnaires), a training manual (see also Appendix: Training Manual) and a video (See also Appendix: Video script) were specifically developed for the survey. These instruments covered all aspects of the survey, including the survey methodology, and were used for this purpose.

Training of coordinators

One dietitian/nutritionist was appointed as coordinator for each province. Two of the provinces with the largest number of EAs (KwaZulu/Natal and Gauteng) employed two coordinators. All coordinators were trained centrally in a four-day workshop by those directors who coordinated the development of specific areas of the survey:

- Design and sampling : D Labadarios, TJvWKotze
- Sociodemographic data : D Labadarios
- Anthropometry : D Labadarios
- Dietary interviews : NP Steyn

- Food models : NP Steyn
- 24-H-RQ : NP Steyn
- QFFQ : U MacIntyre
- FPHIQ : E Maunder
- Hunger scale : G Gericke

The objective of the workshop was to address all aspects of the survey, including the training of fieldworkers. The workshop also included a number of exercises/tasks in order to ensure as comprehensive an understanding of the logistical and practical issues as well as expectations involved in the implementation of the survey as possible. Practical and appropriate suggestions for the improvement of the tools to be employed in the survey were incorporated in the finalisation of the survey tools.

Training of team leaders and fieldworkers

Fieldworkers, recruited locally from each province, according to the prevailing circumstances and needs of each province, implemented the fieldwork under the direct supervision of the coordinator/team leader. The fieldworkers spoke the local language and had some previous nutrition training. They underwent extensive (5 – 6 days) training regarding the survey methods and the survey tools. The pace of training was adapted according to the capabilities of the fieldworkers. The training, at provincial level, was conducted by an experienced dietitian/nutritionist (the coordinator), who had herself/himself been trained by an expert group (the directors of the survey). In order to standardise the training as much as possible, practical exercises and tests were included. In this regard, after the completion of the section on the 24-hour recall all fieldworkers were required to complete a written test. This test required the interviewers to complete 3 typical interviews with a caregiver and to record the responses on 3 separate questionnaires. The questionnaires were then checked by the coordinators and any mistakes/errors were discussed with the fieldworker, as appropriate. Where necessary, relevant sections of the questionnaires were revised. Similarly, after completion of the section on the food frequency questionnaire a written test was also

completed. The same procedure was followed for the remainder of the questionnaires. Fieldworkers who did not reach minimum set standards did not participate in the survey. Fieldworkers, who performed best in these tests and also displayed organisational and interpersonal skills during the training were appointed as team leaders. Additionally, the expert on QFFQ methodology visited each province during the training of the fieldworkers in order to ensure uniformity and to standardise any outstanding issues. This was done because the training of the coordinators indicated that most queries were around the correct completion of this questionnaire. Each fieldworker evaluated the training they received by means of a questionnaire and additional training was given as necessary.

Questionnaires

The following questionnaires, completed in the sequence given below, were designed, tested, validated and used in the survey (see also Appendix: Questionnaires):

The Sociodemographic Questionnaire (S-DQ) provided information on factors relevant to the household regarding the environment in which the child lived

The 24-Hour Recall Questionnaire (24-H-RQ) provided information on the current diet and eating pattern of the child

The Quantitative Food Frequency Questionnaire (QFFQ) provided information on the eating patterns and intake over the previous six months for children older than two years and over one month for children aged between 12 and 23 months. Consequently seasonality effects could be observed

The Food Procurement and Household Food Inventory Questionnaire (FPHIQ) provided information on purchasing patterns and storage of food, which is believed to be essential for policy formulation on food fortification. The Food Procurement section of the questionnaire was completed in all HHs, whereas the Food Inventory section was completed in all HHs in high-risk areas as well as one randomly selected HH in all other EAs

The Hunger Scale Questionnaire (HSQ) provided information on the caregivers' perception of whether hunger was experienced in the HH and by the child.

In order to assist the fieldworkers in quantifying the portion sizes of foods eaten by children, a specially designed kit with food model aids was used for the quantification of food throughout the survey. This kit included wax and foam models of commonly eaten food items, household utensils, dry food (e.g. beans) as well as empty containers. Each fieldworker had been trained using the video and also had a manual with detailed information regarding the correct and standardised completion of all the questionnaires.

Training Instruments:

Training manual

The training manual (see Appendix: Training Manual) was designed to provide each fieldworker with detailed instructions on the:

- Selection of households
- Selection of children within households
- Self introduction at the household
- Interviewing techniques
- Anthropometric measurements
- Filling in of the questionnaires.

Food model aids

The use of food model aids in dietary surveys is generally recommended as essential, since they greatly reduce the frustration of respondents who had formerly searched for words to describe volume, size and weight of food items[2]. In the present survey, food model aids were designed and made according to a modified version of Moore et al[2]. In addition to the food models, which were made from paraffin wax, other dietary aids such as spoons and cups were included in the kit. These dietary aids were used during all 24-hour recall and food frequency interviews. Each fieldworker was supplied with a comprehensive kit, which included the following items:

- 3 x maize wax models (½ cup, 1 cup and 2 cups)
- 3 x meat models (30g, 60g and 100g)
- 1 x vegetable wax model (½ cup)
- 3 x wax bread slices (10mm, 20mm and 30mm thick)
- 1 x average fruit portion
- 1 x plastic container containing 500ml dry beans
- 1 x plastic container containing 500ml dry maize meal
- 1 x set measuring cups
- 1 x set spoons (1 serving spoon, 1 teaspoon, 1 tablespoon)
- 1 x enamel cup with measures indicated
- 1 x plastic glass with measures indicated
- 1 x enamel plate to place models on
- 1 x plastic measuring jug
- 1 x baby bottle
- 1 x ruler
- 1 x clipboard and stationary
- 1 x shoulder bag to carry the dietary aids
- empty containers and packets of food items locally used.

The type of dietary aids included in the kit were selected after carefully considering the foods commonly eaten by children[3-9] of all ethnic groups in South Africa. The two most commonly consumed staple foods were found to be maize porridge and bread. Consequently, 3 different portion sizes of each of these items were included in the kit.

The food model aids were made by melting paraffin wax and stirring in dry food ingredients such as samp or rice. Melted crayons were added to the vegetable and meat models to add colour. The mixture was then decanted into moulds, according to the predetermined volume sizes. Dry cereals (maize meal) and beans were added to the kit in order to add flexibility in determining various portion sizes. These were poured onto the plate provided and then measured with a volume measure.

Training video

Because of the relatively large number of questionnaires used in this survey and the complexity of the procedures, it was felt that a training video was necessary in order to ensure complete understanding and standardisation of the required procedures across all the provinces. Consequently, a video (see Appendix: Video Script) of 2 and one quarter hours duration was developed and used in the training of the coordinators and in all the provinces in the training of fieldworkers.

The video incorporated a step by step guide to filling in all the questionnaires and to doing the anthropometric measurements. It also included detailed procedures in the following order:

- ***The introduction:*** This explained the purpose of the survey and included the responsibilities of the fieldworker. It also prepared the fieldworker on how to conduct the interviews and provided information on interviewing skills
- The socio-demographic questionnaire was explained
- The anthropometric measurements were demonstrated
- The dietary aids were demonstrated and their use in determining portion sizes were clarified
- The 24-hour recall interview and questionnaire were explained
- The food frequency interview and questionnaire were explained
- The food procurement and household inventory interview and questionnaire were explained
- The hunger scale interview and questionnaire were explained

Each section included practical exercises for the fieldworkers to do. Upon the successful completion of a particular section of the video, the fieldworkers were required to complete some practical exercises before proceeding to the next section.

Anthropometric Assessment

Each subject was anthropometrically examined by a trained fieldworker using standardised and internationally described methodology[10]. The following measurements were taken of each child:

- Weight
- Height
- Mid-upper arm circumference, and
- Head circumference.

The latter measurement was only taken if children were younger than 3 years of age. Each fieldworker was equipped with a portable electronic scale and a standard weight for standardising the scale, measuring board, stadiometer and a measuring tape, in order to carry out the examinations (see also Appendix: Training Manual).

Quality Control

This integral part of the study was implemented for the QFFQ and anthropometric measurements in 2 HHs for each EA (see Appendix: Training Manual). Essentially, the coordinator selected 2 HHs randomly after all the 20 HHs that were included in the survey had been selected. During the pilot stage of the survey, the HHs that were selected for the quality control exercise could not be the same as those selected for the validation exercise. In the two randomly selected HHs the QFFQ and the anthropometric measurements were completed again on the same day, but this time by the coordinator or the team leader. The quality control exercise was implemented in every EA and in every province.

Validation of the questionnaires

Reproducibility

Reproducibility is the extent to which similar information is obtained when a measurement instrument, in the case of dietary surveys a food frequency questionnaire, is administered to the same individual on two or more

occasions under similar conditions[11,12]. Validity is the degree to which a measuring instrument reflects the true value of the desired characteristic without contamination by random or systematic errors[13,14]. Thus, in relation to dietary assessment, for an assessment instrument to be valid, here the QFFQ and the 24-H-RQ, it must measure the aspects of diet it was intended to measure[15-17]. The determination of both the reproducibility and the validity of a dietary assessment instrument are an essential part of the development of the instrument. This is necessary in order to, firstly, identify problems within the instrument so as to make necessary adjustments and, secondly, to aid in the interpretation of the results of a dietary assessment study.

In terms of reproducibility, there are two underlying assumptions that need to be considered. First, is the assumption that food intake and factors affecting food intake, such as seasonal variation, have not changed during the time between repeated administrations of the instrument[18]. The repeat administrations of the instrument should be far enough apart so that the respondents cannot remember specific responses from the first to the second administration, but close enough together so that changes in usual dietary intakes are small[14]. The second assumption is that measurement errors are not correlated, i.e. errors occurring in the second administration are not related to those that occurred in the first administration[11]. Part of the measurement error, however, may be correlated between the two measurements with the same instrument, giving spuriously high correlation coefficients[19]. This may occur, for example, when a subject interprets ambiguous wording of a question or misunderstands a portion size in the same way on both occasions.

A review of test-retest correlation from reproducibility studies with one repeat administration of the food frequency questionnaire since 1990[20] has shown a wide range of such correlations ranging from a low of 0,26 for iron with a 12 month interval between administrations[21] to a high of 0,97 for protein after a one week interval[22]. Thus, it seems that the longer the interval between administrations, the weaker the correlation and that reproducibility varies for

different nutrients. Unfortunately, from the point of view of this survey, no reproducibility studies in child populations could be found in the literature.

Relative validity

In terms of the present survey, validity should answer the question “does the QFFQ and the 24-H-RQ measure the actual food, energy and nutrient intake of South African children”. Validity has two implicit components: the first is that the instrument does measure what it is meant to, and, the second, is that the measurements are accurate, i.e. reproducible[13]. Clearly, to be valid, the instrument must have a satisfactory level of reproducibility. On the other hand, the instrument may be highly reproducible but not valid [13,23].

Validation of a dietary assessment instrument implies that the true intakes of the study population are known[24]. True dietary intakes of individuals, however, can never be known with absolute certainty. For example, even if the results of food intakes measured by unobtrusive, accurate weighed observations compare well with food records kept by the subjects over the same period, there is no guarantee that the observed intake represents the usual diet[16,24]. Since the truth is never completely known, validation studies compare one method with another method deemed to be superior[23]. Consequently the term ‘relative validity’ is preferred[25,26] and will be used for the present study.

Relative validation involves the comparison of a less established or less detailed method such as a food frequency questionnaire against a more detailed or more established method such as weighed records[23,27]. The more established method is assumed to provide more accurate estimates of food intake within a study population and is taken as the standard against which the new method is compared[27]. Since no method of dietary assessment is perfect, it is important that the errors of the test and reference measure be independent to avoid spuriously high estimates of validity[23,25,28]. For example, both 24-hour recalls and food frequency questionnaires are subject to the similar errors of memory, understanding and portion size perception, and thus their comparison may not give an accurate reflection of the relative validity of either one[23,29]. A number of ‘reference’ methods for testing the relative validity

of food frequency and the 24-hours recall questionnaires have been described in the literature. The most common ones, with particular emphasis on their applicability to the present survey, include:

- ***Duplicate food portions:*** Although theoretically this is considered to be the most accurate method[30] of assessing dietary intakes, the cost of chemically analysing duplicate portions of food and the reported underestimation of the habitual dietary intakes[31] precluded the use of this method in the present survey. An additional motivation for excluding this method was the expected low literacy level of the survey population
- ***Direct observation:*** This option was also not considered as practical, despite the fact that it has been previously used in children[32], because of its known disadvantages[33,34]. The latter include the recording of foods eaten only during the presence of the observer, the possible altering of the normal food behaviour of the respondent because of the presence of the observer, and the possible altering of the normal household practices to facilitate measuring. In addition the personnel cost of such studies is high in terms of training, time and remuneration
- ***Dietary records*:** This is the most frequently used reference method in validation studies[23]. A serious attempt was made to adopt this method in the present survey (see later on in this section). It was, however, not possible to do so, because of the major requirement that participants must be literate and able to read a scale as well as measuring equipment
- ***Multiple 24-hour recalls***: Although 24-hour recalls are subject to similar sources of error as food frequency questionnaires, multiple 24-hour recalls have been used as a reference measure particularly with children, illiterate populations or when the costs and logistics of a dietary record study are prohibitive[23,35]. In one such validation study[35], four 24-hour recall interviews were conducted over a 12-month period with parents of preschool children and compared with two semi-quantitative food frequency questionnaires. A correlation of between 0,16 and 0,6 between the two methods was reported. However, mean

reported intake was higher from the food frequency questionnaire[35]. Hammond and co-workers[36] (1993) used 14 consecutive 24-hour recalls to validate a food frequency questionnaire in children of five to 11 years of age, whereas Haraldsdottir and Hermansen[37] (1995) compared three 24-hour interviews with eight year old children to a diet history from parents. Rank correlation between macronutrients was moderate, but reported energy intakes from the 24-hour recalls decreased at the third interview, suggesting a fatigue effect. Also, there seemed to be high intra-individual variation between the intakes obtained from the 24-hour recalls. In validation studies with adults, it seems that better results are obtained with more days of recall. The number of days of recall has varied from one[38], to five[39] to 12[40]. Reported correlation coefficients were reported to have varied from 0,15[38] to 0,95[39]. This method was, therefore, adopted for the present survey, since, apart from the practical aspects, it has been used in children specifically.

Preliminary validation

A preliminary testing of the relative validity of the QFFQ and the 24-H-RQ using the weighed food records was carried out in the Western Cape (peri-urban setting) and the Northern Province (rural setting). In each area, a convenience sample of 50 HHs with literate volunteers (mother/caregiver) was selected. Each volunteer was provided with a scale, measuring cups and spoons and a standardised form to record the food intake of the child for each of the three days. The forms were divided into time periods for the meals of each day, to help the recording. The volunteers were shown how to use the measuring equipment and fill in the record forms. The forms were collected on the day after completion. In the Western Cape, the 24-hour recall was conducted when the food records were collected, that is, the last day of the food record was recalled. The volunteers were interviewed using the QFFQ before starting the weighed record. In the Northern Province the 24-hour recall interview was done before the keeping of the weighed record.

Analysis of the data indicated that the administration of the weighed food records method gave variable results depending on the degree of urbanisation of the selected volunteers. The agreement between the weighed food records and 24-recall, although overall acceptable, also varied with the degree of urbanisation of the respondents. Comparisons between the data obtained from the QFFQ and the 24-hour recall were unsatisfactory, as the QFFQ gave a higher mean intake when compared with both the weighed food records and 24-hour recall. Additionally the agreement between quintile distributions was overall poor for all methods and groups.

Relative validation of the main survey

Due to the difficulties experienced with the use of the weighed food records in the preliminary validation studies, it was decided to use three 24-hour recalls as the reference measure for the relative validation of the final QFFQ. The relative validation and reproducibility studies were conducted concurrently with the survey during its pilot phase in the first two EAs (one urban and one rural EA more than 100Km away from each other) in each province.

For the purpose of the survey, therefore, validation meant the comparison of data obtained from the QFFQ with those obtained from 3 separate 24-H-RQs (see Appendix: Training Manual). For the purpose of this exercise, each one of the three 24-H-RQs was completed in the same chosen HH on a Monday, Wednesday and a Friday in a random order. The 24-hour recalls were spread over three weeks of the month and were planned to cover a full week. The second and third recall was done one week apart. It is important to note that the same fieldworker who completed the questionnaires in a given HH selected for the validation returned to that HH to complete the remaining two 24-H-RQs. The validation was done in every second HH in the chosen EA after the 20 HHs in it had been selected.

Repeatability

For the purposes of the survey, repeatability meant the ability of the fieldworker to obtain as accurate information as possible from the same interviewee one

week apart (see Appendix: Training Manual). For this purpose, one HH was selected randomly by the coordinator in a manner similar to that for quality control. In this selected HH, the same fieldworker had to return to complete the QFFQ and the anthropometric measurements a second time. This exercise was done in one HH in every EA in all provinces. All fieldworkers were tested for repeatability during the course of the survey. The coordinator implemented this exercise without the prior knowledge of the fieldworker. During this exercise, a fresh QFFQ was completed without having access to the QFFQ that had already been completed. Similarly, the fieldworker also had no access to the anthropometric measurements made previously.

For the purpose of the survey the 24-H-RQ was tested for reproducibility by administering it on three separate occasions. This was done during the pilot phase of the survey in every province (see also Appendix: Training Manual). Essentially, the households were randomly selected for the repeatability exercise and the same fieldworker was required to visit the selected household on a Monday, a Wednesday and a Friday in a random order. It is important to realise that all the three interviews were completed in the same household regarding the same child selected for inclusion in the survey at the specified time intervals.

Ethical issues

The survey protocol was approved by the Ethics Committee of the University of Stellenbosch. Written, informed consent (see Appendix: Informed Consent) was obtained from the mother/caregiver of each child that was included in the survey.

Data Analysis

After completion of an EA, the questionnaires were checked and signed by the fieldworker's team leaders and/or the coordinators and/or the director of the survey responsible for a particular Province, and dispatched to a central site for data entry. All questionnaires were sent to the data analyst. The questionnaires were again checked by a dietitian and the data was then

entered. The SAS (Version 6.12 for Windows) was used for data entry and analyses under the supervision of two statisticians.

All foods consumed were expressed in grams or millilitres. For the QFFQ foods consumed per day were calculated as follows:

- *Daily intake = (amount consumed x frequency per day x number of days per week x number of weeks per month)/28*

Descriptive statistics (means, standard deviations, medians, interquantile ranges) and frequency distributions were calculated for all nutrients and food groups. Associations between food, energy and nutrient intakes and variables of age, gender, level of urbanisation were calculated. The independent t-test was used to compare results of urban vs rural, male vs female for nutrient intake. The Spearman's correlation was used to obtain an indication of any relationships/trends between some anthropometric parameters and other variables such as household income. The Pearson's correlation was used for detecting relationships/trends between continuous variables, such as anthropometry, and nutrient intake. Confidence intervals were also calculated as appropriate. Odds ratios with corresponding 95% Confidence Intervals were calculated to provide an indication of the severity of the risk factor. For the analysis of the data for the Hunger scale questionnaire, the sample was divided into three groups, namely the "food secure", the "at risk group" and the "experience Hunger" group. These three groups were compared in relation to anthropometric status, nutrient intake and some socio-economic parameters using primarily the Kruskal-Wallis test. The Bonferroni's test in conjunction with the Kruskal-Wallis test was also used primarily for an indication of direction whereas the Chi-square test was used to establish for instance relationships between different hunger groups and different areas of residence. When looking at the individual questions of the questionnaire, each question had two outcomes, "yes" and "no". For each question, two groups were created, those who said "yes" and those who said "no". Selected anthropometric parameters, nutrient intake as well as socio-economic

variables were also compared for these two groups using the Wilcoxon test (non-parametric). Factor analysis with varimax rotation was also calculated.

Similar statistical analyses were used for both the repeatability and the relative validity aspects of the survey. The most frequently used methods in the past for the comparison of results has been the correlation coefficient, either the Pearson or the Spearman Rank and the comparison of means by paired t-tests, Wilcoxon or Kruskal-Wallis, whichever was appropriate. However, recently the usefulness of the correlation coefficient as a measure of agreement has been questioned by several authors[41-43]. This has led several researchers to investigate alternative methods of analysing validation and reproducibility study data. The Bland-Altman plots[44] have recently been used for this purpose in a number of dietary intake validation studies[45-49]. More recently, a method has been proposed by which the ratio of intra-individual to interindividual variation may be used to indicate agreement[50]. The smaller the ratio, the better the agreement is. A further useful measure of agreement is the extent to which individuals are classified into similar quintiles of the distributions of the two methods[51-53]. Several authors have also investigated ways of estimating within and between person variance[54-57], while others[58-60] have applied structural equation models to validation data, with and without the inclusion of a biomarker. The most recent techniques, using a combination of reference methods and biomarkers, known as the ”method of triads” have been described[61,62] for the European Prospective Investigation into Cancer and Nutrition project.

For the relative validation, the mean of the three 24-hour recalls was used as the reference for comparison with the results of the QFFQ. For the reproducibility study, the results of the two administrations of the QFFQ were compared, as were the results of the 24-H-RQs. In both studies, energy, protein, fat, vitamin A, vitamin C, thiamin, niacin, riboflavin, iron and calcium were compared. Energy, nutrient and food intakes were analysed as for the main survey. Pearson’s rank correlation coefficients, paired t-tests, Bland-Altman plots and quintile distributions were used for the analysis of both the relative validation and reproducibility data. In addition to analysis on the raw

data, nutrient intake data were analysed by the Energy Intake to Basal Metabolic Rate ratio (EI : BMR) as described by Goldberg [63].

Energy and nutrient composition was analysed using the computerised Food Composition Tables of the South African Medical Research Council (MRC)[64]. Food groups were analysed according to the groups used on the QFFQ.

Methodology for Dietary Analysis

Entering of data

For data entry, a template was created for each questionnaire using a database programme. The template defined the name (field name), the type (character or numeric) as well as the length (the maximum number of characters for the field) of each variable, and for numeric variables, the number of decimal places. Each subject was represented on a single record, but provision was made for "multiple answer options" as appropriate.

For each EA a computer disk was prepared containing these templates. Experienced data typists were trained on how to enter the data using these templates. They entered the data for a specific EA on their own computers on a pre-prepared disk, which they returned to the statistician once the data entry for a specific EA was completed. The statistician then checked the entered data for any obvious errors, and a printout of the data was made. This printout, together with the original questionnaires was then sent to another trained data typist who checked the entered data manually, namely the typist compared the data on the questionnaires with that of the printouts and marked any differences on the printouts with a red pen. The statistician then went through any discrepancies and corrected them. The data for the specific EA was then added to the main database.

Cleaning of data

Once the data for all EAs was entered, checked and corrected the data was then cleaned. For this purpose and in the case of the 24-H-RQ, the QFFQ and the procurement questionnaires, the first step was to ensure that the data entered had the correct food codes and was within reasonable limits in terms

of the food quantities consumed. When food codes were missing, the description of a food as appeared on the 24-H-RQ, the QFFQ and the FPHIQ questionnaires was used to enter the full name of the food item in question. It was then easy to scan the complete database at a later stage to find any missing codes.

On some occasions, breast milk was entered in the 24-H-RQ as “Breast milk all day”. For the quantification of breast milk intake, six infants were weighed, during the questionnaire validation phase of the survey, before and after a breastfeed over a period of 24 hours. The mean daily intake of breast milk was 800 ml and the mean daily number of breastfeeds was 4. The latter gave a mean breast milk intake of 200 ml daily, a figure that was used in all dietary calculations in the survey. Powdered milk, cereals, syrups, margarine and cooking oil were other food items, which needed to have the reported consumed quantities standardised. All the food codes associated with these items were scanned and checked for correct quantities, namely if, for instance, 250 ml rice crispies was recorded, it was changed to 40 g in accordance with the information given in the Instruction Manual. After it was ensured that all food items were within reasonable limits, the second step was to make sure that the total food intake per subject was within reasonable limits. For the 24-H-RQ all subjects reporting at least one of the following were identified:

- Total energy intake of < 0.33 of the RDA
- Total energy intake of > 8190 for 1-3 year old
- Total energy intake of > 11340 for 4-6 year old
- Total energy intake of > 12600 for 7-9 year old
- Total protein intake of > 4 x RDA for protein
- Calcium intake of > 2 x RDA for Calcium
- Vitamin C intake of > 4 x RDA for Vitamin C
- Vitamin A intake of > 2 x RDA for vitamin A
- Total fat intake of > 60g for 1-3 year old children
- Total fat intake of > 100g for 4-9 year old children.

There were 793 entries in total violating at least one of these defined limits. Each of these entries was checked for the correctness of the entry, or for any obvious errors by a specially trained dietitian. Following this exercise, 726 records were still violating at least one of these defined limits, but the data was a true reflection of what had been entered in the questionnaire. The quantities for individual foods were then checked and, if it was found that the consumption of the specified amounts of food were possible to have been consumed, the values were accepted as being a true reflection of the information provided by the interviewee's. This resulted in discarding the 24-H-RQ data provided by the interviewee in 7 households, since the dietitian regarded the amounts of foods reported to have been eaten by children of that age as unlikely.

For the QFFQ, all subjects who had nutrient intakes that fell outside two standard deviations around the group mean for total energy, total protein, total fat, vitamin C, Vitamin A, iron, calcium, total fibre, total cholesterol, thiamin, riboflavin and niacin were identified. There were 358 entries, which fell outside these defined limits. All these records were checked again for any obvious errors. From the cleaned data (n=2898), 129 entries in all were excluded giving a final total of 2769 entries. The reason for excluding these 129 entries was that 125 of them had an energy intake in excess of 250% of the RDA and 10 entries had an energy intake of less than 10% of the RDA. In general, the most common errors at the point of data entry that were found by the dietitian were a combination of typing errors (e.g. 10 entered as 100) and coding errors (impossible quantities were coded).

For the FPHIQ care was taken to have all food codes included, using the description columns of the questionnaire as the reference point where codes were missing. Quantities were entered without any prescriptive limits. Cabbage, for instance had been entered as 1 head, 1600 g, 1.6 kg or 1 cabbage (see the Instruction Manual in this regard). On the other hand, entries for maize ranged from 250 g to 100 kg. There were, therefore, no "reasonable" limits for quantities and no preset criteria for this specific purpose.

Food Codes

Food composition tables were provided by the Medical Research Council in the form of three different files. The first file contained the names, units and codes of nutrients, the second one contained the food code, nutrient code and nutrient value per 100g of a specific food item and the third file contained the description for each food item and the food group it belonged to. By merging these three files, it was possible to create a record for each food item regarding its food code, nutrient value of each nutrient per 100g for that food item, a full description of a food item and an indication as to which food group this item belonged to.

New food codes were created for food items not present in the food composition tables and for recipes most commonly used by subjects. Some recipes had the same description but were reported by a different name. For each of the most commonly consumed recipes a combination of existing food codes was created. Trained dietitians decided upon these combinations after taking into account the individual components of the recipes and the quantities used in preparing a particular dish. These codes were added to the food consumption tables with nutrient values reflecting the combinations they consisted of.

Although foods were classified according to the basic food groups, certain foods were further sub-grouped within a given basic food group. For instance, fresh fruit was sub-grouped into vitamin C – rich or vitamin A – rich fruits for the purpose of more specific group analysis. These “new” food sub-groups were used particularly when analysing the most common foods eaten, procured or formed part of the household inventory.

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