Dietary Diversity and Nutrient Adequacy In Women of Childbearing Age In a Senegalese Peri-urban Community

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Wat gaal yegoo
(Together the community raises the pirogue)
Lébou expression

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Abstract

The validity of two measures of dietary diversity derived from a qualitative diversity questionnaire (reference periods of 1 or 7 days) by comparison with nutrient intake from three 24-hour recalls was investigated in 51 women (18 – 45 y) in a peri-urban community in Senegal, West Africa. Significant positive correlations (range: $r = 0.30$ to $r = 0.64$) were found between intakes of calcium, iron, zinc, vitamin A, vitamin C, thiamine, riboflavin and vitamin B_6 and diversity score based on number of different individual foods derived from data obtained from the 7-day reference period. Data from the diversity score from the 1-day reference period was less well correlated with the 24-hr recalls. Our data suggest that a diversity measure based on foods derived from a diversity questionnaire would be useful in the monitoring of nutrient intake changes over time within populations.

Résumé

La validité de deux mesures de diversité alimentaire dérivé d'un questionnaire de diversité qualitatif (périodes de référence étant de 1 ou 7 jours) en comparaison avec l'apport nutritif de trois rappels de 24 heures a été examiné chez 51 femmes (18 – 45 ans) d'une communauté peri-urbaine du Sénégal. Des corrélations positives (r = 0.30 à r = 0.64) ont été établies entre la consommation de calcium, de fer, de zinc, de vitamine A, de vitamine C, de thiamine, de riboflavine et de vitamine B_6 et le score de diversité basé sur le nombre d'aliments obtenus de la période de référence de 7 jours. Le score de diversité obtenu de la période de référence de 1- jour corrélait moins avec les rappels de 24 heures. Nos résultats suggèrent qu'une mesure de diversité estimée des aliments rapportés sur un questionnaire de diversité puisse être utile pour le monitorage de changements temporels d'apport de nutriments chez des populations.

Contribution of Authors

The candidate worked with Dr. T. Johns, the thesis supervisor and Dr. K. Gray-Donald, the thesis co-supervisor to develop the research question and project objectives. The candidate sought out and obtained funding for the project.

Subsequently, the candidate developed the questionnaire tools, hired a local research partner, and collected all data with the research partner. The candidate was responsible for data management, which included coding of raw data, verifying data, and building CANDAT and SAS files. The candidate conducted all analyses and prepared initial draft of manuscript. For further data analysis and interpretation, Dr. T. Johns and Dr. K. Gray-Donald provided guidance.

The paper *Dietary Diversity and Nutrient Adequacy in Women of Childbearing Age in a Peri-Urban Community in Senegal, West Africa* was co-authored by the members of the committee.

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1.0 Introduction

Dietary diversity is identified as an important element of a high quality diet (Tucker, 2001; Johns, 2003). Although there are few data to defend the health benefits of a diverse diet, it has been the mainstay of public health recommendations for many years (Krebs-Smith *et al*, 1987; Hertzler *et al*, 1974). Dietary guidelines in developed countries advocate consumption of a variety of foods both within foods groups and between food groups (US Department of Agriculture Human Nutrition Information Service, 1992; Health Canada, 1992). Several reasons have been postulated as to why a diet containing a variety of foods might ensure health. The first of these reasons is an adequate intake of nutrients, in part due to our limited knowledge of the repertoire of dietary components beneficial for health as well as the known variation of nutrient composition between foods. In addition, the bioavailability of important micronutrients is greatly improved when selected foods are consumed in combination (Rao & Prabhavathi, 1978; FAO/WHO, 2002). Dietary diversity is also thought to decrease the chances of both deficiency and excess and to decrease the chances of unhealthy levels of toxicants. There is much evidence of the benefits of dietary diversity. A more diverse diet has been associated with a number of improved health outcomes such as birth weight (Rao *et al*, 2001), child anthropometric status (Allen *et al*, 1991; Hatløy *et al*, 2000; Onyango *et al*, 1998; Taren & Chen, 1993; Tarini *et al*, 1999), improved hemoglobin concentrations (Bhargava *et al*, 2001), reduced incidence of hypertension (Miller *et al*, 1992), and reduced risk of mortality from cardiovascular disease and cancer (Kant *et al*, 1995) and reduced morbidity (Wahlqvist *et al*, 1989; Hsu-Hage & Wahlqvist, 1996).

Dietary diversity in the context of the developing world is particularly relevant. Diets are typically low in dietary diversity with emphasis on a small number of starchy staples and a limited quantity of animal products and fresh fruits and vegetables. This type of diet is at risk of leading to deficiencies or excesses of several micro or macronutrients (Tontisirin *et al*, 2002). Because diversity is considered to protect against nutrient deficiency and excess, food-based approaches emphasizing diversity are strongly advocated as sustainable approaches in the effort to improve nutrient status (WHO/FAO, 1996; Underwood, 2000; ILSI, 2002).

Simple, reliable and valid tools are important in development work for the purposes of assessment, the design of targeted intervention programs, and the monitoring and evaluating of the impact of policies and programs. To this end, researchers have explored the use of dietary diversity indicators as proxy measures of diet quality in general and adequacy of certain nutrients in particular, an important health concern in the developing world. If a diet with a high level of diversity does provide an adequate amount of required nutrients, then measuring that diversity would be a good way of measuring adequacy. Dietary diversity indicators are promising because they are potentially based on simple, easy to collect data.

Documentation of dietary data is important in planning, evaluating and justifying policies and strategies related to nutrition interventions. Dietary assessment in developing countries is particularly challenging and quantification of food intake is particularly difficult in populations that eat from shared bowls (Torheim *et al*, 2001). With poor health and nutrient deficiencies common to the developing world, and methods of diet assessment often costly, an inexpensive simple tool to assess the nutritional quality of a diet in a community would be very useful. Studies measuring dietary diversity in the developing world have indicated that tools based on dietary diversity can capture important aspects of a population's diet (Arimond & Ruel, 2002; Hatløy *et al*, 1998; Hatløy *et al*, 2000; Ogle *et al*, 2001; Onyango *et al*, 1998; Rose *et al*, 2002; Rose & Tschirley, 2003; Tarini *et al*, 1999; Torheim *et al*, 2003).

2.0 Review of the Literature

2.1 ESTIMATING DIETARY INTAKE

Dietary intake estimation involves collection of information on types and quantities of foods eaten. The method chosen is dictated by the dietary information of interest, the population being studied, the precision desired, the cost, the length of time and the social and physical context (Dwyer, 1999). For individual dietary assessment, diet history, multiple 24-hour recalls, weighed food records, and food frequency questionnaires have been used.

Researchers have often used weighed food records to collect quantitative dietary intake data in developing countries, because it is thought to be one of the most accurate of methods. It is however, time consuming and expensive. In addition, it has a high respondent burden and because it can be disruptive to daily routines, it may not be an accurate reflection of usual intake (Gibson, 1990).

The food frequency questionnaire also examines individual intake. This method requires that the participants recall usual frequency of consumption over a given period, which could be daily, weekly, or monthly. The semi-quantitative food frequency questionnaire includes estimates of usual portion sizes such as small, medium or large or in comparison to a "standard" serving size. The quantitative food frequency includes more precise food portion sizes such as usual weight, volume or household measures

(Thompson & Byers, 1994). Nutrient intake is determined by summing the reported frequency multiplied by the amount consumed over all reported foods and expressed in grams consumed per day. It is a reflection of a longer period of consumption, and may allow observations of seasonality.

The 24-hour recall is relatively easy and less time consuming than weighed food records and may be better at characterizing individual intakes than food frequency questionnaires. Indeed, some researchers have found that African women are better able to respond to specific questions related to the previous day rather than to report habitual food habits and intakes over a period of time (Gibson & Ferguson, 1999). This method is a reflection of current dietary consumption. Participants are required to recall all food and beverages consumed during a 24-hour period. One of the principal advantages of the 24-hour recall is the speed and ease of its administration. In addition, the respondent's literacy level does not affect the quality of information and the respondent burden is limited. Furthermore, the immediacy of the recall period means that respondents are usually capable of remembering the food consumed. Also, because the recalls take place after the food has been consumed, the assessment method does not interfere with dietary behaviour.

Although the 24-hour recall is fairly easy to complete, participants may vary in their ability and willingness to recall, describe, and quantify foods that have been consumed. Therefore, it is important that interviewers are trained to ask probing questions to facilitate recall. The probes must remain neutral such that the interviewer does not influence the responses. In order to obtain adequate description of food items, interviewers must ask about the preparation of foods and brand names in addition to types of specific ingredients. Food portion models and calibrated utensils have been successfully used in previous studies to help participants in description of quantities and types of foods (Posner *et al*, 1992; Moore *et al*, 1967; Labadarios, 1999; Ferguson *et al*, 1995).

When administering the 24-hour recall, there are several important issues to consider. Respondents may overestimate information that is perceived as having more status, such as consumption of meat and refined cereals. For the opposite reason, consumption of vegetables and unrefined cereals and use of tobacco and alcohol may be under reported (Gibson & Ferguson, 1999). In addition, single 24-hour recalls can only be used to describe food intake of groups, not individuals. Because of intra individual variation in intake, multiple recalls are required in order to obtain an estimate of usual intake (Gibson, 1990). Finally, non-consecutive days should be included for repeating 24-hour recalls in an effort to minimize error introduced by dietary intakes on adjacent days (National Research Council, 1986).

Twenty-four hour recalls have been used successfully in the developing country context. For example, this method was used to assess intakes in pregnant women in Malawi (Ferguson *et al*, 1995). Relative validity was measured by comparing the intakes from two 24-hour recalls to weighed records of the same days. Iron and zinc measures were similar for both methods. Later, dietary information obtained from three 24-hour recalls in the same population compared well to biochemical indices of iron such as serum iron and percentage transferrin saturation and zinc from hair (Gibson & Huddle, 1998).

There are several challenges to measuring food intake in a West African population. Most notably, meals are often consumed from a common bowl, and therefore quantities may be difficult to establish. In addition, the successful execution of the 24-hour recall requires professionals trained in the collection of dietary intake.

Recently, a research group set out to validate a quantitative food-frequency (QFFQ) in Mali (Torheim *et al*, 2001). The tool was designed to measure habitual food and nutrient intake of one season in rural communities in Mali. Food intake for the week preceding the interview was measured with a 69-item QFFQ. These intakes were subsequently compared with intakes from 2-day combined weighed and recalled diet records. Subjects were men and women aged 15-59 years. Spearman rank correlations between intake of food groups from the QFFQ and the diet record were calculated. The median correlation coefficient for nutrient intake was 0.40. Men were found to have higher coefficients than women. Overall, intakes of most food groups and nutrients determined from the QFFQ were higher than those measured by the diet record. Therefore, a moderate correlation was observed, but the QFFQ overestimated intake when compared to the diet record.

A revised version of this QFFQ was tested in Mali by the same group (Parr *et al*, 2002). The dietary intake for the week prior to the interview was assessed with a 164-item QFFQ. This intake was compared to the intake measured with a 2-day weighed record with weighed recipes. Subjects were men and women aged 15-45 years. Spearman's rank correlation for energy and nutrients ranged from 0.16 (% energy from protein) to 0.62 (retinol equivalents). This version of the QFFQ underestimated total food weight. The ability to rank and categorize subjects according to dietary intake was similar in both versions. However, the QFFQ did not determine absolute intakes in a consistent manner.

Although it is important to recognize cultural differences between memory and ability to quantify portions, these studies provide promise for the use of a FFQ in similar populations. The question remains as to whether removing the quantitative nature of the QFFQ disturbs the ability to categorize subjects according to nutrient intake.

2.2 DIETARY DIVERSITY: TERMS DEFINED

The following is an overview of the literature on dietary diversity and nutrient adequacy in the context of the developing world. To begin, several terms are defined.

Nutrient adequacy has referred to the attainment of recommended intakes of key nutrients for health. However, in the literature there has been no gold standard list of nutrients and nutrient levels to define adequacy. Instead, researchers have chosen nutrients based on relevance to the community and data base availability. For the measurement of adequacy, some studies have chosen the Nutrient Adequacy Ratio (NAR) and the Mean Nutrient Adequacy Ratio (MAR). The use of these terms was first explored by Madden & Yoder (1972) and further developed by Guthrie & Scheer (1981). Subsequently, the concept has been used in both developed and developing countries

(Krebs-Smith *et al*, 1987; Hatløy *et al*, 1998). NAR is the ratio of an individual's intake of a nutrient over the recommended intake of that nutrient (the requirement for 97% of the population). MAR is the average of the NARs. Each NAR is usually truncated at 100% so that a very high intake of one nutrient is limited in its ability to mask a low intake of another. Although this masking effect is limited, difficulties remain in interpretation if a population or an individual consumes a diet high in some nutrients but low in others. Another important limitation of using the MAR index is that all nutrients are given equal weight. For instance, in calculating the score riboflavin, iron and vitamin A are treated in the same manner. Certainly, all nutrients are important, however deficiencies of some are more urgent health priorities than others.

Dietary diversity is most commonly defined as the number of different foods or food groups consumed over a given dietary measurement period. Food Variety Score (FVS) and Dietary Diversity Score (DDS) are two indices that have been used as measures of diversity. FVS is obtained from a count of the number of foods consumed over a given reference period and DDS is from a count of food groups consumed over a given reference period. The measurement period has most commonly ranged from 1 to 3 days or 7 days. In developed countries, a basic count of foods or food groups has been employed (Krebs-Smith *et al*, 1987). Alternatively, other researchers have further analyzed food intake such that the number of servings of different food groups may be accounted for or food items are differentially weighted (Kant *et al*, 1993). However, studies conducted in developing countries have tended to use only single food counts or food group counts. Several research groups have used both unique food counts and food group counts. Several studies have used dietary diversity indicators by household rather than by individual.

2.3 DIETARY DIVERSITY: DEVELOPING COUNTRY STUDIES

While dietary diversity research in the developed world context is extensive (Hodgson *et al,* 1994; Kant, 1996; Drewnowski *et al,* 1997), the investigation of dietary diversity as an indicator of nutrient adequacy in developing countries has only been recent. A review of the literature to date has found studies conducted in Niger (Tarini *et al*, 1999), Kenya (Onyango *et al*, 1998), Vietnam (Ogle *et al*, 2001), Mali (Hatløy *et al*, 1998; Hatløy *et al*, 2000; Torheim *et al*, 2003), Ghana and Malawi (Ferguson *et al*, 1993), Mozambique (Rose *et al*, 2002; Rose & Tschirley, 2003), Ethiopia (Arimond & Ruel, 2002) and China (Stookey *et al*, 2000). These studies have used different numbers of foods and food groups as well as different measurement time periods, different cut-off values, and some have used mathematical models. The choice of subjects has also varied. Dietary measurement has been on either adult women, or adult men and women, or children, or whole households.

The following is a summary of these studies and a description of how well their dietary diversity indicators address nutrient adequacy. **Table 2.1** (page 32) provides a summary of the salient points. For additional information, two comprehensive review articles provide more detailed descriptions of diet quality indexes tested in the developed world (Kant, 1996) and dietary diversity in relation to dietary quality, nutrient adequacy, measures of nutritional status and food security in the developing world (Ruel, 2002).

Two indices of dietary diversity were validated against nutrient adequacy in 77 children 13 – 58 months of age living in Mali (Hatløy *et al*, 1998). The study employed two diversity scores: FVS and DDS. FVS, based on a count of number of foods and DDS, based on 8 food groups were calculated based upon quantitative dietary assessment of each child using direct food weighing for 2-3 days. A count of the number of food groups or food items consumed provided a good assessment of the nutritional adequacy of the diet. The food groups were divided as follows: staples (e.g.: ground nuts, rice, millet, beans), vegetables, fruit, meat, milk, fish, egg, green leaves, other (e.g.: oil, sugar, sweets). Participants cited 75 different food items. Nutrients that were examined were: protein, fat, vitamin A, vitamin C, thiamine, riboflavin, niacin, folic acid, iron, calcium in addition to overall energy. Researchers measured nutrient adequacy using NAR and MAR. A MAR equal to 0.75 was used as a cut-off point for a nutritionally adequate diet. A positive but weak correlation was found between FVS and MAR ($r = 0.33$, $p < 0.001$) and between DDS and MAR ($r = 0.39$, $p < 0.001$). In regression analysis, DDS was found to be more strongly associated with nutrient adequacy than FVS. The implication being that increasing the number of food groups has a greater impact on dietary quality than increasing the number of foods in the diet. However, this interpretation by the authors must be considered cautiously. Correlations of 0.33 and 0.39 are not likely to be different enough in a practical sense to warrant using one score over another.

The authors tested different cut-off points for FVS and DDS in order to find the optimal values that could correctly identify as many inadequate diets as possible (high sensitivity) without losing too much ability to identify those with a nutritionally adequate diet (specificity). The best cut-off points found to predict nutrient adequacy were 6 for food group diversity and 23 for food variety. With a cut-off for FVS of 23, the sensitivity was 87% and the specificity was 29%. With a cut-off for DDS of 6, the sensitivity was 77% and the specificity was 33%. The authors recognized that the results are site-specific, however they suggested that the methodological approach used might be considered in future study areas. Given the poor sensitivity and specificity, further research would be useful in determining whether these values could be improved.

Recently, the same research group investigated the use of a Quantitative Food Frequency Questionnaire (QFFQ) to assess food variety (Torheim *et al*, 2003). The validity of three diet quality indexes (FVS, DDS and MAR) was evaluated using data obtained from QFFQ validation exercises that involved two separate study groups: A (sample size = 75) and B (sample size = 70). FVS, DDS, and MAR derived from the QFFQ were compared to the same indexes obtained from 2-day weighed records (WR). They concluded that FVS and DDS can be assessed by the QFFQ. In addition, the ranking of individuals according to FVS and DDS from the QFFQ was compared to the ranking of individuals according to MAR obtained from WR. Spearman's correlation coefficients between FVS obtained from the QFFQ and WR for men were 0.49 ($p < 0.01$) and 0.35 ($p < 0.05$) in study A and B, respectively. Values for DDS were 0.20 (not significant) and 0.39 ($p < 0.05$) for study A and B respectively. Correlations for women were lower and not significant. For the total sample, Spearman's correlation coefficients between MAR obtained from QFFQ and WR were 0.40 ($p < 0.01$) and 0.49 ($p < 0.01$) for study A and B, respectively. The researchers investigated to what extent the two diet variety scores derived from the QFFQ reflect overall nutritional quality (MAR based on WR). FVS and

DDS derived from the QFFQ weakly correlated with MAR from the WR. Correlations for study A were 0.36 ($p < 0.01$) and 0.35 ($p < 0.01$) for FVS and DDS, respectively. Correlations for study B were 0.24 ($p < 0.05$) and 0.29 ($p < 0.05$) for FVS and DDS, respectively. These correlations are similar to work done previously by this group (Hatløy *et al*, 1998). Ranking of individuals in study A found 36% of the subjects placed in the same quartiles of FVS and MAR, while 5% were in opposite quartiles. For DDS, the values were 43% and 8%, respectively. In study B, 29% were classified into the same quartiles of FVS and MAR, while 9% were in opposite quartiles. For DDS, the values were 34% and 6%, respectively. This study was able to demonstrate weak correlations between diversity measures obtained from QFFQ and WR.

Ogle *et al* (2001) employed a similar methodology to Hatløy *et al* (1998) in order to explore the association between food variety (as described by FVS and DDS) and nutrient intake among 217 rural Vietnamese women, aged 19 – 60 years. Data were grouped into two geographic regions: the Mekong Delta and the Central Highlands. FVS and DDS were calculated on the basis of an adapted food frequency methodology with a recall period of seven consecutive days (7dFFQ). Face to face interviews were conducted in the homes of the participants. The questionnaire included commonly used foods that were divided into 12 food categories. These food categories were those used by the National Institute of Nutrition in previous national surveys: rice, other cereals, starchy roots, green leafy vegetables, other vegetables, fish/seafood, meat, eggs, nuts/legumes, fruits/juice, oils/fats, beverages/biscuits/sweets. In order to determine usual portion sizes, life-sized photos of foods and prepared dishes were used during interviews. In addition, several households were asked to weigh and record all foods used during three days, and team members weighed foods whenever possible. The 7dFFQ registered 120 different food items. The FVS for individual women ranged from 6 to 39. The number of food groups, or the DDS, ranged from 5 to 11. The nutrients that were examined were carbohydrate, protein, fat, calcium, iron, zinc, vitamin A, thiamine, riboflavin, niacin, vitamin C, and folate, in addition to overall energy.

Associations between variables were tested by grouping values into three categories (terciles). In each region, the group in the highest variety tercile was compared to that of the lowest. Women in the highest tercile of FVS (consumed 21 or more different foods in 7 days) had significantly higher (actual values not reported) intake of most nutrients that were studied compared to those in the lowest tercile FVS (consumed 15 foods or less). In the Mekong Delta, women in the high FVS group had significantly higher mean intakes of all nutrients compared to the low FVS group ($p < 0.01$ for energy, protein, calcium and zinc; $p < 0.001$ for carbohydrate, fat, iron, vitamin A, thiamine, riboflavin, niacin, folate and vitamin C). In the Central Highlands, the difference was significant for only several nutrients ($p < 0.05$ for energy and thiamine; $p < 0.001$ for protein, fat and niacin). Women with a DDS greater or equal to 8 had significantly higher nutrient adequacy ratios for energy, protein, niacin, vitamin C, and zinc. The high FVS group was found to have intakes of 21-39 items. The lower end of this scale agrees well with the best cut-off point of 23 items that was calculated by Hatløy *et al* (1998). The authors were also interested in the significance of wild vegetables in the diet. An analysis of wild vegetable consumption and FVS found that a greater variety of wild vegetables paralleled a higher dietary diversity. Despite these interesting findings, the authors describe no strong associations between both FVS and DDS and nutritional status indicators such as hemoglobin, serum ferritin, serum retinol and anthropometric measures (actual values not reported).

Onyango *et al* (1998) found that dietary diversity as defined by the number of different foods consumed was associated with nutrient intake in 154 Kenyan children of 1-3 years of age. Three non-consecutive 24-hour recalls were conducted in order to determine food intake. A dietary diversity score was calculated by counting the number of unique food items consumed by the child during each of the three days. The reported score was an average of the three days. The nutrients investigated were protein, vitamin C, vitamin A, thiamine, riboflavin, niacin, iron, and calcium in addition to energy. Data were divided into two groups for comparison of variables: those with a diet diversity score over five, and those with a score less than or equal to five. A diet diversity score over 5 found significantly higher intakes of most nutrients compared to those with a score of five or lower ($p < 0.001$ for calcium, riboflavin and thiamine; $p < 0.01$ for energy and niacin; $p < 0.05$ for protein, vitamin A and vitamin C).

Another study that looked at the association between diversity and nutrient intake also confirmed the positive association between dietary diversity and intake of a variety of nutrients (Tarini *et al*, 1999). The diet in 60 children 2 – 4 years old in rural Niger was assessed with a 3-day modified weighed intake technique. All food items consumed by each participant were recorded over a 3-day period. Raw ingredients of meals were weighed as well as the final cooked amount. For meals that were shared from a common bowl, the number of mouthfuls was counted and multiplied by the mean mouthful weight derived from the average weight of three mouthful samples. Diversity score was defined as number of food groups over the three days. Eleven food groups were defined as: cereals, green leafy vegetables, other vegetables, pulses/nuts, roots/tubers, fat, fruits, legumes, milk/eggs, meat and sugar. Diversity score was measured against a nutritional quality score (NQS) that examined energy, protein, vitamin A, and zinc. A diversity score less than or equal to 5 was associated with a significantly lower NQS compared to a score greater than or equal to 6.

However, an additional study conducted in Ghana and Malawi reports only a weak association between diversity and nutrient intakes (Ferguson *et al*, 1993). Food intake was measured by weighing over a 3-day period in rural children from Ghana and Malawi. The average number of different food items consumed per day was the measure of dietary diversity. The total number of food items recorded ranged from 62 in Malawi to 76 in Ghana. Dietary diversity was positively associated with consumption of prestigious foods such as chicken, meat, milk, eggs, tea and bread. In Malawi, dietary diversity was positively associated with energy intakes ($r = 0.33 - 0.41$, $p < 0.02$), which was probably related to snacking. Those individuals who had more diverse diets consumed more snacks such as fruits, roots, groundnuts, sugar cane and local cakes. In both Malawi and Ghana, dietary diversity was not correlated with protein, fat and calcium densities of the diets.

The association between dietary diversity and child nutritional status has been explored in several countries in the developing world. Arimond & Ruel (2002) in Ethiopia drew on dietary data from the large Ethiopia 2000 Demographic and Health Survey to derive food group diversity measures. These values were significantly associated with height-for-age Z-scores. Hatløy *et al* (2000) also investigated diversity and child growth in urban Mali. With socio-economic factors controlled, low FVS or DDS was associated with twice the risk of being stunted or underweight. In Kenya, researchers used the average of three 24-hour recalls to sum the number of individual foods eaten by a toddler (Onyango *et al*, 1998). This diversity score was associated with the following nutritional status measures: height for age, weight for age, weight for height, triceps skinfold, and mid upper arm circumference. All measures were higher in the group with diversity score greater than five, with only weight for age being significantly higher ($p = 0.005$).

In Mozambique, researchers tested the Mozambican Diet Assessment Tool, a low-cost rapid tool, for how well it assessed the quality (diversity) of 616 household diets (Rose *et al*, 2002) by classifying them into three categories. A food-group classification and scoring system was applied to household data previously collected in a quantitative diet study in northern rural Mozambique. The tool is based on a simple qualitative diet assessment using a 24-hour recall of household food intake. In each household, the person in charge of food preparation was asked to recall all food items that had been eaten by all household members during the previous 24 hours. Points were given to each food item based on the food group it belonged to. The four food groups, in descending order of score value, were as follows: animal foods (e.g.: meats, fish, eggs), legumes and nuts, cereals and tubers, vegetables and fruits. The scoring rationale was based upon nutrient density, bioavailability, and usual portion sizes consumed (those foods eaten in smaller quantities were allocated a lower score than those foods with similar nutrient content but eaten in larger quantities). All points were summed for each household. Diets with a score of at least 20 were considered to be of acceptable quality. Diets of less than 12 points were considered to be of very low quality. Those households identified by the tool as having a diet of acceptable quality had significantly higher mean intakes of energy, protein, and iron (there was no difference for vitamin A) ($p < 0.05$) and also had significantly higher mean scores on the Mozambican Diet Quality Index ($p < 0.05$). The index functioned as a gold standard measure of overall diet quality. It was a composite measure based on the nutrient intakes of energy, protein, vitamin A, iron, and seven other nutrients computed from data from the quantitative household-level 24-hour recall. A maximum of 2 points was assigned to each component of the index to yield a range of 0 to 10. To determine each component score, the NAR for the nutrient is calculated for the household (truncated at 1.0) and multiplied by 2. Households that scored 7.5 or higher were considered to have a high quality diet. Although the tool classified diets into three groups that were significantly different with respect to nutrient content, there was a great deal of misclassification. Sensitivity, ability to detect those with low intakes, was quite low at the cut-off point of 20. For energy, protein, vitamin A and iron, sensitivity was 67.7, 83.0, 44.1 and 65.1%, respectively. Increasing the cut-off point to 23 improved the sensitivity to 81.2, 90.2, 60.5 and 77.0%, respectively, but of course decreased the specificity. Hence, the tool shows potential to describe the diet of households; however increasing sensitivity at the expense of specificity jeopardizes its practical use.

Also at the household level, Rose & Tschirley (2003) reported that when the number of adult equivalents in a household was known, the number of times per day that a household consumed a food from each of 11 food groups was good at predicting nutrient intake. Food groups included grains, tubers, beans, nuts and seeds, animal products, vitamin A-rich fruits and vegetables, vitamin C-rich fruits and vegetables, other fruits and vegetables, sugars, oils, and other foods (e.g.: beverages, candy). Researchers developed a dietary intake prediction model based on the types of foods eaten in the previous 24-hour period with the purpose of predicting a household's dietary intake level without having to perform detailed quantitative data collection. The study used previously collected data from a quantitative 24-hour recall technique performed on 388 households in 16 rural villages in Northern Mozambique. Two recall interviews for each of the three main seasons were performed. Researchers asked the person who prepared food most often to identify all food items that had been consumed in the household the previous 24 hours. A total of 119 food items were recorded. Linear regression was employed to help develop a method to predict nutrient intakes from food group consumption. Nutrient intake of each household was described by a Nutrient Intake Ratio (NIR), the equivalent of a NAR for a household. The numerator is the sum of all individual intakes of a nutrient in a household and the denominator is the sum of all recommended nutrient intakes. The predicted frequency of low intakes (less than 75% of the recommendation) for energy, protein, vitamin A and iron was very similar to the measured frequency, but significance level was not mentioned. The authors conclude that these results demonstrate an inexpensive method for monitoring diets at the population level in Mozambique, which would be very useful for assessing progress in targeted areas.

In summary, much of the recent research on dietary diversity and nutrient adequacy in the developing world is indicating a positive association between the two variables. A summation of individual food items consumed has been found to be positively associated with nutrient intake (Ferguson *et al*, 1993; Onyango *et al*, 1998). Studies that investigated food groups also found a positive association (Rose & Tschirley, 2003; Arimond & Ruel, 2002; Tarini *et al*, 1999). Both food groupings and individual foods have been found to be significantly associated with nutrient intake (Hatløy *et al*, 1998; Ogle *et al*, 2001). In addition, a recent study found that a measure of individual foods given a score based on food group association was able to correctly categorize a household according to nutrient intake (Rose *et al*, 2002). Most of the studies have not controlled for energy, which may account for these positive results.

For those studies that have explored the use of food groups, researchers have developed groupings based on available foods; however not all researchers have classified food items in the same manner. In order for a dietary diversity indicator based on food groups to relate to nutrient intake, the groupings must be developed with consideration for nutrient content of each individual item in the group. The question remains as to whether different animal foods should be placed in separate categories or grouped together. Moreover, some researchers believe that food groups should be weighted given differences in nutrient density, bioavailability and usual quantities consumed (Rose *et al*, 2002). Another study has emphasized the importance of the frequency of food groups consumed (Rose & Tschirley, 2003).

The dietary measurement period in these studies has also varied. The aim has been to use a long enough period such that the information collected is meaningful, but a short enough period such that data collection is feasible. In addition, researchers have either obtained data on an individual level or a household level.

The ability to determine the proportion of a population or to identify a particular area that is nutritionally at risk or deficient is an important goal. To this end, researchers have looked at scoring systems. Diversity indicator cut-off values have varied from study to study and comparisons may not be appropriate given contextual differences. Some studies have assigned cut-off values based on data distribution. For example, Ogle *et al* (2001) used terciles. Some have used an approach based on sensitivity and specificity (Hatløy *et al*, 1998; Rose *et al*, 2002). Further research is needed to confirm the effectiveness and applicability of such a concept to dietary monitoring of populations.

2.4 DIETARY DIVERSITY: THE URBAN SETTING

Most research investigating dietary diversity in the developing world has taken place in the rural setting, however, urban and peri-urban diets are an emerging concern for nutrition researchers. Dietary habits of both the rich and poor are shifting towards a greater emphasis on calories, saturated fats, added sugars and added salts (Popkin, 2001; Haddad, 2003). In urban and peri-urban centers, the shift of diet from one rich in diversity to one comprising a smaller number of high-energy foods is driven by changing food preferences due to income growth, changes in relative food prices, urbanization, changing food choices resulting from food technology, and changes in food distribution systems (Haddad, 2003). Along with decreased activity levels, this nutrition transition is associated with increased levels of chronic diseases, such as cardiovascular disease, diabetes, cancer and obesity that are currently being witnessed in the urban setting (King, 1998; WHO/FAO, 2003). Meanwhile, diseases more commonly associated with developing countries persist. This "double burden" of disease where non-communicable diseases are emerging while infectious diseases and problems of under-nutrition remain significant is seen not only within populations (Vorster et al, 1999; WHO/FAO, 2003) but also within households (Garrett & Ruel, 2003). A tool that could monitor change over time in areas experiencing rapid dietary transition would be very useful and dietary diversity indicators might be helpful in this regard.

Although the urban experience tends to lead to these aforementioned changes, this may not always be the case. For instance, Huang & Bouis (1996) found that urban migration of a population in China led to an increased consumption of fruit, meat, fish, milk and eggs, which were positive changes relative to their previous diet. Therefore, although there are clear data supporting the unhealthy influence of urbanization on diet, this may not always be the case.

2.5 IRON INTAKE AND MILLET

Countries in sub-Saharan Africa have experienced increasing difficulty in meeting urban food needs with local products. A shift away from domestically produced cereals such as millet to imported rice and wheat is particularly notable in urban Senegal (Reardon, 1993), illustrated by the increase in annual per capita rice consumption from 50 kg in the 1960's to 60 kg in the 1990's (Tardif-Douglin & Diouf, 1998). Increased consumption of imported rice in Dakar is thought to result from the desire for convenience foods. As urban women enter the workforce, the local coarse grains such as traditional millet and domestic rice become less desirable due to longer preparation times

(Ross, 1980). Moreover, prices tend to be relatively low for cereal products as a result of low world cereal prices, food aid, overvalued exchange rates, and direct subsidization (Pearce, 1990).

Causes of anemia include low iron intake, parasites, chelators, blood loss and other nutrient factors such as vitamin A deficiency (Hodges *et al*, 1978). Iron deficiency anemia is often caused by inadequate iron intake in habitual diets in concert with poor bioavailability of dietary iron usually from a diet mainly consisting of plant foods. The absorption of iron from food is a complex process influenced by the form and quantity of iron, the presence of modifiers such as inhibitors and enhancers of iron absorption, and an individual's iron status (Hallberg, 1981).

Although pearl millet has been measured to contain between 4.5 (Oyenuga, 1968) and 11 (Agte *et al*, 1995) times more iron than rice, it also has higher levels of phytates, which are major inhibitors of iron availability (Hallberg, 1981; Harland & Oberleas, 1987; Reddy *et al*, 1989). In addition, the iron in millet is non-heme, a less bioavailable form of the mineral (Hazell, 1987). In Senegal, millet gruel and porridge are often eaten mixed with powdered milk, which further decreases iron availability. However, indications are that if cooked with several key iron enhancers, the availability of iron can be increased (Rao & Prabhavathi, 1978; FAO/WHO, 2002). For example, in Senegal, millet is also eaten as a prepared dish (*thiaré diene*) containing tomato and fish, which are important iron enhancers. Although promising, studies are conflicting as to whether total iron bioavailability is greater than, less than, or equal to rice.

One study compared total iron content and iron bioavailability of three commonly consumed meals in Senegal that were comprised of either pearl millet (*Pennisetum typhoides*) or imported white rice (Guiro, 1991). Subjects consumed each of the following meals: a pearl millet couscous dish, pearl millet gruel dish, and a rice dish. The extrinsic tag method was used to measure *in vivo* iron absorption. The iron absorption was 4.8% for the pearl millet couscous dish, 1.2% for the pearl millet gruel dish, and 10.4% for the rice dish. Although percent of total iron absorption from the meal was greater for the dish with rice, the pearl millet couscous dish yielded a greater amount of bioavailable iron (0.326 mg compared to 0.279 mg), presumably due to the greater initial iron content coming from millet. The pearl millet gruel dish, however yielded an unexplained much lower amount of bioavailable iron (0.069 mg). It remains unclear whether substitution of rice with millet would yield a greater overall amount of bioavailable iron, the same amount, or less.

Another study conducted on prepared Indian meals comprised of either rice or pearl millet (*Pennisetum typhoides*) showed that the bioavailability of iron in millet is significantly changed when it is consumed as a composite meal (Agte *et al*, 1995). *In vitro* percent dialysability under simulated gastrointestinal conditions was used as an indicator of iron bioavailability. Meals only differed with respect to cereal used. The total amount of dialyzable iron was greater and statistically significant for pearl millet meals (mean = 3.16 mg ± 1.49) compared to rice meals (mean = 0.69 mg ± 0.28). The iron availability measured from the composite meals was greater and statistically different

($p < 0.05$) from the weighted average of bioavailabilities of individual ingredients, indicating that an interaction between ingredients is altering the state of iron availability.

2.6 TARGET POPULATION

2.6.1 Senegal: Diet Diversity

Concern for the preservation of diet variety in Senegal heightened in the late 1990's. Structural adjustment policies led to currency devaluation in West Africa in 1994. Studies showed that subsequent food consumption patterns were altered in urban areas (Diagana, 1999). One important change observed was a reduction in diet variety, particularly in the poorest communities. Consumers sacrificed consumption of non-staple foods in order to defend caloric intake levels. These non-staple foods included meat, edible oils, fruit and vegetables and imported canned milk. Moreover, when vegetables were consumed, a decreased variety in those chosen was noted, with an obvious move towards cheaper produce. This is particularly important given that previous research had already indicated low levels of dietary diversity in West African poor (Reardon, 1993) and low intake of vitamins and protein (Kelly *et al*, 1995).

Yoff, Senegal was chosen as the study site for reasons additional to the above. Firstly, Yoff has been threatened culturally and physically by modern industrial developments, with increased severity over the past several decades. Recent construction has decreased potential areas of agricultural land use, and in particular, has destroyed some of the permanent food sources such as fruit trees. Secondly, years of French colonialism have brought the "green revolution" and cash crops to Senegal. This has drastically altered traditional agricultural practices and devastated the generational information base about self-sufficient natural farming. Thirdly, the inhabitants of Yoff do not belong to one socio-economic class, and therefore differences between eating habits of families are expected. This is important if one wants to investigate the relationship between diversity and adequacy. Fourthly, working as a westerner in a developing country context, one anticipates some difficulty with collaboration. The NGO CRESP had worked successfully in the village for several years, and hence a certain degree of cooperation from the villagers was expected.

2.6.2 Senegal: Food Habits

In Yoff, transition from a rural to a peri-urban community resulted in change from the traditional water-based method of cooking to one based on oils. Moreover, traditional, local foods were replaced with imported foods. Indeed, Senegalese people in general have shifted their diet to one high in energy-dense foods and low in micronutrients (Ministère de la Santé, 1999). The diet is described to contain a high amount of fats and oils, rice, bread, potatoes and manioc, and a low amount of fish, legumes, animal products and fruits and vegetables. Several studies are indicating that anemia might be an important health concern in women and children (Charbonneau & Laberge Gaudin, 2001; Ministère de la Santé, 1999).

Meals are served and eaten from a common plate, usually placed on the floor. Diners surround the plate and eat from the side closest to them using either a hand or a spoon. Only the very old and the chiefs of the village have their own separate bowls. If families are very large, men, women and children may all eat in separate groups.

Historically, plant foods have been important to the Senegalese diet. For example, traditional leafy vegetables have been used as condiments and as flavoring agents in stews. They have adapted well to the dry climate of the Sahel, and are relatively inexpensive to produce. During the rainy season, they may be harvested and dried for later use in the dry season. In addition, fruit trees have been an important source of essential nutrients. Unfortunately, the pressures of a growing population, increasing urbanization, industrialization, and modern agriculture, and the resulting cultural changes are negatively affecting plant resources. Indeed, a recent survey in Senegal describing the importance of traditional leafy vegetables in the culture, medicine and local cuisine (Seck *et al* 1999), noted that their use in the diet is decreasing.

In fact, the population tends to consume a low amount of fruits and vegetables in general. Reasons include affordability and accessibility on a personal scale, and poor weather and soil conditions and loss of small-scale farmland on a population scale. Following the 1994 devaluation of the Senegalese currency, a study of food consumption suggested that this economic change had a significant impact on dietary habits (Fouere *et al*, 2000). In particular, the quantity and diversity of fruit and vegetable intake declined, especially among the poor. In addition, poor infrastructure has resulted in low accessibility of fresh produce from rural areas to the urban centres. Low consumption has also been the result of poor soil quality due to intensive agricultural practices, drought, industry and construction.

2.6.3 Senegal: Geography

Senegal is the western-most country on the African continent. It is, for the most part, flat with a natural vegetation of dry savannah woodland. It lies between 12 and 17 degrees latitude north of the equator, at the western end of the Sahel. The western border of the country runs 600 km along the Atlantic Ocean. The Cap Vert peninsula, jutting into the ocean contains the capital city, Dakar, with its surrounding suburbs and satellite towns, of which Yoff is one. In 2001 the population of Senegal was estimated at over 10 million with a population growth rate of 2.93%. Since the 1960's the population has been rapidly shifting to the urban centers. Today, fifty percent of the population lives in cities. Indications are that this figure is still increasing. Literacy, as defined as those over the age of 15 who can read and write, is 33%. Senegal's economy is based on agriculture and is largely dependent on groundnuts (peanuts) as a cash crop. Production levels of subsistence crops such as corn, millet and sorghum are in decline and Senegal now imports more than 35% of its food requirements. Fishing, an important activity on the coast, supplies domestic and overseas markets. The climate pattern is defined by rainfall. The rainy season is considered June to October, and the dry season November to May.

Yoff is an old traditional fishing village that was established over 400 years ago, before the colonization of Africa (Zeitlin, 1996). Historically, its inhabitants participated in fishing, farming, and herding of cattle on a large tract of land. In 1964, however, the government appropriated the land and the community moved from a state of independence to a suburb of Dakar, the capital city of Senegal. Currently, Yoff is comprised of seven districts: Tonghor, Ndeungagne, Layène, Ngaparou, Ndénatte, Dagoudane and Mbenguène. Although fishing continues today, there has been a decrease in fishing stock in the past several decades (Dumez & Kâ, 2000). In addition, Yoff has witnessed an overall decrease in farming and an increase in unemployment. The population of Yoff has increased from a population of 25,000 ten years ago to nearly 50,000 today resulting in decreased land available for crops and fruit trees (Mack, 1996; Dumez & Kâ, 2000). The village consists mainly of the Lébou, an ethnic group that shares the Wolof language. As a consequence of past French rule, many also speak French to varying degrees. Several other groups found in the village are the Sérères, the Diolas, the Pulhars and some non-Senegalese such as Ghanaians and Nigerians. Although Islam was well established some 700 years ago in West Africa, the Lebou mix traditional spiritual practices with Muslim traditions (UNESCO, 1997).

2.6.4 Women and Nutrition

The goal of good nutrition for communities is a worthy one unto itself, however there are other reasons for its importance. Healthy, nutritionally adequate communities have a better chance at being prosperous, economically viable, and sustainable. The health of women is directly linked to the health of communities. Women bear children, are caregivers, are household managers and often times work outside the home (WHO, 2000). Given the importance of both the productive and reproductive roles of women, it is clear that healthy women help to ensure healthy communities. Achieving and maintaining good nutritional status are important to ensuring good overall health and therefore good nutrition and healthy eating are important goals for women especially throughout the childbearing years (Tinker, 1998; Tinker & Ransom, 2002). Women of childbearing years were also chosen because of the paucity of health and nutrition data in this population in Yoff.

2.7 STUDY RATIONALE

A well-nourished population is requisite to the long-term development of a country. Poor nutrition is well known to decrease productivity and to exert considerable strain on available resources. The evaluation and monitoring of the move towards adequate nutrition in a population is an important component of development. However, nutritional assessment of populations often requires more time and resources than are available. Moreover, overall measures of nutritional status rather than detailed analyses are often all that are required to monitor progress over time, and hence low-cost methods designed for this purpose would be very useful. To this end, measures of dietary diversity have been proposed to assess the adequacy of nutrient intakes.

With poor health and nutrient deficiencies common to the developing world, and methods of diet assessment often costly, an inexpensive simple tool to assess the nutritional quality of a diet in a community would be very useful. Researchers to date have derived measures of diversity from established methods of dietary assessment such as 24-hour recalls and food frequency questionnaires, however a tool that specifically measures diversity directly has yet to be validated.

2.8 STUDY OBJECTIVES

- To determine whether a tool that measures food diversity (as measured by both a food count and a food group count) can be used as a proxy measure of nutrient intake for three 24-hour recalls collected from women of childbearing years in the peri-urban village of Yoff, Senegal.

- To assess whether hemoglobin, a biochemical indicator of nutritional status, is associated with dietary diversity.

- To document usual dietary intake of women of childbearing years in the peri-urban community of Yoff, Senegal during the dry season (December – March).

The focus of the manuscript that follows is an investigation into the ability of a non-quantitative food frequency questionnaire to obtain dietary diversity data that reflects nutrient intake in a population. The study community is an old fishing village in Senegal that has experienced a great change in dietary habits within the past 20 years primarily due to urban expansion.

Table 2.1 Summary of studies in developing countries that have investigated dietary diversity and nutrient adequacy.

Author	Country	Subjects	Dietary Measure	Measured Outcome	Dietary Diversity Indicator	Food Groups	Nutrient Adequacy/ Nutritional Status Results
Arimond & Ruel, 2002	Ethiopia	M&F 1-3y n=4,624	24-h food group recall 7-d food group recall	*Height forAge Z-scores (HAZ)*	*24-h food group diversity:* # different food groups eaten during 24-h period (total=8) *7-d food group diversity:* *# different food groups eaten during 7-d period* (total=7) (grains combined with roots/tubers)	Grains, roots/tubers, vitamin A-rich F&Vs, other F&Vs, meat/poultry/fish/egg/ cheese/yogurt, milk, legumes, fats/oils	*Positive correlation between:* Food group diversity (24-h food & 7-d) & HAZ *HAZ significantly different between:* Lowest and highest tercile of 24-h diversity
Fergusson *et al*, 1993	Ghana & Malawi	M&F 3-6y n=148[a]/65[b]	Mean of 3 days Direct Weighing	*Nutrient densities:* fat, protein, iron, calcium, zinc	*DD:* *# different foods eaten/d* (mean of 3 days) (total=76[a]/62[b])	NA	*No correlation between:* DD & fat[ab], protein[ab], calcium[ab], zinc[a], iron[a] densities *Negative correlation between:* DD & iron[b], zinc[b] densities *Positive correlation between:* DD & energy intake [b]
Hatløy *et al*, 1998	Mali	M&F 1-5y n=77	Mean of 2-3 days Direct Weighing	*MAR:* energy, fat, protein, iron, calcium, vitamin A, B_1, B_2, B_3, C, folate	*FVS:* # different foods eaten during 2-3 d period (total=75) *DDS:* # different food groups eaten during 2-3 d period (total=8)	Staples (rice, millet, beans), GLV, other vegetables, fruit, meat, fish, milk, egg, other (sugar, sweets)	*Pearson's correlation:* MAR & FVS = 0.33 MAR & DDS = 0.39 *Best Cut-Off Points:* DDS=6 FVS=23

DD=Dietary Diversity; FVS=Food Variety Score; DDS=Dietary Diversity Score; GLV=Green Leafy Vegetables; HH=Households; NA=Not Applicable; MUAC=mid-upper arm circumference; TSF=triceps skinfold; HA=height for age; HW=height for weight; WH=weight for height; FFQ=food frequency questionnaire; MAR=mean adequacy ratio; NQS=nutritional quality score; [a] Study in Ghana; [b] Study in Malawi; [c] Study in 1996; [d] Study in 1999

Table 2.1. - *Continued*

Author	Country	Subjects	Dietary Measure	Measured Outcome	Dietary Diversity Indicator	Food Groups	Nutrient Adequacy/ Nutritional Status Results
Hatløy *et al*, 2000	Mali	M&F 6-59mo $n_{(urban)}$=526 $n_{(rural)}$=1789	HH-level 24-h food frequency	*Stunting, underweight, wasted*	*HH FVS:* # different foods eaten previous day in HH (total=104) *HH DDS:* # different food groups eaten previous day in HH (total=10)	Staples, vegetables, leaves/gathered foods, oil/sugar, fruit, nuts/pulses, meat, fish, milk, egg	*Urban areas:* Lower FVS & DDS = 2X risk of stunting or underweight *Rural areas:* No association
Ogle *et al*, 2001	Vietnam	F 19-60y n=217	7-d FFQ	*MAR:* energy, carbohydrate, fat, protein, iron, calcium, zinc, vitamin A, B_1, B_2, B_3, C, folate	*FVS:* # different foods eaten during 7-d period (total=120) *DDS:* # different food groups eaten during 7-d period (total=12)	Cereals, starch, GLV, other vegetables, fruits/juice, meat, fish/seafood, eggs, nuts/legumes, oil/fats, sauces, drinks/sweets	*FVS≥21:* Significantly greater intake of most nutrients *DDS≥8:* Significantly higher MAR of energy, protein, zinc, vitamin B_3, C
Onyango *et al*, 1998	Kenya	M&F 1-3y n=154	Mean of (3) 24-h recalls	*% recommended:* energy, protein, iron, calcium, vitamin A, B_1, B_2, B_3, C *Body measures:* MUAC, TSF, HA, WA, WH	*DD:* *# different foods eaten/d* (mean of 3 days)	NA	*DD>5:* Significantly higher intake of all nutrients, better anthropometric measures

DD=Dietary Diversity; FVS=Food Variety Score; DDS=Dietary Diversity Score; GLV=Green Leafy Vegetables; HH=Households; NA=Not Applicable; MUAC=mid-upper arm circumference; TSF=triceps skinfold; HA=height for age; HW=height for weight; WH=weight for height; FFQ=food frequency questionnaire; MAR=mean adequacy ratio; NQS=nutritional quality score; [a] Study in Ghana; [b] Study in Malawi; [c] Study in 1996; [d] Study in 1999

Table 2.1. - ***Continued***

Author	Country	Subjects	Dietary Measure	Measured Outcome	Dietary Diversity Indicator	Food Groups	Nutrient Adequacy/ Nutritional Status Results
Rose *et al*, 2002	Mozambique	All members of HH n=388 HH	HH-level quantitative 24-h recall	*Diet Quality Index (DQI):* Composite measure based on: energy vitamin A iron proteins 7 nutrients	*Mozambique Diet Assessment Tool (MDAT):* All foods eaten by all members of HH in previous 24 hrs. Ea food given score (1-4) based on food group association	1. Vegetables, fruits, oils, sugars, condiments 2. Cereals, tubers 3. Beans, nuts 4. Meats, fish, eggs, milk prods	*Positive correlation between:* MDAT & DQI for all nutrients except vitamin A *Best Cut-Off Point:* MDAT $\geq$ 23 (acceptable quality)
Tarini *et al*, 1999	Niger	M&F 2-4y n=60	Mean of 3 days modified weighed intake	*NQS:* energy, protein, vitamin A, zinc	*Diversity Score (DS):* # different food groups eaten during 3-d period (total=11)	Cereals, roots/tubers, GLV, other vegetables, fruits, meat, milk/eggs, pulses/nuts, legumes, fat, sugar	*DS≥6:* Significantly greater NQS
Torheim *et al*, 2003	Mali	M&F 15-59y[c] 15-45y[d] n=75[c]/70[d]	Mean of 2 days weighed/ recalled food record (WR)	*MAR:* energy, fat, protein, iron, calcium, vitamin A, B_1, B_2, B_3, C	*FVS from a 7-d FFQ:* # different foods eaten during 7-d period (total=69[c] or 164[d]) *DDS from a 7-d FFQ:* # different food groups eaten during 7-d period (total=11)	Cereals, legumes, vegetables, green leaves, fruit, meat, fish, milk, eggs, oil/sugar, other (spices, tea, coffee)	*Spearman's rank correlation[c]:* $MAR_{(WR)}$&$FVS_{(7\text{-}dFFQ)}$=0.36 $MAR_{(WR)}$&$DDS_{(7\text{-}dFFQ)}$=0.35 *Spearman's rank correlation[d]:* $MAR_{(WR)}$&$FVS_{(7\text{-}dFFQ)}$=0.24 $MAR_{(WR)}$&$DDS_{(7\text{-}dFFQ)}$=0.29

DD=Dietary Diversity; FVS=Food Variety Score; DDS=Dietary Diversity Score; GLV=Green Leafy Vegetables; HH=Households; NA=Not Applicable; MUAC=mid-upper arm circumference; TSF=triceps skinfold; HA=height for age; HW=height for weight; WH=weight for height; FFQ=food frequency questionnaire; MAR=mean adequacy ratio; NQS=nutritional quality score; [a] Study in Ghana; [b] Study in Malawi; [c] Study in 1996; [d] Study in 1999

3.0 Manuscript

Dietary Diversity and Nutrient Adequacy in Women of Childbearing Age in a Peri-Urban Community in Senegal, West Africa

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3.1 ABSTRACT

Objective: To assess the validity of two measures of dietary diversity derived from a qualitative diversity questionnaire by comparison with nutrient intake from three 24-hour recalls in a peri-urban community in Senegal.

Design: Three non-consecutive 24-hour recalls were conducted during the dry season (December 2003 – March 2004). Nutrient intakes were compared with a Food Diversity Score (FDS) and a Food Group Diversity Score (GDS) created from a Diversity Questionnaire for 1 day (1dDQ) and 7 days (7dDQ) as well as from the same data set. FDS represented a total of 60 foods and GDS a total of 11 food groups.

Subjects: Sixty-one women (18 – 45 y) from randomly selected households in Yoff, a community on the coast of Senegal.

Results: Positive correlations (range: r = 0.3 to r = 0.64) were found between intakes of several key nutrients (calcium, iron, zinc, vitamin A, vitamin C, thiamine, riboflavin and vitamin B_6) and FDS from the 7dDQ. Correlations were weaker or non-existent for the 1dDQ. Weaker correlations were found for GDS.

Conclusions: The 7dDQ is a quick and simple tool providing a measure of diversity and shows promise in the assessment of nutrient intake at the population level. Future research could confirm its potential as a component of population surveys that aim to describe the overall condition of a population.

Sponsorship: Canadian International Development Agency (CIDA), Le Fonds de la recherche en santé Québec (FRSQ).

Descriptors: dietary diversity, food variety, Africa, Senegal, nutrient adequacy, dietary intake of women, dietary assessment methods

3.2 INTRODUCTION

While the evaluation and monitoring of malnutrition is an important component of development work, nutritional assessment of populations often requires more time and resources than are available. However, overall nutritional measures rather than detailed analyses are often all that are required to monitor progress over time, and hence low-cost methods designed for this purpose would be useful. To this end, measures of dietary diversity have been proposed to assess the adequacy of nutrient intakes. Conceptually, dietary diversity is identified as an important element of a high quality diet (Tucker, 2001) and in practice, it is supported though government guidelines (US Department of Agriculture Human Nutrition Information Service, 1992; Health Canada, 1992) and international organizations (WHO/FAO, 1996).

A diet consisting of a variety of foods is thought to ensure nutritional adequacy associated with the known variation of nutrient composition between foods, the enhancement of the bioavailability of some important nutrients and our limited knowledge of the repertoire of dietary components beneficial for health. If diversity does indeed provide an adequate amount of required nutrients, then measuring diversity would be a good way of measuring adequacy. Recent research in developing countries has explored dietary diversity as an indicator of nutrient adequacy (Hatløy *et al*, 1998; Ogle *et al*, 2001; Onyango *et al*, 1998; Tarini *et al*, 1999; Torheim *et al*, 2003; Ruel, 2003) and food security (Hoddinott & Yohannes, 2002; Ruel, 2003).

The value of using dietary diversity indicators has yet to be clearly established and has been little explored in a peri-urban setting. The aim of this study is to determine whether a tool that measures food diversity can be used as a proxy measure of nutrient intake for three 24-hour recalls in a peri-urban community in Senegal, West Africa. In addition, the association between hemoglobin, a biochemical indicator of nutritional status, and dietary diversity was investigated.

3.3 SUBJECTS AND METHODS

3.3.1 Study Area and Population

The investigation was carried out in the West African peri-urban community of Yoff, Senegal, a coastal village of over 50 000 inhabitants and 15 km from the capital city of Dakar. With loss of cultivated fields and fruit trees as well as diminishing fish stocks and diversity (Dumez & Kâ, 2000) in recent years, and the suggested high prevalence of anemia in children (Ministère de la Santé, 1999; Charbonneau & Laberge Gaudin, 2001), nutrient adequacy has become a source of concern.

Criteria for inclusion in the study were female, current residence in the village, age 18 to 45 years, and absence of debilitating illness. Of the total of 77 households approached, five declined to participate due to lack of interest or time and 2 households did not have women of childbearing years. Of the 70 households that agreed to participate, 6 of the women withdrew from the study and 3 moved from the village during the course of the study, leaving 61 women to complete all three 24-hour recalls. Fifty-one women completed the diversity questionnaire.

Approval for the study was granted by McGill University's Ethics Committee. In the village, permission for the study was secured by the Mayor's office in Yoff subsequent to a presentation of the objectives and methods of the study to the community elders. All participants gave verbal and written consent. Upon completion of data collection, preliminary study results were presented to the community at a village meeting.

3.3.2 Study Design

A descriptive, cross-sectional study design was employed to assess food consumption. A nutritionist and a local female community worker with previous training in basic nutrition conducted most interviews together. Both participated in the development of the methods and questionnaires to ensure a common understanding of the goals and objectives of the project and the meaning of the questions in the questionnaires. To ensure that the verbal translations by the community worker would be accurate, the worker's written translation of the questionnaire tools from French into Wolof were compared to the tools that were translated back into French by a second community worker. Discrepancies and ambiguities between the two versions were addressed. A pilot study tested the appropriateness of the 24-hour recall method and the socio-demographic questionnaire and the functionality of the proposed tools. Any needed changes in approach were made accordingly.

3.3.3 Sampling Procedure

Data were collected during the dry season for the period beginning December 2002 and ending March 2003. All 7 districts in Yoff village were included in the study, with the proportion of participants chosen from each district based on census data. The random walk sampling method (Gibson & Ferguson, 1999) was used to select participants from each district. Each of the 7 districts has a traditional administrative center called the "penc" from which several roads spring and lead outwards towards the geographical periphery. Sampling in each district began at this center moving outward along a randomly chosen road. The first household on the road was visited and subsequently every third household until the district boundary was reached or the required number of participants was obtained. If the district boundary was reached before all participants had been recruited, researchers returned to the center to randomly choose another road until the required number of women was obtained.

In each household, defined as a group of people who consumed the main meals together, the researchers explained the study to the family head and obtained his/her permission before explaining the study to all women available in the house at that time. If more than one woman of childbearing years was interested in participating in the study, one woman was randomly chosen by lottery, her questions were answered, and written consent was obtained.

3.3.4 Interviews

A nutritionist and a local community partner collected all dietary, demographic, anthropometric data. Both spoke French and the community partner spoke fluent Wolof, the local language of Yoff. All interviews were conducted in the homes of the participants.

Socio-Demographic Assessment

A socio-demographic survey was directed at both the household head, if present, and the participant. The survey included demographic information and data on socioeconomic conditions such as housing and employment.

Dietary Assessment

Three non-consecutive 24-hour dietary recall interviews with an approximate month separation between each were used to describe food intake. Participants were asked to recall and describe all items consumed, including liquids and non-food items, during the previous 24-hour period, commencing with the first item eaten after waking up and ending with the last item eaten before waking up the following morning. Food models and calibrated local utensils were available at each interview to help participants describe quantities of foods eaten. In addition, monetary value was used to quantify several individually purchased food items and street foods such as bread, butter and donuts. Weight equivalency of each individual food item cited was determined by weighing five samples of the item using an electronic scale with a precision of ± 1g. The average weight was calculated for edible portions. In order to facilitate the quantification of non-solid food items such as rice dishes and porridge, participants ate main meals in a separate calibrated bowl provided by the researchers or in their own dishware that was subsequently referred to during the 24-hour recall interview. Information regarding ingredients and preparation methods for multi-ingredient recipes consumed in the community was obtained during the 24-hour recalls. In addition, the researchers created standardized recipes by assisting five women during the cooking process of each recipe.

In total, 31 recipes were compiled and used in the calculation of intake from the 24-hour recall questionnaires. These recipes were broken down and their components were added to a general food list. In addition, several food items were combined for practical purposes. For example, all species of fish were combined under one heading, as were different forms of pasta. The result was 86 unique food items that were eaten either as purchased or as incorporated into recipes. These 86 foods were considered for inclusion in the diversity scores. The contribution of 3 cereals (rice, wheat and millet) to the overall caloric intake of the sample population was determined by combining all recalls collected and calculating the percent kilocalories.

The CANDAT Nutrient Calculation System (2000) was used to process the dietary data obtained from the 24-hour recalls. Nutrient composition data for foods consumed by the participants were derived from the WorldFood2 Dietary Assessment System (1996) and incorporated into the program.

To assess validity of 24-hour recall data, prediction equations (Schofield, 1985) based on weight, age and sex were used to estimate the basal metabolic rates (BMR) of the subjects. The ratio of reported energy intake to BMR was subsequently calculated and compared to values used by Black *et al* (1996).

A Diversity Questionnaire (DQ) was conducted on 51 of the participants. This non-quantitative food frequency questionnaire was conducted before the initiation of the third 24-hour recall for each participant. The food list, meant to cover all major food items consumed, was based on information obtained from the first two 24-hour recalls of all subjects as well as discussions with key informants in the village. Each participant was asked to identify which of the 87 foods or recipes in a list they had consumed during the previous 24-hour period (1dDQ) and 7-day period (7dDQ) prior to the interview.

Diversity Indexes

For this study, two indexes of diversity were used: Food Diversity Score (FDS) and Group Diversity Score (GDS). FDS was defined as the total number of different food items consumed during the recall period; GDS was defined as the total number of different food groups consumed during the recall period. Both indexes were calculated from the three dietary measures: the summation of three 24-hour recalls, the 1dDQ and the 7dDQ, corresponding to recall periods of 3 days, 1 day and 7 days, respectively. The total number of food groups was 11: Cereal 1(rice & wheat), cereal 2 (millet), milk/milk products, meat, poultry, eggs, fish, fruit, vegetable 1, vegetable 2 (starchy vegetables), nuts/legumes. **Table 3.2** provides food group description and a list of major food items consumed. There was no quantity threshold for including an ingredient as a consumed food item. The food groupings used are similar to those established by Torheim *et al* (2003) where nutrient-rich animal foods are emphasized. The GDS and FDS did not include fats/oils and sweets given that energy deficiency was not considered to be an important problem in the study village and spices were excluded because they were not considered to provide great enough quantities of nutrients compared to other foods.

Anthropometry and Biochemistry

Age and height were obtained from the national identity card of each participant. Weight was measured using a mechanical spring scale on the second recall visit. During the period of weight measurement, the scale was assessed every morning for accuracy with a known quantity of water. Body Mass Index (BMI) was computed by weight(kg)/height(m)^2.

After completing the third 24-hour recall, hemoglobin (Hb) values were analyzed immediately using a HemoCue™ unit (HemoCue AB, Angelholm, Sweden). Participants with low Hb values were offered ferrous sulphate / folic acid tablets to be taken for 21 days, anti-parasitic tablets to be taken for 3 days and were referred to the local hospital for a free consultation with a health-care worker and further free treatment if necessary.

3.3.5 Data Analysis

Dietary data were analyzed using the SAS system for windows version 8.2 (SAS Institute, 1999-2001). Most nutrient intakes were not normally distributed, therefore the data were transformed. Adjusted nutrient intakes were calculated on transformed data and converted back to original units to be used as estimates of the distribution of usual intakes. Pearson's correlation coefficients were used to assess the degree of association between the diversity measures and individual nutrients obtained from the reference method. For a one-sided distribution with á = 0.05 and â = 0.20 and the ability to identify a correlation of 0.35 or greater, 49 subjects were required (Hulley *et al*, 2001).

3.4 RESULTS

3.4.1 Sample Characteristics

Women were between the ages of 18 and 45 years (**Table 3.1**). Most had always lived in the village and most were of the Lébou culture and Muslim. No participant was visibly pregnant at the time of interviewing. Mean BMI was 22 and positively correlated ($r = 0.43$, $p < 0.001$) with age. BMI ranged from 16 – 39 with 29.5% having a BMI below 18.5, the cut-off point used by the WHO to identify chronic energy deficiency, and 28% having a BMI over 25. Three quarters of the participants were married. Two thirds had children, with half having children less than 5 years of age. One quarter of the women had never been to school. More than one third of the women cited some form of employment, with the vending of food items most common.

Hemoglobin concentration measurement revealed 56% below the WHO cutoff value for anemia of <12 g/dL for non-pregnant women (WHO/UNU/UNICEF, 2001) (**Figure 3.1**). Nineteen percent fell below the cut-off point for moderate anemia (10 g/dL) and 3% fell below the cut-off point for severe anemia (7 g/dL). The mean hemoglobin concentration was 11.4 ± 1.7 g/dL.

3.4.2 Food Intakes

For the purpose of evaluating the contribution of individual food items to the diet, all recipes were separated into their individual food components and frequency of consumption was determined using a spreadsheet program. When recipes were broken down into their components, the DQ obtained similar frequency results to the 24-hour recall (**Table 3.2**). Looking at total frequency for the group, the 1dDQ corresponded well to the 24-hour recall for the most universally eaten food items such as white French bread, white rice, milk, fish, tomato, onion and garlic. However, less ubiquitous items such as millet gruel (*fondé*), banana, jujube (*Zizyphus* spp.), or baobab fruit (*Adansonia* spp.) juice were not captured as well. The 7dDQ was a much better approximation to the 24-hour recall for these less eaten items.

The 7dDQ provided important information regarding overall food habits of the women in the community. All participants ate some type of cereal. All had eaten white French bread at least once. Most individuals had white rice, milk, fish, tomato, onion and garlic during the week. Fruit was less common, with tamarind as an ingredient in sauces being the most common followed by orange, banana and jujube.

3.4.3 Nutrient Intakes

The distribution of adjusted intakes for protein, vitamins and minerals is described in quantiles along with the mean (**Table 3.3**). Values are compared to FAO/WHO recommendations. Participants at the 50^{th} percentile met the recommended intakes for vitamin B_{12} and vitamin A. Participants at the 75^{th} percentile met the recommendations for vitamin C, riboflavin, niacin, and vitamin B_6. The mean protein intake was higher than the calculated mean requirement. However, the 90^{th} percentile value for calcium, iron, zinc and thiamine, was below the recommended values. The overall ratio of energy intake to BMR was calculated to be 1.8.

3.4.4 Diversity Scores

Mean diversity scores when fats/oils, spices, sweets, and supplements were excluded were out of a possible total of 60 food items **(Table 3.4)**. Scores were calculated for 1dDQ, 7dDQ and the three 24-hour recalls. The 1dDQ yielded a lower mean FDS compared to the 7dDQ and the 24-hour recalls. The mean GDS was also lower for the 1dDQ compared to the 7dDQ and the 24-hour recalls, but the difference was not as striking. Mean values of FDS and GDS for the 7dDQ were similar to the corresponding values for the 24-hour recalls.

Table 3.5 outlines the Pearson's correlations between FDS derived from 1dDQ, 7dDQ and three 24-hour recalls and nutrient intakes derived from the average of three 24-hour recalls. Carbohydrate, calcium, iron, zinc, vitamin A, vitamin C, thiamine, riboflavin, vitamin B_6 and vitamin B_{12} correlate well with FDS derived from the 24-hour recalls (range: 0.36 – 0.64). Carbohydrate and vitamin C correlations were the same for FDS derived from the 7dDQ, but calcium, iron, zinc, thiamine and riboflavin correlations were slightly lower (range: 0.35 – 0.52) and vitamin A, niacin, vitamin B_6 and vitamin B_{12} were higher (0.39 – 0.54). Although the 1dDQ gave positive correlations, the values were usually lower than for the 7dDQ. Overall, calcium, vitamin A, vitamin C, thiamine, riboflavin and vitamin B_6 had the highest correlations, with zinc and iron having slightly weaker correlations. Scatter plots of all correlations were examined and no further information was gained. Including fats/oils, spices, sweets, and supplements in the diversity scores resulted in no substantial change in correlations and in some cases, worsened the correlation. Using Pearson's correlation, no association was found between hemoglobin measurement and either of the diversity scores.

The overall distribution of values for the diversity score that represents total number of foods (FDS) was compared to that for the diversity score that represents total number of foods groups (GDS). FDS values more closely approached a Gaussian distribution than did GDS values. **Figure 3.2** describes the distribution of FDS for the 1dDQ with a value range of 7 – 17. This FDS distribution is contrasted by that of GDS for 1dDQ (**Figure 3.3**) with a smaller value range of 4 – 10. Similarly, the FDS distribution for the 7dDQ has a greater range of values (12 – 29) (**Figure 3.4**) compared to the GDS distribution (5 – 9) (**Figure 3.5**). Moreover, FDS had a unimodal distribution for the 7dDQ, which contrasts the bimodal distribution of GDS for the 7dDQ.

3.4.5 Nutrient and Food Diversity

The major contributors of energy intake were tomato rice stew with fish, white wheat French bread, and white rice stew with fish. This corresponded very well to the original diversity questionnaire where most people consumed these 3 items.

The major contributors of protein were fish, white wheat French bread and whole dry cow's milk. This also corresponded well with the diversity questionnaire where most people consumed these 3 items.

The three main cereals consumed in the village are imported white rice (24% total caloric intake), imported wheat (consumed as bleached flour baked into bread) (13% total caloric intake), and local pearl millet (*Pennisetum typhoides*) (9% total caloric intake).

A summary of the main contributors of some key nutrients to the diet of the study population is found in **Table 3.6**. In total, participants cited 143 different food items including individual foods and prepared recipes. Foods or recipes contributing up to 50% of the mean nutrient intake are listed.

Little variety in calcium contributors to the diet was found. The most significant source of calcium is whole dry cow's milk. According to the 1dDQ, most people consume it every day **(Table 3.2)** and yet calcium intake correlates well with FDS. This suggests that those who eat a more diverse diet, rather than just a greater quantity, are more likely to consume greater quantities of milk. Although some individuals consumed more calcium than others, not one person met the FAO/WHO recommendation of 1000 mg, a value based on Western European, American and Canadian data.

Important iron contributors are millet, fish and mutton, with millet providing the greatest quantity. The most frequently consumed of these three is fish. Iron intake correlates with FDS, suggesting that the consumption of millet and mutton helps to distinguish between individuals in a diversity score with respect to iron. No individual met the requirement for iron intake. Moreover, because the diet consists mainly of non-heme iron bioavailability is relatively low. No association was found between iron intake and hemoglobin concentration suggesting that factors other than inadequate iron intake might be contributing to anemia, such as low iron bioavailability from foods or infection. An in depth analysis exploring heme and non-heme sources of foods and hemoglobin was not done given the large proportion of iron intake derived from plant sources and the established clinical practice in this area of treating anemia with mebendazole, an anthelmintic medication. The latter indicates common knowledge that parasites are prevalent, which can affect iron status.

French baguette, mutton and tomato rice stew with fish are the top three contributors of zinc. None of these foods contribute large amounts of the nutrient, and this is evident when one considers that very few individuals met the requirement. Most individuals eat most foods mentioned for zinc and therefore those foods do not help to discriminate between individuals in a diversity score. The one exception is mutton and hence, presumably zinc correlates with FDS in part due to whether someone has eaten mutton.

The main source of vitamin A is carrot cooked in stews followed by butter. Although liver was available in the village, very few individuals ate it. Likewise, red palm oil, used to prepare a special sauce (*soupo kandia*), was not eaten on a regular basis due to the cost of okra, an essential ingredient in this particular sauce. Over half of the participants surpassed vitamin A intake recommendations. Given that carrots and butter are available year-round, it is postulated that the number of people who have met requirements would not decrease over different seasons but only rise, for example during mango season, and okra season. Vitamin A is correlated with FDS. Presumably, those individuals who eat a greater variety of foods tend to eat carrots. These values were calculated using Retinol Equivalents (RE). Using the new Retinol Activity Equivalents (RAE) might yield a lower total vitamin A intake due to the different activity of provitamin A carotenoids.

Vitamin C is the nutrient most highly correlated with FDS. The top three vitamin C contributors are oranges, cassava, and millet couscous stew with fish. All of these items are not eaten by all individuals on a regular basis and therefore a diversity score may be able to discriminate between individuals. Moreover, the variety existing within the vitamin C contributors (fruits, stews, vegetable) also allows a diversity score to identify those individuals with a lower vitamin C intake.

Thiamine intake is well correlated with FDS. The top sources of thiamine are French baguette, whole milk, millet couscous stew with fish, and millet porridge. Most individuals consume baguette and milk; therefore millet foods are those most likely to distinguish individuals.

Riboflavin is also well correlated with FDS. The top contributors are whole milk, mutton, baguette, curdled milk, and millet couscous stew with fish. Again, the majority of individuals consume milk and baguette therefore the other food items contribute to a greater extent to the FDS.

3.5 DISCUSSION

In this study, a measure of food diversity derived from a qualitative food frequency questionnaire was compared to nutrient intake obtained from the mean of three 24-hour recalls. Food diversity was defined by the number of foods consumed (FDS) or the number of food groups consumed (GDS). We found that measures of diversity were associated with calcium, iron, zinc, vitamin A, vitamin C, thiamine, riboflavin and vitamin B_6 as documented by the three 24-hour recalls. These results are similar to earlier studies that have suggested that diversity indicators might be good predictors of nutrient adequacy. We found that FDS correlated better than GDS with nutrient intake. These results differ from Hatløy *et al* (1998) where a score based on food groups had a stronger correlation than a score based on individual foods. The difference in results may be partly attributed to what was included in the score. Their individual food score included all food items consumed. Foods with little or no nutritional content such as condiments and spices were also part of the score, which may have weakened the association between the individual food score and nutrient intake. Also, the difference between the correlation for individual foods compared to that for food groups is very small and hence not likely to be different enough in a practical sense to warrant using one score over another.

The diversity questionnaire with the 7-day recall period yielded very similar diversity scores to the sum of the three 24-hour recalls which suggests that the former would be useful in describing overall dietary habits. The diversity questionnaire was also able to highlight those foods that are eaten by most of the population, suggesting that the 7dDQ would be useful for identifying food fortification possibilities. Although the diversity score might be used for community monitoring over a period of time, the absence of quantified food intake limits its usefulness because frequency of consumption does not necessarily reflect importance of intake. For example, according to the mean of the 24-hour recalls, millet is the greatest contributor of iron **(Table 3.6)**, however the most frequently consumed of the top iron contributors is fish **(Table 3.2)**.

A dietary diversity index has additional limitations. High variability of certain nutrients such as vitamin A is common (Rose *et al*, 2002) and hence a single tool that assesses all components of dietary intake may be ambitious. Also, there may be other factors affecting nutritional status. Hemoglobin was used here as one important biochemical indicator of nutritional status. Although the distribution curve for hemoglobin is wide and skewed to the left, suggesting a population with a high prevalence of anemia, we were unable to relate iron intake to Hb. Low bioavailability of iron-rich foods and parasitic infections are likely to be responsible for anemia, and hence a diversity score would not identify this problem.

The FDS had a consistently better overall distribution of values than its food group counterpart, suggesting that a FDS is a more sensitive measure than a GDS. Studies in other countries that used different food groupings did not find this to be the case, perhaps highlighting the importance of setting and food group definition when applying the diversity concept.

An average of three 24-hour recalls was used as the dietary reference method to obtain nutrient intake values that could be compared to GDS and FDS obtained from the DQ. There are several advantages to the 24-hour recall method. For instance, it is open-ended and relies on memory of only the past 24 hours. Furthermore, it is less invasive than food records. There are, however, certain limitations of the 24-hour methodology that must be acknowledged. For instance, under- and over-reporting of food intake have been well documented (Westerterp *et al*, 2002). Overestimation of items perceived to have more status and underestimation of items associated with lower status are often a concern. Under or overestimation was considered to be minimal by the community worker who was born and raised in the village. The ratio of EI to BMR was calculated to be 1.8, an expected value for a population whose daily activities include standing work such as cooking, cleaning, and caring for children (Black *et al*, 1996). Therefore overall bias to reported energy intake is considered minimal. Additional limitations include unintentional memory lapses and unintentional inaccuracy of food quantity estimation. To circumvent the problem of poor recall and difficulty with portion estimation, food models were used as in previous studies (Moore *et al*, 1967; Labadarios, 1999; Ferguson *et al*, 1995). In addition, a trained nutritionist was in charge of all data collection to ensure accuracy and consistency of the information obtained.

One important limitation of the 24-hour methodology cited has been the necessity for repeated interviews on different days and seasons in order to minimize error due to intra individual intake (Gibson, 1990; National Research Council, 1986). The present study aimed to describe habitual food habits for the months of December through to March. This period is part of the dry season when fresh produce is typically less available and more expensive, and hence presumably when nutrient intake is lower than during more plentiful seasons. Three 24-hour recalls were thought to be sufficient in order to obtain average nutrient intake values for that time period.

The quantification of food can be difficult because of the custom of eating the main meals from a common bowl. Some researchers have circumvented this problem by counting number of handfuls or spoonfuls eaten (Torheim *et al*, 2001). While this approach certainly has its advantages, namely that the participant is not required to change their usual eating style, it tends to be time-consuming and has the potential to greatly influence both food quantity and quality, given that the consumption of each meal is observed by a researcher in the home of the participant. Moreover, this method is at risk of great error through multiplication if quantity contained in a handful or spoonful is inaccurately estimated.

To quantify non-solid food items, such as rice, participants were asked to eat main meals in a separate bowl. Given the social importance of mealtime, eating in this manner may have contributed to a decreased appetite and hence a decreased intake of main meals. However, women in the village are accustomed to eating separately from time to time when they are pregnant, ill, arrive late from work or work away from home during mealtime. Moreover, most participants indicated little change in satiation from regular meal days.

The quality of the diversity questionnaire results may have been influenced by the previous two 24-hour recalls. As with all dietary assessment methods, the DQ is subject to errors associated with the respondent's willingness and ability to communicate accurate information. As the study progressed, participants became more comfortable answering questions regarding food intake and were able to express themselves with greater facility. Had the DQ been conducted prior to all 24-hour recalls, it is possible that participants would have been less willing or able to provide information. It is also possible, however, that participants modified their responses to the DQ based upon prior 24-hour recall experience with the interviewers. Given the different line of questioning and the simplicity of the DQ, this issue is thought to be minimal.

The quality of the DQ results may have been influenced by the previous 24-hour recalls. As with all dietary assessment tools, the questionnaire is subject to errors associated with the respondent's willingness and ability to communicate accurate information. As the study progressed, participants became more comfortable answering questions and were able to express themselves with greater facility. Had the DQ been conducted first, it is possible that participants would have been less willing or able to provide information.

Although in theory absolute number of foods consumed would be very useful for determining adequacy in a population, the establishment of international diversity cut-off points may be unrealistic. Diets vary from one country to another with respect to food types and quantities consumed. A value in one setting may be meaningless in another. Rather, dietary diversity might be most useful for monitoring changes in a given population. In addition, to measuring diversity, the DQ tool itself has the potential to discover new opportunities for food fortification, given that it outlines the foods that are ubiquitous in the diet.

The 7dDQ was easier to implement and required less time to complete than the 24-hour recalls. Between five to ten minutes were required to carry out the DQ compared to 30 minutes for each 24-hour recall. While the information gained from the DQ was not quantitative, it provided a good representation of the important food items consumed in the community. The 7dDQ corresponded well to the 24-hour recall for frequency of food items eaten. The 7dDQ also correlated with the same nutrients as the 24-hour recall.

This study provides evidence for usefulness of indicators of diversity derived from a 7dDQ to evaluate nutrient intake over time for populations. The FDS correlated well with calcium, iron, zinc, vitamin A, vitamin C, thiamine, riboflavin and vitamin B_6. The FDS derived from the 7dDQ was found to be very similar to that derived from the 24-hour recall. Hence, the 7dDQ might be the key to the applicability of the food diversity concept to nutrient assessment in population studies. Future research might investigate the geographic applicability of this methodology.

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Table 3.1 Characteristics of study participants.

Variable	Value
Age (y)[ab]	30 ± 8
BMI (kg/m^2)[ab]	22 ± 5
BMI = 16 – 18.49 (%)	30
BMI = 18.5 – 24.9 (%)	41
BMI = 25 – 29.9 (%)	18
BMI = 30 – 40 (%)	11
Married (%)[b]	74
Have children (%)[b]	67
Have children < 5 (%)[b]	49
Never been to school (%)[b]	25
Employed (%)[b]	39
Hemoglobin (g/dL)[c]	11.4 ± 1.7
No. people in household[ab]	14.7 ± 7.3

[a] Values are mean ± s.d.
[b] n=61
[c] n=59

Table 3.2 Frequency of food items cited for diversity questionnaire (1d and 7d periods) and 24-hour recall (3d period). If cited by an individual, item is counted once regardless of frequency or quantity consumed. All recipes broken down into individual food items. Spices, fats/oils, sweets, and supplements excluded. Number of individual food items = 55.

Food Group	Food Item	Cited Frequency					
		1dDQ		7dDQ		24-hr Recall (3d)	
		n=51	% (of 51)	n=51	% (of 51)	n=61	% (of 61)
Cereal 1	White Rice	49	96	51	100	56	92
	Rice Noodles	0	0	5	10	9	15
	White Wheat French Bread	49	96	51	100	61	100
	White Wheat Pasta	4	8	10	20	9	15
Cereal 2 Millet (*Pennisetum typhoides*)	Millet Gruel (fondé)	10	20	23	45	24	39
	Millet Couscous (thiaré)	19	37	34	67	28	46
	Millet Porridge (bouille)	1	2	6	12	3	5
	Millet Donut	5	10	13	25	16	26
Milk/Milk Products	Milk, whole: powdered/liquid	45	88	50	98	59	97
	Curdled Milk (lait caillé)	15	29	26	51	28	46
	Cheese	3	6	4	8	3	5
	Yogurt	0	0	1	2	2	3
Meats	Mutton (sheep meat)	7	14	18	35	35	57
	Beef	1	2	6	12	7	11
	Liver	1	2	3	6	3	5
Poultry	Chicken	0	0	3	6	10	16
Eggs	Egg	2	4	3	6	7	11
Fish/Seafood	Fish	50	98	51	100	61	100
	Shrimp	0	0	1	2	1	2
	Sea Snail (*Cymbium* spp.)	10	20	42	82	29	48

Table 3.2 - *Continued*

Food Group	Food Item	Cited Frequency					
		1dDQ		7dDQ		24-hr Recall (3d)	
		n=51	% (of 51)	n=51	% (of 51)	n=61	% (of 61)
Fruits	Orange/mandarine	14	27	31	61	29	48
	Apple	2	4	4	8	5	8
	Pineapple	0	0	0	0	1	2
	Mango	0	0	0	0	1	2
	Gerte toubab (*Terminalia catalpa*)	2	4	4	8	1	2
	Banana	1	2	13	25	13	21
	Jujube (*Zizyphus* spp.)	2	4	14	27	12	20
	Watermelon	0	0	0	0	1	2
	Tamarind	20	39	46	90	41	67
	Lemon	1	2	4	8	5	8
	Grapefruit	1	2	4	8	3	5
	Coconut	1	2	1	2	1	2
	Bissap Juice (*Hibiscus sabdariffa*)	0	0	4	8	3	5
	Baobab Fruit Juice (*Adansonia* spp.)	4	8	10	20	8	13
	Raisin	1	2	1	2	2	3

Table 3.2 - *Continued*

Food Group	Food Item	Cited Frequency					
		1dDQ		7dDQ		24-hr Recall (3d)	
		n=51	% (of 51)	n=51	% (of 51)	n=61	% (of 61)
Vegetables: nonstarchy	Tomato: fresh/concentrate	50	98	51	100	59	97
	Bitter Tomato (*Solanum incanum*)	0	0	3	6	3	5
	Cucumber	0	0	0	0	2	3
	Carrot	24	47	42	82	41	67
	Cabbage	17	33	27	53	34	56
	Eggplant	8	16	12	24	13	21
	Turnip	4	8	25	49	9	15
	Lettuce	2	4	8	16	11	18
	Green Bean	0	0	3	6	7	11
	Okra	12	24	32	63	6	10
	Pumpkin	0	0	0	0	3	5
	Green Pea	0	0	0	0	1	2
	Garlic	50	98	51	100	61	100
	Onion	51	100	51	100	61	100
Vegetables: starchy	Cassava	22	43	30	59	37	61
	Potato/French Fries	8	16	30	59	33	54
	Sweet Potato	6	12	11	22	12	20
Nuts/Legumes	Groundnut: roasted/paste	15	29	28	55	36	59
	Cowpea (*Vigna unguiculata*)	2	4	5	10	3	5
	Netetou (*Parkia biglobosa*)	12	24	44	86	32	52

Table 3.3 Distribution of adjusted nutrient intakes from mean of three 24-hour recalls compared to the FAO/WHO vitamin and mineral recommended nutrient intakes (FAO/WHO, 2002).

Nutrient	FAO/ WHO	Mean	Percentile				
			10th	25th	50th	75th	90th
Protein (g)†	47 (mean) 26-80 (range)	69	53	59	68	76	86
Calcium (mg)	1000	434	282	333	422	505	620
Iron (mg)	29.4‡	9.6	5.3	7.6	9.4	11.6	13.4
Zinc (mg)	9.8	7.9	5.6	6.8	7.8	8.7	9.7
Vitamin A (RE)	500	717	332	476	605	901	1110
Vitamin C (mg)	45	38	16	27	34	52	60
Thiamine (mg)	1.1	0.8	0.5	0.6	0.8	0.9	1.0
Riboflavin (mg) *	1.1	1.0	0.5	0.7	0.9	1.2	1.4
Niacin (mg) *	14	13	9	10	12	16	18
Vitamin B6 (mg) **	1.3	1.3	0.8	0.9	1.2	1.5	1.8
Vitamin B12 (mcg) **	2.4	3.5	1.1	1.7	2.6	4.4	5.8

†Using 0.75 g/kg/d (FAO, WHO & UNU, 1985)
‡Assuming 10% dietary iron bioavailability (diet of small amounts of fish and vitamin C)
*Data transformation not required
**Data transformation not possible

Table 3.4 Food diversity scores (FDS) and group diversity scores (GDS) for 1dDQ, 7dDQ and 24-hour recall. Fat/oil, spices, sweets and supplements are excluded. Values are expressed as mean (range) ± s.d. [95% confidence interval].

Questionnaire Tool	Food Diversity Score (FDS) (total # foods = 60)	Group Diversity Score (GDS) (total # food groups = 11; representing 60 food items)
1dDQ (n=51)	11.8 (7 – 17) ± 2.5 [11.1, 12.5]	6.3 (4 – 10) ± 1.2 [6.0, 6.6]
7dDQ (n=51)	19.5 (12 – 29) ± 3.5 [18.5, 20.5]	7.9 (5 – 9) ± 1.0 [7.6, 8.2]
24-hour recall (n=61)	18.6 (9 – 25) ± 3.5 [17.7, 19.5]	8.1 (4 – 11) ± 1.2 [7.8, 8.4]

Table 3.5 Correlation statistics for adjusted micro- and macronutrient intakes and food diversity score (FDS) for 1dDQ, 7dDQ and 24-hour recall.
Total number of food items = 60 (fat/oil, spices, sweets and supplements excluded).

Nutrient	**1dDQ** (n=51) recall period=1d		**7dDQ** (n=51) recall period=7d		**24-hour Recall** (n=61) recall period=3d	
	Pearson correlation (r)	p-value	Pearson correlation (r)	p-value	Pearson correlation (r)	p-value
Kcal	0.27	0.0586	0.36	0.0086	0.34	0.0074
Protein	0.30	0.0304	0.39	0.0052	0.37	0.0038
Carbohydrate	0.34	0.0134	0.41	0.0030	0.41	0.0010
Fat	0.09	0.5484	0.21	0.1381	0.16	0.2077
Calcium	0.32	0.0223	0.46	0.0007	0.59	<0.0001
Iron	0.40	0.0041	0.39	0.0044	0.47	0.0001
Zinc	0.31	0.0262	0.35	0.0117	0.48	0.0001
Vitamin A	0.55	<0.0001	0.52	<0.0001	0.41	0.0009
Vitamin C	0.37	0.0079	0.64	<0.0001	0.64	<0.0001
Thiamine	0.45	0.0008	0.52	0.0001	0.53	<0.0001
Riboflavin *	0.37	0.0071	0.48	0.0004	0.59	<0.0001
Niacin *	0.39	0.0044	0.39	0.0044	0.32	0.0107
Vitamin B_6 **	0.43	0.0016	0.54	<0.0001	0.48	<0.0001
Vitamin B_{12}**	0.41	0.0026	0.51	0.0001	0.36	0.0049

* Data transformation not required
** Data transformation not possible

Table 3.6 Mean and percent contribution of most important contributors from mean of three 24-hour recalls. Values are to 50% of mean energy and nutrient intake. Total number of individual foods and mixed dishes = 143. N=61.

Energy & Nutrients	Food Items	Mean (%)
Energy (kcal)	Tomato rice stew with fish (thiebu diene bu xonx)	308 (12.7)
	White wheat French bread	288 (11.9)
	White rice stew with fish (thiebu diene bu weex)	211 (8.7)
	White rice, plain	171 (7.0)
	Millet couscous stew with fish (thiaré diene)	137 (5.6)
	White granulated sugar	128 (5.3)
	Total of food list	**1243 (51.2)**
	Overall mean intake	**2428 kcal**
Protein (g)	Fish	16 (22.3)
	White wheat French bread	9 (13.3)
	Whole dry cow's milk	5 (6.9)
	Mutton (sheep meat)	4 (6.3)
	Tomato rice stew with fish (thiebu diene bu xonx)	4 (5.3)
	Total of food list	**38 (54.1)**
	Overall mean intake	**70 g**
Carbohydrate (g)	White wheat French bread	55 (16.3)
	Tomato rice stew with fish (thiebu diene bu xonx)	43 (12.8)
	White rice, plain	38 (11.2)
	White granulated sugar	33 (9.8)
	Total of food list	**169 (50.1)**
	Overall mean intake	**337 g**
Fat (g)	Tomato rice stew with fish (thiebu diene bu xonx)	13 (14.6)
	Butter	9 (9.5)
	Millet couscous stew with fish (thiaré diene)	8 (8.3)
	White rice stew with fish (thiebu diene bu weex)	7 (8.2)
	Whole dry cow's milk	5 (5.4)
	Mayonnaise	4 (4.5)
	Total of food list	**46 (50.5)**
	Overall mean intake	**91 g**
Calcium (mg)	Whole dry cow's milk	166 (38.0)
	Curdled cow's milk (lait caillé)	42 (9.5)
	Tap water	24 (5.4)
	Total of food list	**232 (52.9)**
	Overall mean intake	**439 mg**

Table 3.6 - *Continued*

Nutrients	Food Items	Mean (%)
Iron (mg)	Millet couscous stew with fish (thiaré diene)	1.6 (16.2)
	Millet gruel (fondé)	1.0 (10.4)
	Millet couscous (thiaré)	0.9 (9.0)
	Fish	0.6 (6.3)
	Mutton (sheep meat)	0.6 (6.1)
	White wheat French bread	0.5 (5.4)
	Total of food list	**5.2 (53.4)**
	Overall mean intake	**9.7 mg**
Zinc (mg)	White wheat French bread	0.9 (11.8)
	Mutton	0.9 (10.6)
	Tomato rice stew with fish (thiebu diene bu xonx)	0.6 (7.9)
	Whole dry cow's milk	0.6 (7.6)
	White rice, plain	0.5 (6.8)
	White rice stew with fish (thiebou diene bu weex)	0.5 (6.1)
	Total of food list	**4.0 (50.8)**
	Overall mean intake	**7.9 mg**
Vitamin A (RE)	Carrots	335 (44.4)
	Butter	79 (10.5)
	Total of food list	**414 (54.9)**
	Overall mean intake	**754 RE**
Vitamin C (mg)	Orange	10 (21.9)
	Fruit drink	3 (6.8)
	Cassava	3 (6.7)
	Millet couscous stew with fish (thiaré diene)	2 (5.1)
	Tomato rice stew with fish (thiebu diene bu xonx)	2 (4.6)
	Whole dry cow's milk	2 (3.6)
	Cabbage	1 (3.1)
	Total of food list	**23 (51.8)**
	Overall mean intake	**44 mg**
Thiamine (mg)	White wheat French bread	0.11 (14.6)
	Fish	0.10 (12.6)
	Whole dry cow's milk	0.05 (6.7)
	Millet couscous stew with fish (thiaré diene)	0.05 (6.2)
	Millet gruel (fondé)	0.04 (5.0)
	Tomato rice stew with fish (thiebu diene bu xonx)	0.04 (4.6)
	Millet couscous (thiaré)	0.03 (4.3)
	Total of food list	**0.42 (54.0)**
	Overall mean intake	**0.80 mg**

Table 3.6 - *Continued*

Nutrients	Food Items	Mean (%)
Riboflavin (mg)	Whole dry cow's milk	0.22 (22.5)
	Mutton (sheep meat)	0.10 (10.1)
	White wheat French bread	0.08 (8.5)
	Fish	0.06 (6.1)
	Curdled cow's milk (lait caillé)	0.05 (5.0)
	Total of food list	**0.51 (52.2)**
	Overall mean intake	**0.98 mg**
Niacin (mg)	Fish	3.8 (28.9)
	White wheat French bread	0.9 (7.1)
	Tomato rice stew with fish (thiebu diene bu xonx)	0.7 (5.2)
	Mutton (sheep meat)	0.6 (4.8)
	White rice stew with fish (thiebou diene bu weex)	0.6 (4.4)
	Total of food list	**6.6 (50.4)**
	Overall mean intake	**13.1 mg**
Vitamin B_6 (mg)	Fish	0.3 (22.6)
	Tomato rice stew with fish (thiebu diene bu xonx)	0.09 (7.0)
	White rice stew with fish (thiebou diene bu weex)	0.08 (6.1)
	Millet couscous stew with fish (thiaré diene)	0.07 (5.6)
	White rice, plain	0.07 (5.3)
	Whole dry cow's milk	0.06 (4.3)
	Total of food list	**0.67 (50.9)**
	Overall mean intake	**1.3 mg**
Vitamin B_{12} (mcg)	Fish	1.3 (37.8)
	Sheep's liver	0.6 (17.2)
	Total of food list	**1.9 (55.0)**
	Overall mean intake	**3.5 mcg**

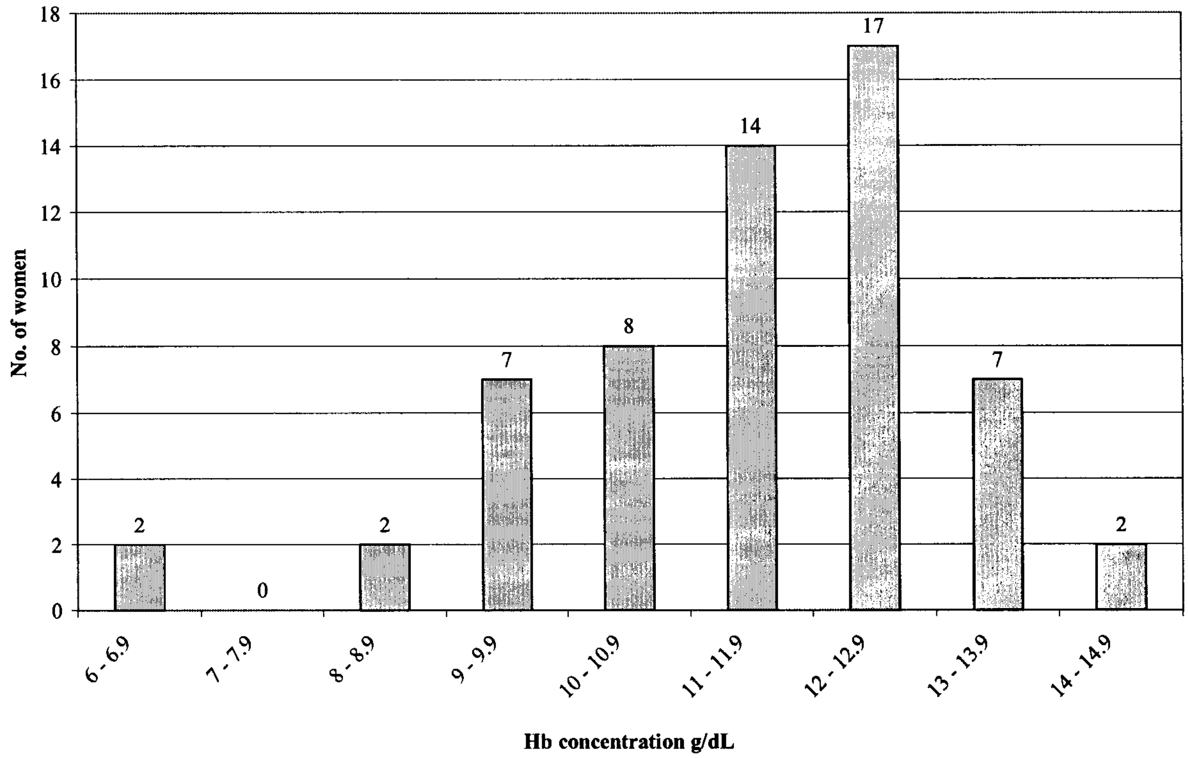

Figure 3.1 Distribution of hemoglobin (Hb) concentrations (n=59). Cut-off used for classifying anemia: Hb < 12 g/dL.

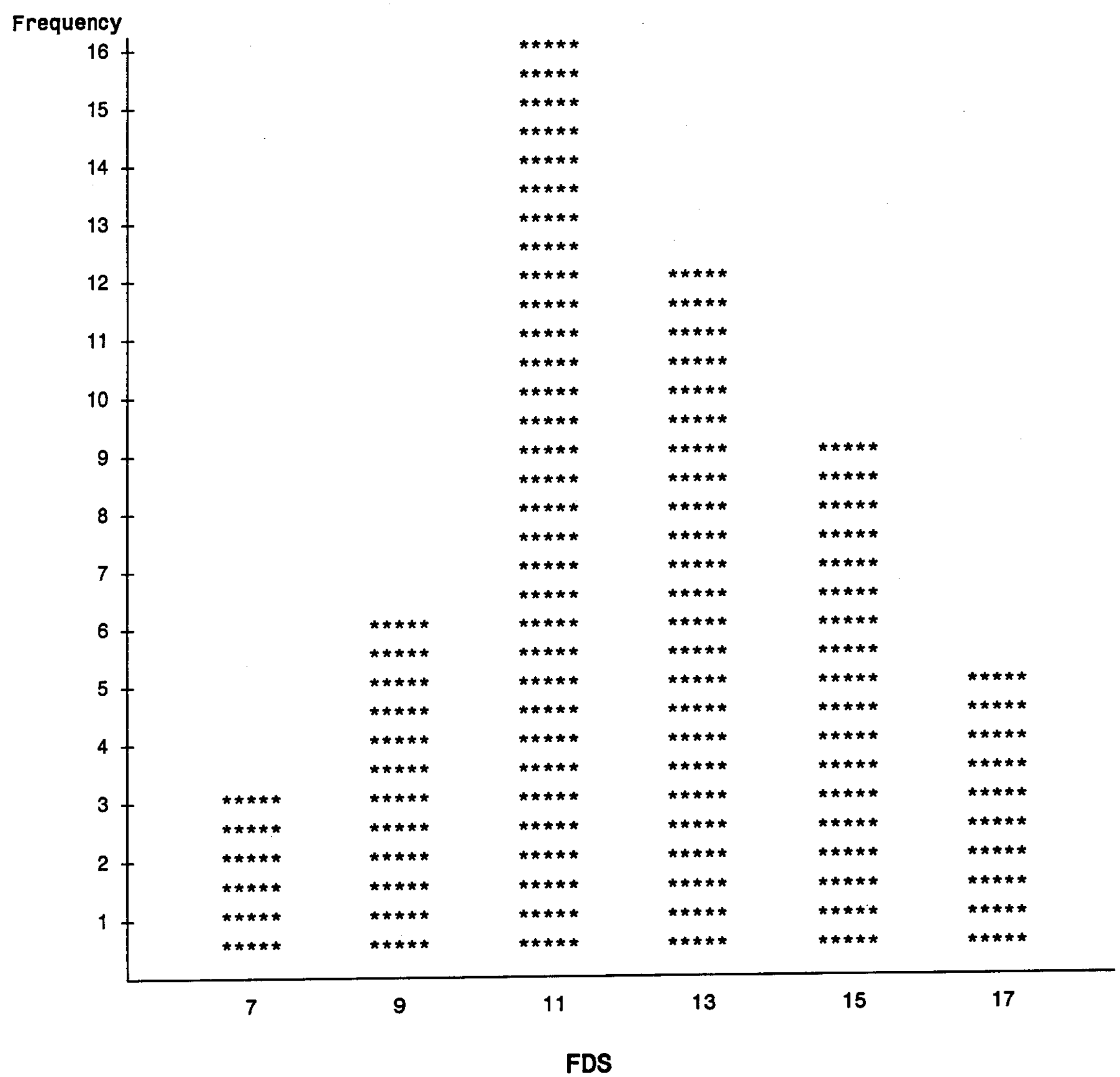

Figure 3.2 Frequency bar chart for Food Diversity Score (FDS) for 1dDQ (no fat/oil, sweets, spices, supplements).

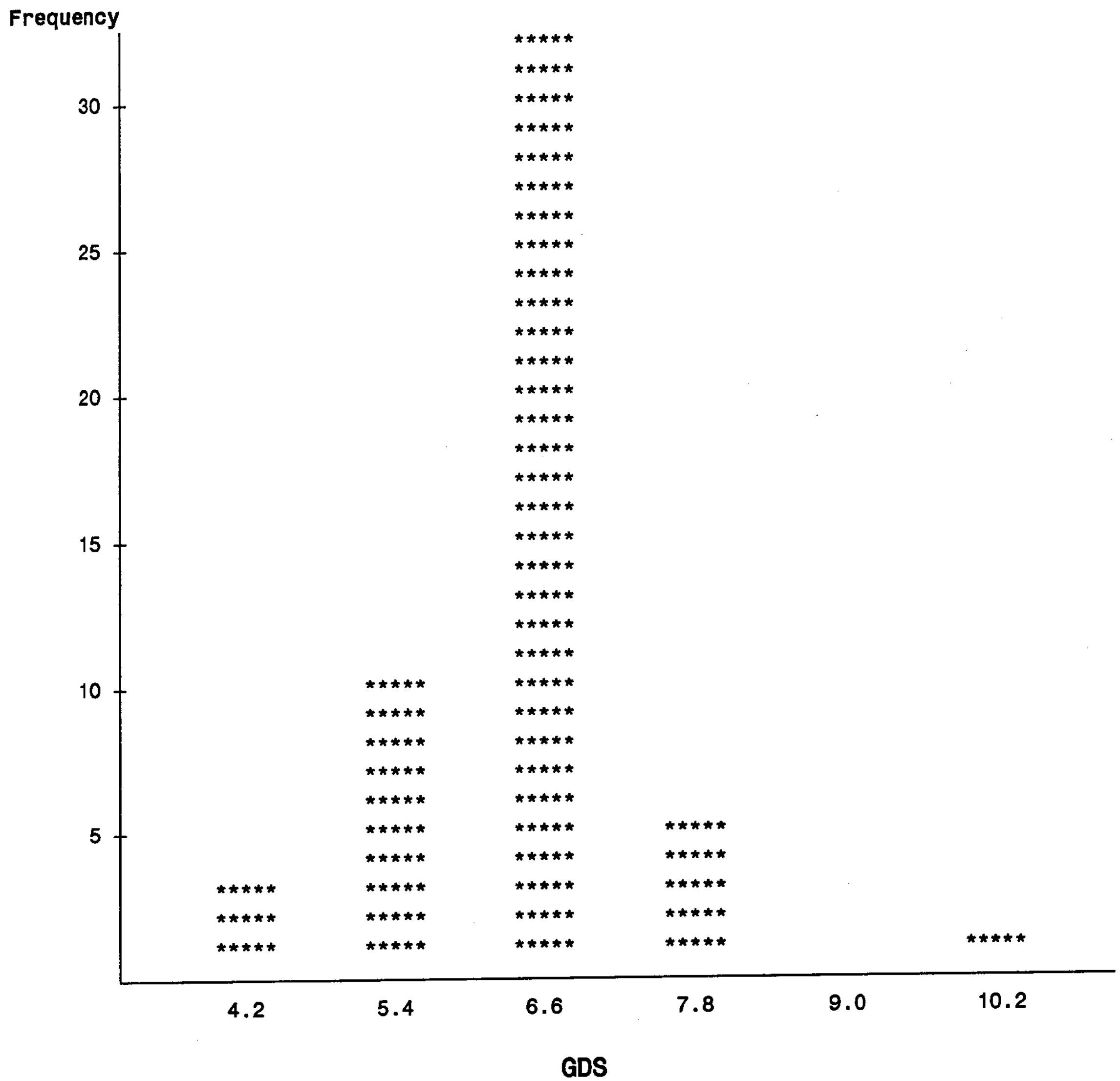

Figure 3.3 Frequency bar chart for Group Diversity Score (GDS) for 1dDQ (no fat/oil, sweets, spices, supplements).

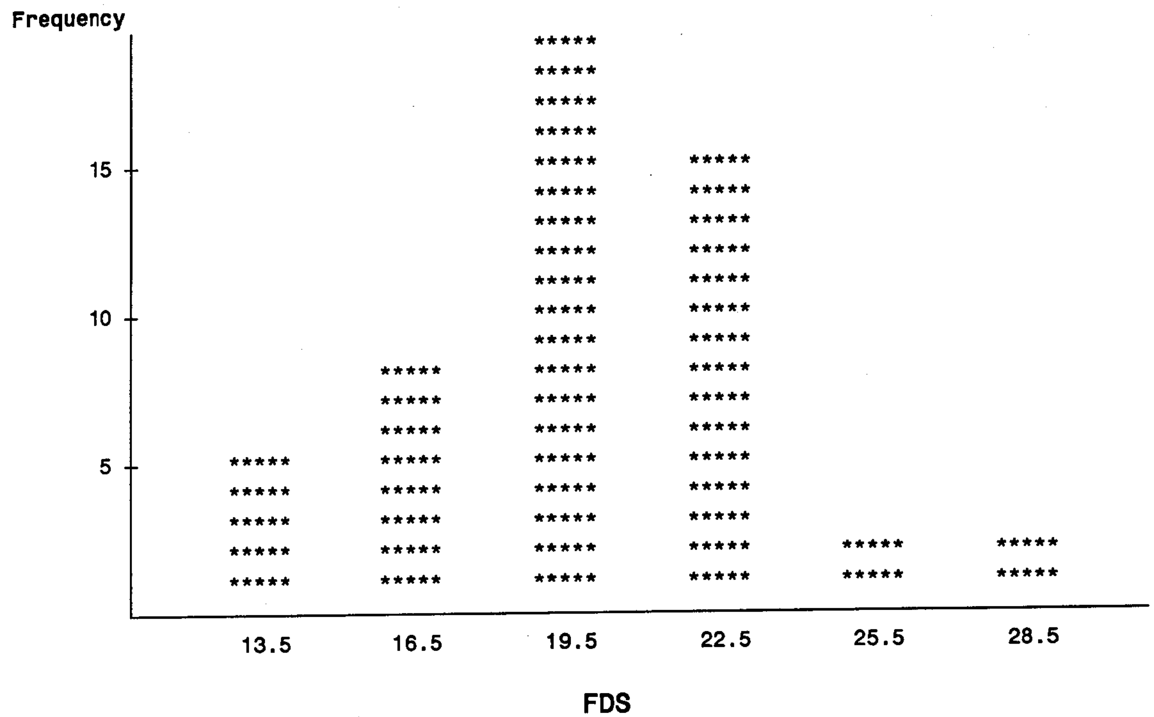

Figure 3.4 Frequency bar chart for Food Diversity Score (FDS) for 7dDQ (no fat/oil, sweets, spices, supplements).

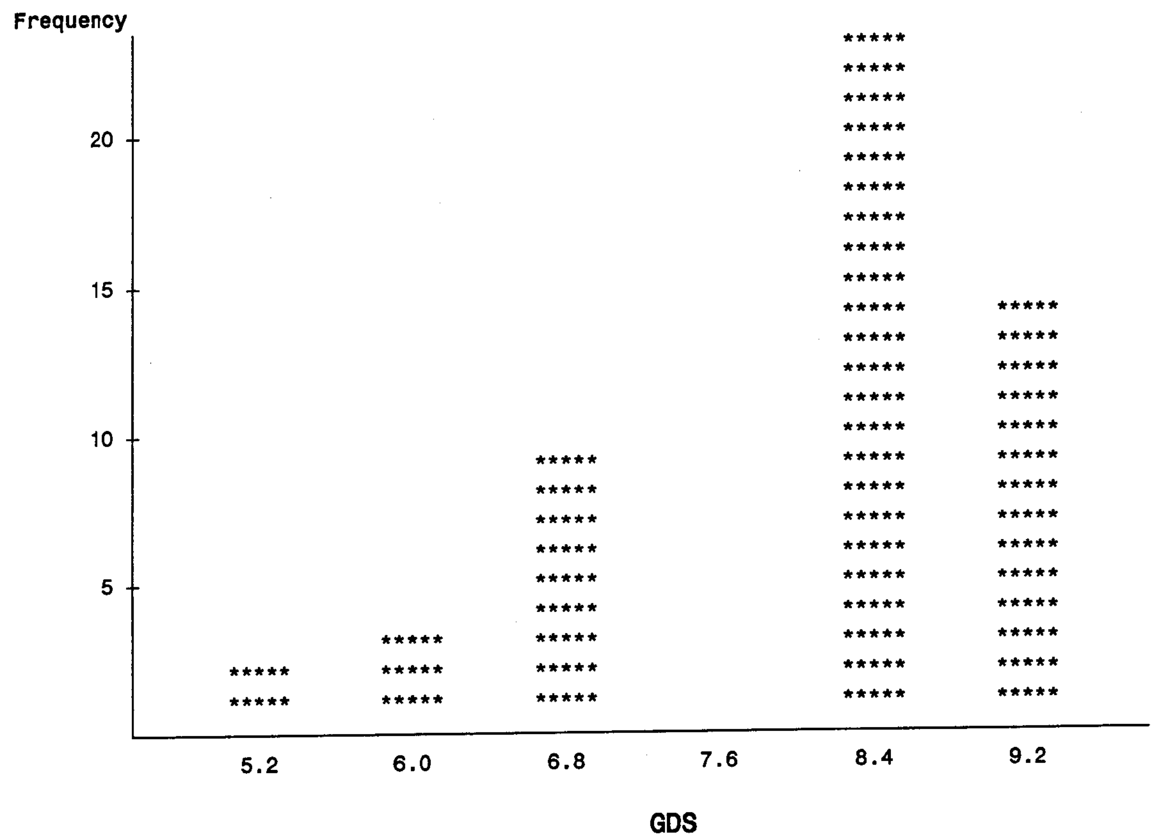

Figure 3.5 Frequency bar chart for Group Diversity Score (GDS) for 7dDQ (no fat/oil, sweets, spices, supplements).

4.0 Conclusion

This study has explored whether dietary diversity, defined as the number of different foods or food groups consumed, can serve as a proxy indicator of nutrient intake in a peri-urban community in West Africa. To directly measure dietary diversity, Hatløy *et al* (2000) used a simplified food list questionnaire to determine the number of foods consumed in the household the previous day. To our knowledge, ours is the first such questionnaire aimed at the individual.

The results of the study provide evidence that a diversity indicator based on numbers of food items consumed over a 7-day period as measured by a diversity questionnaire food list is able to evaluate nutrient intake in a population. Strong associations were seen between diversity score and intake of vitamin A, vitamin C, thiamine, vitamin B_6 and vitamin B_{12}. Weaker, but still significant associations were found for calcium, iron, zinc, riboflavin and niacin. These results support previous research in developing countries that has also demonstrated that the nutritional quality of the diet improves with a greater number of individual foods (Hatløy *et al*, 1998; Ogle *et al*, 2001; Onyango *et al*, 1998; Rose *et al*, 2002; Tarini *et al*, 1999; Torheim *et al*, 2003). However, contrary to several studies (Hatløy *et al*, 1998; Ogle *et al*, 2001), grouping foods resulted in weaker correlations despite attempts to group food in a variety of ways. This study suggests that a score based on individual food items might be more useful. Further research in diverse settings would help to further elaborate on this.

Studies have shown an association between diversity and anthropometric status (Arimond & Ruel, 2002; Hatløy *et al*, 2000; Onyango *et al*, 1998). In the present study, hemoglobin, a biochemical indicator of nutritional status, was not associated with iron intake or diversity indices. Hemoglobin status is influenced by a variety of factors in addition to iron intake, and hence hemoglobin may not be an ideal indicator for dietary diversity. The hemoglobin distribution, however, does have value in describing the sample population. It suggests that anemia is an important health issue for women in the community.

Overall, protein intake was adequate in the study population. However, for most individuals, the consumption of calcium, iron, zinc and thiamine was below recommended levels. Vitamin A intake was met at the 50^{th} percentile of intake distribution. Vitamin C intake was met at the 75^{th} percentile of intake distribution. This study was conducted during the dry season when fresh produce is less available, therefore one must interpret these data cautiously.

In summary, our data suggest that the women in the community are lacking several important micronutrients in their diet. Further dietary studies at different times of the year would help to confirm this. In addition, hemoglobin measurements indicate that anemia might be an important health issue. Finally, the data suggest that dietary diversity indicators can act as proxy measures of nutrient intake. The implication being that these indicators would be useful in documenting the rapid changes occurring in peri-urban and urban settings of the developing world, and in the monitoring of change resulting from nutrition interventions. Further studies with larger sample sizes and additional indicators of nutritional status would help in the exploration of the relationship between measures of diversity and nutrient intake.

Globally, undernutrition still affects a larger percentage of the population, however diseases related to overnutrition are emerging as a new health threat. Contributing factors are urbanization and changing economies, which have lead to simplification of diets emphasizing small numbers of energy-dense, nutrient-poor foods. The resulting decrease in dietary diversity is a common theme in many rapidly evolving communities such as Yoff village and threatens the good health and longevity offered by a diverse diet that prevents nutritional deficiencies and chronic diseases. Promotion of dietary diversity will be an important component in the arsenal addressing several key nutrition issues such as micronutrient deficiency, the nutrition transition and nutrient bioavailability.

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Appendix 1

Consent Form for Study Participants

FORMULAIRE DE CONSENTEMENT
Chercheur: Dina Spigelski
ONG CRESP (820.92.00)

DECLARATION DE PARTICIPANTE

Moi, ..., confirme que:

L'ONG CRESP et l'Université Mc Gill au Canada m'ont demandé de participer dans ce sondage C'était bien expliquer que:

- Il y a trois buts de ce sondage :
- De déterminer le genre et la quantité des aliments que les femmes à Yoff mangent pour nous indiquer si les femmes mangent les bons aliments pour la santé.
- De déterminer le taux d'anémie au sein de la population Yoffoise.
- De déterminer le taux du diabète au sein de la population Yoffoise.
- Pour avoir l'information par rapport aux aliments :
- On me demandera des questions par rapport au genre et à la quantité des aliments que je mange.
- On me demandera ces questions 3 fois; chaque fois sera un jour différent.
- On demande cette information de 65 femmes á Yoff.
- Chaque entrevue durera 30 minutes.
- L'information que je donne sera confidentielle.
- Pour avoir l'information par rapport au taux d'anémie et au diabète :
- On me demande d'être piqué 2 fois, 2 jours différents.
- Le chercheur piquera sur mon doigt pour avoir une goutte de sang selon le processus suivant :
- On nettoie le doigt avec l'alcool
- On pique le doigt avec une aiguille neuve
- On utilise un petit tube pour récupérer une goutte de sang
- On met le tube dans une machine pour lire les résultats
- Il n'y a pas de risques associés avec ce processus.
- Les résultats anonymes du groupe seront présentés à une réunion à la fin de l'étude (environ le mois de mars).
- La chercheure me donnera les résultats des tests pour l'anémie et le diabète.
- Je pourrai contacter le chercheur pour connaître mes résultats personnels par rapport à la nutrition.
- Je pourrai arrêter ou refuser de participer à n'importe quel point durant les entrevues.
- Le fait de refuser de participer ou de ne plus répondre aux questions, ne m'endommage pas.
- L'information ci dessus a été expliquée
- par..(nom de chercheur ou de traducteur)
- en .... (lang.) et je comprends cette langue et j'ai bien compris les explications.
- On m'a donné le temps de poser des questions quand je n'ai pas bien compris les explications.
- Je ne suis pas obligée de participer à cette étude.

J'accept volontairement de participer à cette étude.

Lieu: ....

Date: ....

X..
(Signature)

DECLARATION DE CHERCHEUR

Moi, Dina Spigelski, confirme que:

- J'ai expliqué toute l'information dans ce document à la participante.
- Je lui ai dit de demander des questions s'il y a quelque chose qui n'est pas claire.

Lieu: ....

Date: ....

X..
(Signature)

DECLARATION DE TRADUCTEUR

Moi, ..., confirme que:

- J'ai traduit ce document de français à wolof.
- J'ai traduit toutes les questions de la participante au chercheur.
- J'ai traduit toutes les réponses du chercheur à la participante.

Lieu: ....

Date: ....

X..
(Signature)

Appendix 2

Socio-demographic Questionnaire

QUESTIONNAIRE SOCIO/DÉMO/SANTÉ

1	**Code du sujet :**
2	**Date de l'interview:** ____ dec (1) / jan (2) / fev (3) / mar (4)
3	**Type de logement :** Bâtiment à étages (1) / maison détachée (2) / concession (3)
4	**La cour :** Carreaux (1) / dalle (2) / sable (3)
5	**Fleurs / plantes :** Oui (1) / non (2)
6	**Quartier :** Tonghor (1) / Ndénatte (2) / Dagoudane (3) / Ndengagne (4) / Mbenguène (5) / Ngaparou (6) / Layène (7)

LE MÉNAGE		
7	Nom du chef de la famille (CDF)	
8	Est-ce que le CDF travaille?	Oui (1) ____________ Non (2) ____________
9	Est-ce que vous êtes mariée?	Mariée (1), Séparée (2), Divorcée (3), Célibataire (4), Veuve (5)
10	Est-ce que le CDF est votre mari?	Oui (1) Non (2) NA (9)
11	Est-ce que votre mari travaille?	Oui (1) ____________ Non (2) ____________ NA (9)
12	Est-ce que vous travaillez?	Ne travaille pas hors ménage & ne fait pas de commerce(1) Travaille à domicile et fait du commerce de chez soi (2)______ Travaille hors du ménage (3) ____________
13	Il y a combien de personnes dans la famille?	
14	Est-ce que la famille a des membres à l'étranger?	Oui (1) ____________ Non (2)
15	Est-ce que la famille a des membres qui suivent des études a une école privée au Sénégal?	Oui (1) Non (2)

HABITUDES ALIMENTAIRES		
16	Est-ce qu'il y a quelqu'un dans la famille qui pêche?	Oui (1) / Non (2)
17	Est-ce que votre famille mange ces poissons que vous pêchez?	Oui (1) / Non (2) / NA (9)
18	Est-ce que votre famille cultive des fruits et légumes?	Oui (1) / Non (2)
19	Est-ce que vous les mangez?	Oui (1) / Non (2) / NA (9)
20	Si oui, lesquels?	________________________________ / NA (9)
21	A part des fêtes, est-ce que votre famille mange des animaux que vous élevez?	Oui (1) / Non (2)
22	Si oui, lesquels?	Poulets (1) / Moutons (2) / Chèvres (3) / NA (9)
23	En générale, est-ce qu'il y a des aliments que vous vouliez manger de plus?	Oui (1) / Non (2)
24	Si oui, ils sont lesquels?	________________________________ / NA (9)
25	Pourquoi vous ne les mangez pas assez?	Trop chère (1) / Pas disponible à Yoff (2) / Autres à préciser (3)________________ / NA (9)
LA RÉPONDANTE		
26	Quelle est votre age?	
27	Quel est votre groupe ethnie?	Lébou (1) / Wolof (2) / Sérère (3) / Pulaar (4) / autre (5) _____
28	Quel est votre dernier niveau d'instruction à l'école?	Primaire (1) / moyen (2) / secondaire (3) / supérieure (4) / jamais était à l'école (5)
29	Est-ce que vous avez des enfants?	Oui (1) / Non (2)
30	Combien?	___ / NA (9)
31	Combien <5ans?	___ / NA (9)
32	Est-ce que vous allaitez un enfant maintenant?	Oui (1) / Non (2) / NA (9)
33	Est-ce qu'un médecin vous a dit que vous avez le diabète?	Oui (1) / Non (2)
34	Est-ce que vous le soignez maintenant?	Oui (1) / Non (2) / NA (9)
35	Comment?	_________________________ / NA (9)
36	Est-ce qu'un médecin vous a dit que vous avez l'anémie?	Oui (1) / Non (2)
37	Est-ce que vous la soignez maintenant?	Oui (1) / Non (2) / NA (9)
38	Comment?	_____________________ / NA (9)

Appendix 3

Diversity Questionnaire

La diversité alimentaire et le niveau des nutriments à Yoff, Sénégal: Un sondage des femmes de 18 à 45 ans

FORMULAIRE DE DIVERSITÉ

Code du sujet : _____ Date de l'interview : _____________ Journée de manger : __________

	Hier	***7 jrs***		***Hier***	***7 jrs***
Céréale: Importé			***Fruits***		
Riz (blanc)			Orange / Mandarine		
Sombi			Pomme		
Nouilles au riz			Ananas		
Pain (baguette)			Mangue		
Macaroni/spaghetti			Gerte Toubab		
Couscous marocain			Banane		
Mooxams			Jujube		
Croissant			Pastèque		
Céréale: Locale			Tamarin		
Fonde			Citron		
Lax			Pamplemousse		
Thiare			Noix de coco		
Bouille au mil			Jus de bissap		
Pain au mil			Jus de bouye		
Beignets au mil			Raisin sec		
Lait / Prod Laitier			***Légumes***		
Lait en poudre			Tomate		
Lait caillé			Diahoute		
Crème à soo			Concombre		
Lait en liquide			Carotte		
Fromage			Choux		
Lait concentré			Aubergine		
Yaourt			Navet		
Viande			Laitue		
Mouton			Haricot vert		
Chèvre			Gombo		
Bœuf			Courge		
Foie			Sauce soble		
Saucisse			Pois vert		
Volaille			Cassava		
Poulet			Pomme de terre / frits		
Œufs			Patate sucrée		
Œuf			***Noix/Légumineuses***		
Poisson/Fruit de mer			Arachide		
Morceau			Ndambe (pâte au niebe)		
Thon pour ndeki			Soul (pâte au nététou)		
Boulettes de poisson			***Gras additionné***		
Crevette			Huile de palme		
Yet			Beurre / margarine		
Repas:Sauce (ñaari chin)			Mayonnaise		
Soupo kandia/domoda			Graisse de mouton		
Mafé			***Mets sucré***		
Basse/Mboum			Sucre		
Thiou			Boisson (coka, fanta)		
Repas (benechin)			Biscuit		
Thieb bu weex/xonx/mbaxal			Chocolat		
Daxine			Crème glacée		
Thiare gen			Bonbon		
Fataya			Chewing gum		
Journée normale?			***Suppléments: Fer***		

Appendix 4

24-Hour Recall Questionnaire

RAPPEL DE 24-HRES

1	Code du sujet:	2	Date de l'interview: _______ dec (1) / jan (2) / fev (3) / mar (4)
3	No de l'interview: 1 / 2 / 3	4	Journée de manger: lun (1) / mar (2) / mer (3) / jeu (4) / ven (5) / sam (6) / dim (7)

S'il vous plait, dites-nous tous ce que vous avez mangé et bu hier.
Commencez avec la première chose que vous avez pris après avoir vous réveiller.

Hre	Lieu m=maison a=ami(e)	Aliments & breuvages: Repas	Aliments & breuvages: Description	Quantité	Poids (g)
		NDEKI	Pain		
			Beurre		
			Café		
			Lait		
			Sucre		
		AIN:			
		REER:			

5. **Journée normale?** Oui/non Si non, pourquoi? __________	6. **Suppléments ?** Oui / non Lesquels? ________________	7. **Argile?** Oui / non Pourquoi? ______________ Quantité/jour :______________	8. **Cigarettes?** Oui / non #/jour : _____
Commentaires/recettes á développer :			

Appendix 5

McGill University Ethics Certificate