

Validity of 24-Hour Dietary Recall in Children Age 8 to 16 in Western Kenya

by

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Thesis submitted in partial fulfillment of
the requirements for the degree of
Master of Science in the Department of
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ABSTRACT

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Abstract

Objective: The primary objective of this study is to test the validity of 24-hour dietary recall methods compared to the gold standard of measured portions and observed food intake in the study population for improvement of this assessment in similar low-resource settings.

Study Population: Located in Western Kenya in Nyanza Province, Migori County is the setting for this research. Children were recruited from two out of four primary schools taking part in a larger study. Children ranged in age from eight to sixteen, an age range within which accuracy of diet recall has been found to increase as children age.

Methods: Thirty-eight children were observed eating a measured meal at their school. Thus, for our study sample we know exactly what children consumed at this meal. The next day, the selected children were invited back to complete an interviewer-assisted 24-hour dietary recall using methods adapted for use in the study population. Single sample t-tests were conducted in order to test the validity of the dietary recall methods by comparing recalled food amounts with the gold standard of measured portions and observed food intake. Finally, two-sample t-tests were conducted in order to compare differences across age, sex, standard and school.

Results: The dietary recall methods used to obtain recalled food amounts do not appear to be a valid method for obtaining detailed information about children's food intake in

our study population. For the large majority of food volume and macro- and micro-nutrient categories, the mean deviation for recalled values and those measured and observed was statistically different from 0 ($p < .05$). However, results appear to have been largely influenced by serving methodology, a potential confounder in this study, suggesting that the dietary recall method may in fact be valid after accounting for serving methodology.

Conclusions and Implications: Although the small sample size limits firm conclusions, the results provide evidence-based direction for future food intake validation studies and improvement of this assessment in similar low-resource settings. Future studies should increase the sample size in order to reach more robust conclusions and carefully consider approaches to improve the validity of this assessment in low-resource populations.

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1. Introduction

During the beginning of the 20th Century there was a major concern among agriculture professionals as to how to feed a world that would grow from 2.5 billion in 1950, to nearly 7 billion in 2010. Paul Ehrlich's 1968 book, *The Population Bomb*, brought 19th century arguments to a wider audience, citing mass starvation, and other social upheavals, as the result of exponential population growth. However, what Ehrlich and 19th century scholars did not anticipate was the success and subsequent adoption of innovations in agriculture technologies that had been developed between 1940 and 1960. The growth and spread of these technologies and innovations would come to be known as the Green Revolution. The Green Revolution allowed the global food supply to keep pace with the growing population and curb malnutrition in destitute regions of the world that adopted the new technologies. However, 50 years after Green Revolution technology transformed agriculture in Asia and Latin America, malnutrition rates in Africa have stagnated, experiencing slow improvements and even increases in some areas. Kenya is one African country where improvements in malnutrition rates, especially in rural, isolated regions, have stagnated despite steady economic growth over the past decade.

1.1 Study Setting and Study Population

Located in Western Kenya in the Nyanza Province, Migori County is the setting for this research (Figure 1). Migori County is an example of an isolated rural area experiencing food insecurity, high rates of under-nutrition and a high disease burden, reinforcing the cycle of poverty in isolated areas of the county. Migori County is situated in the most southwest corner of Kenya, bordering Tanzania to the south, Lake Victoria to the west and the Maasai Mara National Reserve to the East. The Luo, an ethnic group of western Kenya, make up the large majority of the study population. The Luo are the third largest tribe in Kenya, following the Kikuyu and the Luhya, comprising approximately 13% of the Kenyan population (Wrong, 2009). The Luo are known for their political involvement during Kenyan independence (Wrong, 2009). However, since independence, the Luo consider themselves socially and politically marginalized, a trend that has continued since Luo presidential candidate Raila Odinga lost the election in 2013. The majority of Luo in Migori County are members of the Seventh-day Adventist Church, although small communities of Muslim and Catholic individuals exist. The Suba are the second most prevalent ethnic group in Migori County. However, they were not represented by more than 5% in the study population.

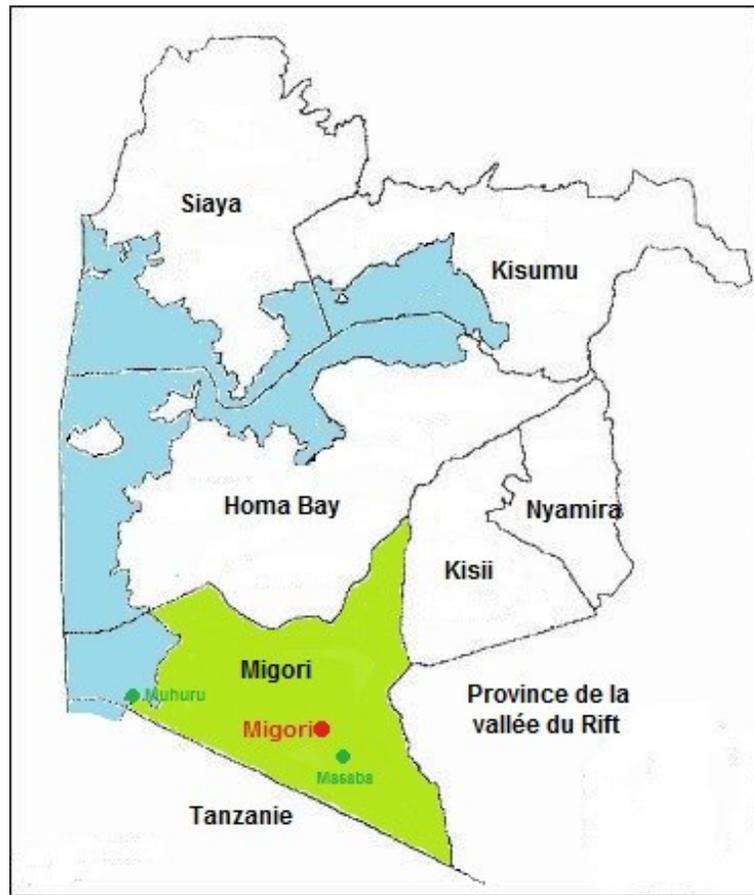


Figure 1: Administrative Counties of Nyanza Province (Omondi, 2011)

Migori County includes a wide range of environments. Dry, sandy communities bordering Lake Victoria in the west rely heavily on fishing for their livelihoods, compared with the lush green hills in the northeast region where most people make their living off of growing sugar cane. Migori town, the capital of Migori County, acts as the conduit through which raw goods travel on their way to Nairobi. Fish from Lake Victoria, including tilapia, Nile perch and omena, are bought from local fisherman, transported to Migori and then to the Central Province where large factories process and

package the fish for sale. The Sony Sugar Company operates outside of Migori, in Awendo, adding value to the raw sugar cane produced by many farmers in the area. South of Migori, Isebania is a bustling Tanzanian border town through which trade and travel occurs. Towns in western Migori County, on the shores of Lake Victoria, can be isolated due to poor road conditions, challenging terrain and long distances and the rainy season makes for hard travel in the northeast region as roads become impassable. The isolated nature of Migori County makes it comparable to other isolated areas in Kenya and East Africa, thus suggesting the applicability of our research to similar populations.

1.2 Study Design and Purpose

Validation study activities were conducted under the umbrella of a larger study, *Dietary intake, weight status and cognition in primary school children in Muhuru Bay, Kenya*, conducted by Dr. Sara Benjamin Neelon (PI). The purpose of Dr. Benjamin Neelon's study was to obtain baseline descriptive data on the nutrition and cognitive status of school children age 8 to 17 years in Muhuru Bay, Kenya. The study aimed to examine associations between nutritional status, using anthropometrics and dietary intake, and cognition in school children. The baseline data collection of the larger study was the first step toward informing a potential school-based garden intervention, an intervention that could provide school-age children with a consistent food supply rich in vitamins and

minerals to prevent the potential negative effects of nutrient deficiency. The dietary intake assessment, using the 24-hour dietary recall, will allow the research team to identify specific kinds of under-nutrition prevalent in the community. This information could then be used to tailor a potential school-based garden intervention to address under-nutrition in the community. The validity of the 24-hour dietary recall methods in the study population will be tested by a nested validation study within Dr. Benjamin Neelon's larger study. This paper presents the results of the validation study, which aims to test the validity of 24-hour dietary recall methods compared to the gold standard of measured portions and observed food intake in the study population. The results from the validation study will inform the dietary intake methodology used in Dr. Benjamin Neelon's study.

1.3 Context

Kenya is a low-income country located in East Africa with a population of 43 million in 2012 and nearly 46% of its population living below the national poverty line (World Bank, 2013b). Kenya has the leading economy in the East African community and has experienced steady growth since 2003 with annual gross domestic product (GDP) increases ranging from 2 to 7% (World Bank, 2013b). Agriculture in Kenya is the leading economic sector, employing an estimated 75% of the Kenyan population and accounting for one-fourth of Kenya's GDP (World Bank, 2013; World Bank, 2013b).

Kenya has a largely rural population, with three-quarters of all Kenyans residing in rural areas where subsistence agriculture is prominent. However, even with agriculture's economic prominence, food production barely meets the energy needs of the current Kenyan population, which is expected to grow to 96 million by 2050 (FAO, 2005; World Bank, 2011). Issues such as environmental degradation and lack of investment in agriculture and market creation for smallholder farmers continue to threaten the sustainability of the nation's food supply.

Food insecurity remains a challenge, particularly for vulnerable populations, including those residing in rural or arid areas, single parent households, and urban slums. Approximately one-third of children in Kenya suffer from chronic malnutrition as measured by inadequate height for age (stunting) (Kenya National Bureau of Statistics & ICF Macro, 2010). Stunting has been shown to affect cognitive development in children and can affect a child's ability to perform well in school and later in life (Cornelio-Nieto, 2007). Additionally, 20% of children are underweight and 5.8% of children suffer from acute malnutrition caused by drastic changes in food intake over a short period of time. Acute malnutrition in Kenya can be caused by environmental conditions such as droughts that may reduce a community's food supply, a problem that is fairly common in semi-arid and arid areas of Kenya (Kenya National Bureau of Statistics & ICF Macro, 2012). Post-election violence in 2007 also contributed to increases

in food insecurity in areas where farmland was destroyed. Vitamin A and iron deficiencies are among the most common micronutrient deficiencies in the country, and have been the reason for many national food fortification initiatives in the past (Kenya National Bureau of Statistics & ICF Macro, 2012). However, these and other micronutrient deficiencies are still widespread, and gaps in consumption of key micronutrient rich foods can have important implications for growth, cognition and overall health (Kenya National Bureau of Statistics & ICF Macro, 2012).

At the same time that Kenya is facing a problem of under-nutrition, urban adult populations are beginning to see increases in the number of those who are overweight or obese. This double burden presents a unique challenge to policy makers and public health professionals working to better the nutrition of the population.

High disease burdens further compound issues of food insecurity and under-nutrition in children in Kenya and in Nyanza Province in particular. Malaria, diarrhea, pneumonia and HIV/AIDS are among the top contributors to infant and under-5 mortality and have a strong synergism with nutritional status (WHO, 2011). Diseases, especially those affecting malnourished children, are exacerbated by under-nutrition, and under-nutrition increases a child's risk of disease (Scrimshaw, 1997). Malaria is endemic in all of Nyanza province, disproportionately affecting those living close to Lake Victoria, as well as children (Division of Malaria Control [Ministry of Public Health

and Sanitation], Kenya National Bureau of Statistics, and ICF Macro, 2011). Children are also particularly susceptible to water borne illnesses that can cause diarrhea and even death at young ages (WHO, 2013; Brooks, 2003; Tate, 2009). Lack of access to clean water in rural areas of Nyanza contributes to increases in diarrheal disease burden, particularly in children. Similar trends have been found for pneumonia, with children accounting for the majority of the disease burden (Tornheim, 2007).

Nyanza Province currently has the highest prevalence of HIV/AIDS in Kenya and accounts for 15.3% of Kenya's HIV prevalence (NACC and NASCOP, 2012; Buvé, 2001). The HIV/AIDS epidemic and corresponding high disease burdens disproportionately affect Nyanza province, and the inland fishing communities on the shores of Lake Victoria (Buvé, 2001; NASCOP, 2007). Transactional sex and the "fish-for-sex" phenomenon, where fish serve as a commodity in transactional sex deals, likely increase one's risk of contracting HIV in these communities (Béné, 2008). Living in an area with high disease burden puts children at a greater risk of becoming undernourished as a result of disease, and at a greater risk of disease as a result of being undernourished, perpetuating poor growth and cognitive outcomes, and a cycle of poverty in vulnerable communities (Kenya National Bureau of Statistics & ICF Macro, 2012; FAO, 2005).

1.4 Background

At the beginning of the 1990s, there was a push to begin a dialogue between agriculture researchers and nutritionists to tackle problems of malnutrition still plaguing a large percentage of the African population. With this dialogue came the evaluation of agriculture interventions using human nutrition status measures. Literature on the integration of global nutrition goals and agriculture activities shows a shift from describing nutritional status as a measure of adequate energy intake to micronutrient deficiencies, diet diversity, anthropometric measures and, most recently a combination of all of the above. Girard and colleagues have most recently reviewed the effect of agriculture and food production interventions on nutrition status (2012). While distal causes to changes in diet composition and food intake have been identified, a more proximal pathway to improved nutritional status is changes in food and nutrient consumption (Girard, 2012). However, methods for measuring diet composition and food intake vary greatly, are implemented with varying degrees of rigor, and may not account for all changes in diet consumption that occur as a result of an intervention (Masset 2012).

There is a large body of literature looking at the effect of household food production strategies on nutrition outcomes. This literature highlights the various methods for measuring diet consumption and the range of accuracy and consistency

with which they are implemented (Girard, 2012; Masset, 2012). In addition to household food production strategies, international non-governmental organizations (NGO) and local initiatives aiming to improve child nutrition are increasingly looking to community and school garden programs as a vehicle to improve child nutritional status. These programs leverage a combination of education, agriculture training, and increases in fruit and vegetable intake to bring about nutrition-related improvements in children (Jensen, 2013). However, not much is known about the effectiveness of the programs. Such programs and initiatives stand to benefit from the development and implementation of rigorous assessment methods that are adapted to the population in which they will be used.

This study responds to a call by Masset et al. (2012) to study intermediate outcomes between food production interventions and improved nutritional status in order to better understand the ways in which agriculture interventions are affecting child nutrition. Agriculture and nutrition inputs in the form of education, technology and training result in increased production of nutrient rich foods, increased household income and spending on food and health, and increased calorie, protein and micronutrient intake (Girard, 2012; Masset, 2012). Masset et al. highlight that large-scale effectiveness studies often lack the power to make claims about the effectiveness of an intervention due to poor study design and insufficient sample sizes. Instead, researchers

should work to establish a group of studies assessing the effect of agriculture interventions on intermediate outcomes (2012). We will concentrate on diet composition and food intake as intermediate outcomes on the path to improved nutritional status in children.

Below we will review common food intake measures and dietary assessment tools used in international settings to understand children's diets. We will also review what is known about the accuracy and validity of 24-hour dietary recalls in children, important lessons learned during the evolution of the 24-hour dietary recall in adults and children, new technologies, and the limitations associated with each.

Dietary assessment methods measure food intake and diet composition for purposes including diet surveillance, nutritional epidemiology, and clinical and intervention research. Different methods used in international settings include dietary food records or food diaries, food frequency questionnaires, diet diversity scores, blood tests and the interviewer administered 24-hour dietary recall. Food records are valuable for tracking diet intake in real time. However, food records require participants to be highly motivated and literate in order to obtain good data (National Cancer Institute, 2013) and are thus not as useful in children. Additionally, food records may bias food intake downward as a result of tracking intake at each eating occasion (National Cancer Institute, 2013). Food frequency questionnaires are valuable if a nutrition professional or

researcher is hoping to obtain broad information about an individual's typical intake or collect dietary information from a large number of individuals in a short amount of time and at a low cost (National Cancer Institute, 2013). However, food frequency questionnaires lack a high level of detail about specific intake information. Individual diet diversity scores act as a proxy for nutrient adequacy and have been validated in several countries in various age and sex groups (FAO, 2011). However, further research is needed in order to understand how to calculate diet diversity scores across countries, gender and age (FAO, 2011). Blood tests are often used to test intake of specific micro-nutrients, most commonly vitamin A and iron, and have been used to assess micro-nutrient intake in children in a number of studies (Faber, 2002; Schipani, 2002). However, blood tests require analysis in a laboratory and can be invasive, costly and time intensive. Finally, interviewer administered 24-hour dietary recalls allow nutrition professionals and researchers to obtain detailed information on an individual's food intake after consumption occurs (National Cancer Institute, 2013) reducing the likelihood that one would alter their intake. Multiple twenty-four-hour dietary recalls are considered the gold standard method for assessing diet composition and food intake in the United States and in international settings. However, they are more commonly used in children in the United States and other developed countries compared to

developing countries because that is where most validation and accuracy testing has occurred.

The automated multiple-pass method (AMPM) is the 24-hour dietary recall method used by the United States Department of Agriculture (USDA) for the National Health and Nutrition Examination Survey (NHANES) and the current gold standard. AMPM is a product of professional insight and cognitive studies conducted by Baranowski and Domel about how study participants report food intake (1994) and more recently studies that investigate cognitive processes in children's dietary recalls specifically (Baxter, 2009). The AMPM is a 5-step process that is employed to accurately obtain 24-hour dietary recall measurements from study participants. The gold standard of multiple 24-hour dietary recalls has been used in children ranging in age from 8 to 11, in a large number of studies including national surveys in the United States (Dwyer, 2003). Literature reviews and meta-analyses have determined that accuracy of dietary recall has been found to increase rapidly in children age 8 and above (Livingston, 2000). The large majority of these studies look at agreement between recalled and observed food items as well as intrusion (food items recalled but not observed) and omission rates (food items observed but not recalled) (Baxter, 2009). Additionally, studies that look at agreement between recalled and observed energy and macro- and micro-nutrient profiles often fail to take into consideration accuracy for items and amounts, and thus

overestimate accuracy for energy and macro- and micro-nutrient profiles, “masking the complexities of recall error” (Baxter, 2009). Intrusion and omission rates in U.S. studies vary according to the characteristics of the child being interviewed as well as the way in which the interview is conducted and can range anywhere from 10 to 60% (Baxter, 2009). Researchers have found that child recalls are influenced by the number of recalls conducted, order of recall by gender, meal, survey format, age, sex, and body mass index (BMI) (Baxter, 2009).

The AMPM has continued evolving with the introduction of new technology. Much research has been done about how individuals remember what they ate, how accurate they are in reporting portion sizes, useful estimation tools and the importance of proper training that have contributed to the gold standard and evolving technologies today. We will discuss recent technology and methods used to obtain an accurate measure of dietary intake and how these new technologies have since been validated.

Krall et al. reported that factors such as intelligence, age, mood, attention, gender and how often a participant is exposed to certain foods have important implications for the accuracy of dietary recall among study participants (1988). Krall and colleagues found that food uncommon in an individual’s diet, or ceremonial foods, enhance the accuracy of recall (1988). More recent studies have also found differential accuracy of dietary recall in adults and children across body mass index (BMI) percentile (Baxter,

2006) and body weight measures (Livingstone, Robson and Wallace, 2004), which could have important implications for dietary recall in overweight and obese populations.

A number of studies have looked at how accurately participants can estimate portion sizes and what tools have been useful in increasing accuracy of portion size estimates. Poor portion size estimation among adult participants was found when a dietary recall was conducted without the use of any food portion estimation tools (Guthrie, 1984). Faggiano et. al. found that adult participants were able to estimate portion size in weight within 20% when using pictures with different food portions as a tool (1992). The use of 4 successively larger portions also helped children age 9 to 19 correctly estimate portion size 60% of the time (Lillegaard, 2005). A more recent study conducted in South Africa found correlations between nutrients from weighted food portions and recalled food portions ranging from 0.84 to 0.99 in children ages 12 and 13 (Steyn, 2006).

Dietary recall and portion size estimation have been improved through the use of properly trained interviewers and participants, probing methods and amount estimation tools (Willett, 2012). Accuracy greatly improved after participants were trained in estimating food portions (Yuhas, Bolland and Bolland, 1989). Additionally, proper training of interviewers is important to ensure that all necessary questions and probing questions are asked and all needed information is obtained from study participants

(Willett, 2012). Accuracy in children improved when multiple 24-hour recalls were conducted over a given time period (Baxter, 2009). Familiar portion references such as cup or bowl size, brand name package sizes and three-dimensional food models also improved accuracy when estimating portion size (Willett, 2012). De Keyzer et al. found that photographs of different food portions increased accuracy of portion size estimation (2011) and including 8 images of increasing portion sizes further increased the accuracy of portion size estimates among participants (Subar, 2010). These studies have helped guide the development of appropriate portion size estimation tools for children, particularly in the development of a child-friendly computer assisted 24-hour dietary recall (Baranowski, 2011).

The introduction of automated recall technology and computer assisted interviews has further improved the accuracy of dietary recall and portion size estimation in adult and child populations. The Automated Self-Administered 24-hour recall (ASSA24) developed based off of the AMPM model reduces bias presented by poorly conducted interviews. Follow-up questions and probes are less likely to be missed when conducting a computer assisted dietary recall versus an interviewer administered dietary recall (Willet, 2012). Researchers and clinicians are increasingly adopting the ASA24 web-based software in order to assess diet composition in research participants and patients. The ASA24 has been adapted and is in the process of being

validated in the United States for use in children using the Food Intake Recording Software System, version 4 (FIRSSt4) (Baranowski, 2012b). Initial studies comparing the accuracy of interviewer administered 24-hour dietary recall in children to computer assisted interviews show that increases in accuracy occur in children age 10 to 13 when using the computer-assisted interview software compared to an interviewer-administered 24-hour dietary recall (Baranowski, 2012). However, matches between interviewer administered 24-hour dietary recalls and the computer assisted 24-hour dietary recalls decreased significantly in children ages 8 and 9 (Baranowski, 2012). The FIRSSt4 has used these findings to create a simpler, more user-friendly computer assisted recall. The FIRSSt4 includes only foods reported by children in the NHANES and food probes are simplified so that children are not asked questions about food preparation methods or added fat that may have occurred during preparation. The FIRSSt4 also provides children with food images in order assist with recall and portion size estimation (Baranowski, 2012b). While the most accurate, up-to-date 24-hour dietary recall methods reviewed above are valuable tools in developed countries with the resources and technology needed to implement them, they are challenging to implement in low resource settings due to resource and technological limitations. Therefore it is essential that researchers develop and validate dietary recall methods that are adapted to their population.

New technologies including a hand scanner built to reflect fruit and vegetable intake through the identification of carotenoid antioxidants in the body (Ermakov, 2005), as well as food intake using photography and SMS technology are promising. However, the hand scanner does not work as good on dark skin, which is a major limitation for research being conducted in Africa, and specifically Kenya, and photography methods are still in their infancy.

24-hour dietary recalls are the gold standard for assessing diet composition and food intake. A validated version of the 24-hour dietary recall adapted from the current high technology software could prove valuable in helping design and evaluate household and community agriculture interventions with the goal of improving child nutrition status in low-resource settings. The financial and temporal feasibility of interviewer-administered 24-hour dietary recalls in a low-resource setting make it a valuable tool for global health nutrition research. As nutrition is increasingly being studied outside of a clinical research setting, there is a need for an accurate method that can be used in the field. Increasing numbers of community-based nutrition programs, domestically and abroad, will require evaluation in order to assess their ability to reach target nutrition goals and make decisions about program effectiveness.

2. Methods

2.1 Recruitment and Selection of Participants

Validation study activities were conducted as part of a larger study, *Dietary intake, weight status, and cognition in primary school children in Muhuru Bay, Kenya*, conducted by Dr. Sara Benjamin Neelon (PI). Institutional Review Boards at Duke University and the Kenya Medical Research Institute approved all procedures of the larger study. Therefore, informed consent for the sub-sample of children selected to take part in the validation study was received during consent for the larger study. As a first step in recruitment, a member of the research team approached the school's principal to explain the purpose and procedures of the larger study before any staff and children from within the school were invited to participate. The head principals provided written informed consent to allow the study to be conducted within their school (Appendix A). A total of four schools were recruited to take part in the baseline data collection associated with the larger study.

Once a head principal provided consent for the school's participation, a meal was scheduled at the school and all students and parents or guardians were invited to hear about the larger study. At this event, the research team first presented the details of the project and then asked all parents or guardians if they were willing to have their child participate. During the presentation, parents were reminded that there were no direct

benefits to them or their children. Families who opted not to participate were not treated any differently than those that did. At the end of the event, or at a later date if the parent preferred, the research team obtained written consent from all parents who wished to have their children involved in the research (Appendix B). Children between the ages of 13 and 17 were also asked to provide verbal assent to participate just prior to the assessment (Appendix C). This verbal assent was in addition to the required parental permission form (Appendix B).

All children in each school were invited to participate in the larger study (thus, there were no further selection procedures and no child-level exclusions). The validation study assessments were part of the larger study; therefore the sub-sample of children selected to participate in the validation study completed the same assessments as children who took part only in the larger study. For families who were unable to attend the dinner event, our data collection staff was available during data collection at each school to explain the study to parents and obtain consent from those wishing for their children to take part. Participation in the study was entirely voluntary; no child was penalized or stigmatized for not participating by study staff. For the larger study, the research team conducted assessments with approximately 1,200 children in total in the four recruited schools, their teachers, and their head principals. The school children taking part in the larger study ranged in age from 5 to 17 years of age.

2.2 Recruitment and Selection of Participants for Validation Study Sub-sample

Recruitment of the sub-sample of children for the validation study took place during two of the four recruitment meals hosted by the larger study. Two of the four recruited schools were chosen to take part in the validation study based on the ability of the research team to attend the school meal and conduct dietary assessments with the sub-sample of children the day following the school meal. Children were selected from standards, or grades, 3 through 6 because these standards include children age 8 and above, the age above which accuracy of diet recall has been found to increase with children's age (Livingston, 200). Generally, children in standards 3 through 6 are about 10 years of age, but can range in age from 8 to 16 as a result of grade repetition and non-traditional schooling patterns. We will refer to the two schools from which the validation sub-sample was selected as School A and School B. Twenty students from School A and forty students from School B were selected from those in attendance at the optional meal (n=60). In School A, every fourth student in attendance was systematically selected by order of arrival, for a total of 20 students, including 5 from each of the 4 standards. In School B, every fifth student in attendance was systematically selected by student identification number, for a total of 40 students, including 10 pupils from each standard. Differences in school and standard size account for the differential number of children selected across school and standard.

2.3 Meal Observations

Food portions at the school meal were accurately measured for the sub-sample of children who would take part in the validation study. The school meal consisted of meat, rice, and additions of onions and tomatoes. Recipes for each food item at each school were established through discussions with the head principal and the local cooks in charge of preparing the meal. Ingredient amounts were standardized across both schools in line with reported recipes and average intake of food additions, including oil, salt, tomatoes and onions as determined through informal discussions with local cooks, research assistants and caregivers.

Head principals requested responsibility to organize the logistics of the meal and were thus responsible for deciding the food portion size for everyone present at the meal. The head principal took into account how much food was available and suggested a measured amount that would ensure all attending children received the same portion. Food was measured using the United States (US) customary cup and was measured by research assistants. Children at School A received one-fourth a cup of meat and one cup of rice. Children at School B received two-thirds a cup of meat and 2 cups of rice. Children at School B were initially served 1 cup of rice and two-thirds a cup of meat. However, the head principal requested that children receive an additional 1 cup of rice when there was remaining rice and because this quantity would ensure equity between

those not selected to conduct dietary recalls the next day and those selected into the validation study sub-sample. The serving methodology used at School B is potential confounder in this study and will be discussed in-depth below. The vast majority of attending children consumed everything on their plates. Deviations from this assumption, including spilling and sharing within the group of selected children was tracked and documented by research assistants attending the event as observers. These children were subsequently excluded because we could not determine the actual amount consumed (n=4). The selected children were invited back the next day to complete the interviewer assisted 24-hour dietary recall.

2.4 Dietary Recall

The 24-hour dietary recall methodology was adapted from the AMPM and ASA24 using feasible interview mechanisms and contextually appropriate tools. The 24-Hour Dietary Recall Protocol is included in Appendix D. The adapted 24-hour dietary recall method included a standardized interview protocol with questions and probes that mimic the function of a computer assisted dietary recall, such as the ASA24 (Appendix E). It also included culturally appropriate food image references in the form of three-dimensional food models and standard serving dishes common in the population to help increase accuracy of portion size estimates (Figure 2).

Dietary recalls were conducted with study participants the day after the school meal. All recalls were conducted after breakfast, once the child had arrived at school, and before lunch. Children were asked to recall the previous 3 meals starting with lunch the previous day, followed by supper and then breakfast that morning.

Of the 60 children selected to take part in the nested validation study, 44 children in total completed the interviewer assisted 24-hour dietary recall the day following the school meal. Children were excluded from the study if they did not consume the whole portion served at the school meal (n=4), were not present the following day to complete the dietary recall (n=2) or if the study team was unable to complete the dietary recall before lunch the day after the school meal (n=10). These exclusions decisions were made based on the reality of meal observation conditions and mean that the measured and the observed amounts are the same for all participants included in the final analysis (n=44).

Table 1: Number of 24-hour dietary recalls conducted with children, by standard and by school (n=44)

Standard	School A (n=8)	School B (n= 36)
3	5	7
4	3	9
5	0	10
6	0	10

Project investigators used established instruments and methods to collect a 24-hour dietary recall, where the participants were asked to report any food or beverages consumed during the previous 24 hours and to quantify those foods and beverages. Children were not expected to recall additions of fat or salt that occurred during food preparation. However, they were expected to recall vegetable additions including tomatoes and onions that are often included in small amounts, in addition to the main food item of rice and meat. Children were also asked to verify their name, teacher and standard collected during the meal observations on the pupil data collection form (Appendix F). In order to determine age, children were asked what year they were born and then which month they were born in. If the child could not recall this information they were asked if they knew how old they were and were then asked if they could recall the year and month of birth. If the child could still not recall this information it was assumed that they were born in the second half of the year they could have been born in given their self-reported age. While this is a conservative measure, it could lead to misclassification of children by age group.

At School A, all eligible children in standards 3 and 4 were interviewed the day after the optional meal (Table 1). Pupils in standards 5 and 6 were not interviewed due to time constraints. At School B, all eligible children in standard 3 through 6 were interviewed the day after the optional meal (Table 1). Thus, for students in both School

A and School B (n=44) we know exactly what they consumed for one meal during the previous day. Consistent numbers of children were selected from each standard by design (Table 2). Additionally there were an equal number of males and females, typical of the class make-up in lower- and middle-primary school standards (Table 2). The majority of children (64%) represent an age range typical in standards 3 through 6. However, 36% are older than the typical age range due to grade repetition and non-traditional schooling patterns (Table 2).

Table 2: Age, sex and standard of children who completed 24-hour dietary recalls (n=44)

Child Characteristic	Count	Percentage of Sample (%)
Sex		
Male	23	52
Female	21	48
Standard		
3	12	27
4	12	27
5	10	23
6	10	23
Age		
8-12 years	28	64
13-16 years	16	36

Dietary recalls were conducted by Sylvia Sable, a member of the study team trained in the 24-hour dietary recall methodology, with the help of a project translator fluent in both English and the local language and a project research assistant. This team worked together to conduct the recall, translate questions, probes and responses and record responses on the pupil data collection form (Appendix F). Twenty-four-hour dietary recalls for the sub-sample of children selected to be interviewed the day after the school meal were excluded from the larger study because the recall included the school meal, which may not represent a normal day of intake for the children.

All children in the study received a small parcel of food or drink (a packet of milk or a granola bar) as an incentive for participation. The parcel of food was not contingent on whether the child completed the study or not, but was given to anyone who had consented and was approached to begin study assessments.



Figure 2: 24-hour dietary recall tools and interview station

2.5 Data Analyses

Deviations of the recalled food amounts from the observed food amounts were assessed for each child to obtain a sample of deviations from the observed food amounts. Deviations from the observed food amounts could be positive, an overestimate, or negative, an underestimate.

Validity of the 24-hour dietary recall method was analyzed using STATA v.13.0 (StataCorp, 2013) software. Food volumes and macro- and micro- nutrient profiles for observed and recalled food amounts were assessed using Nutrition Data system for Research software version 2013 (2013) developed by the Nutrition Coordinating Center (NCC), University of Minnesota, Minneapolis, MN (Schakel, 2001;Schakel, 1997, Schakel,

1988). Food amounts were described in volume (cups), energy (kilocalories), fat (grams), protein (grams), carbohydrates (grams), iron (milligrams), vitamin C (milligrams) and vitamin A (international units). Iron and vitamin A were chosen because they represent the most common nutrient deficiencies in our study population. Additionally, vitamin A and vitamin C are valuable indicators for fruit and vegetable consumption and may vary as a result of differential recall of fruit and vegetable additions. Results are presented in aggregate form, as well as by age, sex, standard and school where applicable. Intrusion (foods recalled but not observed) and omission (foods observed but not recalled) counts and percentages were calculated at the aggregate level. Only food items were taken into account when calculating intrusions and omissions. Therefore, beverages were not included when calculating intrusions or omissions.

Of the 44 children that completed the interviewer assisted 24-hour dietary recall the day following the school meal, only children with zero intrusions and zero omissions were included in the final analysis (n=38). Intrusions were reported in 6 out of the 44 children (13.6%). Omissions of rice and meat or just meat were reported in 4 out of the 44 children (9.1%). All omissions (n=4) occurred in children who also reported intrusions (n=6). Even though those reporting intrusions and omissions were a small percentage of total children, including them severely biased the results of the analysis, giving an inaccurate picture of the validity of our methods in the participant population

with zero intrusions and omissions. More importantly, this exclusion decision allows testing of solely the validity of our dietary recall methods and eliminates the possibility of confusing valid macro- and micro-nutrient recall, from intrusions and/or omissions, for valid food intake recall (Baxter, 2009). Intrusion and omission counts and percentages are presented separately in the results section.

A single sample t-test was used in order to test the null hypothesis that the mean deviation of recalled values from observed amounts was not statistically different than 0 (n=38), what we would expect if the recalled amount perfectly equaled the observed amount for all children in the population being tested. Therefore, any category in which we find statistical significance will indicate a value statistically different than 0. If different, this translates into questionable validity of the methods. Single sample t-tests were conducted across age, sex, standard and school and differences within each category were quantified and interpreted using a two-sample t-test. An extension of this methodology would be to run a regression model with the mean of deviations as the outcome and a range of explanatory variables such as age, sex, standard and school. However, the small sample size in this study lends itself better to interpretation of differences these variables using the point estimates, standard deviations and p-values from the two-sample t-test.

2.6 Data Analyses Justification

Out of a number of statistical tools, a single sample t-test was the most appropriate to compare recalled food volumes and macro- and micro-nutrient amounts with observed volumes and amounts in order to test the validity of a 24-hour dietary recall method compared to the gold standard of measured portions and observation. First, we considered measures of inter-rater reliability in order to assess agreement between the food volumes and macro- and micro-nutrient profiles for recalled and observed food amounts. Statistical measures for inter-rater reliability that were considered for the analysis of our set of continuous variables included, Pearson correlation coefficients, intra-class correlation coefficients, limits of agreement with Bland-Altman plots, and the paired t-test. While each may seem appropriate at first consideration, the methods listed are used where there are two raters who evaluate the same thing but neither can be defined as the truth and where variation exists within each rater category. In this case we have the true value (the measured and observed food amounts) and a single estimate of that true value (the recalled food amounts) and little to no variation in the observed food amounts. Pearson correlation coefficients and intra-class correlations coefficients cannot provide valuable data because of a lack of variation in the observed food and nutrient amounts that resulted from the study design. The fact that we excluded participants who did not consume their entire portion further created a

lack of variation in our observed food and macro- and micro-nutrient amounts. This exclusion decision was made based on the limitations of accurately measuring left-overs in the study setting and the fact that we predicted the large majority of our selected subsample would finish all of their food portions. Bland-Altman plots, which show the degree of agreement and also whether agreement changes as a function of the underlying value (Gibson, 2005), are not useful in this case because of the different measured food amounts when comparing measures across School A, School B and individuals who did not consume meat due to dietary restrictions (n=2). Inherent differences in the underlying measured food amounts in each of these three cases limits the information one can glean from Bland-Altman plots. Limits of agreement and the paired t-test are similar in that they both use the mean of the differences between the paired measures and compare this to 0, what we would expect if the two measures agreed perfectly (Ludbrook, 2010; Institute for Digital Research and Education, UCLA, 2013). However, both tests assume that pairs of observations exist in the data. This assumption is at odds with the reality of our data. We only have a single measurement (the recalled food amount) and a known (the observed food amount). Due to this difference, we selected the single sample t-test because it allowed us to test the validity of our single measure (the recalled food amount) in comparison with the observed measured food amount and did not depend on variation within the observed food

amounts. However, it is important to understand that this statistical significance test does not allow one to claim that lack of statistical significance means that the mean deviation was 0, what we would expect if the two measures agreed. This is because contrary to most statistical significance tests that tests whether the alternative hypothesis is plausible, this study is trying to test whether the null hypothesis, that the mean deviation was not statistically different from zero, is plausible. One cannot definitively make this statement even at varying degree of plausibility or with a larger sample size. However, one can obtain evidence-based direction for future studies.

Further, for the single sample t-test to be valid for sample sizes less than 30 the underlying distribution of the variable being tested must be normal. In Appendix G, we have included histograms depicting the deviations from zero, what we would expect if our recalled amounts perfectly equaled the observed amounts for all participants in the study population, for all food volume and nutrient categories. The majority of these distributions appear to be reasonably normally distributed.

Using a large number of hypothesis tests increases the possibility for a false positive, rejecting the null hypothesis when it is in fact true, and is an additional limitation to our data analysis methods. However, due to the small sample size, this study will not adjust for multiple testing, instead we will interpret 95% confidence intervals in order to make conclusions about our data.

In our analysis, macro- and micro- nutrient profiles are largely a function of the recalled and observed volumes for rice and meat. However, because we held children responsible for knowing whether vegetables were added to the main food items, differences in micro-nutrient profiles, specifically vitamin C and vitamin A, may vary as a result of differential recall of fruit and vegetable additions. For this reason, and because these values should be presented in similar future analyses, we have included the macro- and micro-nutrient profiles in our analysis.

3. Results

The dietary recall methods used to obtain recalled food amounts do not appear to be a valid method for obtaining detailed information about children’s food intake in our specific sample. For the large majority of food volume and macro- and micro-nutrient categories, the null hypothesis, that the mean deviation of recalled values is equal to 0, was rejected, and recalled values were determined to be statistically different from 0, what we would expect if the recalled amount equaled the observed amount perfectly for all participants. However, results appear to have been largely influenced by serving methodology, a potential confounder in this study which differed across schools, suggesting that the dietary recall method may in fact be valid after accounting for serving methodology.

Table 3: Known food amounts and percent daily value for participants who consumed rice and meat, by school (n=36)

Food and Nutrient Category	School A (n=4)	Percent Daily Value ^a	School B (n=32)	Percent Daily Value ^a
Volume (cups)				
Rice	1.00	-	2.00	-
Meat	0.25	-	0.67	-
Energy (kcal)	296.00	-	644.00	-
Fat (g)	8.03	12	20.22	31
Carbohydrates (g)	44.80	15	89.80	30
Protein (g)	9.25	19	21.83	44
Iron (mg)	2.45	14	5.25	29
Vitamin C (mg)	0.93	2	2.48	4
Vitamin A (IU)	18	0	49.00	1

^a Based on a 2,000/day calorie diet

Table 3 shows the percent daily value for known macro- and micro-nutrient amounts. This table describes the nutritional significance of macro- and micro-nutrient amounts outlined in the results.

Intrusions were reported in 6 out of the 44 participants (13.6%) and ranged from 1 to 3. Omissions of rice and meat or just meat were reported in 4 out of the 44 participants (9.1%). All omissions (n=4) occurred in children who also reported intrusions (n=6). Intrusions and omissions were more likely in males and participants from School A. All omissions and all but one intrusion were reported in children aged 8 to 12.

Table 4 shows the results of the single sample t-test used to test the null hypothesis that the mean deviation of recalled values is equal to zero, what we would expect if the recalled amount perfectly equaled the observed amount for all children in the population being tested. All but one category was statistically different from zero. Recalled mean meat volumes were 0.01 cups higher than the observed volume, with a 95% confidence interval of (-0.05, 0.07), and the null hypothesis of a mean deviation equal to 0 was not rejected. Participants underestimated consumption in all other categories, a trend we see throughout the data even when broken down by sex, age group, standard and school.

Table 4: Comparison of the mean of deviations to 0, what we would expect if the recalled amount equaled the known amount perfectly, for all participants (n=38)

Food and Nutrient Category	Mean of Deviations (SD)	95% CI ^a	p-value ^b
Volume (cups)			
Rice	-1.07 (0.39)	-1.19, -0.94	<0.001
Meat	0.01 (0.19)	-0.05, 0.07	0.72
Energy (kcal)	-228.68 (113.77)	-266.08, -191.29	<0.001
Fat (g)	-1.79 (5.11)	-3.47, -0.11	0.04
Carbohydrates (g)	-47.72 (17.34)	-53.42, -42.02	<0.001
Protein (g)	-3.75 (5.24)	-5.48, -2.03	<0.001
Iron (mg)	-1.98 (0.97)	-2.30, -1.66	<0.001
Vitamin C (mg)	-0.46 (1.19)	-0.85, -0.07	0.02
Vitamin A (IU)	-8.42 (24.60)	-16.51, -0.34	0.04

^a CI: Confidence Interval

^b From a single sample t-test

A breakdown of the data by sex and age group reveals agreement across all food and nutrient categories except for potential differences in the mean deviations for vitamin C and vitamin A. No differences were observed across standards (results not shown). The 95% confidence intervals for vitamin C and vitamin A in males reveal a tendency to more largely underestimate vitamin C and vitamin A intake than females and p-values from the single sample t-test suggest that females (Table 5) recalled vitamin C and vitamin A consumption, a function of vegetable recall, better than males (Table 5). However, upon using a two-sample t-test to compare these differences the mean of deviations for vitamin C (p=0.28) and vitamin A (p=0.29) were not found to be statistically different across sex. Similar to differences of vitamin C and vitamin A recall across sex, differential vitamin C and vitamin A recall was only mildly present across

ages, showing that younger participants recalled vitamin C and vitamin A slightly better than their older counterparts (Table 6). However, the two-sample t-test revealed no statistical difference across age group (Table 6).

Table 5: Comparison of the mean of deviations to 0, what we would expect if the recalled amount equaled the known amount perfectly, by sex and sex comparison using the mean difference of deviations (n=38)

Food and Nutrient Category	Males (n= 19)			Females (n= 19)			Comparison		
	Mean of Deviations (SD)	95% CI ^a	p-value ^b	Mean of Deviations (SD)	95% CI ^a	p-value ^b	Mean Difference of Deviations (SD) ^c	95% CI ^a	p-value ^b
Volume (cups)									
Rice	-1.03 (0.45)	-1.25, -0.81	<0.001	-1.10 (0.33)	-1.26, -0.95	<0.001	0.07 (0.13)	-0.19, 0.33	0.57
Meat	0.02 (0.24)	-0.09, 0.13	0.72	0.00 (0.13)	-0.06, 0.07	0.94	0.02 (0.06)	-0.11, 0.14	0.78
Energy (kcal)	-218.21 (144.80)	-288.00, -148.42	<0.001	-239.16 (73.52)	-274.59, -203.72	<0.001	20.95 (37.26)	-54.61, 96.51	0.58
Fat (g)	-1.58 (6.09)	-4.51, 1.35	0.27	-2.01 (4.07)	-3.97, -0.04	0.05	0.43 (1.68)	-2.98, 3.84	0.80
Carb (g)	-46.12 (20.10)	-55.81, -36.43	<0.001	-49.32 (14.43)	-56.27, -42.36	<0.001	3.20 (5.68)	-8.32, 14.71	0.58
Protein (g)	-3.24 (7.05)	-6.64, 0.16	0.06	-4.27 (2.49)	-5.47, -3.07	<0.001	1.02 (1.72)	-2.46, 4.51	0.55
Iron (mg)	-1.89 (1.26)	-2.50, -1.28	<0.001	-2.08 (0.59)	-2.36, -1.79	<0.001	0.19 (0.32)	-0.46, 0.83	0.56
Vitamin C (mg)	-0.67 (1.36)	-1.32, -0.01	0.05	-0.24 (0.97)	-0.71, 0.25	0.29	-0.42 (0.38)	-1.20, 0.35	0.28
Vitamin A (IU)	-12.74 (28.05)	-26.26, 0.78	0.06	-4.11 (20.44)	-13.96, 5.75	0.39	-8.63 (7.96)	-24.78, 7.52	0.29

^a CI: Confidence Interval

^b From a single sample t-test

^c Males – Females

Table 6: Comparison of the mean of deviations to 0, what we would expect if the recalled amount equaled the known amount perfectly, by age group and age group comparison using the mean difference of deviations (n=38)

Food and Nutrient Category	Age 8-12 (n=23)			Age 13-16 (n=15)			Comparison		
	Mean of Deviations (SD)	95% CI ^a	p-value ^b	Mean of Deviations (SD)	95% CI ^a	p-value ^b	Mean Difference of Deviations (SD) ^c	95% CI ^a	p-value ^b
Volume (cups)									
Rice	-1.05 (0.40)	-1.23, -0.88	<0.001	-1.09 (0.38)	-1.30, -0.88	<0.001	0.03 (0.13)	-0.23, 0.30	0.81
Meat	0.05 (0.17)	-0.02, 0.13	0.14	-0.06 (0.20)	-0.17, 0.06	0.31	0.11 (0.06)	-0.01, 0.23	0.08
Energy (kcal)	-214.52 (107.41)	-260.97, -168.08	<0.001	-250.40 (123.46)	-318.77, -182.03	<0.001	35.88 (37.8)	-40.80, 112.56	0.35
Fat (g)	-0.99 (4.75)	-3.05, 1.06	0.33	-3.02 (5.57)	-6.11, 0.07	0.05	2.02 (1.69)	-1.40, 5.45	0.24
Carb (g)	-47.15 (18.02)	-54.94, -39.35	<0.001	-48.60 (16.81)	-57.91, -39.29	<0.001	1.46 (5.83)	-10.36, 13.27	0.80
Protein (g)	-2.60 (5.15)	-4.83, -0.37	0.02	-5.53 (5.04)	-8.32, -2.74	<0.001	2.93 (1.70)	-0.51, 6.37	0.09
Iron (mg)	-1.86 (0.97)	-2.28, -1.44	<0.001	-2.17 (0.99)	-2.72, -1.63	<0.001	0.31 (0.32)	-0.34, 0.97	0.34
Vitamin C (mg)	-0.39 (1.28)	-0.95, 0.16	0.15	-0.56 (1.07)	-1.14, 0.04	0.06	0.16 (0.40)	-0.65, 0.96	0.69
Vitamin A (IU)	-7.13 (26.62)	-18.64, 4.38	0.21	-10.40 (21.89)	-22.52, 1.72	0.09	3.27 (8.26)	-13.48, 20.02	0.69

^a CI: Confidence Interval

^b From a single sample t-test

^c (Age 8-12) - (Age 13-16)

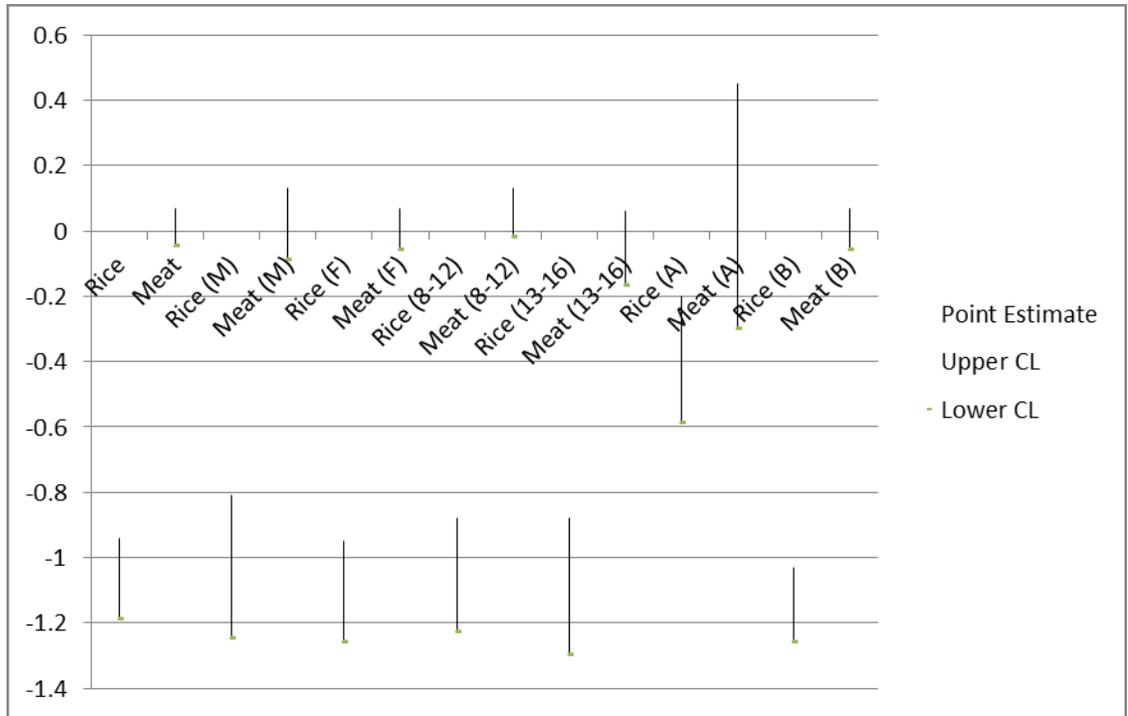


Figure 3: Mean deviations and confidence intervals for rice and meat volume, aggregate and by sex, age group and school

Single sample t-tests were also conducted to test the null hypothesis that the mean of the deviations for recalled values were equal to the observed values in children, in School A (Table 7) and School B (Table 8). Notable differences were observed from the single-sample t-test. First, rice volumes were more largely underestimated in School B (-1.26, -1.03) compared to School A (-0.59, -0.20). Second, meat volumes included approximately equal deviations above and below zero at School A (-0.30, 0.45) compared to School B where deviations were more closely centered around 0 (-0.06, 0.07). Figure 3

shows the differential rice and meat deviations compared to the aggregate data and by sex and age group. All confidence intervals reasonably align except the confidence interval for rice in School A (Figure 3). The two sample t-test comparing the mean difference of deviations in School A and School B also highlight the difference in rice volume estimates in School A compared to School B, finding that rice volumes were statistically different by school ($p < 0.001$) (Table 9). Energy and carbohydrate agreement also reflect the difference in rice volume estimates in School A compared to School B (Table 9).

Table 7: Comparison of the mean of deviations to 0, what we would expect if the recalled amount equaled the known amount perfectly, for School A (n=4)

Food and Nutrient Category	Mean of Deviations (SD)	95% CI ^a	p-value ^b
Volume (cups)			
Rice	-0.40 (0.12)	-0.59, -0.20	0.01
Meat	0.07 (0.24)	-0.30, 0.45	0.58
Energy (kcal)	-60.00 (61.47)	-157.81, 37.81	0.15
Fat (g)	1.43 (5.69)	-7.62, 10.48	0.65
Carbohydrates (g)	-17.44 (5.14)	-25.62, -9.26	0.01
Protein (g)	-0.01 (4.36)	-6.95, 6.93	0.9957
Iron (mg)	-0.58 (0.42)	-1.25, 0.09	0.07
Vitamin C (mg)	-0.19 (1.18)	-2.08, 1.69	0.76
Vitamin A (IU)	-3.50 (23.29)	-40.72, 33.72	0.78

^a CI: Confidence Interval

^b From a single sample t-test

Table 8: Comparison of the mean of deviations to 0, what we would expect if the recalled amount equaled the known amount perfectly, for School B (n=34)

Food and Nutrient Category	Mean of Deviations (SD)	95% CI ^a	p-value ^b
Volume (cups)			
Rice	-1.15 (0.33)	-1.26, -1.03	<0.001
Meat	0.00 (0.19)	-0.06, 0.07	0.90
Energy (kcal)	-248.53 (101.55)	-283.96, -213.10	<0.001
Fat (g)	-2.17 (5.00)	-3.92, -0.43	0.02
Carbohydrates (g)	-51.28 (14.50)	-56.34, -46.22	<0.001
Protein (g)	-4.19 (5.22)	-6.01, -2.37	<0.001
Iron (mg)	-2.15 (0.88)	-2.46, -1.84	<0.001
Vitamin C (mg)	-0.49 (1.20)	-0.91, -0.07	0.02
Vitamin A (IU)	-9.00 (25.01)	-17.73, -0.27	0.04

^a CI: Confidence Interval

^b From a single sample t-test

Table 9: Mean Difference of Deviations, School A and School B

Food and Nutrient Category	Comparison		
	Mean Difference of Deviations ^a	95% CI ^b	p-value ^c
Volume (cups)			
Rice	0.75 (0.17)	0.41, 1.09	<0.001
Meat	0.07 (0.10)	-0.14, 0.27	0.50
Energy (kcal)	188.53 (52.24)	82.57, 294.49	<0.001
Fat (g)	3.60 (2.67)	-1.82, 9.03	0.19
Carbohydrates (g)	33.85 (7.38)	18.88, 48.82	<0.001
Protein (g)	4.18 (2.72)	-1.34, 9.70	0.13
Iron (mg)	1.57 (0.45)	0.65, 2.48	0.001
Vitamin C (mg)	0.29 (0.63)	-0.99, 1.58	0.65
Vitamin A (IU)	5.50 (13.15)	-21.17, 32.17	0.68

^a School A - School B

^b CI: Confidence Interval

^c From a single sample t-test

Intrusion and omission rates reported in this study are lower than those reported in similar studies that conducted next day recalls in the United States with children of

similar ages, with 86% of the children that completed the 24-hour dietary recall the day following the school meal reported 0 intrusions or omission. In similar studies fourth grade children, around age 10, had a 32% omission rate and 13% intrusion rate (Baxter, 1997) and children ages 8 and 9 recalled 77.9% of the food items that they had been observed consuming (Lytle, 1993). Additionally, underestimation is a well document phenomenon in 24-hour dietary recalls in children and our results align with what has been found in previous studies regarding underestimation, particularly in School A (Livingston, 2000). While less work has been completed on portion size recall in children age 8 to 12, Steyn and colleagues found correlations between nutrients from weighted food portions and recalled food portions ranging from 0.84 to 0.99 in children ages 12 and 13 in South Africa (2006). The present study finds larger deviations of recalled food portions, especially in School B, which may be partially attributable to serving methodology. Finally, improved recall of meat may be in part because it is an uncommon food in our study population and uncommon foods have been found to be recalled with greater accuracy (Krall, 1988).

4. Discussion

4.1 Project Summary

The results suggest that the dietary recall methods used to obtain recalled food amounts are not a valid method for obtaining detailed information about children's food intake in our specific study group. They also highlight important trends in the 24-hour dietary recall in children age 8 to 16 in the population including the role that serving methodology plays in food recall, underestimation of foods across age, sex and standard and better recall of vegetables in females.

This study finds that serving methodology may play an important role in food recall and is a potential confounder in this study. The study results were obtained without taking into consideration different serving methods used at School B. Prior to meal preparation at School B, the head principal decided food portions for those attending the meal. After serving the decided amount of food (1 cup of rice and two-thirds cups of meat) to our sub-sample of children, the head principal requested that children receive an additional 1 cup of rice, as there was still rice remaining. Therefore, children at School B received 1 cup of rice at two distinct serving occasions. The serving methods used at School B may have influenced how children recalled food portions in the previous 24 hours. This hypothesis is supported by a single sample t-test that was conducted on artificially adjusted data to reflect only the initial serving sizes at School B

(1 cup of rice and two-thirds cups of meat). This single sample t-test found that very few of the food volume and macro- and micro nutrient categories were statistically different than 0 (Table 10). These adjusted results suggest that the serving methodology used at School B may have biased the results of our analysis downwards, thus accounting for the large underestimates in known food amounts in our study population. This could have important implications in populations that eat family style using a single plate because distinct serving instances may be harder to define and quantify.

Underestimation may also be due in part because children were being interviewed in a food scarce environment and expressed to the project translators feeling uncomfortable about disclosing true food amounts in case the translator did not have as much. Finally, better recall of vegetables in females could be explained by differential gender roles in the household where girls may be more likely than boys to take part in food preparation activities and thus be more familiar with the cooking process and ingredients used.

The approach and methodology used in this study can serve as a model for further investigation of validity of 24-hour dietary recall in the proposed study population, a population that food intake validation studies have not been conducted in. The outlined approach and methodology of this study is robust and capable of producing valuable results. This study included a diverse sample and evaluation of a wide range of measurements including food volume as well as macro- and micro-

nutrients. Precise measurements and observations of food intake created a controlled eating environment outside of a lab. These strengths should be replicated in similar studies.

Table 10: Artificially adjusted data comparing the mean of deviations to 0, what we would expect if the recalled amount equaled the known amount perfectly, for all participants (n=38)

Food and Nutrient Category	Mean of Deviations (SD)	95% CI ^a	p-value ^b
Volume (cups)			
Rice	-0.17 (0.32)	-0.28, -0.07	0.0021
Meat	0.01 (0.19)	-0.05, 0.07	0.72
Energy (kcal)	-11.44 (17.26)	-46.42, 23.53	0.51
Fat (g)	-0.03 (4.76)	-1.59, 1.53	0.97
Carbohydrates (g)	-3.16 (21.07)	-10.08, 3.77	0.36
Protein (g)	0.50 (5.00)	-1.14, 2.15	0.54
Iron (mg)	-0.08 (0.99)	-0.41, 0.24	0.62
Vitamin C (mg)	-0.45 (1.18)	-0.83, -0.06	0.03
Vitamin A (IU)	-8.39 (24.57)	-16.47, -0.32	0.04

^a CI: Confidence Interval

^b From a single sample t-test

4.2 Dietary Recall Limitations

Dietary recall methods have well-known limitations that must be considered in all studies using these methods (Willet, 2012). Recall inaccuracies may arise simply because you are asking someone to remember something that happened in the past and they misremember details about their food intake (Willet, 2012). Additional limitations are present in settings where food supply is affected by seasonality and agriculture cycles (Willet, 2012). This is often the case in developing countries, such as Kenya, that rely heavily on agriculture and subsistence farming within the country to make up the

food supply. In such a setting, a single 24-hour dietary recall is unable to capture changes in food intake that may occur over the course of a year. However, that may not have been as large of a concern in this study. In communities in Western Kenya that rely heavily on the fishing industry to support their livelihoods, the food supply may be less dictated by seasonality and agriculture cycles. While individuals in fishing communities on Lake Victoria may have small household gardens to supplement their food supply, the majority of households are reliant on the fish trade to obtain needed food items. The fishing trade, which is less affected by seasonality and agriculture cycles, provides the community with a more consistent supply of food items that varies less over the course of the year than communities that rely solely or largely on agriculture. Researchers have attempted to ameliorate these limitations by combining the 24-hour dietary recall methodology with other food intake measures, such as food frequency questionnaires, or increasing the number of 24-hour dietary recalls conducted in the study population over the course of 1 year (Willet, 2012).

4.3 Project Limitations

The sample size and the number of food items included in the analysis present important limitations to this study. This study intended to obtain a sample size of up to 30 children from each of the four recruited schools. 30 children would have provided the validation study with a sub-sample of approximately 10% of the larger study

population. Thirty was also chosen because it was the number of interviewer assisted 24-hour dietary recalls that could be conducted before lunch the day following the school meal, or 24 hours after the school meal. However, the teacher strike that took place in Kenya during June and July 2013 caused the school meals to be scheduled within close proximity to one another limiting the ability of the researchers to select a sub-sample of children for the validation study from all of the four schools and prevented the researchers from obtaining the desired sample size.

The sample size also presents important limitations for the data analysis methods used. For the single sample t-test to be valid in sample sizes less than 30 the underlying distribution must be normal. In Appendix G we have graphed the deviations from zero for all food volume and nutrient categories included in our analysis. A normal distribution seems approximately present in the majority of categories, however it is hard to determine this conclusively with the size of our sample. Additionally, the number of food items included in the analysis was smaller than intended. School meals were anticipated to have three separate food items: rice, meat and a vegetable. However, the vegetable dish was omitted from the menu for children at each of the schools without the knowledge of the researchers. Onions and tomatoes were considered additions to the main food items, rice and meat.

A final limitation involves the type of food that was used. Rice served with meat was chosen because meat would act as incentive for parents and children to attend the school meal. However, meat is not a common food in the population being studied. It is usually eaten for special occasions and not commonly consumed more than once a week. Due to meat's rarity in the daily diet of participants and the perception in the study population that meat is a treat, children may be able to recall it better, than foods that are more common in their daily diet (Krall, 1988).

4.4 Lessons Learned and Implications for Future Research

Future studies should consider increasing the sample size and number of food items at each meal in order to reach more robust conclusions. Similar studies may benefit from entering into a formal agreement with head principals and food preparation teams to ensure that all foods on the menu are prepared as agreed. This process may benefit from a more detailed explanation to schools of why serving size matters in the context of the study objectives and identifying components of the study that should be highlighted in order to convey the research objectives effectively. This may be accomplished by sharing a short brochure outlining the study and its objectives with all those involved.

Researchers should also take into consideration the serving methods used when assessing dietary intake in children as a first step in better understanding the

underestimation of portions and foods eaten in our study population. Future studies should also aim to understand the differential recall of vegetables in boys and girls. If this trend persists at larger sample sizes it could have important implications for the understanding of micro-nutrient deficiencies in a study population.

Finally, researchers should consider the reality of food consumption and interview conditions where the research is being conducted and adapt 24-hour dietary recall methods accordingly. Understanding the local food system, common foods in your population, typical serving dishes used and how individuals quantify food can lend much information to how one should adapt their recall methodology.

Appendix A

Dear Sir or Madame,

We are writing to invite your school to participate in the study detailed below. If you agree to allow the pupils (children) and staff at your school to participate, please write your signature at the bottom of the page to serve as consent.

Title: Dietary intake, weight status, and cognition in primary school children in Muhuru Bay, Kenya

Research Investigators:

Sara Benjamin Neelon, Sherryl Broverman, Rebecca Brouwer, Elizabeth Turner, Eve Puffer, Nikki Georggi, Sylvia Sable; Duke University
David Ndetei; University of Nairobi

Purpose of Study

The goal of this study is to explore how food and beverage intake might affect nutrition status and intelligence.

Potential Risks and Discomforts

We do not expect any risk or harm to the participant as a result of this study. Students from Duke University will collect height, weight, arm size (circumference), and some basic information about participating children and staff. They will also ask each participant what he or she ate and drank yesterday, and will ask them some questions to understand how they think and process information. Children and staff may choose not to participate in the study, or may stop participating at any time, without consequence. Children and staff do not need to respond to any questions they do not feel comfortable answering.

Potential Benefits

There will be no immediate benefits for participating in this research. However, if your school takes part, this will help researchers know more about future projects such as the impact of community or family gardens on child development.

Confidentiality

Any sensitive information including names will not be disclosed to any persons other than those involved in the study. We will keep all information in a locked filing cabinet that is accessible only to the research team for the purpose of this study only. All information will be destroyed in 7 years.

Incentive

Each participant will receive a carton of milk or the equivalent for participation in the study.

PARTICIPATION IN THIS STUDY IS ENTIRELY VOLUNTARY. ANY STUDENT OR STAFF MEMBER MAY REFUSE TO ANSWER ANY OF THE QUESTIONS ASKED DURING THE RESEARCH FREELY.

If you accept for your school to participate in this study, please write your signature below:

Principal Signature: Date:

If you have any questions, please contact Sara Benjamin Neelon at sara.neelon@duke.edu, or you may call the in-country contact at 254-729-588-806. Thank you very much.

Appendix B

Parent Informed Consent Form (used for parents of all children, ages 5-12)

Dear Sir or Madame,

We are writing to invite your child to participate in the study detailed below. If you agree to allow your child to participate, please write your signature at the bottom of the page to serve as consent. For parents of children 13-17, they will also provide assent.

Title: Dietary intake, weight status, and cognition in primary school children in Muhuru Bay, Kenya

Research Investigators:

Sara Benjamin Neelon, Sherryl Broverman, Rebecca Brouwer, Elizabeth Turner, Eve Puffer, Nikki Georggi, Sylvia Sable; Duke University
David Ndetei; University of Nairobi

Purpose of Study

The goal of this study is to explore how food and beverage intake might affect nutrition status and intelligence.

Potential Risks and Discomforts

We do not expect any risk or harm to the participant as a result of this study. Students from Duke University will collect height, weight, arm size (circumference), and some basic information about your child. They will also ask your child what he or she ate and drank yesterday, and will ask them some questions to understand how they think and process information.

Your child may stop participating at any time, without consequence. Your child does not need to respond to any questions they do not feel comfortable answering.

Potential Benefits

There will be no immediate benefits for participating in this research. However, if your child takes part, this will help researchers know more about future projects such as the impact of community or family gardens on child development.

Confidentiality

Any sensitive information including names will not be disclosed to any persons other than those involved in the study. We will keep all information in a locked filing cabinet that is accessible only to the research team for the purpose of this study only. All information will be destroyed in 7 years.

Incentive

Each participant will receive a carton of milk or the equivalent for participation in the study.

PARTICIPATION IN THIS STUDY IS ENTIRELY VOLUNTARY. YOUR CHILD MAY REFUSE TO ANSWER ANY OF THE QUESTIONS ASKED DURING THE RESEARCH FREELY.

If you accept for your child to participate in this study, please write your signature below:

Parent Signature: Date:

If you have any questions, please contact Sara Benjamin Neelon at sara.neelon@duke.edu, or you may call the in-country contact at 254-729-588-806. Thank you very much.

Kuom Migosi kata Mikayi,

Wandikoni mondo warwak nyathini obedie somo matut ma ondiki piny kae. Ka iyie mondo nyathinki obedie somoni, to yie iket ranyisi mar lweti (signecha mari) e giko weche mondiki e otas ni. ne jonyuol nyithindo duto kiud higni 13-17, wabiro kawo ayie kawuok kuom nyathini e yor dhok kata wach ma oa e dhoge.

Wi wach: Gik ma ichamo, pek mar del, weche, obuongo kod paro nyithind skul primary man Muhuru Bay e piny Kenya.

Jok Matimo Tich Somo Matut

Sara Benjamin Neelon, Sherryl Broverman, Rebecca Brouwer, Elizabeth Turner, Eve Puffer, Nikki Georggi, Sylvia Sable; Duke University
David Ndetei; University mar Nairobi

Gima Omiyo Itimo Somoni

Dwaro mar somoni en mondo ongi kaka chiemo kod gik ma imadho nyalo loko kaka chiemo tiyo e del kod rieko.

Ajali Kata weche maricho manyalo wuok e wachni.

Ok wageno gimoro marach kata ajali manyalo timore ni ngato angata. Kaaye somoni. Jopuonjre Duke University biro kaw pim mar bor, pek mar del, kaka kor badi romo, kod weche machuno e mi nyathini. Gibiro penjo nyathini gima ne ochamo kata madho nyoro, beude gibiro penjo moko mondo ginge kaka nyathini paro kata ngado weche moko. Wageno ni penjo gi ok bi kawo dakika mokalo (20) piero ariyo.

Nyathini nyalo yiero mondo owee somo ni e saa asaya maonge kum moro amora. Nyathini nyalo yiero mondo kik oduok penjo moro amora ma owinjo ka ok en go thuolo.

Weche Mabeyo Manyalo Wuokie

Onge ber mabiro wuok kanyo gi kanyo ne ngato angato ma obetie somoni. To kata kamano, ka nyathini obedo e somoni, to mano biro konyo jotim nouro ni ngeyo matut. Kuom somo mabeyo e udalo mabiro kaka pnothe mag skul nyalo konyo e dougruok mar nyathi.

Siri

Wach moro amora ma opondo moriwo nying ok bi ul ne ngato angata mopogore gi jotim nonro ni. Weche duto ibiro kan e sanduk ma olor kod kiful ma iyawo kod jotim. Nonro ni kende ne nonro mar somo ni. Weche duto ma okaw ibiro kethi bang higni abiriyo.

Gima Inyalo Yudo

Ngato angata ma biro betie somoni biro yudo box mar chak kata gimoro ma rom kod box mar chak kuom bet e somoni.

EN YIERONI MONDO IBED E SOMONI NYATHINI NI THUOLO MONDO OTAMRE DUOKO PENJO
MORO AMORO MA OPENJE SAA MA ITIMO NONRO NI.

Ka iyie mondo nyathini obedi e somoni, to yie mondo indik ranyis mar lweti (signecha mari)
piny kae.

Signecha mar janyuol.....Tarik ma kawuono:

Ka in kod penjo moro amoro, to inyalo tudri kod Sara Benjamin Neelon sara.neelon@duke.edu,
kata inyalo goyo sim ni ngat ma nitie Kenya e namba mar 254-729-588-806. Wagoyoni
erokamano ahinya.

Appendix C

Child Assent Script (for children ages 13-17)

We are trying to learn about how what children eat might affect how they learn in school and how healthy their bodies are.

We have some questions to ask you about what you ate yesterday. We would also like to see how heavy you are, how tall you are, and the size of your arm. And after that we would like to ask you to list some words so we can test your memory. That memory game might be hard, but do not worry. It is supposed to be hard.

If you decide to do these things with us, it will take about 10 minutes.

You get to decide whether or not you want to do this, and no one will be mad at you if you decide not to. It will not make any difference to your grades in school. If you try it and decide that you want to stop, that is OK too. Just tell me that you would like to quit.

What else would you like to know about answering questions, being measured, and doing the memory game? If you do not have any questions now, you can still ask me at any time, okay?

Would you like to answer these questions, be measured, and play the memory game, or would you rather not?

CHILD ASSENT SCRIPT (Fom Manyiso Yie Mar Nyathh)

Watemo nono kaka gik ma nyithindo chamo nyalo donjore gi ngimagi e school kata ka ber gi ngima dendgi.

Wan gi penjo moko kuom gik ma nyoro ichamo.

Bende wagombo neno kaka iyot kata ipek , bor mari kod kaka kor badi romo.

Bang' mano to dwaher mondo iwach weche moko mondo wapi. M gordo paro ni kata pachi. Tuk paro nyalo bedo matek to kata kamano kik idew oningo obed matek.

Ka iyie tugo ni biro kaw gimoro dakika apar.

Be iyie tugo kodwa?

Inyalo ng'ado ka iyie mar tugo kata ooyo, bende onge nga'ma biro neno marach kodi kuom tamori, ma ok bi kelo pogruok moro amora.

Ang'o kendo ma igombo ng'eyo kuom duoko penjo , kuom pimi kod tugo?

Ka ionge gi penjo sani, inyalo penjo samoro amora.
Donge mano ber?

Appendix D

24-Hour Dietary Recall Protocol

Regardless of what time of day you interview the participant, you will ask them **to recall everything they ate and drank for the previous three meals or prior 24 hours starting with the most distant meal and moving forward**. You will be using an adapted version of the multiple pass method to collect this data. The first pass collects information about **WHAT** the participant ate or drank; the second pass collects quantifying information about **HOW MUCH** (amount, number and size) they ate or drank. The third pass collects descriptive information about how the meal was prepared (fried or boiled) and other descriptive qualities (salt added, oil, tomatoes, onions used?). Use the following protocol as a guide for each dietary assessment.

Important Note: If the participant mentions water at any of the meals, ask “Did someone boil or treat the water for you or was it raw?”

You will enter data on this portion of the data collection form. The **WHAT** (type of food) is listed in the **FOOD/BEV** column, the **AMOUNT** is listed in the **AMOUNT** column, and you can write special notes in the notes section for any of the descriptive information. Note that something is required in the **FOOD/BEV** column for each meal (write “nil” if no food/bev was taken). You should number the meals from 1 to 3 starting with the most distant meal and moving forward. Please write the numbers in the left most column under the meals.

TWENTY FOUR-HOUR DIET RECALL: Please ask the participant what s/he ate and drank for each meal yesterday and record below, indicating “nil” if they ate nothing. DO NOT LEAVE ANYTHING BLANK.

	FOOD/BEV	AMOUNT	Notes
Breakfast:			
Lunch:			
Supper:			
Other Food:			

** If <8 years old: Did you eat supper yesterday? “What did you eat?”

(All children) Did you go to bed hungry last night? Yes No

Unique number of food items:

Introduction

1. Establishing Comfort

It is essential that the data collectors make the participants feel comfortable. This will begin at the very first interaction with the participant and should continue throughout the entire assessment. The data collectors should make sure the participants feel comfortable with all aspects of the assessment and should continue to explain anything if it seems as though the participant may not fully understand the instructions.

2. The Activity and Measurement Aids

The data collectors will have already conducted the agriculture knowledge and food security section, the anthropometric measures and introduced themselves to the participant. Following the anthropometric measures the data collectors will conduct a 24-hour dietary recall on each participant. First, the data collectors should briefly explain the activity, the measurement aids and ask the participant to explain what is about to happen. Please see the sample transcript for an example.

3. Reporting 'Nil' or Nothing

During the introduction (and throughout the recall) it is essential that the data collectors make clear that it is okay if the participant did not eat anything for one of the meals. They should explain that if this is the case, participants should report or say 'nil' or nothing.

Quantifying Food Amounts

1. Measures

- a. *Cups*: Cups will be the most common measurement entered and should be used for any food or beverage that cannot be counted as distinct pieces. Anything indicated as "per 1 cup" in the data-entry rules should be recorded in number of cups eaten.
- b. *Tablespoon, Teaspoon*: Tablespoon and teaspoon will be used for smaller quantities and when applying the entry rules. In the case of data entry rules, the data collectors will not have to record these values. They will be applied only after an item with a data-entry rule is recorded in the units indicated in the data-entry rules (cups or number of pieces).
- c. *Number of Pieces*: Number of food items should be used only when food can be counted in distinct pieces (ex: pieces of chapatti or number/pieces of mangos). Whenever this measure is used the data collector should assess the size of the piece if it is not already including in the size guidelines. If a food item is included in the size guidelines then the data collector should just record the number of distinct pieces reported by the participant. (S)he should not include the size.

2. Measurement Aids:

- a. *Measuring cups, spoons, and standard serving dishes*: Measuring cups (1 cup, $\frac{1}{2}$ cup, $\frac{1}{3}$ cup, and $\frac{1}{4}$ cup), spoon measures (tablespoon, teaspoon) and standard serving mugs will be available as measurement aids. The measuring cups can be used as a measurement aid for any food or beverage that will be measured using cups. The data collector may need to calculate portions of the household cups and record that value (for example, if the child says they had half of the $\frac{1}{4}$ cup amount, the data collector would write $\frac{1}{8}$ cup on the

data collection form; if a child points to the halfway line of the uji cup, mark $\frac{1}{2}$ of the quantity marked on the cup).

- b. *Food Models*: Food models will be available for reference for some of the most common food items. Rice/ugali, bean and green vegetable models will be available in $\frac{1}{2}$, $\frac{1}{4}$ and $\frac{1}{8}$ cup measures. The standard household measurement size (e.g., $\frac{1}{2}$ cup) is affixed to the bottom of the food model.
- c. *Circles*: The circle template will aid in determining the size of any circular food item not previously standardized (ex: chapatti, mandazi). Data collectors will ask participants to point to the appropriate radius and record it on the data collection form in inches.
- d. *Squares and Rectangles*: The square and rectangle template will be used to determine the size of any square or rectangular food item not previously standardized (e.g., maize). Data collectors will ask participants to draw (or point to) the size of the reported food item beginning at the lower left corner of the laminated template using an erasable marker. They will then record the size of the food item using a vertical and a horizontal measurement.

24-Hour Dietary Recall Sample Transcript

DC= Data Collector | P=participant over 8 years of age **

[Late morning, before the students' lunch break]

** Remember, if child is <8 years old, only ask:

Did you eat supper yesterday?

What did you eat?

Did you go to bed hungry last night? Yes No

DC: *Hello, we are going to spend a few minutes talking about everything that you ate or drank yesterday. It is okay if you did not eat or drink anything for one of the meals you can just say 'nil'. We will start by thinking about lunch yesterday. Do you remember what you ate when you went home for lunch yesterday? For lunch, did you have "nil" or did you have something to eat or drink?*

P: I had some chapatti and a piece of mango. And I drank water.

DC: *Thank you. Did someone boil or treat the water you drank or was it raw?*

P: It was boiled. [Mark in the “notes” section of the data collection form”]

DC: *Great, thank you. Now think back to yesterday after school. Did you have anything to eat or drink for supper? Again, you can say nil if you had no food or drink yesterday at supper.*

P: I had rice for supper.

DC: *Ok, thank you. Now think back to this morning before you came to school. Did you have anything to eat or drink for breakfast? If so, what did you have?*

P: I drank tea before school.

DC: *Did you eat or drink anything else throughout the day while you were at school or after you came home yesterday? Did you have anything else to eat or drink this morning?*

P: Just some boiled water.

DC: *Great! So now we will talk about how much of everything you ate and drank. You can use these cups and models to help you remember. I will help you. Now, how many pieces of chapatti and slices of mango did you have for lunch yesterday?* P: I had one piece of chapatti and three mango slices.

DC: *Thank you. How many cups of boiled water?*

P: I drank 2 cups of water.

DC: *Great, thank you. How big were the three mango slices (probe so that you are able to quantify using the mango as your frame of reference – i.e., $\frac{1}{4}$ mango or $\frac{1}{2}$ a mango; you may also use the food models or other measures; for the chapatti you can use the Circles measurement aid)? Now for supper, you said that you had rice to eat. How much rice did you have?*

To estimate cup measures of some food items (rice, ugali, fish, beans), use one of the following measurement aids.

- *Measuring Cups and common serving dishes with known capacities:*
- *Food Models of known quantity:*
- *Food portion visual (circles, rectangles)*

P: I had one cup of rice (they will probably point to which aid they believe matches the amount of rice eaten).

DC: *Thank you. For breakfast this morning, how much tea did you drink? One cup? Two cups? Half a cup? (data collectors should use household teacup aid)*

P: I had two cups of tea.

DC: *Thank you. Lastly, how many cups of water did you drink yesterday or this morning that was not during breakfast, lunch, or supper? (data collectors should use measure cup aids)*

P: I drank two cups of water throughout the day

DC: *Thank you very much! Did you go to bed hungry last night? Yes No*

Appendix E

Dietary Recall Probes

1. General Probes by Food Type

The probes below are a starting point for common foods in western Kenya. It will be updated as more information becomes available.

Food Type/Food Name	Description	Dietary Recall Probe
BEVERAGES		
Chai/Tea	A hot beverage made as strungi (strong tea) or chachak.	Strungi: Coffee, tea or cocoa mixed with hot water, sugar. No milk added. Chachak: Coffee, tea or cocoa mixed with water and milk, sugar.
Nyuka, Uji, Porridge	Hot cereal in brown or white	Brown: millet, cassava, sugar, water White: maize, sugar
Water	Water	<ul style="list-style-type: none"> • Raw, from the lake/river, not boiled • Boiled • Treated
GRAIN BASED		
Rice	White rice	Vegetable oil, salt
Ugali	Cooked brown or white	Brown: Millet or millet and cassava White: Cassava or maize *If maize, must probe to find if it is sifted or unsifted.
Chapati	An Indian flatbread	Ask if took chapatti plain or if added something on top.
Mandazi	East African donut	Ask if took mandazi plain or if added something on top.
VEGETABLES & TUBERS		
Kachumbari Salad	Cold salad	Tomatoes, onions, salt
Spinach *In DIG trained houses	A dish made out of spinach (sometimes mixed with kale)	Spinach, tomato, onion, salt, vegetable oil

Beet Root *In DIG trained houses	Eaten raw or in addition to dishes	Eaten plain when raw, should probe for in other foods (sukuma, meat, rice etc.) when parent has been trained by DIG.
Avocado	Eaten raw	Avocado, salt
Sukuma wiki	A dish made out of kale (sometimes mixed with spinach)	Kale, tomato, onion, salt, vegetable oil
Dek, Boo or Osuga	A dish made out of traditional vegetables (equivalent of spider weed)	Traditional vegetable, water, tomato, onion, salt, vegetable oil
Nyoyo, Githeri	Kenyan traditional meal of dry maize and beans.	Maize, beans, onion, tomato, salt, water, vegetable oil
Sweet potato	Sweet potato, boiled and served	Sweet potato, water
Irish Potato	Irish potato, boiled, seasoned and serve	Irish potato, water, salt, onion, tomatoes, vegetable oil
LEGUMES		
Beans	Beans, soaked overnight, simmered with other ingredients until almost soft	Beans, tomato, onion, vegetable oil, salt
Lentils, green grams	Cooked lentils served alone or with other vegetables and seasonings.	Lentils, tomato, onion, vegetable oil, salt
MEAT, POULTRY, FISH, EGGS		
Omena, Dagaa	Small herring, usually sold dry then fried or boiled	Omena/Dagaa, vegetable oil, salt, tomato, onion, water (if boiled)
Fish (Nile perch, tilapia, Okoko, catfish)	Type of fish prepared one of five ways <ul style="list-style-type: none"> Fried, boiled, roasted, fried & boiled, dried and boiled 	Type of fish, vegetable oil, tomato, onion, salt, water (if boiled)
Nyoma Choma	Beef, goat, sheep or chicken put over coals, grilled and chopped up. Chicken is only served on special occasions. Meat may be fried.	Type of meat, vegetable oil (if fried)
Kenyan "Soup"	Beef stew, goat stew, chicken	Type of meat, vegetable oil,

	stew or any other animal stew served with a tomato sauce	salt, tomato, onion, water (for boiling)
Eggs	A cooked egg and vegetable dish	Egg, tomato, onion, salt, vegetable oil

2. Size Guidelines: The following food items will have standardized sizes, therefore data collectors are NOT required to determine the size of these food pieces (but may do so if the participant is able to recall the size):

- Any whole fruit or vegetable

3. Equivalent Food Terminology

Food	Alternate Name
Herring fish	Omena or Daga
Porridge	Nyuka, Uji
Lentils	Green grams
Tea	Chai

Appendix F

PUPIL DATA COLLECTION FORM

School: _____

Teacher: _____

Interviewer Initials: _____
Date: _____/_____/_____
Scanned? <input type="checkbox"/> Yes <input type="checkbox"/> No
Sent to Duke? <input type="checkbox"/> Yes <input type="checkbox"/> No
Data entry: _____/_____/_____
QA: _____/_____/_____

Class # (circle): 1 2 3 4 5 6 7 8

Name: _____ Year of Birth: _____ Unique ID #: _____

Sex: Male Female Pupil Assent Received: Yes No

ANTHROPOMETRIC MEASURES: Please take two readings of each measurement

Mid-Upper Arm Circumference to nearest 0.1 cm: _____ (1) _____ (2)

Height to nearest 0.1 cm: _____ (1) _____ (2)

Weight to nearest 0.1 kg: _____ (1) _____ (2)

TWENTY FOUR-HOUR DIET RECALL: Please ask the participant what s/he ate and drank for each meal yesterday and record below, indicating "nil" if they ate nothing. DO NOT LEAVE ANYTHING BLANK

	FOOD/BEV	AMOUNT	Notes
Breakfast:			
Lunch:			
Supper:			
Other Food:			

*If <8 years old: Did you eat supper yesterday? "What did you eat?"

(All children) Did you go to bed hungry last night?: Yes No

NDS Data entry: _____
QA: _____/_____/_____

COGNITIVE ASSESSMENT

Animals

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Words

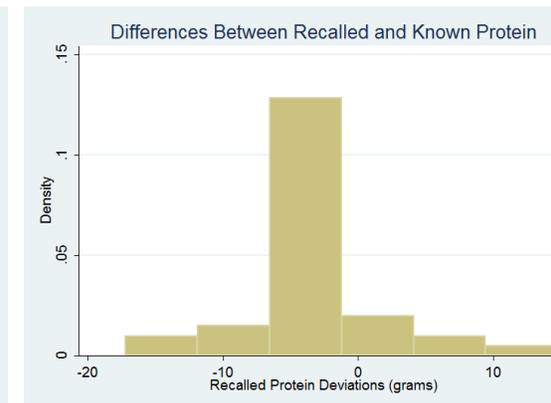
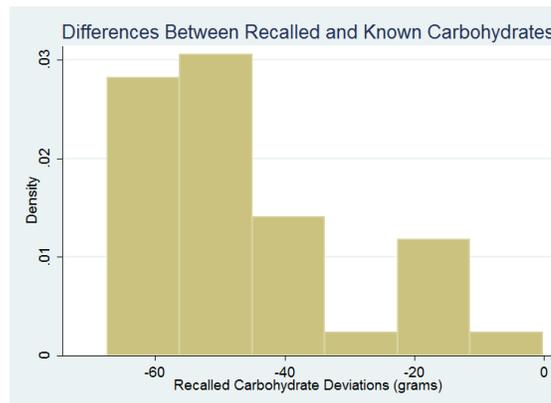
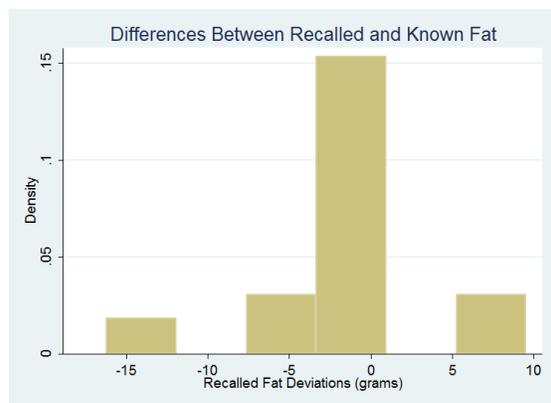
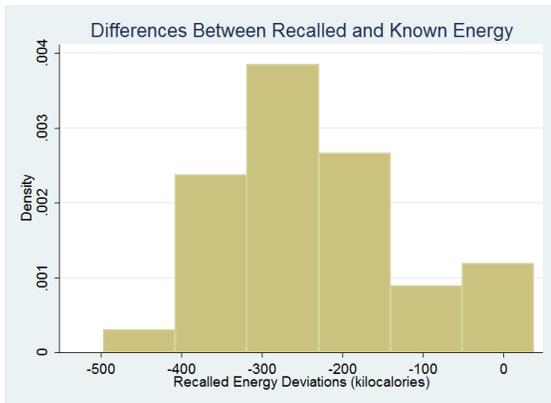
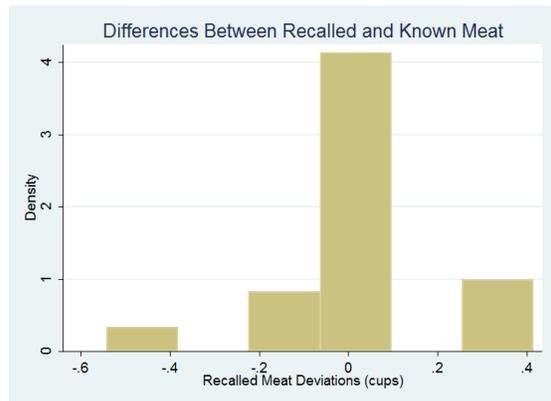
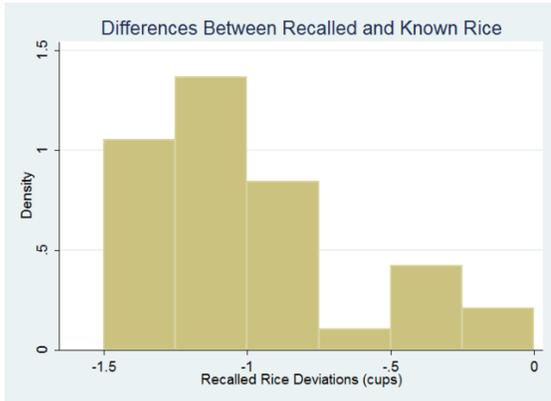
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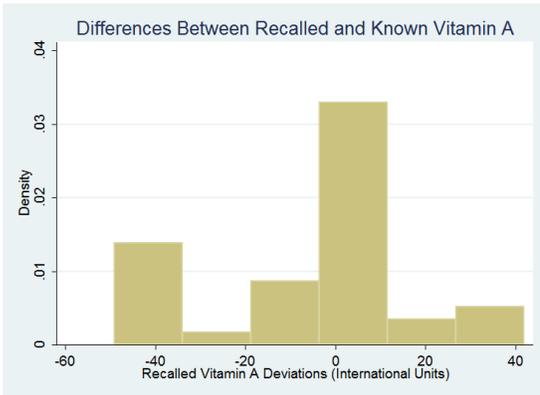
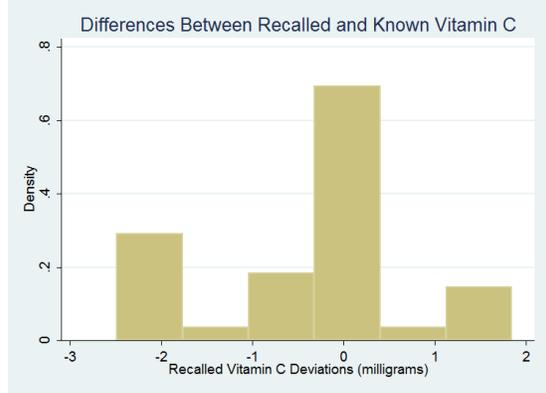
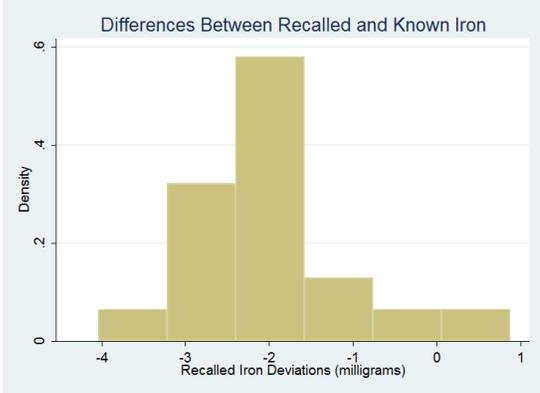
Please circle the letter used in the
"P" words activity:

P M N R S T D K

Total animal list ____
Minus errors: - ____
Animal list score: ____
Total "P" words list ____
Minus errors: - ____
"P" words score: ____

Appendix G





References

- Baranowski, T., & Domel, S. B. (1994). A cognitive model of children's reporting of food intake. *American Journal of Clinical Nutrition*, *59*, 212S-217S.
- Baranowski, T., Islam, N., Baranowski, J., Martin, S., Beltran, A., Dadabhoy, H., Adame, S. H., Watson, K.B., Thompson, D., Cullen, K. W., & Subar, A. F. (2012). Comparison of a web-based versus traditional dietary recall among children. *Journal of the American Dietetic Association*, *112*, 527– 532.
- Baranowski, T., Islam, N., Douglass, D., Daddabhoy, H., Beltran, A., Baranowski, J., Thompson, D., Cullen, K. W., & Subar, A. F. (2012b). Food Intake Recording Software System, version 4 (FIRSt4): a self-completed 24-h dietary recall for children. *Journal of Human Nutrition and Dietetics*, doi: 10.1111/j.1365-277X.2012.01251.x
- Baranowski, T., Baranowski, J. C., Watson, K. B., Martin, S., Beltran, A., Islam, N., Dadabhoy, H., Adame, S. H. Cullen, K., Thompson, D. Buday, R., & Subar, A. (2011). Children's accuracy of portion size estimation using digital food images: effects of interface design and size of image on computer screen. *Public Health Nutrition*, *14*(3), 418-425.
- Baxter, S. D., Smith, A. F., Nicholas, M.D., Guinn, C. H., & Hardin, J. W. (2006). *Nutrition Research*, *26*(6), 241-248.
- Baxter, S. D., Thompson, W.O., Davis, H.C., & Johnson M.H. (1997). Impact of gender, ethnicity, meal component, and time interval between eating and reporting on accuracy of fourth-graders; self-reports of school lunch. *Journal of the American Dietetic Association*, *97*(11), 1293-1298.
- Baxter, S. D. (2009). Cognitive processes in children's dietary recalls: insight from methodological studies. *European Journal of Clinical Nutrition*, *63*(Supplement 1), S19–S32.
- Béné, C. & Merten, S. (2008). Women and fish-for-sex: transactional sex, HIV/AIDS and gender in African fisheries. *World Development*, *36*(5), 875–899.
- Brooks, J. T., Shapiro, R. L., Kumar, L., Wells, J. G., Philips-Howard, P. A., Shi, Y., Vulule, J. M., Hoekstra, R. M., Mintz, E., & Slutsker, L. (2003). Epidemiology of

sporadic bloody diarrhea in rural western Kenya. *The American Journal of Tropical Medicine and Hygiene*, 68(6), 671-677.

Buvé, A., Carael, M., Hayes, R. J., Auvert, B., Ferry, B., Robinson, N. J., Anagonou, S., Kanhonou, L., Laourou, M., Abega, S., Akam, E., Zekeng, L., Chege, J., Kahindo, M., Rutenberg, N., Kaona, F., Musonda, R., Sukwa, T., Morison, L., Weiss, H. A., & Laga, M. (2001). The multicentre study on factors determining the differential spread of HIV in four African cities: summary and conclusions. *AIDS*, 15, 127-31.

Cornellio-Nieto, J. O. (2007). The effects of protein-energy malnutrition on the central nervous system in children. *Revue Neurologique*, 44(Supplement 2), S71-S74.

De Keyzer, W., Huybrechts, I., De Maeyer, M., Ocke, M., Slimani, N., van 't Veer, P., & De Henauw, S. (2011). Food photographs in nutritional surveillance: errors in portion size estimation using drawings of bread and photographs of margarine and beverages consumed. *British Journal of Medicine*, 105(07), 1073-1083.

Division of Malaria Control [Ministry of Public Health and Sanitation], Kenya National Bureau of Statistics, and ICF Macro. (2011). 2010 Kenya Malaria Indicator Survey. Nairobi, Kenya: DOMC, KNBS and ICF Macro.

Dwyer, J., Picciano, M. F., & Raiten, D. J. (2003). Future Directions for What We Eat in America, NHANES: The Integrated CSFII-NHANES. *Journal of Nutrition*, 133, 576S-581S.

Ermakov, I. V., Sharifzadh, M., Ermakova, M., & Gellermann, W. (2005). Resonance Raman detection of carotenoid antioxidants in living human tissue. *Journal of Biomedical Optics*, 10(6).

Faber, M., Phungula, M. A. S., Venter, S. I., Dhansay, M. A., & Benadé, A. J. S. (2002). Home gardens focusing on the production of yellow and dark-green leafy vegetables increase the serum retinol concentration of 2-5-y-old children in South Africa. *American Journal of Clinical Nutrition*, 76, 1048-1054.

Faggiano, F. P., Vineis, D., Cravanzola, et. al. (1992). Validation of a method for the estimation of food portion size. *Epidemiology*, 3, 379-382.

FAO (2005). Nutrition Country Profile: Republic of Kenya. Food and Nutrition Division, Food and Agriculture Organization of the United Nations.

- FAO (2011). Guidelines for Measuring Household and Individual Dietary Diversity. Nutrition and Consumer Protection Division, Food and Agriculture Organization of the United Nations.
- Gibson, R. S. (2005). *Principles of Nutritional Assessment, Second Edition*. New York, New York: Oxford University Press, Inc.
- Girard, A. W., Self, J. L., McAuliffe, C., & Olude, O. (2012). The Effects of Household Food Production Strategies on the Health and Nutrition Outcomes of Women and Young Children: A Systematic Review. *Paediatric and Perinatal Epidemiology*, 26(1): 205-222.
- Guthrie, H. A. (1984). Selection and quantification of typical food portions by young adults. *Journal of the American Dietetic Association*, 84, 1440-1444.
- Institute for Digital Research and Education, UCLA (2013). Stata Annotated output, T-test. University of California Los Angeles, Institute for Digital Research and Education.
- Jensen, P. (2013). The Urban Gardens Program for HIV-Affected Women and Children: A Review and Look to the Future. Washington, DC: FHI360/FANTA.
- Kenya National Bureau of Statistics, & ICF Macro. (2010). Kenya Demographic and Health Survey 2008-09. In K. a. I. Macro. (Ed.). Calverton, MD
- Krall, E. A., Dwyer, J. T., Coleman, K. A. (1988). Factors influencing accuracy of dietary recall. *Nutrition Research*, 8(7), 829-841.
- Lillegaard, I.T., Overby, N. C., Andersen, L. F. (2005). Can children and adolescents use photographs of food to estimate portion size? *European Journal of Clinical Nutrition*, 59, 611-617.
- Livingston, M. B. E., & Robson, P. J. (2000). Measurement of dietary intake in children. *Proceedings of the Nutrition Society*, 59(02), 279-293.
- Livingstone, M. B. E., P. J. Robson, & J. M. W. Wallace. (2004). Issues in dietary intake assessment of children and adolescents. *British Journal of Nutrition*, 92, s213-s222.

- Ludbrook, J. (2010). Confidence in Altman-Bland plots: A Critical review of the method of differences. *Clinical and Experimental Pharmacology and Physiology*, 37(2), 143-149.
- Lytle, L. A., Nichaman, M. Z., Obarzanek, E., Glovsky, E., Montgomery, D., Nicklas, T., Zive, M., & Feldman, H. (1993). Validation of 24-hour recalls assisted by food records in third-grade children. The CATCH Collaborative Group. *Journal of the American Dietetic Association*, 93(12), 1431-1436.
- Masset, E., Haddad, L., Cornelius, A., & Isaza-Castro, J. (2012). Effectiveness of agricultural interventions that aim to improve nutritional status of children: systematic review. *British Medical Journal*, 344: d8222
- NACC and NASCOP (2012). Kenya AIDS Epidemic update 2011. Nairobi, Kenya: NACC, and NASCOP.
- NASCOP (2007). Kenya AIDS Indicator Survey 2007. Nairobi, Kenya: National AIDS and
- STD Control Program (NASCOP), National Public Health Laboratory Services (NPHLS), Kenya Medical Research Institute (KEMRI), National AIDS Control Council (NACC), Kenya National Bureau of Statistics (KNBS), National Coordinating Agency for Population and Development (NCAFD), U.S. Centers for Disease Control (CDC), U.S. Agency for International Development (USAID), World Health Organization (WHO), United Nations Joint Programme on HIV/AIDS (UNAIDS)
- National Cancer Institute (2013). ASA24. US Department of Health & Human Services, National Cancer Institute at the National Institutes of Health, Division of Cancer Control and Population Sciences, Applied Research Program.
- Omondi (2011). Nyanza Counties, Migori. Wikimedia commons (figure 1): http://commons.wikimedia.org/wiki/File:Nyanza_Counties_-_Migori.jpg#file
- Schakel, S.F. (2001). Maintaining a nutrient database in a changing marketplace: Keeping pace with changing food products - A research perspective. *Journal of Food Composition and Analysis*, 14, 315-322.

- Schakel, S.F., Buzzard, I.M., & Gebhardt, S.E. (1997). Procedures for estimating nutrient values for food composition databases. *Journal of Food Composition and Analysis*, 10, 102-114.
- Schakel, S. F., Sievert, Y. A., & Buzzard, I. M. Sources of data for developing and maintaining a nutrient database. *Journal of the American Dietetic Association*, 88, 1268-1271.
- Schipani, S., van der Haar, F., Sinawat, S., & Maleevong, K. (2002). Dietary intake and nutritional status of young children in families practicing mixed home gardening in northeast Thailand. *Food and Nutrition Bulletin*, 23(2), 175- 180.
- Scrimshaw, N. S., SanGiovanni, J. P. (1997). Synergism of nutrition, infection, and immunity: an overview. *The American Journal of Clinical Nutrition*, 66(2), 4645-4775.
- StataCorp. 2013. Stata Statistical Software: Release 13. College Station, TX: StataCorp LP.
- Subar, A. F., Crafts, J., Zimmerman, T. P., Wilson, M., Mittl, B., Islam, N. G., McNutt, S., Potischman, N., Buday, R., Hull, S. G., Baranowski, T., Guenther, P. M., Willis, G., Tapia, R., & Thompson, F. E. (2010). Assessment of the accuracy of portion size reports using computer-based food photographs aids in the development of an automated self-administered 24-hour recall. *Journal of the American Dietetic Association*, 110, 55-64.
- Tate, J. E., Rheingans, R. D., O'Reilly, C. E., Obonyo, B., Buron, D. C., Tornheim, J. A., Adazu, K., Jaron, P., Ochieng, B., Kerin, T., Calhoun, L., Hamel, M., Laserson, K., Breiman, R. F., Feikin, D. R., Mintz, E. D., & Widdowson, M. (2009). Rotavirus Disease Burden and Impact and Cost-Effectiveness of a Rotavirus Vaccination Program in Kenya. *The Journal of Infectious Diseases*, 200(Supplement 1): S76-S84.
- Tornheim, J. A., Manya, A. S., Oyando, N., Kabaka, S., Breiman, R. F., & Feikin, D. R. (2007). The epidemiology of hospitalized pneumonia in rural Kenya: the potential of surveillance data in setting public health priorities. *International Journal of Infectious Diseases*, 11(6), 536-543.
- Yuhas, J. A., Bolland, J. E., & Bolland, T. W. (1989). The impact of training, food type, gender, and container size on the estimation of food portion sizes. *Journal of the American Dietetic Association*, 89, 1473-1477.

- WHO (2011). Child Mortality: Millenium Development Goal (MDG) 4. The World Health Organization, The Partnership for Maternal, Newborn and Child Health.
- WHO, 2013. Diarrhoeal disease, Fact Sheet. World Health Organization, Media Centre.
- Willet, W. (2012). *Nutritional Epidemiology: Chapter 4: 24-Hour Recall and Diet Record Methods*. Oxford University Press.
- World Bank, The (2011). Population Projection Tables by Country and Group. The World Bank Group.
- World Bank, The (2013). Data: Indicators. The World Bank Group.
- World Bank, The (2013b). Data: By Country, Kenya. The World Bank Group.
- Wrong, Michela (2009). *It's Our Turn to Eat: The Story of a Kenyan Whistle-Blower*. Harper Collins Publishers.