Assessment of dietary intake and body mass index in a nutritionally deprived population in rural Democratic Republic of Congo

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Abstract

Introduction: In the Democratic Republic of Congo (DR Congo), about 70% of the total population and more than 40% of children under the age of 5 are undernourished. In such an area, assessment of nutritional adequacy is vital as it can provide valuable data for policymakers that can be used for advocacy to focus on particular problems that need to act on. Thus, this cross-sectional study aimed to assess nutritional adequacy of diet and body mass index (BMI) in a nutritionally deprived population in rural Bandundu Province in the DR Congo and compare our findings to other African studies by doing a literature review.

Methods: Dietary intakes of 76 subjects from 12 systematically selected households were collected using 3 days weighed food records. The weights of food consumed by individuals were converted in energy and macronutrients using relevant food composition tables. The individual intakes and energy percent from macronutrients (E%) were assessed for adequacy by comparing with the recommended intakes and acceptable macronutrients distribution ranges (AMDRs), respectively. Weight and height data were also collected from 440 adults using calibrated equipment and standardized techniques. The WHO BMI cut-off points were used for assessment. To investigate the socio-demographic factors associated with being underweight, logistic regression was used. A semi-systematic review was adopted to search for relevant published articles. We searched 3 online electronic databases, 4 online journals, 5 authors and the reference lists of the identified key articles. Then the findings of the selected articles were compared with our study findings.

Results: Protein and fat intakes were below the recommended intakes in all age groups, in spite of energy intake being adequate. The E% from protein and fat were both far below the lower limits of the AMDRs. The diet was highly monotonous, dominated by cassava, approximately 80% of the participants energy was derived from cassava. Comparing this finding with other African studies, our participants had the most monotonous diet of all the free-living African populations. Based on the BMI assessments, 47% of the overall adults were underweight, 52% were in the normal weight range and 1% were overweight. Using logistic regression model, we found significant association with underweight status and participant’s age, but not in sex or residence village. Comparing these figures with other studies in Africa, our study reported one of the thinnest free-living adult populations in Africa.

Conclusion: This study revealed an extremely monotonous diet and a high prevalence of underweight. Therefore, immediate nutritional interventions are warranted to alleviate the current problems. In long term perspective, efforts to enhance agriculture diversity, empower the economic development and enrich the diet with animal products should be considered.

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III. List of abbreviations

AMDRs	Acceptable Macronutrient Distribution Ranges
AOR	Adjusted Odds Ratio
BMI	Body Mass Index
BMR	Basal Metabolic Rate
CHO	Carbohydrates
CI	Confidence Interval
COR	Crude Odds Ratio
DR Congo	Democratic Republic of the Congo
DRIs	Dietary Reference Intakes
EER	Estimated Energy Requirement

EI	Energy Intake
E%	Energy percent
FAO	Food and Agriculture Organization
IFAD	International Fund for Agricultural Development
IOM	Institute of Medicine
Kcal	Kilocalorie
MDG	Millennium Development Goal
PA	Physical Activity
PAL	Physical Activity Level
RDA	Recommended Dietary Allowance
SD	Standard Deviation
SPSS	Statistical Package for Social Sciences
SSA	Sub-Saharan Africa
STROBE	STrengthening the Reporting of Observational Studies in Epidemiology
TEE	Total Energy Expenditure
TEI	Total Energy Intake
UN	United Nations
UNDP	United Nations Development Programme
WFP	World Food Programme
WFR	Weighed food records
WHO	World Health Organization

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1. Introduction

1.1. General overview

Nutritional adequacy, i.e. a nutritionally adequate diet, is the cornerstone of an individual's well-being, it promotes health, may help extend one's life span, and can help prevent the occurrence of chronic diseases (1). Individuals are classified as having adequate nutrition when they have sufficient intake of essential nutrients, needed to fulfill their nutritional requirements for optimal health (2). Nutritional inadequacy is a serious public health concern in low-income countries. It is a leading cause of undernourishment, which is experienced when food intake is continuously insufficient to meet the dietary requirements. In contrast, undernutrition is defined as the outcome of undernourishment and repeated infectious diseases (3). Undernutrition has detrimental effects on a person's health as it impairs physical, mental and cognitive development as well as it compromises the immune system (4). Women and children are more vulnerable to nutritional deficiencies than other members of the community. It has been estimated that nearly half (45%) of all childhood deaths can be linked to undernutrition (5-7).

1.2. Global and regional burden of undernourishment

The target of the first UN millennium development goal (MDG 1) is to halve the proportion of people suffering from hunger by the year of 2015 (3). Significant progress has been made towards reducing the number of undernourished people. Between 1990 and 2014 it has decreased from around 1015 million (18.7% of the world population) to 805 million (11.3% of the world population) (3, 8). Despite the overall progress, significant regional variations still persist (3). Almost all of the undernourished people (98 %) live in low-income countries, with Africa and Southern Asia regions being the most affected (3, 8). Around 24% (214 million) of the Sub-Saharan Africa's (SSA) population were unable to meet their dietary requirements in 2012-14. Thus, around one in four persons is likely to have suffered from chronic hunger; unable to get sufficient amount of food to maintain an active life (3).

1.2.2. Democratic Republic of Congo (DR Congo)

The DR Congo is one of the SSA countries, where malnutrition is highly prevalent. Approximately 70% of the total population and more than 40% of children under the age of five are undernourished (9, 10). According to the Global Hunger Index, the country has the highest number of undernourished people in Africa and the highest prevalence of undernutrition in the world (11). Poverty, inadequate food production and poor quality of food are some of the main contributors towards this huge burden (9). Despite the fact that the country is endowed with large arable land, and abundant natural resources, the economy remains stagnant due to political unrest, lack of proper management and heavy corruption (9). Subsistence agriculture provides the main source of food for many Congolese households, however, majority of them cultivate small pieces of land using traditional methods of farming, which make them unable to secure their daily food production (9). Cassava (*manioc*) is the main crop in many parts of DR Congo, both as a staple food and a cash crop (12, 13). Generally, the crop is as popular in many other parts of Africa as rice in Asia, or as potatoes and wheat in Europe (13). It is one of the most drought-resistant perennial tropical crops which can grow up to 1 to 3 meters in height. Both leaves and roots are edible and are considered as the most nutritionally valuable parts of the crop (12, 13). However, nutrient composition in these parts varies widely; the roots (accounting for 50% of the mature cassava crop) are rich in carbohydrate but poor in protein, while the leaves (accounting for 6% of the mature cassava crop) are rich sources of protein and fat (13, 14, p.58). The root carbohydrate content is twice as high as in the leaves, and the leaf protein content is 5 to 10 times higher than in the roots (which is comparable to the protein content of an egg). The fat content in the cassava plant is about 10 times higher in the leaves than in the roots (13).

1.3. Methods of nutritional assessment

Nutritional assessment is defined as the interpretation of information collected from ABCD studies (Anthropometric, Biochemical/biophysical, Clinical and Dietary) to determine whether an individual or population are well or malnourished (15, p.2). Assessment of nutritional adequacy is vital as it can assist in documenting the type, magnitude, location and causes of undernutrition and nutritional deprivation among different populations (16). Thus, the information obtained can provide valuable data for policy making, planning, program design and evaluation (15, p.2). In the system of nutritional assessment, dietary and anthropometric methods are used as indicators in assessing the progress towards reaching the MDG 1 (3).

1.3.1. Dietary method

As noted above, dietary assessment is one particular type of nutritional assessment. There are different methods used for dietary assessment, including retrospective methods (24-hour recall, dietary history and food frequency questionnaire) and prospective methods (estimated food records and weighed food records) (15, p.41-47, 17, 18). Selecting the most suitable assessment method depends on several factors consisting of detailed information required, level of accuracy and precision needed, time period of interest, budget and characteristics of staff members and subjects (15, p.41, 17). Generally, dietary intake cannot be estimated without error and none of these methods are able to provide a fully accurate measurement (19). The weighed food records (WFR) is currently considered to be the most accurate method, and it has been referred to as the “imperfect golden standard" in dietary assessment (15, p.45, 17). In this method, subjects, parents or proximal caregivers are instructed to weigh all foods and beverages served during a specific period of time, and the potential leftovers. Conventionally, this method is recommended to be used for a seven day period to obtain good quality data, but three to four days are most commonly used due to time and budgetary constraints. In order to have good quality data from this method, subjects need to be familiar with the name of consumed foods, preparation methods, and measurement methods. Besides this, complete follow-up during eating is vital to completeness (15, p.45). WFR has the potential advantage of providing quantitatively accurate information on food consumed during the specific recording time, by direct weighing and by reducing loss of information due to recall problems (15, p.45). However, this method also has some drawbacks. First, it needs motivated and literate participants, which can potentially limit the method's use in some population groups (children, illiterate, immigrants, and elderly). These requirements can lead to a selection bias, which can reduce the generalizability of the findings. In such conditions, collection of dietary data can be done by a researcher or research assistant which may render the method expensive (17). Second, recording individuals' intakes consecutively while they are eating may affect eating habits during data collection and may reduce accuracy of usual intake estimates, due to a high participation burden (17, 20).

1.3.1.1. Assessment of dietary intake from food consumption data

When food consumption of an individual is quantified or measured using dietary methods, it is possible to estimate the nutrient intakes using food composition tables. These tables provide information regarding the energy and nutrient content of the most commonly consumed foods in specific areas (15, p.65, 21). Nutrients are components in foods which are necessary for the growth and survival of an individual. They are categorized into two main groups: macronutrients and micronutrients (14, p.64). Macronutrients are required in large amounts for growth, metabolic reactions, energy, and for other basic body functions. Common macronutrients include protein, fat and carbohydrates (22, p.9). On the other hand, micronutrients are required in micro-quantities (small amounts) and provide the necessary cofactors for many enzymes in an individual's metabolism (i.e. energy turnover, synthesis of DNA, RNA and protein, etc.), and include vitamins and minerals also called trace elements (22, p.93-95).

1.3.1.2. Energy and macronutrients

Human beings need energy to maintain different basic body functions, including metabolism, respiration, circulation, physical work, and protein synthesis (14, p.65; 23, p.83, 23). Energy is derived from the oxidation of macronutrients, in which fat generates 9 kcal/g, protein and carbohydrate each release 4 kcal/g. Alcohol also provides 7 kcal/g of energy, but it is not commonly considered part of the food system (macronutrient) as it is not required by the human body for survival and growth (22, 23, p.94; 23, p.83-85). Acceptable Macronutrient Distribution Ranges (AMDRs) is the range of intake for particular energy source (macronutrient) that is related with reducing risk of chronic diseases while furnishing the body with adequate essential nutrients (23, p.72). The AMDR of each macronutrient is expressed as a percent of energy from each macronutrient to the total energy intake (TEI) (23, p.71-72). Each of the AMDR has both an upper and lower boundary, and intakes that fall outside of the boundary are considered as potential risk factors for chronic diseases and deficiency of essential nutrients (23, p.72).

A. Components of energy requirements*:* Human beings require energy for the maintenance of various bodily functions. Energy required to keep basal metabolism and energy needed for physical activity are two main components of such energy requirements (14, p.69).

I. Basal metabolism: Basal metabolism encompasses a numbers of functions that are vital for life existence, such as body temperature, brain, heart and lung function maintenance as well as taking part in the chemical process that keep us alive (liver and kidney) (14, 23 p.69; 23 p.86, 24). Basal metabolic rate (BMR) is the minimum energy required for operating the basal metabolism. The BMR is measured commonly in the morning when the body is at complete physical rest, while awake and in a state of mental relaxation at normal temperature (14, p.69, 24). Unlike energy requirements, variation in the body composition has no effect on BMR, it is stable from day to day and can be estimated using the equations proposed by FAO/WHO/UNU (14, 25, p.70). The equations incorporate three variables: age, sex and body weight of an individual and are expressed as mega joule (MJ) or kilocalories (Kcal) per 24 hours (14, p.70). Depending on the age and lifestyle of an individual, BMR accounts for 45-75 % of the daily total energy expenditure (TEE), the largest component of daily TEE (24). In the assessment of dietary intake, bias in reporting energy intake (EI) is a common problem either by underreporting or overreporting of intake (26). In such case, the ratio of reported EI to estimated BMR (EI: BMR) can be used to determine the degree of the bias. The ratio is called BMR factor and a cut-off point of BMR factor <1.35 is considered to represent underreporting of EI, BMR factors of 1.35-2.39 as normal ranges and BMR factor ≥ 2.4 as overreporting of EI (26, 27), unless high physical activity is known or documented.

II. Physical activity: Following the BMR, physical activity (PA) is the second largest component of daily TEE (24). The energy expended for PA is the most variable component and it accounts for at least 20-30% of the daily TEE (24, 28). In sedentary individuals, only one-third of the TEE used for PA over 24 hours, and the remaining two-thirds goes to BMR. On the other hand highly active individuals can expend twice as much energy as with BMR (23, p.95). Measuring the physical activity level (PAL) of an individual can be used in calculating Estimated Energy Requirement (EER), which is the average daily energy intake that is expected to maintain energy balance in healthy, normal weight individuals of a defined age, gender, weight, height, and level of PA consistent with good health (14, p.71). It is expressed as multiples of BMR and PAL (EER=BMR x PAL). Besides this, EER of an individual can also be calculated using the equations developed by the Institute of Medicine (IOM). The equation incorporates the following variables: age, sex, weight, height and PAL of an individual. PAL are categorized into four levels: sedentary (PAL 1.0-1.39), low active (PAL 1.4-1.59), active (PAL 1.6-1.89), and very active (PAL 1.9-2.5) (23, p.83, 28).

***B.* Macronutrients:** Such nutrients are required by our body in large amounts and include the following:

I. Protein: Proteins are essential building blocks of body tissues and are found virtually throughout the body. Proteins are the second most plentiful substance in human body, water is the first (29). Proteins may function as enzymes, energy sources, hormones, antibodies, nutrient transporters, chemical reaction regulators, and may have other functions in the body (23, p.145, 29). During digestion, protein is broken down in to 20 small molecules called amino acids. Of these, 9 cannot be synthesized in human body, thus they must be obtained from the diet and are called essential amino acids (29). Proteins which contain all the 9 essential amino acids are called complete proteins and animal products like meat, fish, egg, poultry, milk, cheese and yogurt are among the main sources of complete proteins. On the contrary, proteins lacking one or more of the 9 essential amino acids are called incomplete proteins. Plants sources such as legumes, grains, nuts, seeds, cassava leaves and vegetables are some of the incomplete proteins (23, p.145). Adequacy of protein intake is assessed using different Dietary Intake Reference (DIRs). Recommended Dietary Allowance (RDA) is one of the DIRs and is defined as the average daily dietary intake level sufficient to meet the requirement of almost all (97-98%) of healthy individuals (30, 31). RDAs for different age groups of both sexes were estimated by IOM (31). In addition to this, proteins have also AMDRs which varies with age groups, i.e. 5-20%, 10-30%, and 10-35% of the TEI for 1-3 years, 4-18 years and older than 18 years, respectively (23, 30, p.71, 31), thus using RDA or AMDR as reference protein intake of an individual can be assessed for it adequacy. Inadequate intake of protein may have detrimental effects to human health, it causes protein-energy malnutrition, impaired immune system function, can affect brain development (particularly in children), increases risk of acquired infections, elevates susceptibility to systematic disease, and can have other consequences (23, p.151). The overconsumption of protein can lead to side effects including gastrointestinal problems, nitrogen imbalance and kidney disease (23, p.152).

II. Fat: This is the most dense energy provider and it also assists in the absorption and transportation of fat-soluble vitamins like A, D, E, K and other food components, like carotenoids (23, p.123, 29, 32). In addition to these, our body stores energy for future use in the form of fat (32). Like proteins, dietary fat also derives from both animal and plant products; butter, margarine, fatty meat, whole milk, egg yolk, poultry products, vegetable oils, nuts and even cassava leaves are among the principal sources of fat (13, 23, p.132-33). So far except for infants, no DIR was established for total fat intake due to insufficient data to determine a specified intake level at which risk of inadequacy or prevention of chronic disease occur, thus no RDA of fat is present (23, 30, 31, p.123). But AMDR for fat has been estimated: 30-40% of the TEI for age group 1-3 years and 20-35% of the TEI for age group 4-18 years and adults (>18 years) (23, 30, p.71). Thus, the AMDR is used as an option in estimating the potential problems following low and over consumption of fat (30). Intakes below the lower range caused impaired growth, elevated risk of chronic disease, energy imbalance, inadequate absorption and transportation of fat-soluble vitamins and in severe and long lasting deficits possibly undernutrition or even starvation. Overconsumption of fat has also negative effects such as weight gain which can lead to obesity, which is a potential risk factor for coronary heart disease, hypertension, cancer and other non-communicable diseases (23, p.136).

Carbohydrates (CHO): Like the other macronutrients, the primary role of CHO (i.e. sugar and starch) is to provide energy to body cells (23, p.103, 33). In addition, CHO can also be stored to a smaller extent in muscle and liver in the form of glycogen and later be used for energy(33). The human brain requires a continuous supply of glucose (simple sugar) for proper functioning, thus our body’s demand for CHO is depend on the minimum amount of glucose that is used by the brain (23, p.103). Because the human brain remains approximately the same size after 1 year of age, the corresponding RDA of carbohydrates also remains constant for all ages and genders (i.e. 130 gram/day) after the age of 1 year, with the exception of lactating and pregnant women (23, 30, 31, p.106). In the same manner, the AMDR of CHO also remains the same throughout all life stage groups (i.e. 45-65% of the TEI) (31). CHO is found in a wide array of starchy foods: grains or root crops such as cereals, potatoes, rice, cassava roots, corn, flour, pasta, and popcorn are rich sources of CHO. Fruit, vegetables, beans, nuts and milk have also CHO, but in smaller amounts (13, 23, 33). Inadequate and over intake of CHO affects human health negatively; low intake may lead to bone mineral loss, hypercholestremia, impaired development and function of the central nervous system, and can lead to inadequate glycogen stores. Excess intake of CHO may lead to dental caries, cancer, obesity, hyperlipidemia and behavioral changes (23, p.107-8, 33).

1.3.2. Anthropometric methods

Anthropometric methods are the most commonly used method for assessment of individual nutritional status (15, p233). They encompass a variety of simple, cheap, safe and non-invasive measurements of the human body, such as weight, length or height, skinfold thickness, and the bodily circumference at the waist, hip, and chest (34, p.116-117). In children under the age of five assessment of growth by anthropometric data is considered as a suitable approach in evaluating nutritional statuses, while in adults assessment of body composition has been recognized as an adequate approach (35). Body mass index (BMI) is the most commonly used anthropometric measurement of nutritional status in adults. It is determined using the mathematical calculation of weight in kilograms divided by the square of the height in meter (kg/m^2) (34, p.117). It is interpreted by using the international classification recommended by WHO shown in table 1 (36). BMI is easy to use with minimum instruction, and it is a reproducible, objective, validated and cross-culturally accepted method of index. However, it is relatively insensitive and it does not indicate specific nutritional deficiencies, as it is solely depends on the net weight and height of a person (15, p.234, 37). Furthermore, BMI does not incorporate variables such as age, gender and muscle mass, nor does it distinguish between fat mass and lean body mass. Therefore BMI has a potential problem of overestimating the fat content of an individual with high muscle mass (such as a body-builder). On the other hand, BMI can underestimate the fat deposit in individuals with a lower body mass, a circumstance which may occur within the elderly population (15, p.234, 37).

Table 1: The International classification of adult underweight, overweight and obesity using BMI

Classification	BMI(kg/m^2)	
	Principal cut-off points	Additional cut-off points
Underweight	<18. 50	<18. 50
Severe thinness	<16. 00	<16. 00
Moderate thinness	16. 00 - 16. 99	16. 00 - 16. 99
Mild thinness	17. 00 - 18. 49	17. 00 - 18. 49
Normal range	18. 50 - 24. 99	18. 50 - 22. 99
		23. 00 - 24. 99
Overweight	≥25. 00	≥25. 00
Pre-obese	25. 00 - 29. 99	25. 00 - 27. 49
		27. 50 - 29. 99
Obese	≥30. 00	≥30. 00
Obese class I	30. 00 - 34. 99	30. 00 - 32. 49
		32. 50 - 34. 99
Obese class II	35. 00 - 39. 99	35. 00 - 37. 49
		37. 50 - 39. 99
Obese class III	≥40. 00	≥40. 00

Reference: Global database on BMI, WHO (36)

2. Rationale and objectives

2.1 Rationale of the study

The southern part of Bandundu Province raises red flags on a number of nutritional indicators, hence our study interested to document the situation. A large proportion of the population live on subsistence farming and dietary patterns are likely to be monotonous, as dietary choices are made based on local food availability (38). In addition to this, healthcare, educational facilities and other services were less developed in these areas (38). Dietary intake data can be used for advocacy to focus on particular problems that policymakers need to act on. This research aimed to unearth the magnitude of nutritional inadequacy in the Popo-Kabaka District. It has also been reported that most of the people in this district are very poor and thin, as approximately 70% of the total population have been reported to be undernourished (10, 38). Therefore measuring anthropometric measurements in such population are very helpful in documenting the magnitude of underweight individuals in the population.

2.2 General objectives

The general objective of this thesis was to assess the nutritional adequacy of diet and body mass index (BMI) in a nutritionally deprived population in rural Bandundu Province in the Democratic Republic of Congo (DR Congo). The assessment was done by analyzing data obtained from two rural villages in Popo-Kabaka District, Bandundu Province in DR Congo and by conducting a literature review of population-based studies in Africa.

3. Specific objectives

1. To assess the nutritional adequacy of the diet of selected households in the remote rural village of Nkay-Kalengi.
2. To document and assess the BMI distribution in the adult part of the population in the two remote rural villages of Nkay-Kalengi and Indaba.
3. To compare our findings to other population-based studies from Africa by doing a literature review of population-based studies in Africa regarding dietary intake and BMI, in particular studies which had used WFR for estimating food consumption of individuals or studies reporting BMI in adult populations.

4. Subjects and methods

4.1 Study setting

The study was carried out in August 1996 in two villages of Popo-Kabaka District (Nkay-Kalengi and Indaba), located at (5°38–5°43 latitude South, 16°34–16°37 longitude East), district of Popo-Kabaka, province of Bandundu (38). The Bandundu Province covers 300,000 km^2 (almost the size of Norway) with approximately 8.06 million inhabitants in 2010 (39). The Popo-Kabaka District is located in South-Western part of this province, and consists of a savanna tableland with poor sandy soils intersected by forests and relatively more fertile river valleys (Wamba river) running in roughly south-north direction (40). The climate is tropical with an annual rainfall varying around 1200 mm (plenty of rainfall 9 months per year). Subsistence economy prevails, and cassava is the dominant crop in this area, both as a main staple food and as a cash crop. This area has been identified to have many problems hampering its development; for example access is difficult to this area especially during the rainy season. As a result it has limited communication with the capital Kinshasa, where manufactured goods and other products can be purchased. Infectious diseases (malaria, tuberculosis, etc.), poverty, food insecurity and unsafe water supply are highly prevalent in the Popo-Kabaka District (38).

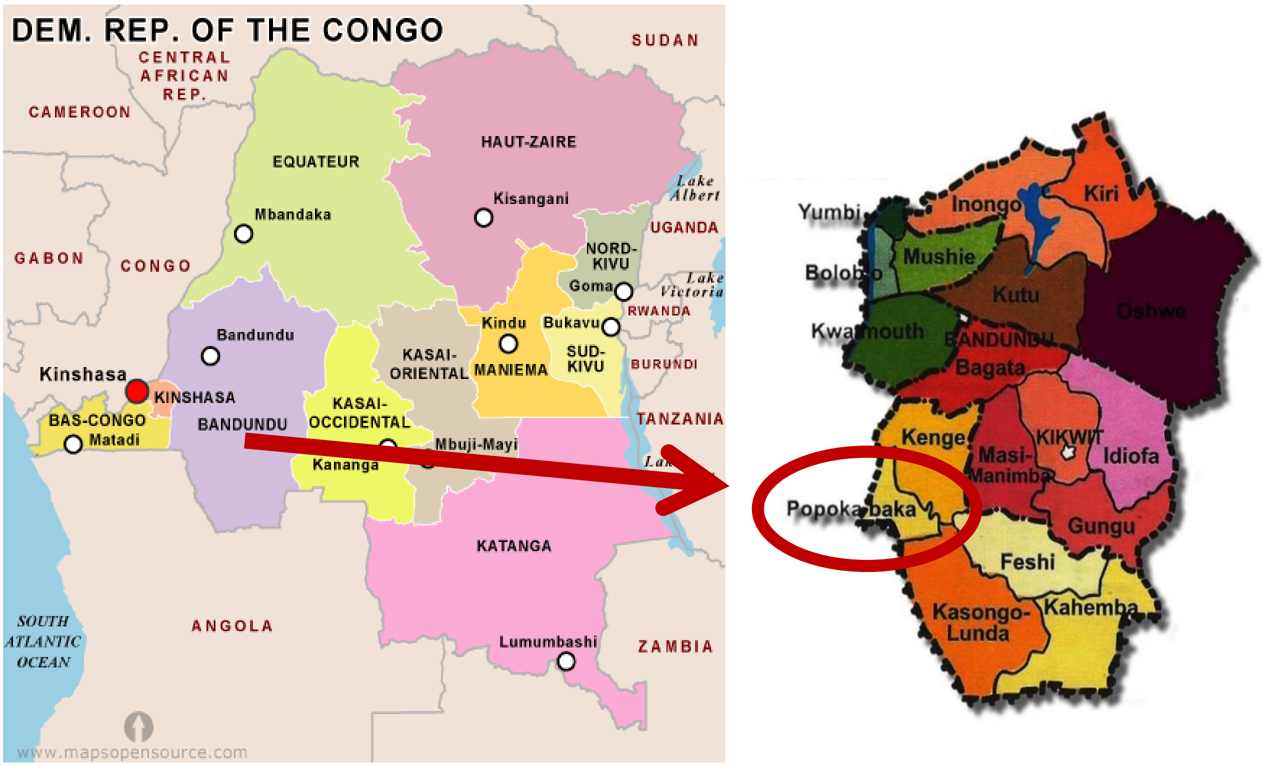


Figure 1: Map of DR Congo, with inset map of Bandundu Province and Popo-Kabaka District

With virtually unchanged living standards in this district, these old data are deemed to be contemporary and relevant to the current nutritional situation of these two villages.

4.2 General study design

The study was a cross-sectional study. It was designed to assess the nutritional adequacy of these nutritionally deprived populations in the District of Popo-Kabaka. Twelve households (out of total 162) in Nkay-Kalengi were selected by using systematic sampling method after the census was made. Information regarding dietary intakes of each study subject was collected using three days WFR. Besides this, anthropometric data were also collected from these two remote rural villages and all households in those villages were included, 162 in Nkay-Kalengi and 51 in Indaba.

4.3 Study population

The study subjects were selected from all age groups. Dietary intakes of 76 subjects living in twelve households were recorded for three consecutive days in Nkay-Kalengi. For the assessment of BMI, data were collected from two villages. All adults in these villages were included, excluding those not present on the day of data collection; altogether 325 adult subjects from Nkay-Kalengi and 115 from Indaba of both sexes were included.

4.4 Data collection, quality and control

4.4.1 Dietary intake

Data was collected using the WFR method. Two trained nutritionists were deployed in a total of 12 households for three consecutive days per household. They arrived at the subject's home at dawn and followed the food preparations and food intake in the whole family until bedtime. Each step of the cooking process was supervised and each raw ingredient of all dishes before cooking was weighed on digital scales and the results rounded to the nearest gram. The total weight of the final dish was also recorded. At the time of food consumption, the individual portions of each constituent of the meal were weighed before eating. Any leftovers were also recorded and the proportion of each constituent was estimated. Over the three food record days, subjects were well informed not to change their normal dietary pattern. Besides weighing dietary intakes, the nutritionists also measured the physical activity (PA) of 11 women by direct observation method during the same three consecutive days. Each type of mother's activity (including sleeping) was measured for its duration and intensity. The main reason that hampered the researchers from measuring the activities for majority of the participants was the nature of living in this area, the study area is very rural with agriculture as backbone for economy. Therefore, people were spread out during day time and the researchers were unable to follow each person individually. Hence, it was decided to follow only the women in all their activities be it agriculture and other activities.

Figure 2: Preparation of "fufu", cassava flour mixed with hot water and weighing the prepared food on a digital scale

4.4.2 Anthropometric measurements

Information was collected regarding subject's sex, age, weight, and height. A total of 440 adults were included from the two rural villages. Weight of each subject was measured to the nearest 0.1 kg on a battery powered digital scale (SECA) and height were measured to the nearest 0.1 cm using a height-measuring board with a sliding head bar following standard anthropometric techniques. For both measurements, subjects removed their jackets, shoes and dressed in light clothing as shown in figure 3. Both weight and height data were collected at the same day from each subject using the calibrated equipment and standardized techniques. Every measurement was taken by the researchers in order to reduce variability among data collectors.

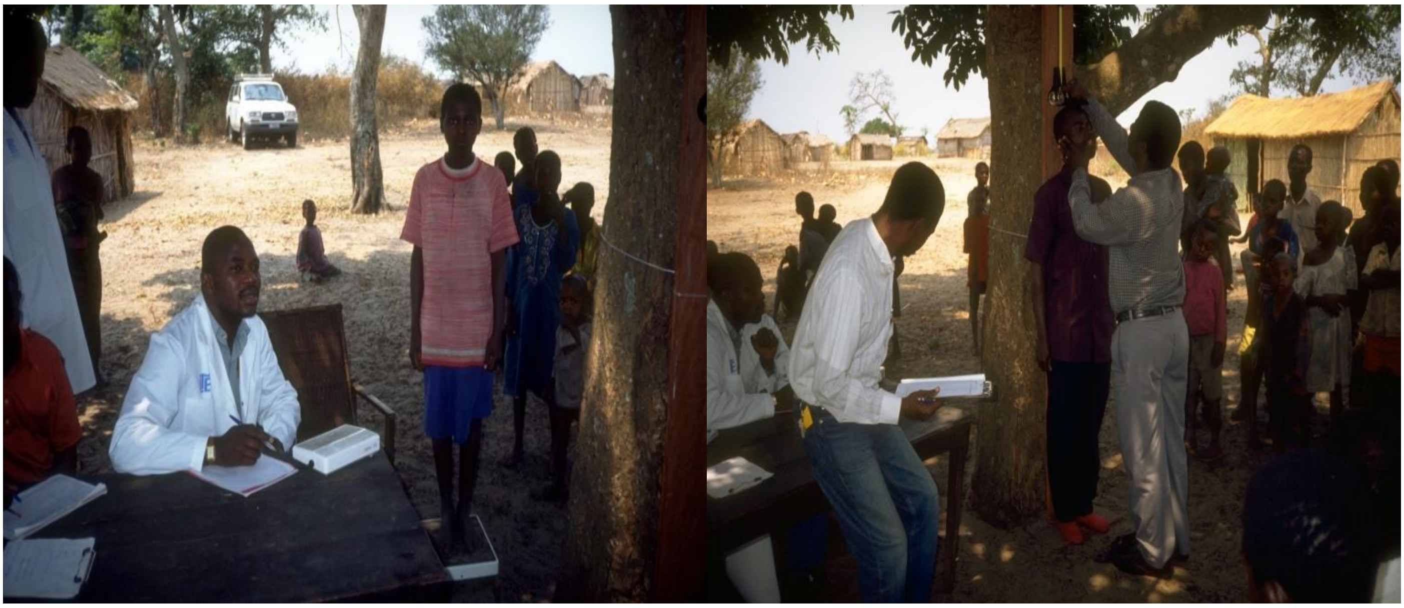


Figure 3: Weight and height measurements from the field work

4.5 Data processing and analysis

For dietary intake: The weights of food consumed by each individual were converted in energy, protein, fat and CHO using the food composition table developed by the FAO for use in Africa and a local food composition table for use in Bandundu province, DR Congo (41, 42). Dietary data were available for 70 subjects (of the 76 subjects), because data from 5 children under 2 years of age were excluded due to missing intake from breastfeeding. In addition, one adult female was also excluded because only part of her daily intake was weighed (incomplete weighing of her intake). Statistical analysis was carried out using the Statistical Package for Social Sciences (SPSS), version 21.0 and subjects were categorized in to three age groups for each sex (3-9 years, 10-17 years and 18-61 years). Using the descriptive statistics mean and standard deviations of energy and macronutrients intakes were obtained by averaging individual intakes over the number of days with WFR complete. To assess adequacy of protein and fat, the percentage of energy from each macronutrient (E %) was calculated by dividing the 3-day average energy provided from each macronutrient by the average 3-day TEI and then multiplying the fraction by 100. The mean energy provided from each macronutrient was obtained by multiplying each mean macronutrient intake (in grams) with the amount of energy released by oxidation of 1 gram of macronutrient (i.e. protein and CHO each release 4 kcal/g and fat 9 kcal/g). The mean E % from protein and fat was assessed for its adequacy by comparing with the AMDRs. In the same way, the mean energy obtained specifically from cassava and its percentage contribution to the mean TEI for each individual was calculated. We subsequently assessed the dominance of cassava in the dietary patterns of this population.

Estimation of BMR for each subject was calculated using the standard equations based on weight, age, and sex (14, p.70) and was used for estimating BMR factors, which is the ratio of reported EI to estimated BMR (EI: BMR). Using the ratio, we assessed the quality of our study in recording individual EI by comparing the calculated BMR factor with cut-off values of BMR factor <1.35 (potentially under recorded), 1.35-2.39 (normal range), and ≥ 2.4 (possible over recorded). Besides those, energy and macronutrients intakes of each individual were also assessed for adequacy by comparing with each individual's EER for energy and RDA for protein and fat. The EER was calculated using the equations developed by IOM based on age, sex, weight, height and PAL of an individual (23, p.83). For those with measured PA, the activities levels were categorized as sedentary (PAL 1.0-1.39), low active (PAL 1.4-1.59), active (PAL 1.6-1.89), and very active (PAL1.9-2.5 (23, p.83, 28). For those without measured PA, we made an assumption that all individual intakes of energy was expended (assumption was done by referring other studies and considering individual weight as stable) (43), thus BMR factor was used to estimate individual's PAL. Then using the equations developed by IOM, EER of each individual was calculated. Regarding the RDA, those proposed by IOM for each macronutrient were used. Thereafter comparisons (EI vs EER and macronutrient intake vs it's RDA) were done using Wilcoxon's signed-rank test and a *p-value* of < 0.05 was used for the level of significance. Besides these percentages of EER (% EER) was also calculated as proportion of EI per day to EER, then % EER used to see the % coverage of EI in relation to EER.

For BMI: As with the dietary intake analysis, BMI data were analyzed using SPSS, version 21.0. BMI of each subject was calculated using the mathematical calculation weight in kilograms divided by the square of the height in meter (kg/m^2). The calculated BMI was categorized in to different BMI-categories using the WHO classification table used for adults BMI (36). Thereafter, BMI-categories were stratified by age, sex and residence village and proportion of each BMI-category was calculated and tabulated. To investigate the socio-demographic factors associated with being underweight, logistic regression was used. We also calculated cumulative proportion of the BMI-categories in different age groups for each sex. Based on this information an ogive graph (cumulative frequency graph) was constructed to illustrate the proportion distribution of BMI-categories in the stratified age groups.

4.6 Ethical considerations

Ethical approval for the study was obtained from Uppsala Academic Hospital Research Ethics Committee. At the time of data collection, no ethics committee existed in DR Congo. Thus, only verbal consent was required and it was obtained from both the community leaders and participants. No further ethical approval was deemed necessary for this current analysis. The research funding was granted by the Swedish Sida/Sarec and Uppsala University.

5. Semi-systematic review of literature

5.1. Objective and rationale of the literature review

The objective of our literature search was to put our own observations from DR Congo of monotonous diets and low BMI in an African perspective. Thus, our literature search aimed to explore if similar diets or BMI distributions had been documented in other free-living African populations and to compare our own findings to other studies. To make our research question focused and manageable within our time frame and resources, we scaled down the review to include only African studies which had used weighed food records for estimating food consumption of individuals or studies reporting BMI in adult populations.

5.2. Search strategy and selection criteria

To address this objective a semi-systematic approach was adopted, with a non-strict protocol to identify and locate a broad range of published material. The following inclusion and exclusion criteria were used:

Inclusion criteria

- Primary research directly related to the research topic
- Studies conducted on free-living humans in Africa
- Published literature in English language
- Only studies which had used WFR for dietary intake assessment or reporting BMI in adults
- Any type of study design
- Including all age groups

Exclusion criteria

- Studies conducted on pregnant or lactating women or adolescents for BMI assessment
- Studies carried out on subjects with any health problem
- Studies assessed dietary intakes of subjects during special time (e.g. religious fasting)
- Studies with no online abstract

5.3. Methods of searching the literature

The four main approaches mentioned by Helen Aveyard, have been used in finding the relevant literature, with the intention of achieving the highest possible retrieval rate (44). These are a) electronic searching of databases, b) reference list searching, c) relevant online journal searching, and d) author searching.

5.3.1 Electronic searching of databases

In this searching approach, three databases have been searched: PubMed, Embase, and Cinahl. We conducted two separate searches in each database, one for dietary intake assessment and other for BMI assessment. Limitations were English language and human species studies in Africa, with no time or age restriction. The strategy that has been used in searching the electronic database is shown in table 2 below.

Table 2: Searching records from electronic databases

Electronic database	Keywords and searching terms (query text)	Limitations	Total number of hits
PubMed (August 2014)	("Diet Records"[Mesh] AND "Africa"[Mesh]) OR ("Diet Records"[Mesh] OR (diet OR diets OR dietary) AND record*[Title/Abstract]) AND ("Africa"[Mesh])	English language Human species studies	284
	("Body Mass Index"[Majr]) AND ("Africa"[Mesh])	English language Human species studies	156
Embase (OVID) (August 2014)	1. ((diet or diets or dietary) adj4 record*).tw. (3766) 2. exp Africa/ or Afric*.tw. (319210) 3. 1 and 2 (88)	English language Human species studies	80
	1. (Body mass index or BMI).tw. (216800) 2. exp *body mass/ (15011) 3. 1 and 2 (13229) 4. exp Africa/ (215528) 5. 3 and 4 (179)	English language Human species studies	174
Cinahl (EBSCO) (August 2014)	S7 S3 AND S6 128 S6 S4 OR S5 45,606 S5 TI Africa* OR AB africa* 25,619 S4 (MH "Africa+") 28,843 S3 S1 OR S2 4,584 S2 TI ((diet OR diets OR dietary) N4 record*) OR AB ((diet OR diets OR dietary) N4 record*) 565 S1 (MH "Diet Records") 4,347	English language Human species studies	128
	S3 S1 AND S2 33 S2 MH "Africa+" 28,843 S1 (MM "Body Mass Index") 3,590	English language Human species studies	33

Summary of the electronic databases searching

By searching the three electronic databases, a total of 855 articles were identified, 492 for the dietary intake assessment and 363 for BMI assessment. All the retrieved articles were exported to EndNote. Initially the titles of the 855 articles were screened and 193 articles (92 for dietary intake and 101 for BMI) were found potentially relevant from this assessment. Thereafter, the online available abstracts for these 193 articles were searched and those with unavailable online abstract were ruled out from the review. Then, abstract assessment were carried out for these with available abstract and only 43 key articles (21 for dietary intake and 22 for BMI) were identified relevant to our research topic. Finally, full text assessment was done for those key articles, and 18 articles (9 for dietary intake and 9 for BMI) were identified as relevant for the final review. More than half of the key articles were found irrelevant after full text assessment either due to poor quality or they were not directly relevant to our research topic. Some studies assessed dietary intake of young children without measuring intake from breastfeeding, such studies were considered not to fully examine the nutrient intake level of the young children and were therefore excluded. We also excluded studies which reported BMI of adolescents, because of the discrepancies in the timing of puberty and changes in anthropometric indices in these communities. Figure 4 shows the flow chart of the entire search.

5.3.2 Hand searching relevant online journals

The key articles identified after abstract assessment were identified to be published in different journals. Of the 43 key articles, 9 were published in the journal of Public Health Nutrition, 5 in the American Journal of Clinical Nutrition, 3 in the Maternal and Child Nutrition. In addition to this, we realized that in the entire search a number of interesting articles were found to be published in these journals. We also put in consideration to our review's inclusion criteria (i.e. only studies conducted in Africa), hence one African journal was included in the search. Thus, the content pages of these four journals were searched for other relevant articles that were not identified through other searching approaches.

1. Public Health Nutrition (1998-2014)
2. American Journal of Clinical Nutrition (2000-2014)
3. Maternal and Child Nutrition (2005-2014)
4. The East African Medical Journal (2000-2014)

After we searched all the published articles in those journals within the above mentioned range of time, we identified only one additional relevant article and this one was included in the review.

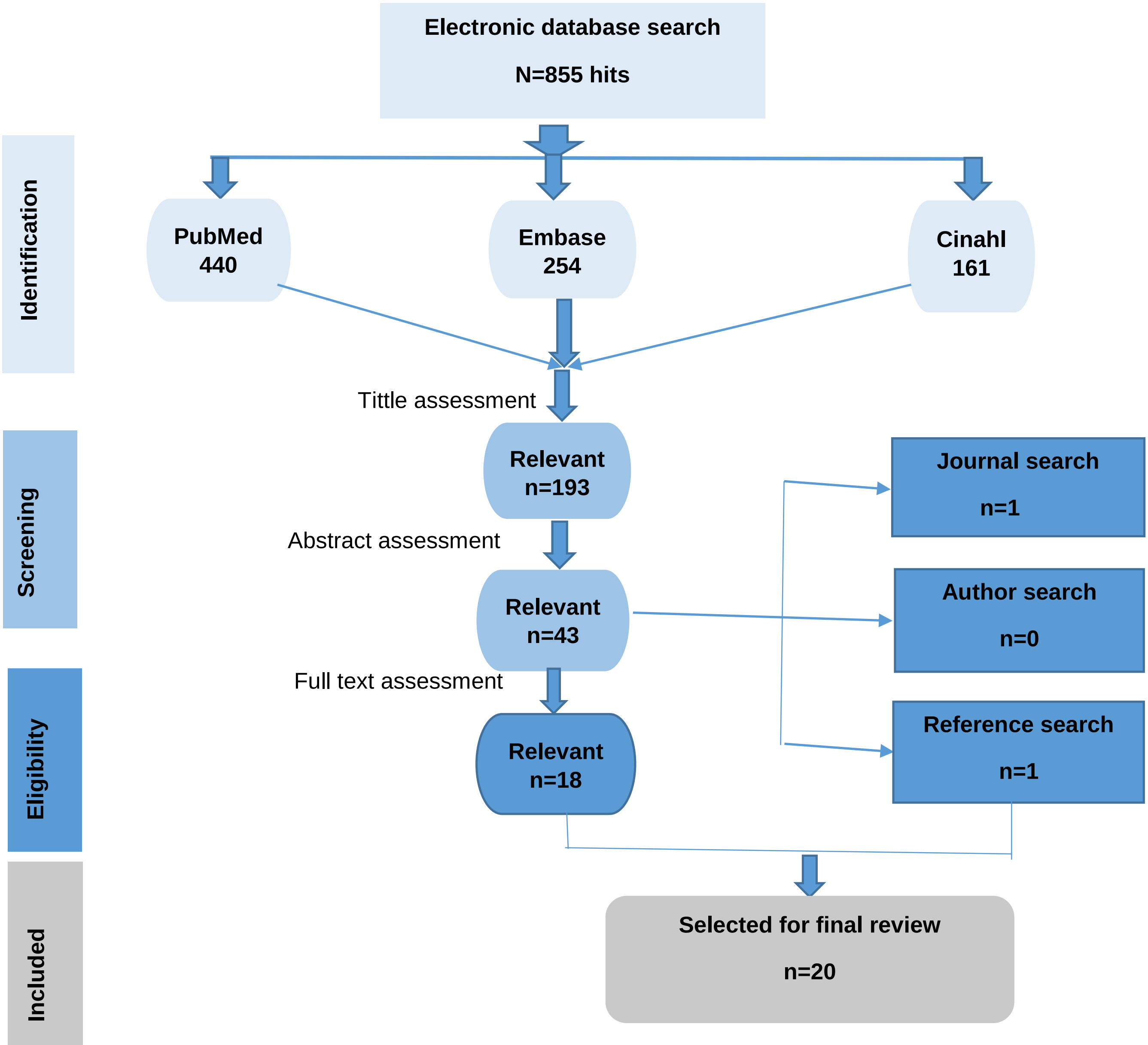


Figure 4: Flow chart of the overall semi-systematic review

5.3.3 Author searching

Throughout the entire electronic database search, it was realized that many of the relevant articles and other interesting articles were written by the same authors. Thus, author searching was carried out with the intention of identifying other relevant articles which were worked by these authors. The search was carried out for 5 authors and limitations included the English language and human species studies in Africa, with no time or age restriction. The final search did not identify any further articles as shown below in table 3.

Table 3: Searching strategy using authors

Author name	Total number of hits	Potentially relevant articles	Number of articles included	Reasons for exclusion of the potentially relevant articles
Gibson RS	231	8	0	2 identified by electronic database(duplicate) 6 irrelevant
Ferguson EL	58	4	0	1 duplicate, 3 irrelevant
MacIntyre UE	22	2	0	1 duplicate 1 not relevant
Abebe Y	33	3	0	1 duplicate 1 unavailable online abstract 1 not relevant
Shetty PS	140	7	0	1 duplicate 5 irrelevant 1 unavailable online abstract

5.3.4 Reference lists searching

Reference lists of the 43 key articles were scrutinized for further references that might be relevant to the research topic. In this search it was noticed that most of the key articles had been used as references for each other. After we went throughout the 43 key article's references we identified only one additional article for further review.

5.4 Quality appraisal of the selected studies

The quality of each selected article was critically appraised using the STROBE statement (STrengthening the Reporting of Observational Studies in Epidemiology). The STROBE statement is a reporting guideline consisting of a checklist of 22 items, including developed recommendations on what should be covered in an accurate and complete report of observational studies. Tables 4 and 5 show summary characteristics of studies included in the review.

Table 4: Characteristics of studies reviewed for dietary intake

Study.no References (Year)	Country	Aim of the study	Study design	subjects	WFR Duration	Main WFR findings/conclusion
Study 1 *Haileslassie K, et al.(5) (2013)*	Ethiopia	To assess feeding habits, nutritional status and related factors of women	Cross-sectional survey	60 women aged 15-49 y	One-day	Nutrients intake were below recommended intakes, except iron far higher
Main study limitations	Efforts to address potential bias were inadequate. Only one day WFR, which opens for social desirability bias.					
Study 2 *McAfee AJ, et al.(45) (2012)*	Seychelles	To assess the nutritional adequacy of children	Cohort	229 children aged 5 years	4-day WF diaries	Nutrients were adequate for most children, except Zn, niacin and vitamin A
Main study limitations	Eligibility criteria, methods of selection were not described at all. Efforts to address bias were insufficient. No specific Dietary Reference Value (DRV) for study area was used (Instead, UK DRV was used). No discussion about generalizability of the study					
Study 3 *Ponka R, et al.(46) (2011)*	Came-roon	To investigate dietary intake, zincemia, and cupremia of schoolchildren	Cross-sectional	Children aged 7-18 years,(211 in rainy, & 200 in dry season)	7-day measured food diaries	Energy and nutrient were below reference values, except Zn, Fe, Mg and vitamin E
Main study limitations	Study's design was not described and was unclear. Eligibility criteria, methods of selection, sample size arrival were not described. Statistical methods were not described adequately. Limitations and generalizability of the study were not discussed.					
Study 4 *Mitchikpe CE, et al.(47) (2009)*	Benin	To analyse the food pattern and resulting energy and nutrient intake of school children	Longitudinal	80 Children aged 6-8 years in 2 seasons	3-day	Energy and nutrient intakes were adequate for most children
Main study limitations	Study design was not mentioned in the title and abstract. Eligibility criteria, missing data, follow up and sample size calculation were not described. No information on potential confounders, limitations and generalizability of the study.					
Study 5 *Gibson RS, et al.(48) (2009)*	Ethiopia	To see if children feeding practices and behaviours conform to the WHO guidelines	Cross-sectional	97 Children Aged 0.5-2 years	1-day	Energy and nutrient intakes were below the estimated need, except protein.
Main study limitations	Study design was not mentioned either on the tittle or abstract. Efforts to minimize bias were not adequate and only one day WFR was done. No information on potential confounders and sample size calculation.					
Study 6 *Gewa CA, et al.(49) (2009)*	Kenya	To compare the relative validity of WFR with 24 h recall.	Cross-sectional	42 Children aged 6-8 years and their mothers	1- day	Dietary intake were inadequate compared with recommended intake
Main study limitations	Background information was insufficient. Eligibility criteria, sample size calculation and generalizability of the study were not discussed. Efforts to tackle bias were not enough and only 1-day WFR.					
Study 7 *Blaney S, et al.(19) (2009)*	Gabon	To assess dietary adequacy and nutritional status in rural communities	Com-munity-based survey	500 subjects in all age groups	7-day	Energy, iron and vitamin A intakes were low but protein was fairly adequate.
Main study limitations	Efforts to avoid potential bias were insufficient. Study results were not interpreted cautiously in relation to other studies results.					

Study 8 *MacIntyre UE, et al. (50)(2001)*	South African	To determine relative validity of the FFQ,WFR and biomarkers	Cross-sectional	74 adults aged 15-65 years	7-day	Nutrient intakes were not far from recommended intakes except calcium.
Main study limitations	No information on setting, dates, eligibility criteria and methods of selection. Effort to address potential bias and confounders were not enough. Sample size calculation, limitations and generalizability of the study were not discussed.					
Study 9 & 10 *Kigutha HN, et a.(49) (1997)*	Kenya	To compare the validity of repeated 24-h with WFR	Cross-sectional	41 Children (*no. 9*) & 41 elderly (*no.10*)	3-day	Energy and nutrient intakes of both groups were not far from recommended intakes.
Main study limitations	Study design was unclear. No information about eligibility criteria, sample size calculation and demographic characteristics. Efforts to address bias were inadequate. No discussion about results, limitations, external validity and funding					

Table 5: Characteristics of studies reviewed for BMI

Study No. References (Year)	Study nation/s	Study aim	Study design	Subjects for BMI used	Confounders controlled	Main findings BMI (%)
Study 11 *Gomes A, et al.(51) (2010)*	Mozambique	To quantify the prevalence of obesity and overweight	Cross-sectional	2913 adults aged 25-64 years	age, sex, residence place, education, family income	Women: <18.5 (11), 18.5-24.99 (64.7), 25-29.99 (14.9), ≥30 (9.4) Men: <18.5 (13.2), 18.5-24.99 (72.5), 25-29.99 (11.2), ≥30 (3)
Main study limitations	Study design was not described in the abstract. Limitations, generalizability and sources of funding of the study were not discussed.					
Study 12 *Tesfaye F, et al.(52) (2007)*	Ethiopia and two Asian nations	To examine the relations between BMI and blood pressure	Cross-sectional	7675 aged 25-64 years *(Ethiopian= 3793)*	age, sex, residence , education, BMI categories & occupation	Ethiopian men :< 18.5 (36.7), 18.5-24.99 (60.8%), ≥25 (2.5), women : <18.5 (42.7), 18.5-24.99 (55.1) ≥25 (2.2)
Main study limitations	No discussion about limitations, and external validity of the study.					
Study 13 *Cilliers J, et al.(53) (2006)*	South-Africa	To explore relationship between BMI and weight control acts	Cross-sectional	360 female university students aged 18±0.4 years	year of birth, weather, medication, accommodation, illness and smoking	Female students <18.5 (7.2), 18.5-24.9 (81.9) 25.0-29.9 (10) ≥30 (0.8)
Main study limitations	No information on relevant dates of the study. Efforts to address bias were not adequate. No information on sample size calculation. Limitations and generalizability of the study were not discussed.					
Study.14 *James WPT, et al.(54) (1999)*	Ethiopia (north region), Zimbabwe and India	To evaluate relationship between children's malnutrition & maternal BMI	community - based survey	3046 Ethiopians aged 32.7 ±9 & 801 Zimbabwe-ans aged 38.4±16	No methods were taken to control confounding	*Ethiopia*: <18.5 (28), 18.5-24.9 (71), 25-29.9 (1) *Zimbabwe*: <18.5 (12), 18.5-24.9 (70), 25-29.9 (18)
Main study limitations	Study design was not descried in the abstract. Eligibility criteria was mentioned only for Ethiopian subjects, No information on potential confounders and no discussion about limitations and generalizability of the study					

Study 15 *Nube M, et al.(55) (1998)*	Ghana	To assess the suitability of BMI as an indicator of living standards	Com-munity -based survey	9214 adults (4961 males and 4243 females) aged 20-64 years	Income and expenditure, educations, access to services, age, housing, & nutritional status of children	*Males*: <18.5 (16.2), 18.5-24.9 (78.5) 25-29.9 (4.7) ≥30 (0.6) *Females*: <18.5 (16.6), 18.5-24.9 (65.3), 25-29.9 (12), ≥30 (6.1)
Main study limitations	Study design was descried neither in the tittle nor in the abstract. Limitations, generalizability and sources of funding were not discussed.					

Study number	**Country**	**Subjects**	**BMI categories (distribution in %)**
Study 16.1 *Shetty PS, et al. (56)(1994)*	Congo (1986-87)	2295 adults women	<18.5 (11.1), 18.5-24.9 (73.7), 25-29.9 (11.8), ≥30 (3.4)
Study 16.2 *(56)*	Ghana (1987-88)	6323 adults of both sex	<18.5 (20), 18.5-24.9 (62.0), 25-29.9 (17.1), ≥30 (0.9)
Study 16.3 *(56)*	Mali (1991)	4868 adults of both sex	<18.5 (16.3), 18.5-24.9 (76.5), 25-29.9 (6.4), ≥30 (0.8)
Study 16.4 *(56)*	Morocco (1984-85)	41,921 adults of both sex	<18.5 (7), 18.5-24.9 (69.1), 25-29.9 (18.7), ≥30 (5.2)
Study 16.5 *(56)*	Tunisia (1990)	10,023 adults of both sex	<18.5 (3.9),18.5-24.9 (58.9), 25-29.9 (28.6), ≥30 (8.6)
Study 17.1 WHO global database on BMI 2007 *(36)*	DR Congo Nationwide (2007)	4097 females aged 15-49 years	<18.5 (18.5), 18.5-24.99 (70.3), 25-29.9 (8.9), ≥30 (2.4%)
Study 17.2 *(36)*	DR Congo Subnationa l (2005)	755 males aged 15-100	< 18.5 (27.8), 18.5-24.99 (61.1), 25-29.9 (8.5), ≥30 (2.6)
Study 17.3 *(36)*	Bandundu province (2007)	688 females aged 15-49 years	<18.5 (30.8), 18.5-24.99 (68 %), 25-29.9 (1.2%), ≥30 (2.4%)

N.B. The detailed critical appraisal for each included study using the STROBE checklist is presented in the appendix.

6. Results

I. Dietary intake

Socio-demographic and anthropometric characteristics of study participants

Of the 76 individuals included from twelve households in Nkay-Kalengi, 70 (92%) had usable WFR data. The sample comprised 34 (49%) males and 36 (51%) females in all age groups with the mean age of 23 ± 16 years. Children aged 3-9 years, adolescents aged 10-17 years, and adults aged 18-61 years represented 25%, 21% and 54 % of the study participants, respectively. The mean ± SD household size in the households was 8 ± 3 persons. Measurements of weight and height were available for 68 and 47 individuals, respectively. For male adults, mean weight and height were 49 ± 6 kg and 161 ± 9 cm, respectively; for female adults, these values were 43 ± 6 kg and 151 ± 7 cm, respectively.

Table 6: Socio-demographic and anthropometric characteristics of study participants in Nkay-Kalengi and completeness of data

	Number N=70 n	%	$\overline{x}$ ± SD[a]		
Households	**12**				
Household size			8 ± 3		
2-6 persons	5	42			
7-10 persons	5	42			
>10 persons	2	16			
Individuals	**70**				
Male	34	49			
Female	36	51			
Age group			23± 16		
3-9 years	18	25			
10-17 years	15	21			
18-61 years	37	54			
Weight	**68**		34 ± 15		
<20 kg	18	27			
20-40 kg	20	29			
41-60 kg	30	44			
Height	**47**		134 ± 25		
<100 cm	7	15			
100-145 cm	22	47			
> 145 cm	18	38			
WFR[b]	**70**			**With PA[c]**	**Without PA**
3 days complete	59	84		9	50
2 days complete	8	12		1	7
1 day complete	3	4		1	2

[a] *mean and standard deviation,* [b] *Weighed food records,* [c]*Physical activity.*

Completeness of the data

Dietary intake for the majority (84%) of participants was complete for 3 days WFR, whereas the remaining 16% of individuals had complete measurements for either one or two days (12% with two days complete WFR and 4 % with one day complete WFR). During data collection, the researchers also observed the PA of 11 women for three consecutive and complete days. Data regarding dietary intakes were incomplete for two of these women (one woman had one day incomplete WFR and the other woman had two days incomplete WFR (table 6).

Macronutrient intakes

Mean and SD of macronutrient intakes of study participant categorized by their age and sex, table 7. Intakes of macronutrient in all age groups were higher in males than in females, except CHO intake in adolescents was higher in females than observed in males. Assesment of macronutirenst intakes in comparision to AMDR and RDA are presented in tables 9 and 11.

Table 7: Macronutrient intakes per day of study participants (N=70) in Nkay-Kalengi

	Average intake per day of Weighed Food Records			
	Male		Female	
Age group	n	$\bar{x}$ ± SD	n	$\bar{x}$ ± SD
3-9 years	9		9	
Protein (g)		15 ± 3		14 ± 7
Fat (g)		19 ± 11		14 ± 11
CHO (g)		247 ± 69		192 ± 97
10-17 years	9		6	
Protein (g)		27 ± 12		18 ± 7
Fat (g)		31 ± 12		18 ± 10
CHO (g)		317 ±116		392 ± 143
18-61 years	16		21	
Protein (g)		29 ± 16		25 ± 11
Fat (g)		40 ± 32		31 ± 18
CHO (g)		519 ± 204		438 ± 116

CHO is carbohydrate.

EI and percentage contribution of energy from cassava to EI

Mean EI, mean energy from cassava, along with the mean % contribution of energy from cassava to the mean EI for each sex and for combined sexes are presented in table 8. The mean EI increased with increasing age in combined sexes and was higher in males than in females. Cassava was the principal energy source and its contribution was more than three-fourths of the mean EI in all age groups. In children of both sexes, the mean energy from cassava contributed 77 % of the mean EI, in which the proportion of contribution was higher in males than in females. Similarly, the role of cassava in adolescents EI was also great. Of the 2043 Kcal mean intake for both sexes, 81% was derived from cassava, of all age groups the highest % contribution was seen in females' adolescents, i.e. 86 % of the EI provided from cassava. As seen in the other age group, adults' energy intake was also dominated by cassava consumption. Of the 2757 Kcal mean intake in males, 83 % was provided from cassava, in females of the 2256 Kcal mean intake 79 % was contributed by cassava and in combined sexes the % contribution was 81 %. These findings suggest that the dietary patterns in those participants were very monotonous as the majority of their energy generated from one source (i.e. cassava).

Table 8: Energy intakes, energy from cassava, and the percentage contribution of energy from cassava to mean energy intakes (E%) of study participants (N=70) in Nkay-Kalengi

	Average for 3 day Weighed Food Records				
	Male		Female		Combined sexes
Age group	n	x̄ ± SD	n	x̄ ± SD	x̄ ± SD
3-9 years	9		9		
Energy (kcal)		1295 ± 247		1148 ± 346	1222 ± 301
Cassava (kcal)[a]		1031 ± 289		874 ± 353	952 ± 323
Cassava (E%)[b]		79± 10		76 ± 18	77 ± 14
10-17 years	9		6		
Energy (kcal)		2079 ± 711		1987 ± 638	2043 ± 660
Cassava (kcal)		1617 ± 541		1715 ± 567	1656 ± 534
Cassava (E%)		78 ± 10		86 ± 6	81 ± 9
18-61 years	16				
Energy (kcal)		2757 ± 748	21	2256 ± 658	2472 ± 733
Cassava (kcal)		2279 ± 609		1779 ± 567	1995 ± 629
Cassava (E%)		83 ± 8		79 ± 11	81 ± 10

Cassava (Kcal)[a] *is the amount of energy provided by cassava,* ***Cassava (E%)[b]*** *is the percentage contribution of cassava to the EI. Mean and SD were tabulated based on individually calculated values.*

Energy derived from macronutrients

The mean percentage of energy derived from macronutrients in comparision with the AMDRs in three age groups are shown in table 9. In children, mean E% from protein and fat were almost half of the lower limits of the AMDRs. In adolescents, mean E% contributed from each macronutrient also fell outside the AMDRs. The mean E% from protein and fat were substantially below the lower limit of the AMDR. Similar to the results determined for the other age groups, adults' energy derived from macronutrients was also fell ouside the AMDRs. The mean pecentage of the energy from protein (4.3 %) and fat (12.1 %) were lower than the current recommendations (for a mimimum intakes of 10 % of protein energy and 20 % of fat energy). To summarize, the percentage of protein and fat were both far below the lower limits of AMDRs. Thus, it could be noted that the consumption of protein and fat yielding foods was too low. The values in this table correlate with values seen in table 7, as dietary patterns were highely dominated with casssva (mainly cassva roots). This may explain why the % protein and % fat were below the lower limit of AMDRs.

Table 9: Mean EI from macronutrients in relation to the AMDRs of study participants (N=70) in Nkay-Kalengi

Age groups	n	Macronutrients	Mean energy (Kcal) from macronutrients	% of mean energy (E%)	AMDR* (E%)
3-9 years	18	Protein	57	4.9	10-30
		Fat	148	12.7	25-35
		CHO	878	69.9	45-65
10-17 years	15				
		Protein	92	4.5	10-30
		Fat	229	11.4	25-35
		CHO	1388	71.5	45-65
18-61 years	37				
		Protein	106	4.3	10-35
		Fat	315	12.1	20-35
		CHO	1892	77.3	45-65

AMDRs are the range of intake for a particular energy source and expresses as percentage of mean energy (E%). Mean energy from macronutrients and E% were tabulated based on individually calculated values.*

BMR factors related to sex and age

The BMR factor was used to assess if reported energy intakes were reasonable in terms of individuals' energy requirements, table 10. The highest mean value was reported in male adolescents, followed by almost similar values in adults of both sexes. The lowest mean value was reported in female children. When we look at the individually calculated values (see Appendix table 19 and 20), it can be seen that 13 participants had a BMR factor < 1.35 (indicating underreporting or biologically implausible energy intakes). Of those 13 participants, 7 were children, 2 were adolescents and 3 were adults. Ten additional participants (8 adults and 2 adolescents) had a BMR factor ≥ 2.4 (indicating high EI or potential overreporting). To sum up, 19 % of the participants had less than the lower limit of BMR factor, and most of them were children. Fourteen percent had higher EI than the reasonable energy requirmet (where the majority were adults).

Table 10: Mean BMR factors per day of study participants in Nkay-Kalengi (N=68)

	Average for 3 day Weighed Food Records			
	Male		Female	
Age group	n	$\bar{x}$ ± SD	n	$\bar{x}$ ± SD
3-9 years	8		8	
BMR factor		1.56 ± 0.27		1.38 ± 0.39
10-17 years	9		6	
BMR factor		1.98 ± 0.64		1.82 ± 0.56
18-61 years	16		21	
BMR factor		1.94 ± 0.52		1.94 ± 0.56

BMR factor (EI/BMR)

Nutrient adequacy

Table 11 presents the mean energy and macronutrient intakes in comparison with the EER and RDA for each sex separately. In children, energy and protein intakes were below the recommended intake values. However, the mean EI was only slightly below the EER (98 % in males and 94 % in females of the EER was covered), thus the differences were not significant ($p > 0.05$ in both sexes). The magnitude of protein inadequacy was statistically significant ($p <0.05$ in both sexes). In adolescents, mean intake of energy was above the recommended intake. The mean EI of males and females were above the EER by 350 Kcal (26 %) and 92 Kcal (3 %), respectively. Protein intake was far below the recommended intake limit and inadequacy was higher in females (22 g below RDA) than in males (13 g lower than RDA). Like in adolescents, mean energy intake of adults was also above the recommended intakes. The mean EI covered almost 100 % of the EER for both sexes (110 % for males and 101 % for females). Similar to other age groups, the protein intake in adults was far below the RDA and only around half parts of the RDA was fulfilled (29 g of the 56 g in males and 25 g of the 46 g in females) and the differences were statistically significant. Regarding fat intake, no comparison was done as RDA for fat have not yet determined by the IOM. However when we look the % of energy from fat (% fat) in relation to AMDR, the % fat was below the lower limit of AMDR in all groups (table 9), thus it could be concluded that the fat intake was inadequate. In summary, energy intake of the participants were adequate (except for energy intake of children which was slightly lower than the EER) in comparison to the recommended intake. Protein and fat intakes were far below the RDA.

Energy expended for physical activity and energy consumed

Energy expended and energy consumed for women with measured PAL are presented in table 12. Of the 11 women, 5 expended greater amounts of energy for PA than what they had consumed. Thus energy was considered negatively balanced, as their output (energy expenditure) exceeded their input (energy consumed). Energy expenditure was almost equal to energy consumed for 4 mothers. Therefore energy was considered balance in these mothers, as the difference between input and output was very small. In the remaining mothers, energy was positively balanced for one mother (input was higher than output), but energy was measured incomplete in mother 3. To sum up, total energy was negatively balanced for 5 mothers, maintain balanced for 4 mothers, positively balanced for one mother and was incomplete for one mother.

Table 11: Mean energy and macronutrients intake per day in comparison to EER and RDA of study participants (N=70) in Nkay-Kalengi

Age group	Per day Male Mean	Female Mean	EER[a]/RDA[b] Male Mean	Female Mean	% EER consumed Male Mean	Female Mean	*p-value[1]*	*p-value[2]*
3-9 years								
Energy (kcal)[a]	1295	1148	1361	1064	98	94	*0.48*	*0.345*
Protein (g)[b]	15	14	19	19			*0.011*	*0.046*
Fat (g)[b]	19	14	ND	ND				
CHO (g)[b]	247	192	130	130			*0.008*	*0.086*
10-17 years								
Energy (kcal)	2079	1987	1729	1895	126	103	*0.018*	*0.465*
Protein (g)	27	18	40	40			*0.66*	*0.028*
Fat (g)	31	18	ND	ND				
CHO (g)	317	392	130	130			*0.008*	*0.028*
18-61 years								
Energy (kcal)	2757	2256	2417	2190	110	101	*0.401*	*0.554*
Protein (g)	29	25	56	46			*0.001*	*0.00*
Fat (g)	40	31	ND	ND				
CHO (g)	519	438	130	130			*0.000*	*0.000*

EER[a] *is the average daily energy intake level predicted to maintain the needs of half of the healthy individuals in a group .**RDA[b]** is the average daily dietary intake level sufficient to meet the requirement of almost all (97-98 %) of healthy individuals in a group.* ***ND*** *(not determined)*. ***%EER consumed*** was calculated as proportion of EI per day to EER. ***P-value[1] and p-value[2]*** *are significances levels between intakes per day and the references (EER and RDA) for male and female respectively. Means were tabulated based on individually calculated values shown in appendix.*

Table 12: Energy expenditures for PA in relation to energy consumed of women (n=11)

	Mother number	Day 1 PAL	Day 2 PAL	Day 3 PAL	Average PAL	Energy consumed (BMR factor)	Difference (EI – PAL)	Energy Balance
	Mother 1	1.48	1.39	1.36	1.41	1.39	0.02	balanced
	Mother 2	1.71	1.66	1.67	1.68	1.69	-0.01	balanced
	Mother 3	1.95	1.41		1.68	1.19	0.49	incomplete
	Mother 4	1.67	1.63	1.88	1.73	1.71	0.02	balanced
	Mother 5	1.81	2.07	1.75	1.88	1.87	0.01	balanced
	Mother 6	1.93	2.23	1.68	1.95	1.45	0.50	negative
	Mother 7	1.97	2	1.9	1.96	1.55	0.41	negative
	Mother 8	2.22	1.47	2.19	1.96	1.8	0.16	negative
	Mother 9	2.04	2.09	1.82	1.98	1.61	0.37	negative
	Mother 10	1.7	2.22	2.24	2.05	2.3	-0.25	positive
	Mother 11	2.25	1.88	2.1	2.08	1.6	0.48	negative
Average					1.85	1.65		

II. Anthropometric data

Socio-demographic characteristics of the study participants

Altogether 440 adults, 325 (74%) from Nkay-Kalengi and 115 (26%) from Indaba were included for BMI assessments. Measurements of weight and height were available from 173 (39%) males and 267 (61%) females, for whom the BMI could be calculated. The mean ± SD height and weight of the participants was 153 ± 10 cm and 44 ± 9 kg, respectively. The mean ± SD age was 37 ± 15 years and participants were stratified into 6 age groups (table 13).

Table 13: Socio-demographic characteristics of the study participants

Characteristic	n (440)	Percentage	Mean ± SD
Sex			
Male	173	39	
Female	267	61	
Age groups (years)			37 ± 15
18 - 24	108	25	
25 - 34	108	25	
35 - 44	86	20	
45 - 54	71	16	
55 - 64	44	10	
≥65	23	5	
Residence village			
Nkay-Kalengi	325	74	
Indaba	115	26	
Height (cm)			153 ± 10
< 145	67	15	
145-160	278	63	
>160	95	22	
Weight (kg)			44 ± 9
< 40	121	28	
40-50	216	49	
>50	103	23	

Distribution of BMI

Table 14 presents BMI distribution separately for each sex and combined sexes, for the whole sample of 440 adults. The WHO BMI cut-off points (table 1) were applied to classify the study participants into different BMI-categories. Overall data when sexes were combined showed that 47% of the participants were underweight, 52% were in the normal weight range, 1% were overweight and no participants were obese. The percentages of men and women who were severely thin (BMI<16) and moderately thin (BMI 16.0 -16.99) were equal in both sexes i.e. 9% were severely thin and 11% were moderately thin for each sex. A higher percentage of men than women were mildly thin (BMI 17.0 -18.49) and a higher percentage of women than men were of normal weight.

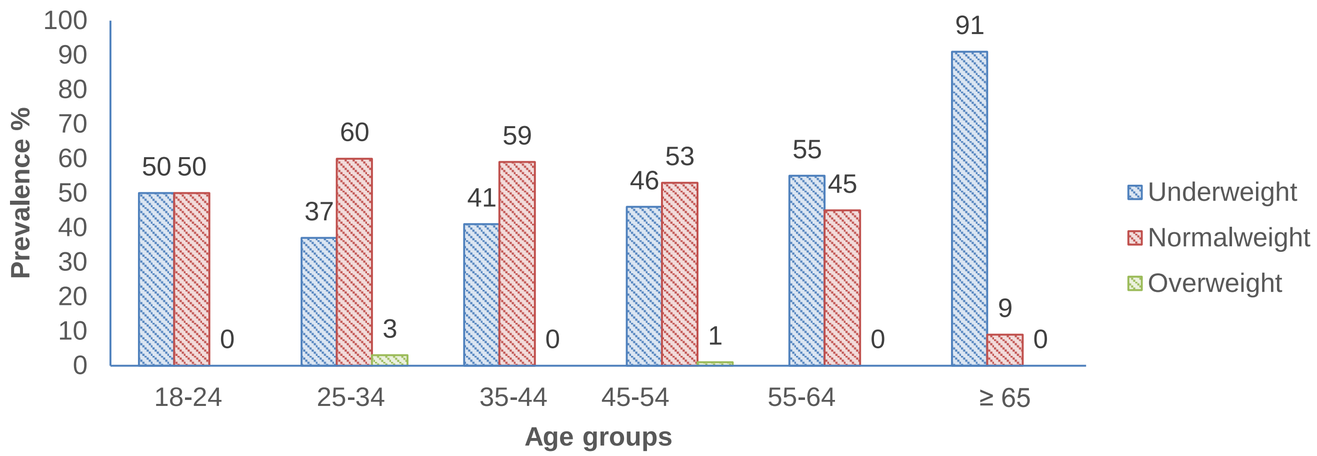
Table 14: Distribution of body mass index by age, sex and sex combined

Men	**18-24 n (%)**	**25-34 n (%)**	**35-44 n (%)**	**45-54 n (%)**	**55-64 n (%)**	**≥ 65 n (%)**	**Total n (%)**
< 16.0	12 (24)	0 (0)	2 (5)	1 (4)	0 (0)	0 (0)	15 (9)
16.0 -16.99	3 (6)	4 (12)	3 (8)	3 (14)	3 (19)	3(20)	19 (11)
17.0 -18.49	15 (31)	8 (24)	10 (27)	9 (41)	6 (37)	10 (67)	58 (33)
18.5 -19.99	10 (21)	10 (29)	14 (38)	4 (18)	3 (19)	1 (7)	42 (24)
20.0 -22.49	7 (14)	11 (32)	8 (22)	5 (23)	4 (25)	1 (7)	36 (21)
22.5 -24.99	2 (4)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	2 (1)
25.0 -27.49	0 (0)	1 (3)	0 (0)	0 (0)	0 (0)	0 (0)	1 (1)
27.5 -29.99	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
≥ 30.0	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Total	49 (100)	34 (100)	37 (100)	22 (100)	16 (100)	15 (100)	**173 (100)**
Women							
< 16.0	6 (10)	2 (3)	3 (6)	4 (8)	4 (14)	4 (50)	23 (9)
16.0 -16.99	4 (7)	11 (15)	4 (8)	7 (14)	3 (11)	1 (12)	30 (11)
17.0 -18.49	14 (24)	15 (20)	13 (27)	9 (18)	8 (29)	3 (38)	62 (23)
18.5 -19.99	15 (25)	20 (27)	11 (22)	12 (25)	7 (25)	0 (0)	65 (24)
20.0 -22.49	18 (31)	21 (28)	15 (31)	14 (29)	6 (21)	0 (0)	74 (28)
22.5 -24.99	2 (3)	3 (4)	3 (6)	2 (4)	0 (0)	0 (0)	10 (4)
25.0 -27.49	0 (0)	2 (3)	0 (0)	1 (2)	0(0)	0 (0)	3 (1)
27.5 -29.99	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
≥ 30.0	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Total	59 (100)	74 (100)	49 (10)	49 (100)	28 (100)	8 (100)	**26 7 (100)**
Combined Sexes							
< 16.0	18 (17)	2 (2)	5 (6)	5 (7)	4 (9)	4 (17)	38 (9)
16.0 -16.99	7 (6)	15 (14)	7 (8)	10 (14)	6 (14)	4 (17)	49 (11)
17.0 -18.49	29 (27)	23 (21)	23 (27)	18 (25)	14 (32)	13 (57)	120 (27)
18.5 -19.99	25 (23)	30 (28)	25 (29)	16 (23)	10 (23)	1 (4)	107 (24)
20.0 -22.49	25 (23)	32 (30)	23 (27)	19 (27)	10 (23)	1 (4)	110 (25)
22.5 -24.99	4 (4)	3 (3)	3 (3)	2 (3)	0 (0)	0 (0)	12 (3)
25.0 -27.49	0 (0)	3 (3)	0 (0)	1 (1)	0 (0)	0 (0)	4 (1)
27.5 -29.99	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
≥ 30.0	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Total	108 (100)	108 (100)	86 (100)	71 (100)	44 (100)	23 (100)	**440 (100)**

Overall, the proportion of overweight individuals was only 1% in each sex. As seen in the table 14, BMI distribution varies with age. For men, those aged ≥ 65 years had the highest percentage of underweight persons, followed in descending order by age groups 18-24, 45-54, 55-64, 35-44 and 25-34. Similarly, the percentage of men of normal weight also varied by age, the distributions were 39%, 61%, 60 % ,41%, 44% and 15% for age groups 18-24 , 25-34, 35-44, 45-54 years, 55-64 and ≥ 65, respectively. The percent distribution of female underweight individuals also varied with age, those aged ≥ 65 years were surprisingly all underweight, whereas approximately half (54%) of 55-64 year olds were underweight. While the remaining age group categories had similar distribution of underweight individuals, age groups18-24 years and 35-44 years each had 41%, in 45-54 years

40% and in 25-34 years 38% of the women were underweight. The percentage of women which had normal weight were similar in most age groups (59%), except in age groups 55-56 years (46%) and ≥ 65 years (0 %). It is worth noting that only 1 % of the participants were overweight, but when we look the percentage distribution specifically by age group, 3% of the males and 3% of the females aged 25-34 years, and 2% of women aged 45-54 years were overweight. Besides table 16, figure 2 also illustrates the proportion of different BMI categories for different age groups in the combined sexes.

Figure 5: Prevalence of underweight, normal weight and overweight by age groups



Factors associated to underweight

Table 15 shows the results of the logistic regression with crude and adjusted odds ratios (ORs), where the dependent variable was "underweight". In the adjusted analysis, women were 24% less likely to be underweight than men, however the association was not statistically significant. Unlike sex, age had significant association with being underweight. Compared with age group 18-24 years (younger adults), age group ≥ 65 years were 10.1 times more likely to be underweight than the younger adults. Even though the age group 55-64 years was 1.3 times more likely to be underweight than the younger adults, but the association was not statistically significant. While in other age groups, the likelihood of being underweight was higher in the younger adults, i.e. age groups: 25-34, 35-44 and 45-54 years were respectively 39 %, 28 % and 10% less likely to be underweight than the younger adults and but the association was not statistically significant. Like sex, residence area had no significant association with underweight status; though residences of Nkay-Kalengi were 1.3 times more likely to be underweight than those from Indaba.

Table 15: Factors associated with being underweight* (total 440)

Characteristics	n (%)	Underweight %	COR [95% CI]	AOR [95% CI]	p-value
Sex					
Male	173 (39)	92 (53)	1	1	
Female	267 (61)	115 (43)	0.67 [0.45, 0.98]	0.76 [0.51, 1.1]	0.03
Age groups					
18 – 24	107 (24)	53 (49)	1	1	
25 – 34	109 (25)	40 (37)	0.59 [0.34, 1.0]	0.61 (0.35, 1.0)	0.05
35 – 44	85 (19)	35 (41)	0.71 [0.40, 1.3]	0.72 (0.40, 1.3)	0.2
45 – 54	71 (16)	33 (46)	0.88 [0.48, 1.6]	0.90 (0.50.1.6)	0.6
55 – 64	45 (10)	25 (56)	1.3 [0.63, 2.5]	1.3 (0.64, 2.4)	0.4
≥65	23 (5)	21 (91)	10.7 [2.4, 47.9]	10.1 (2.2, 45.2)	0.002
Residence					
Indaba	115 (26)	50 (43)	1	1	
Nkay-Kalengi	325 (74)	157 (48)	1.1 (0.8, 2.1)	1.3 (0.8, 2.5)	0.9

**Cut-off point for underweight is BMI < 18.5 kg/m²*

Cumulative distribution of BMI for men

Figure 6 shows an ogive graph (cumulative frequency curve) for men, in which cumulative percentage of BMI distribution displays along the vertical-axis, and BMI categories along the horizontal-axis for different age groups. In young male adults (18-24 years old), 24% were severely thin (BMI<16), 30% had a BMI of ≤16.99, 61% were underweight (BMI<18.49), 82% had a BMI ≤ 19.99, 96% ranged within BMI ≤ 22.49 and all (100%) fell within the normal range of BMI ≤ 24.99. In older men (aged ≥65 years), the percentage distributions were as follows: no participant was severely thin, 20% were within the range of moderate thinness (BMI 16.0 -16.99), 87% of them were underweight, 93% were in the range of BMI ≤ 19.99 and all (100%) of the participants had a BMI ≤ 22.49. In the remaining age groups, 5% in the age group 35-34 years, 4% in 45-54 years, 0% in other two groups (24-35 and 55-64 years) were severely thin. The percentage of participants who were moderately thin or below (BMI ≤ 16.99) in those groups (excluding the age groups 18-24 and ≥65 years) increased with increasing age and the cumulative distribution was 12%, 13%, 18% and 19% in age groups 25-34, 35-44, 45-54 and 55-64 years, respectively. In the same way the percentage of participants who were underweight also increased with increasing age for majority of them, i.e. 36% in 25-34 years, 40% in 35-44 years, 59% in 45-54 years and 56% in 55-64 years. In four age groups (excluding younger and older adults), the cumulative distribution reached 100% within the range of BMI ≤ 22.49, with the exemption of age group 25-34 years where only one man fell within the BMI range of 25-27.49.

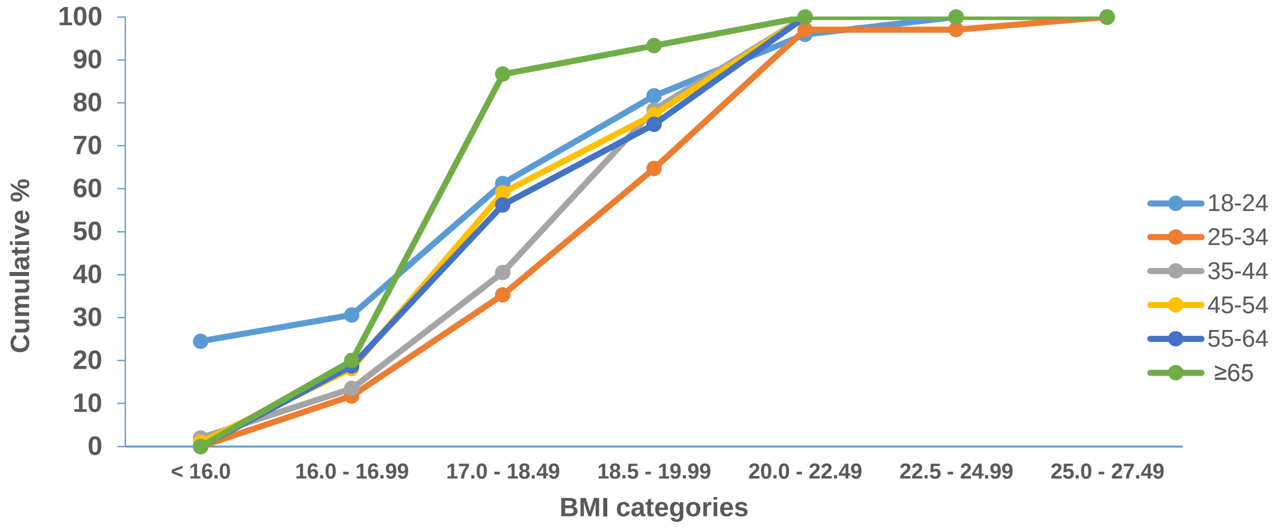


Figure 6: Cumulative distribution of BMI for men by age group

Cumulative distribution of BMI for women

Figure 7 presents an ogive graph for women, in which the cumulative percentage of BMI distribution was plotted on the y-axis against different BMI-categories on the x-axis for different age groups. The cumulative distribution of BMI was almost similar in all age groups (as seen by the overlapping lines), except in those aged 55-64 and ≥65 years. In all other age groups, the percentage of participants who were severely thin was ≤ 10% (range 3-10%). Approximately 18% (range 14-22%) had a BMI ≤ 16.99, closely 40% (range 38-41%) were underweight, and almost all (100%) fell within or lower than the normal range (BMI ≤ 24.99), with the exception of 3 women: 2 of age group 25-34 years and 1 of age group 45-54 were overweight (BMI 25-27.49). In age group 55-64 years, 14% of individuals were severely thin, 25% had BMI≤ 16.99, over half (54%) were underweight, and more than three-fourths (79%) had a BMI ≤ 19.99. The cumulative distribution reached 100% in BMI ≤ 22.49. In older women, the cumulative distribution of BMI was different from that of the other groups; all women were underweight (50 % were severely thin, 63% had BMI ≤ 16.99 and 100% had BMI ≤ 18.49).

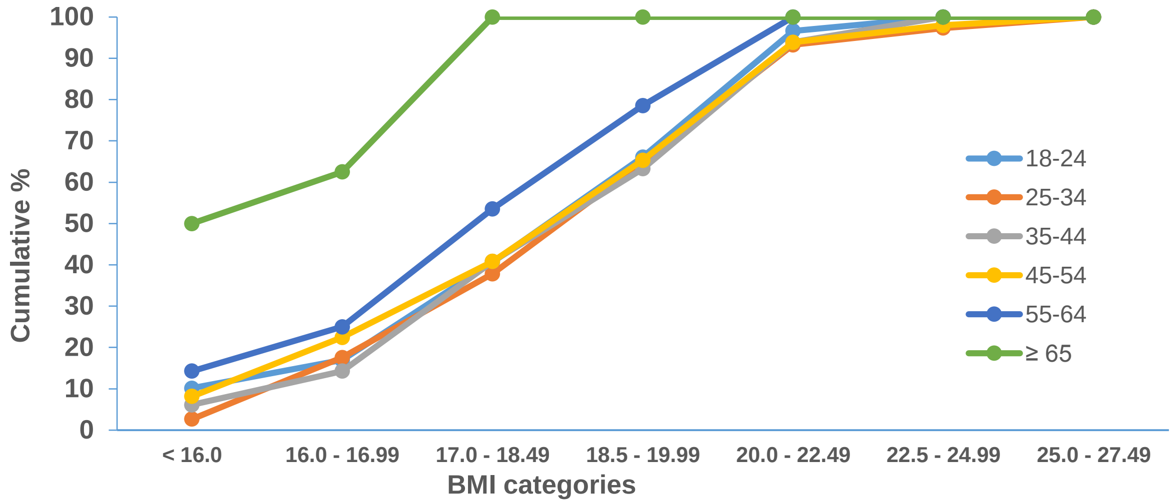


Figure 7: Cumulative distribution of BMI for women by age group

Prevalence of underweight, normal weight and overweight

Figure 8 presents the prevalence of underweight, normal weight and overweight individuals for each sex and for the combined sexes. 47% of the adults were underweight; which equates to 53% of males and 43% of females. Females were slightly more likely than men to be ranged in the normal weight category. The prevalence of overweight individuals within those participants was almost non-existent and it was only 1% in each sex

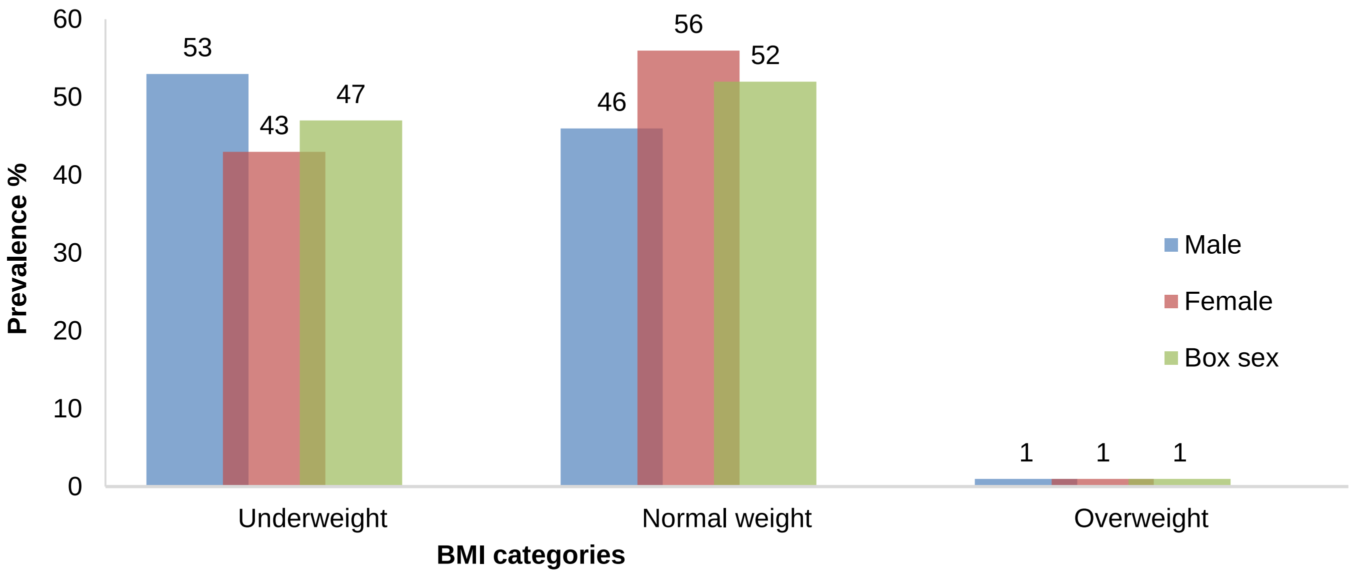


Figure 8: Prevalence of underweight, normal weight and overweight by sex and overall

Distribution of BMI-categories by villages

Figure 9 presents the distribution of BMI separately for residences of Nkay-Kalengi and Indaba. Residences of those villages were similarly affected by underweight status, as 48% of Nkay-Kalengi and 44% of Indaba's residents were underweight. Similarly, the percentage of the residents who were of normal weight was almost the same, i.e. 51% in Nkay-Kalengi and 56% in Indaba. In both villages, the number of overweight residents was not a problem, as only 1% of Nkay-Kalengi residents were overweight and none of the Indaba residents were overweight

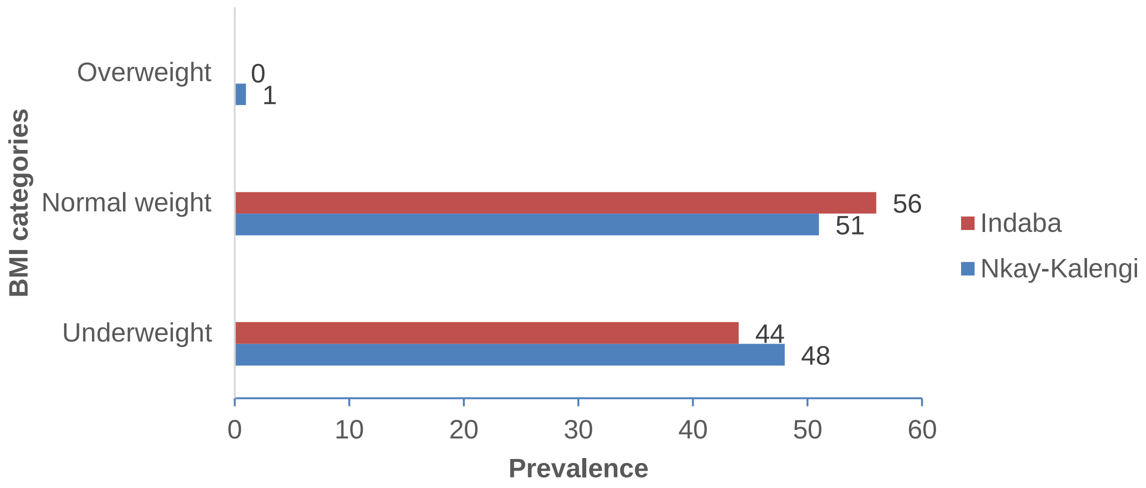


Figure 9: Prevalence of underweight, normal weight and overweight by village

III. Comparison of our study with other population-based studies in Africa

Dietary intake

Our third specific objective was to compare our participants' diet with the diets of other free-living African populations. As shown in table 16, participants in the selected studies belonged to different age groups, thus to make the comparison convenient, we tabulated the selected studies in three age groups similar to our study age categories. The E% from macronutrients was used for comparison. In children included in our study, the E% from protein in both sexes was almost half of the lower limit of the AMDR, whereas in children of the selected studies this value fell within or slightly higher than the lower limit of the AMDR. Therefore our finding was not comparable with any of the selected studies i.e. protein (E%) was more than two folds lower in our study. Not all of the selected studies reported fat intakes. For those including fat intakes, the E% from fat was below the AMDRs except for in Seychellois children, whose E% from fat was almost equal to the upper limit (45). The fat (E%) in children of our study was half of the lower limit of the AMDR, thus the value reflects the result found in other selected studies but the lowest fat level (E%) was observed solely in our study. Throughout the review we identified only one additional study conducted on adolescents which also only reported the protein intake of its participants. The E% from protein (9% in each sex) was almost within the acceptable contribution range, but in our study the protein (E%) was much lower than this selected study's findings; i.e. it was only half in males and only a third in females. Similarly to other age groups, this study revealed that the protein (E%) of adults was much lower than the AMDR and none of the selected study's findings were in agreement with our findings. The adults' protein (E%) in our study was only half of the study which reported lowest protein (E%) (19), and only a third of the study which reported the highest protein (E%) (50). As with other age groups, fat intakes of adults were not reported by all studies (reported intakes available in 3 of 5 studies) and the E% of fat in all of the selected studies including our study was lower than the lower limit of the AMDR except in South-African study (50), but like we observed in children the lowest fat (E%) intake was from our study. To summarize, the current review revealed that the E% from protein and fat were within the lower or below the lower ranges. Thus, it could be concluded that dietary patterns of those African populations were monotonous as E% was not generated in accordance to the AMDRs i.e. low from protein and fat yielding foods and high from starchy foods. Therefore similar to our study particpants, the diets of these populations were also monotonous. However, when the diet of those populations were directly compared with the diet of our study particpants, it was shown that our study participants had the most monotonous diet of all the free-living African populations. Thus, due to such dietary patterns our particpants' health was more in danger than any of the other free-living African populations.

Table 16: Energy and macronutrient intakes and percentage contribution of energy from macronutrients for selected free-living populations in Africa and our participants

Study country (*reference*)	**Sex**	**Age group (years)**	**Energy (kcal**	**Protein (g)**	**Protein (E %)**	**Fat (g)**	**Fat (E %)**	**CHO (g)**	**CHO (E %)**
Ethiopia(48)[a]	Both	1-2	292	7.3	10				
Kenya(16)	Both	3-5	1195	35	12	23	17		
Seychelles(45)	Male	5	1140	39.6	14	42	33	149	53
Seychelles(45)	Female	5	1137	39.5	14	42.7	34	147	52
Benin(47)	Male	6-8	1242	31	10	24	17	237	72
Benin*(47)*	Female	6-8	1123	27	10	19	15	221	75
Kenya(49)	Both	6-8	966	28	11	16	15		
Cameroon*(46)*	Male	7-9	892	22.8	10				
Cameroon*(46)*	Female	7-9	967	24.4	10				
Our study	***Male***	***3-9***	***1295***	***15***	***4.7***	***19***	***13.4***	***247***	***76***
Our study	***Female***	***3-9***	***1148***	***14***	***5***	***14***	***12***	***192***	***67***
AMDR	**Both**	**3-9**			**10-30**		**25-35**		**45-65**
Cameroon*(46)*	Male	10-18	1161	27.5	9				
Cameroon*(46)*	Female	10-18	1165	29.3	9				
Our study	***Male***	***10-17***	***2079***	***27***	***5***	***31***	***13.8***	***317***	***67***
Our study	***Female***	***10-17***	***1987***	***18***	***3.5***	***18***	***7.7***	***392***	***78***
AMDR	**Both**	**10-17**			**10-30**		**25-35**		**45-65**
Ethiopia*(5)*	Male	15-49	2031	61	12				
South-Africa(50)	Both	15-65	2174	77.2	14	73	30	299	55
Kenya(49)	Female	≥20	1101	31	11	17	13		
Gabon*(19)*	Both	All age	1583	31.8	8				
Kenya*(16)*	Both	≥50	2198	64	12	44	18		
Our study	***Male***	***18-61***	***2757***	***29***	***4.1***	***40***	***12.2***	***519***	***75***
Our study	***female***	***18-61***	***2256***	***25***	***4.4***	***31***	***12***	***438***	***78***
AMDR	**Both**	**18-61**			**10-35**		**20-35**		**45-65**

[a] *AMDR for children aged 0-3 is 5-10%.*

BMI distribution of our study in comparison to other population-based studies in Africa

As part of our third specific objective, we compared the BMI distribution of our participants with that of other free-living African adults. The comparison was done separately for each sex as shown below.

***A. For males*:** As shown in table 17, some of the selected studies did not report the prevalence of severe, moderate and mild thinness separately; instead they reported only underweight as a whole prevalence. Overall when all age groups were combined, the prevalence of severe thinness among our study men was 9 %. This prevalence was much higher than any other prevalence reported in the selected studies and it was more than three times higher than the Ghanaian study (49) i.e. the study which reported the highest prevalence of severe thinness from the selected studies. Similar to severe thinness, the proportion of participants which were moderately thin (11%) was also much greater in our study and no single study's finding was comparable with our finding. Like the two BMI categories, prevalence of mid thinness was also much higher in our study (33%) compared to other studies. Therefore after looking the above prevalences, we noticed that our study had more underweight participants than those free-living African adult men reported elsewhere. Study 17.1 carried out by WHO in DR Congo at a subnational level (36) and it reported that 27.8% of the area's adult men were underweight. This finding was almost half of what was reported in our study (53%), thus our finding was higher not only from foreign study's findings but even also from this domestic study. In all of the selected studies, more than half (ranged from 58.9% in Tunisian study to 78.5% in Ghanaian study) of the participants fell within the normal range of BMI, whereas in our study less than half (46%) of the participants had normal weight. Only 1% of the participants were overweight which was substantially lower than other selected studies, excluding the Ethiopian study (2.5%) which was not far from our findings. To sum up the comparison, our study revealed one of the thinnest free-living adult males in Africa and none of the participants in the selected studies experienced such a skewed distribution.

Table 17: Proportion of BMI categories for men in our study and in studies included in our review

Study No.	Study country (reference)	<16	16.0 - 16.99	17.0-18.49	< 18.5	18.5 - 24.99	25.0 - 29.99	≥30
11	Mozambique*(51)*				13.2	72.5	11.2	3
12	Ethiopia*(52)*				36.7	60.8	2.5	
15	Ghana*(55)*	1.2	2.7	12.3	16.2	78.5	4.7	0.6
16.2	Ghana*(56)*	2.8	3.9	13.3	20	62	17.1	0.9
16.3	Mali*(56)*	1.9	3.2	11.2	16.3	76.5	6.4	0.8
16.4	Morocco*(56)*	0.5	1.1	5.4	7	69.1	18.7	5.2
16.5	Tunisia*(56)*	0.3	0.6	3	3.9	58.9	28.6	8.6
17.2	DR Congo(36)*				27.8	61.1	8.5	2.6
	Our study	**9**	**11**	**33**	**53**	**46**	**1**	**0**

Study 17.1 carried out in DR Congo at a subnational level

Besides table 17, an ogive graph was also used to illustrate graphically how the BMI distribution of our study varied from the selected studies. As shown in figure 11, 9% of the participants were severely thin, 20% had a BMI of ≤16.99, 53% were underweight, almost all (99%) fell within BMI ≤ 24.99 and the cumulative distribution reached 100% in BMI ≤ 27.49. This finding was not in line with any finding obtained in the selected studies. The line which represents our study (red color) projected until the top alone and no single study was overlapped or closely lined with our study. This indicates that our participants were much thinner than any other free-living African adults reported in the selected studies.

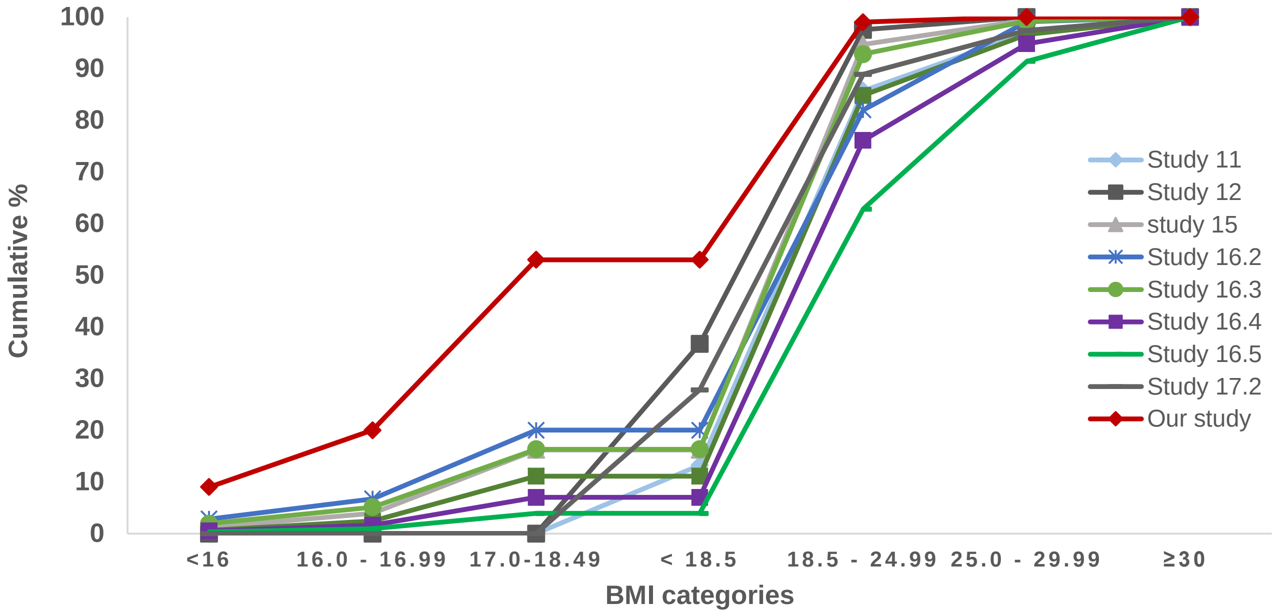


Figure 10: Cumulative distribution of BMI for our study in comparison to the selected studies for men

B. For females: As with men, the proportions of severe, moderate and mild thinness were also remained unreported by some of the selected studies (table 18). The overall proportion of severe thinness in our study women was 9%. Comparing this proportion with those reported in the selected studies, it was much higher than all of the other studies, and three times higher than the Ethiopian study (45*)* which had the highest percentage of severely thin participants. 20 % of our participants were moderately thin or below a BMI of 16.99, and this figure was higher than all findings reported in the selected studies. The percentage of our study women who were underweight was 43% and this finding was in line with the finding of the Ethiopian study (52) which was 42.7%. Following the Ethiopian study, the next highest underweight proportion of participants was reported in a study carried out in our Province Bandundu (42). This provincial proportion of underweight individuals was 12.3% lower than our finding. Thus, it could be estimated that our particpants were among the thinnest residences of the Bandundu Province. Besides this, study 17.1 was also obtained from the DR Congo and conducted nationwide, and data was retrived from the WHO global database on BMI (42). The resulting proportion of underweight individuals (18.5%) was lower than both our own and provincial findings. This supporting information shows that the province itself had a higher proportion of underweight individuals compared with that of the nationalwide finding.

Table 18: Proportion of BMI categories for women in our study and in the studies included in our review

Study No.	Study country (reference)	<16	16.0 - 16.99	17.0-18.49	< 18.5	18.5 - 24.99	25.0 - 29.99	≥30
11	Mozambique*(51)*				11	64.7	14.9	9.4
12	Ethiopia*(52)*				42.7	55.1	2.2	
13	South-Africa*(46*				7.2	81.9	10	0.8
14.1	Ethiopia*(45)*	3	5	20	28	71	1	
14.2	Zimbabwe*(45)*	1	2	9	12	70	18	
15	Ghana*(55)*	1.6	3.2	11.8	16.6	65.3	12	6.1
16.1	Congo*(49)*	0.6	1.8	8.7	11.1	73.7	11.8	3.4
16.2	Ghana*(49)*	2.8	3.9	13.3	20	62	17.1	0.9
16.3	Mali*(49)*	1.9	3.2	11.2	16.3	76.5	6.4	0.8
16.4	Morocco*(49)*	0.5	1.1	5.4	7	69.1	18.7	5.2
16.5	Tunisia*(49)*	0.3	0.6	3	3.9	58.9	28.6	8.6
17.1	DR Congo(42)				18.5	70.3	8.9	2.4
17.3	DR Congo(42)				30.7	67	1.2	1.2
	Our Study	**9**	**11**	**23**	**43**	**56**	**1**	**0**

Study 17.1 was carried out in nationwide in DR Congo and study 17.3 was from our province Bandundu.

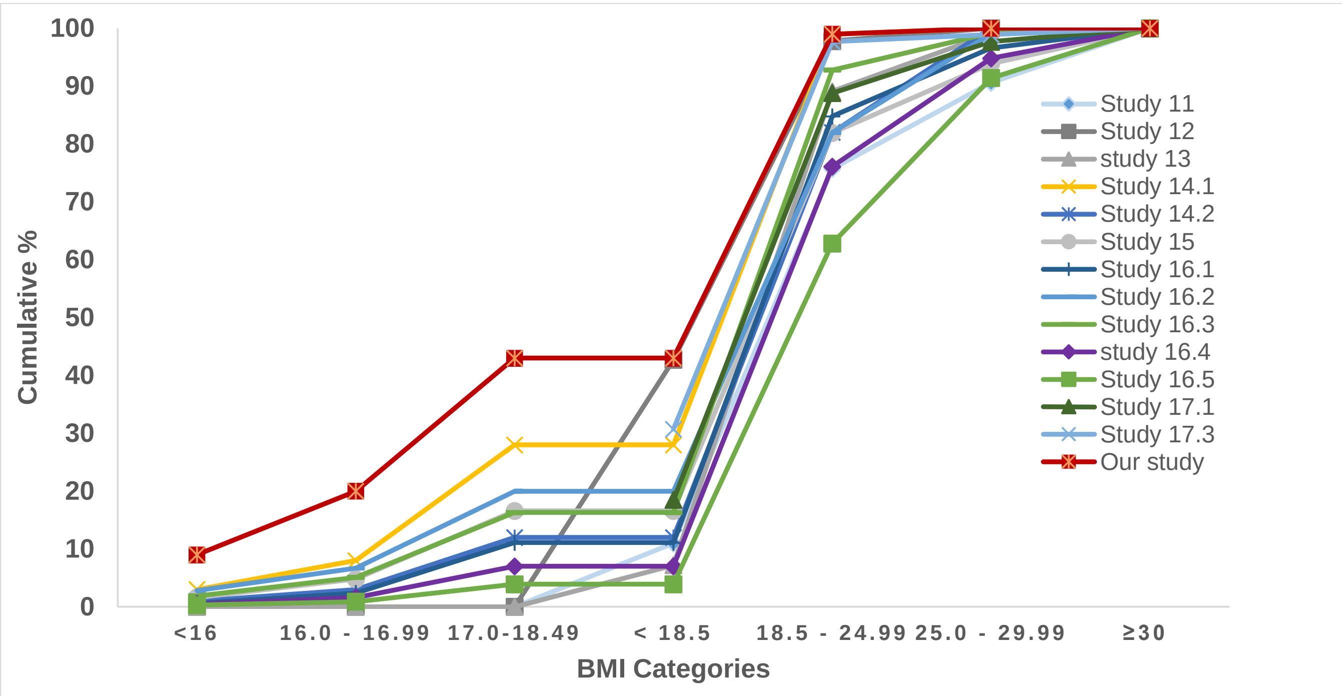


Figure 11: Cumulative distribution of BMI for our study in relation to the selected studies for women

In relation to our study high degree of underweight individuals was almost absent in Tunisia (49) and Morocco (49), with respective proportions of 3.9% and 7%. The possible reason for such huge variation could be due to the better standard of living present in that region compared to the SSA region. As displayed in figure 12, almost all (99%) of our study participants fell within or below the normal BMI range (BMI ≤ 24.99). This finding overlapped with the result of the two Ethiopian studies as well as with the study from Bandundu, whereas the finding from the Tunisian study was far from our study (62.8% of Tunsian women had BMI ≤ 24.99). The cumulative distribution of our study reached 100% within the range of BMI ≤ 27.49. Similar to our study, many other studies showed a cumulative distribution of close to or precisely 100% within the range of BMI ≤ 29.99 (ranged from 90.6 to 100%). To summarize the comparison, as seen in men our study also found one of the thinnest free-living adult women in Africa and none of the selected studies (excluding the Ethiopian study) have been documented such low BMI.

7. Discussion
7.1 Methodological discussion
Dietary intake:

This part of the study assessed the nutritional adequacy of the diet of selected households in the remote rural village of Nkay-Kalengi. During the period of data collection, a number of efforts were undertaken to ensure the data was of good quality. First, since the majority of participants were semi-literate and underage, retrospective methods of dietary assessment were unsuitable due to the potential for recall bias. Thus, in order to obtain reliable dietary data of the household a data collector taking direct measurements of food preparation and consumption during the time of the study. Therefore the WFR method, which is currently considered the most accurate method in dietary assessment (imperfect golden standard), was used to collect good quality data. Secondly, prior to study commencement, a census was made in the study area and the resulting information was used to prepare a sample frame which contained a list of all eligible households. In order to minimize selection bias, systematic sampling was subsequently used to select the study households. Thirdly, it is known that people from rural areas are more likely to be affected in their eating patterns if a foreign person stays in their home continuously recording their dietary consumption (49). This may reduce accuracy of usual intake estimates. Thus, to minimize such a bias in our study, data were collected by two trained nutritionists who had adequate knowledge about the study area's language, rules of food service, local courtesies and taboos, as well as local eating mannerisms and patterns. In addition, before data collection the purpose and methods of the study were clearly explained to all participants and they were also well informed not to alter their usual dietary patterns over the recording period of three days. Data collection time included any day of the week, with the exception of Sunday. This day was excluded because Sundays stands out as a particular day in terms of activities and food. Finally, traditionally in this area all family members eat from a common pot, with the exception of the household's father who eats alone as shown in figure 10 (57). This culture made it relatively difficult for the nutritionists to measure an individual's portion intake. Therefore, the nutritionist asked the family to separate individual's portion from the common pot. Such individual portions of each constituent of the meal were weighed using calibrated scales before consumption. Thereafter family members were served from the common pot but each individual was informed to eat only from his or her own portion i.e. from the separated portion. During the time of consumption, each individual (particularly children) was under continuous supervision not to eat from others portion. At last any leftovers from individual portion was also weighed and recorded and it value was reduced from the weight of the original individual portion to get the amount of consumed. Thus, after looking at all of the aforementioned efforts, it is more likely that the obtained data more accurately reflected that of participant consumption. Though WFR is the most accurate method and efforts were done to increase the accuracy of usual intake estimates, there are also drawbacks to the method. For example, the presence of the data collector in the participants' households during the time of food consumption might alter the feeding habit of the participants. In addition to this, the uncommon eating habit introduced (on common pot while also separating individual portions) could also affect the amount of food consumed by the children.

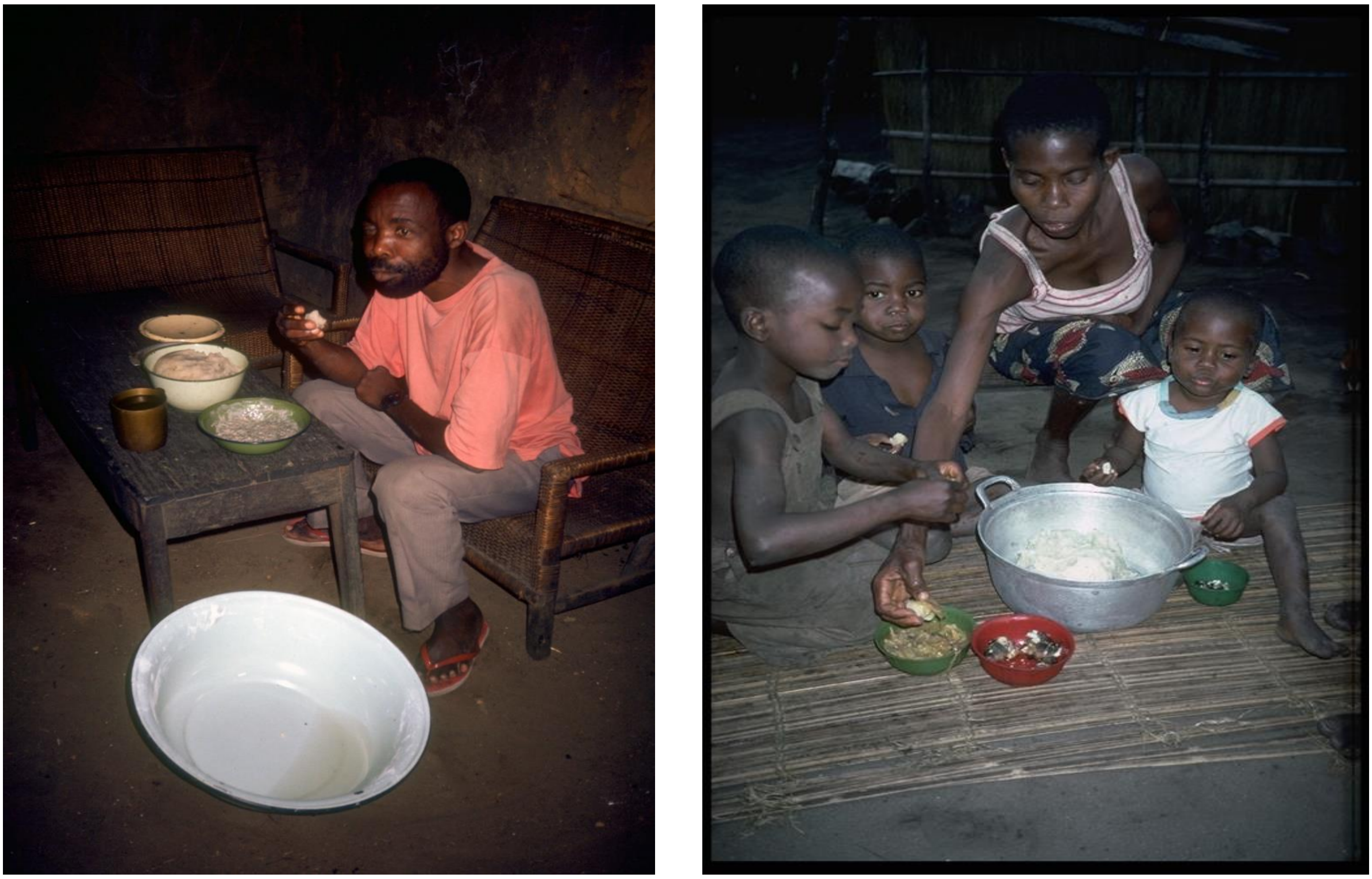


Figure 12: Traditional eating habit in the study area

BMI assessment

For BMI assessment part, neither sampling nor sample size calculations were conducted. All adult residents of Nkay-Kalengi and Indaba were included, excluding those not present on the day of data collection (n=121), hence minimizing the selection bias. Weight and height were measured using calibrated instruments and following standard anthropometric techniques to minimize measurement bias. Both weight and height data were collected consecutively and every measurement was taken by the researchers in order to minimize variability among data collectors. In short, the researchers did all their measures in accordance to internationally acceptable and standardized procedures to obtain reliable anthropometric data. Thus, we viewed this data as it documented the real height and weight of the study population. But, due to the missed data of those 121 adults (most of them males), results obtained from this data might not be directly representative of the whole adult population and therefore cannot be generalized as such.

7.2 Discussion of the main findings

I. Dietary intake

The dietary assessment from three days WFR of this study showed that protein and fat intakes were below the recommended intakes in all age groups, whereas energy (excluding EI in children which was slightly below the EER) intake was adequate in relation to the recommended intake (table 11). Similarly, the E% from protein and fat were both far below the lower limits of AMDRs (table 9). The study also assesed the E% derived specifically from cassava and its contribution was 77% of the EI in children and the contribution was equal in adolescences and adults i.e. was 81% of the EI (table 8). Thus, dietary patterns of those participants were extremely monotonous as cassava (E%) dominated the TEI of the individuals. One possible reason for this extremely monotonous diet could be due to the quality of soils present in this area. As noted before agriculture provides the main source of food in this area, however vast parts of the area are occupied by sandy soils called Ferralic Arenosols (58). These are poor soils characterized by a low clay content (<10%), a very small content of organic matter and a low PH value (acidic). Therefore the soil is deemed unsuitable for modern agriculture (56). Due to its resistance to adverse environments, cassava is the most highly harvested crop from such types of soil. Therefore it is likely that the diet of these participants was highly restricted to cassava. Ferralic Arenosols are suitable for extensive livestock farming (farming in area with low agriculture productivity), but the feeding value of savannas and steppes on these soils have mineral deficiencies or imbalances, therefore this type of farming requires feed supplements. But, residents of this area are very poor, deeming extensive livestock farming unaffordable. So, poverty could also be another reason that hampered those participants from consuming animal products. Besides the poor quality of soils and poverty, accessing to this area is also difficult especially during the rainy season due to poor transportation possibilities. As a result, this area has limited communication with the capital Kinshasa, where foods and other products can be purchased. So the poor transportation system may have also played a role in participant dietary restriction. Consequently, cassava consumption provided the principal source of macronutrients. As mentioned before, the two parts of cassava (i.e. the leaves and roots) varied in nutritional composition and constitution. The roots, which constitute 50% of mature cassava crop are rich in CHO but poor in protein, while the leaves which constitute 6% of the mature cassava crop are rich sources of protein and fat. Thus, in areas where dietary patterns are monopolized by cassava, roots are more likely to be consumed in larger amounts than the leaves due to their larger constitution of the crop. Hence, this could be the reason why intakes of protein and fat were far lower than the recommended intakes. Besides this, the cassava crops grown in this area have very tiny leaves, which might reduce the availability of the leaves in the diet. This is also another possible reason that could be related with the low protein and fat intakes.

In this study it has been reported that intakes of energy and macronutrient in all age groups were higher in males than in females, except CHO intake in adolescents was higher in females than observed in males. The probable reason for the higher intakes in adult males could be linked to the tradition of eating habits in this area i.e. where adult males (particularly fathers) eat alone, whereas other family members share food from a common pot (57). Thus, intakes could have been higher in adult men than women. On the other hand the higher CHO intake in female adolescents might be explained by the fact that household food preparation in this area was dominated by females (57). Therefore, due to this closer accessiblity to food and the ability to eat while cooking, female adolescents might have had better dietary intakes than in males.

Using the BMR factor (EI/BMR) our study also assessed whether the reported EIs were plausible in terms of individuals' energy requirements. From the individually calculated values (table 19 and 20), 19% of the participants had less than the lower limit of BMR factors i.e. < 1.35, and most of them were children. On the other side, EI of the 14% of the participants were also reported above the maximum energy required i.e. BMR factors ≥ 2.4, and majority of them were adults. The high rate of underreporting in children might be due to missing food intake data due to child feeding in neighboring houses; potentially contributing to a low BMR factor. Additionally, those children might have also been sick during the data collection time, which could have adversely affected their usual intakes, contributing to a lower BMR factor. On the other hand, the high BMR factor seen in adults might be due to the fact that majority of the adults in this area engaged in high energy demanding agricultural work. Thus, such reported energies may have been really consumed as high physical activity required high EI. So such high physical activities resulted in high EI, subsequently leading to high BMR factors (as high EI was divided by BMR). Therefore we assumed the reported EIs were less likely to be overestimated.

II. BMI assessment

In this part of the study, we assessed the BMI distribution of adults in the two remote rural villages. The study revealed that 9% of the overall adults were severely thin, 11% were moderately thin, 27% were mildly thin, 52% were in the normal weight range, 1% were overweight and no participants were obese (table 14). The probable reasons for this high prevalence of underweight individuals (nearly half) could be due to monotonous dietary patterns in the area (as seen in the 12 households). As noted before the residents of this area partake in high energy demanding work as their daily income largely banks on the subsistence agriculture. However as the area is occupied by Ferralic Arenosols soils, the subsistence agricultural are likely restricted to only a few crops such as cassava, consequently leading to monotonous dietary patterns. In such cases energy imbalances could happen (where energy expenditure exceeds energy consumed), resulting in low body weight corresponding with low BMI. Additionally, low economic development and poor access to health services are highly prevalent in this area. These problems have been exist in this area for a long period of time and are commonly experienced by the residents of this area throughout their entire lifespan (including childhood, adolescence and adulthood). Therefore, cumulative exposure to the outcomes of problems such as: poverty, infectious diseases, nutritional deprivation, and unsafe drinking water might also contribute to such low adult BMIs.

This study also investigated the socio-demographic characteristics associated with underweight status. We found a significant association with underweight status and participant age, but not in sex or residence village (table 15). Compared with age group 18-24 years, the age group ≥ 65 years was tenfold more likely to be underweight. The strong association between age and being underweight might be explained by the fact that older people are more likely to have a numbers of chronic conditions and functional impairments that could adversely affect their nutritional status. In the other age groups, although the BMI distribution varied for the younger adults, the associations with underweight status were not statistically significant. In this investigation, sex was not significantly associated with underweight status. But it was determined that women were 24% less likely to be underweight than men. The probable reason for this finding could be due to the higher absence of men during the data collection time (the majority of the 121 absentees were men). Considering the highly active lifestyle in this area, we predicted that those absent during data collection were more likely those engaging most of their time in field work. This assumption suggests their health status and corresponding body weight might be heavier compared with those who spent most of their time at home. At the end, this study revealed that underweight status was not significantly associated with residence village, which indicates that the magnitude of underweight individuals was distributed almost similarly in both villages.

8. Conclusion

Nutritional inadequacy was found a serious public health concern in this study area. Based on the dietary assessment, cassava was the main staple food constituting almost the entire diet of the population (ranged 70-95%). Consequently, nearly 80% of the particpants' energy was derived single-handedly from cassava, this implies the diet was extremely monotonous. This study revealed that the protein and fat intakes were short of the international recommended intakes in all age groups. As a result the E% generated from those macronutrients were also far lower than the lower limit of the AMDRs. However, the energy (excluding EI in children) intake was above the recommended intake. When the diet of our particpants was compared with the diet of other free-living African populations, it was shown that our study participants had the most monotonous diet. In the anthropometric assesment, the BMI distribution was extremely skewed towards thinness (nearly half of the adult population was underweight). Compared this figure with other studies, our study reported one of the slimmest free-living populations in Africa under non-war and non-famine conditions.

9. Recommendations

Operational

- The low dietary diversity and high prevalence of underweight reported in the study area indicates that immediate nutritional interventions are warranted. The government and other agencies like UN and non-governmental organization (NGO) should consider actions to alleviate the current nutritional problems. Which action that is most suitable is outside the scope of this study.
- In long term perspective, efforts to enhance agriculture diversity should be considered.
- Empowering the economic development of the population should be motivated (example by creating opportunities that could reduce poverty and improve transport).
- Efforts to use the Wamba river that flows through this area (40), for nutritional improvements should be considered.
- Efforts to enrich the diet with animal products should be considered.

For policy

- It is important that the country's line ministries (Health, Agriculture, Education and Water and Sanitation) to work hand in hand to improve the nutritional situation.

For research

- Though the living standards in the study area remain unchanged, there is need for further research to update the information on the nutritional status of the study population, because the current data was collected many years ago. The research should look into whether the nutritional situation has remained unchanged, improved or deteriorated.
- Further research should also investigate local coping strategies by the community for improving their own nutritional status.

References

1. Heaney RP. Dairy intake, dietary adequacy, and lactose intolerance. Advances in nutrition. 2013;4(2):151-6.
2. Castro-Quezada I, Roman-Vinas B, Serra-Majem L. The Mediterranean diet and nutritional adequacy: a review. Nutrients. 2014;6(1):231-48.
3. FAO, IFAD, WFP. The State of Food Insecurity in the World 2014. Strengthening the enabling environment for food security and nutrition. Rome: FAO; 2014 [12.02.2015]. Available from: http://www.fao.org/3/a-i4030e.pdf.
4. Martins VJ, Toledo Florencio TM, Grillo LP, do Carmo PFM, Martins PA, Clemente AP, et al. Long-lasting effects of undernutrition. International journal of environmental research and public health. 2011;8(6):1817-46.
5. Haileslassie K, Mulugeta A, Girma M. Feeding practices, nutritional status and associated factors of lactating women in Samre Woreda, South Eastern Zone of Tigray, Ethiopia. Nutrition journal. 2013;12:28.
6. Forrester TE, Badaloo AV, Boyne MS, Osmond C, Thompson D, Green C, et al. Prenatal factors contribute to the emergence of kwashiorkor or marasmus in severe undernutrition: evidence for the predictive adaptation model. PloS one. 2012;7(4):e35907.
7. World Health Organization. Children: reducing mortality 2013 [20.05.2014]. Available from: http://www.who.int/mediacentre/factsheets/fs178/en/.
8. Van Royen K, Lachat C, Holdsworth M, Smit K, Kinabo J, Roberfroid D, et al. How can the operating environment for nutrition research be improved in sub-Saharan Africa? The views of African researchers. PloS one. 2013;8(6):e66355.
9. Kandala NB, Madungu TP, Emina JB, Nzita KP, Cappuccio FP. Malnutrition among children under the age of five in the Democratic Republic of Congo (DRC): does geographic location matter? BMC public health. 2011;11:261.
10. FAO, IFAD, WFP. The state of Food Insecurity in the World 2010. Addressing food insecurity in protected crises. Rome: FAO; 2010 [12.02.2015]. Available from: http://www.fao.org/docrep/013/i1683e/i1683e.pdf.
11. International Food Policy Research Institute. Global Hunger Index 2011 [02.02.2015]. Available from: http://www.ifpri.org/sites/default/files/publications/ghi11.pdf.
12. Nzwalo H, Cliff J. Konzo: from poverty, cassava, and cyanogen intake to toxico-nutritional neurological disease. PLoS neglected tropical diseases. 2011;5(6):e1051.

13. Montagnac JA, Davis CR, Tanumihardjo SA. Nutritional Value of Cassava for Use as a Staple Food and Recent Advances for Improvement. Comprehensive Reviews in Food Science and Food Safety. 2009;8(3):181-94.
14. Antonsson-Ogle B GO, Hambræus L, Holmgren G, Tylleskär T. Nutrition, Adriculture and Health: when resources are scarce. second revised ed: Uppsala University, Sweden; 2000.
15. Gibson RS. Principles of nutritional assessment: Oxford university press; 2005.
16. Kigutha HN. Assessment of dietary intake in rural communities in Africa: experiences in Kenya. The American journal of clinical nutrition. 1997;65(4 Suppl):1168s-72s.
17. Tucker KL. Assessment of usual dietary intake in population studies of gene-diet interaction. Nutrition, metabolism, and cardiovascular diseases : NMCD. 2007;17(2):74-81.
18. Vucic V, Glibetic M, Novakovic R, Ngo J, Ristic-Medic D, Tepsic J, et al. Dietary assessment methods used for low-income populations in food consumption surveys: a literature review. The British journal of nutrition. 2009;101 Suppl 2:S95-101.
19. Blaney S, Beaudry M, Latham M, Thibault M. Nutritional status and dietary adequacy in rural communities of a protected area in Gabon. Public Health Nutr. 2009;12(10):1946-59.
20. Rebro SM, Patterson RE, Kristal AR, Cheney CL. The effect of keeping food records on eating patterns. Journal of the American Dietetic Association. 1998;98(10):1163-5.
21. Lennernas M. Dietary assessment and validity: To measure what is meant to measure. Food & Nutrition Research. 1998;42:63-5.
22. SAY J. Eating and drinking: nutrient and fluid requirements for health. Compendium of Clinical Skills for Student Nurses. 2006:92. Compendium of Clinical Skills for Student Nurses. 2006:92.
23. Dietary Reference Intakes: The Essential Guide to Nutrient Requirements. Otten JJ, Hellwig JP, Meyers LD, editors: The National Academies Press; 2006.
24. FAO, WHO, UNU. Human energy requirements. Report of a joint FAO/WHO/UNU Expert Consultation Rome2001 [13.02.2015].
Available from: ftp://ftp.fao.org/docrep/fao/007/y5686e/y5686e00.pdf.
25. Schofield WN. Predicting basal metabolic rate, new standards and review of previous work. Human nutrition Clinical nutrition. 1985;39 Suppl 1:5-41.
26. Johansson L, Solvoll K, Bjorneboe GE, Drevon CA. Under- and overreporting of energy intake related to weight status and lifestyle in a nationwide sample. The American journal of clinical nutrition. 1998;68(2):266-74.

27. Mendez MA, Wynter S, Wilks R, Forrester T. Under- and overreporting of energy is related to obesity, lifestyle factors and food group intakes in Jamaican adults. Public Health Nutr. 2004;7(1):9-19.
28. Gerrior S, Juan W, Peter B. An easy approach to calculating estimated energy requirements. Preventing chronic disease. 2006;3(4).
29. Contributors W. Protein: Wikipedia, The Free Encyclopedia; [13.02.2015]. Available from: http://en.wikipedia.org/w/index.php?title=Protein_(nutrient)&oldid=646939293.
30. Trumbo P, Schlicker S, Yates AA, Poos M. Dietary reference intakes for energy, carbohydrate, fiber, fat, fatty acids, cholesterol, protein and amino acids. Journal of the American Dietetic Association. 2002;102(11):1621-30.
31. Dietary Reference Intakes (DRIs): Estimated Average Requirements [14.02.2015]. Available from: http://www.nal.usda.gov/fnic/DRI/DRI_Tables/recommended_intakes_individuals.pdf.
32. Contributors W. Fat: Wikipedia, The Free Encyclopedia; [14.02.2015]. Available from: http://en.wikipedia.org/w/index.php?title=Fat&oldid=646495828.
33. Contributors W. Carbohydrate: Wikipedia, The Free Encyclopedia; [14.02.2015]. Available from: http://en.wikipedia.org/w/index.php?title=Carbohydrate&oldid=645468610.
34. Lindstrand A, Rosling H. Global Health: An Introductory Textbook: Studentlitteratur; 2006.
35. McDowell MA, Statistics NCfH. Anthropometric reference data for children and adults: US population, 1999-2002: US Department of Health and Human Services, Centers for Disease Control and Prevention, National Center for Health Statistics; 2005.
36. WHO. Global Database on Body Mass Index: BMI classification and an interactive surveillance tool for monitoring nutrition transition [03.03.2015]. Available from: http://apps.who.int/bmi/index.jsp?introPage=intro_3.html.
37. Daniels SR. The use of BMI in the clinical setting. Pediatrics. 2009;124(Supplement 1):S35-S41.
38. Diasolua Ngudi D, Banea-Mayambu JP, Lambein F, Kolsteren P. Konzo and dietary pattern in cassava-consuming populations of Popokabaka, Democratic Republic of Congo. Food and chemical toxicology : an international journal published for the British Industrial Biological Research Association. 2011;49(3):613-9.
39. Contributors W. Bandundu province: Wikipedia, The Free Encyclopedia; [24.05.2014]. Available from: http://en.wikipedia.org/w/index.php?title=Bandundu_Province&oldid=609242808.
40. Tshala-Katumbay D, Banea-Mayambu J, Kazadi-Kayembe T, Nunga-Matadi R, Bikangi-Nkiabungu F, Edebol Eeg-Olofsson K, et al. Neuroepidemiology of konzo – a spastic

para/tetraparesis of acute onset in a new area of the Democratic Republic of Congo. African Journal of Neurological Sciences. 2001;20:pp.8-12.

41. L'Harmattan. Aliments et denrées alimentaires traditionnels du Bandundu en R.D. Congo: répertoire et composition en nutriments [15.03.2015]. Available from: http://www.editions-harmattan.fr/index.asp?navig=catalogue&obj=livre&no=41210.
42. FAO. Food composition table for use in Africa. Rome: FOA; 1968 [03.05.2015]. Available from: http://www.fao.org/docrep/003/x6877e/x6877e00.htm.
43. Black AE. Critical evaluation of energy intake using the Goldberg cut-off for energy intake: basal metabolic rate. A practical guide to its calculation, use and limitations. International journal of obesity and related metabolic disorders: journal of the International Association for the Study of Obesity. 2000;24(9):1119-30.
44. Aveyard H. Doing a literature review in health: McGraw-Hill Education; 2007.
45. McAfee AJ, Mulhern MS, McSorley EM, Wallace JM, Bonham MP, Faure J, et al. Intakes and adequacy of potentially important nutrients for cognitive development among 5-year-old children in the Seychelles Child Development and Nutrition Study. Public health nutrition. 2012;15(9):1670-7.
46. Ponka R, Fokou E. Dietary intake, zincemia and cupremia of Cameroonian schoolchildren of Ngali II. International journal of food sciences and nutrition. 2011;62(4):377-84.
47. Mitchikpe CE, Dossa RA, Ategbo EA, Van Raaij JM, Kok FJ. Seasonal variation in food pattern but not in energy and nutrient intakes of rural Beninese school-aged children. Public health nutrition. 2009;12(3):414-22.
48. Gibson RS, Abebe Y, Hambidge KM, Arbide I, Teshome A, Stoecker BJ. Inadequate feeding practices and impaired growth among children from subsistence farming households in Sidama, Southern Ethiopia. Maternal & child nutrition. 2009;5(3):260-75.
49. Gewa CA, Murphy SP, Neumann CG. A comparison of weighed and recalled intakes for schoolchildren and mothers in rural Kenya. Public health nutrition. 2009;12(8):1197-204.
50. MacIntyre UE, Venter CS, Vorster HH. A culture-sensitive quantiative food frequency questionnaire used in an African population: 2. Relative validation by 7-day weighed records and biomarkers. Public health nutrition. 2001;4(1):63-71.
51. Gomes A, Damasceno A, Azevedo A, Prista A, Silva-Matos C, Saranga S, et al. Body mass index and waist circumference in Mozambique: urban/rural gap during epidemiological transition. Obesity reviews : an official journal of the International Association for the Study of Obesity. 2010;11(9):627-34.

52. Tesfaye F, Nawi NG, Van Minh H, Byass P, Berhane Y, Bonita R, et al. Association between body mass index and blood pressure across three populations in Africa and Asia. Journal of human hypertension. 2007;21(1):28-37.
53. Cilliers J, Senekal M, Kunneke E. The association between the body mass index of first-year female university students and their weight-related perceptions and practices, psychological health, physical activity and other physical health indicators. Public Health Nutr. 2006;9(2):234-43.
54. James WPT, Ferro-Luzzi A, Sette S, Mascie-Taylor CGN. The potential use of maternal size in priority setting when combating childhood malnutrition. European Journal of Clinical Nutrition. 1999;53(2):112-9.
55. Nube M, Asenso-Okyere WK, Van Den Boom GJM. Body mass index as indicator of standard of living in developing countries. European Journal of Clinical Nutrition. 1998;52(2):136-44.
56. Bailey KV, Ferro-Luzzi A. Use of body mass index of adults in assessing individual and community nutritional status. Bulletin of the World Health Organization. 1995;73(5):673-80.
57. Bentley GR, Aunger R, Harrigan AM, Jenike M, Bailey RC, Ellison PT. Women's strategies to alleviate nutritional stress in a rural African society. Social Science & Medicine. 1999;48(2):149-62.
58. FAO U. Soil map of the world 1997 [9.04.2015].

Available from: http://www.fao.org/docrep/019/as357e/as357e.pdf.

Appendixes

Table 19: Different aspects of energy consumed in relation to age and weight for child and adolescent study participants in Nkay-Kalengi (n=33).

	Age (years)	Weight (kg)	BMR[a] (Kcal)	Average daily energy consumed (Kcal)	BMR-factor	PAL[b]	EER[c]	Proportion of EER consumed (%)
Male 3-9 years	4	13.8	808	1070	1.32		1216	88
	4	15.5	833	1766	2.12		1757	101
	5			994				
	6	15.0	840	1012	1.20		1031	98
	7	19.3	933	1455	1.56		1400	104
	7	16.9	879	1409	1.60		1491	95
	7	16.2	865	1369	1.58		1472	93
	8	17.6	895	1312	1.47		1277	103
	8	13.3	798	1272	1.59		1244	102
Female 3-9 years	4	13.5	802	866	1.08			
	4	11.3	753	870	1.16		960	91
	4	12.1	771	932	1.21		995	94
	5	13.4	801	1536	1.92			
	5	13.5	803	819	1.02		977	84
	6	13.8	810	1599	1.98		1498	107
	7	11.2	747	821	1.10		892	92
	7			1498				
	8	16.8	876	1393	1.59			
Male 10-17 years	10	22.0	1045	1642	1.57		1589	103
	10	20.8	967	2302	2.38		1886	122
	11	13.5	886	1196	1.35			
	11	19.8	1106	2569	2.32		1695	152
	11	21.8	990	2282	2.31			
	13	23.6	1064	3435	3.23		2488	138
	15	24.5	1080	1394	1.29		1220	114
	16	21.3	1024	1502	1.47		1087	138
	16	31.6	1246	2391	1.92		2136	112
Female 10-17 years	10	19.3	929	2153	2.32		1927	112
	11	24.8	1049	1288	1.23			
	13	29.3	1105	1576	1.43		1627	97
	15	35.8	1257	2677	2.13		2386	112
	15	36.5	1134	1468	1.29		1639	90
	16	29.6	1107	2765	2.50			

[a] Basic metabolic rate, [b] Physical activity level, [c] Estimated Energy Requirement,

Table 20: Different aspects of energy consumed in relation to age and weight for adult study participants in Nkay-Kalengi (n=37).

	Age (years)	Weight (kg)	BMR[a] (Kcal)	Average daily energy consumed (Kcal)	BMR factor	PAL[b]	EER[c]	Proportion of EER consumed (%)
Male	22	49.1	1430	2284	1.6		2506	91
18-61 years	27	46.9	1472	3683	2.5			
	27	48.4	1420	2308	1.63			
	28	54.6	1514	2954	1.95		3063	96
	28	53.2	1493	2348	1.57			
	34	54.8	1517	4285	2.82			
	35	44.8	1399	2082	1.49			
	37	59.9	1574	2135	1.36		2364	90
	39	47.6	1431	3098	2.16		2672	116
	39	45.2	1403	2277	1.62		2315	98
	39	54.7	1514	2646	1.75			
	42	51.9	1481	3443	2.32			
	51	45.7	1409	1936	1.37		1750	111
	54	47.0	1424	2089	1.47			
	56	49.5	1453	4060	2.79		2613	155
	61	34.7	956	2479	2.60		2056	121
Female	19	35.9	1024	1592	1.55	1.96	2006	79
18-61 years	19	41.6	1108	2576	2.33		2440	106
	21	34.0	996	1751	1.76		1893	92
	21	46.5	1234	3598	2.92		2392	150
	22	59.9	1377	2353	1.71	1.73	2405	98
	23	45.6	1166	2982	2.56			
	24	39.8	1081	2483	2.30	2.05	2216	112
	26	35.2	1013	1466	1.45	1.95	1975	74
	28	38.9	1068	1802	1.69	1.68	1962	92
	29	42.6	1122	3588	3.20			
	29	41.7	1042	1747	1.68	1.98	2052	85
	31	51.6	1278	1524	1.19	1.68	2147	71
	34	47.3	1240	1983	1.60	1.41	2148	92
	37	40.5	1181	2665	2.26		2210	121
	38	53.8	1297	2337	1.80	1.96	2542	92
	39	45.9	1228	1639	1.33		1910	86
	45	40.0	1177	1885	1.60	2.08	2448	77
	50	45.7	1227	1600	1.30			
	53	53.3	1293	2803	2.17	1.88	2393	117
	58	43.9	1211	2023	1.67			
	60	44.9	1068	2971	2.78		2090	142

[a] Basic metabolic rate, [b] Physical activity level, [c] Estimated Energy Requirement,

Table 21: Dietary content in relation to age and weight for child and adolescent study participants in Nkay-Kalengi (n=33).

	Age (years)	Weight (kg)	Average protein consumed (g)	Average protein consumed (E %)	RDA[a] protein (g)	Average fat consumed (g)	Average fat consumed (E %)	Average CHO[b] consumed (g)	Average CHO consumed (E %)
Male 3-9 years	4	13.8	14.9	6	19	15.1	13	210	78
	4	15.5	16.3	4	19	21.2	11	371	84
	5		13.6	5	19	21.4	19	142	57
	6	15.0	15.7	6	19	23	20	165	65
	7	19.3	15.5	4	19	15.9	10	242	66
	7	16.9	11.8	3	19	15.2	10	291	83
	7	16.2	9.1	3	19	4.3	3	244	71
	8	17.6	20.8	6	19	42.4	29	274	83
	8	13.3	15.1	5	19	8.1	6	279	88
Female 3-9 years	4	13.5	13.8	6	19	20.6	21	160	74
	4	11.3	5.6	3	19	1.6	2	88	40
	4	12.1	13.8	6	19	10.8	10	193	83
	5	13.4	8.5	2	19	7.6	4	352	92
	5	13.5	8.5	4	19	7.9	9	78	38
	6	13.8	24.7	6	19	15.7	9	336	84
	7	11.2	20.0	10	19	27.1	30	126	61
	7		22.1	6	19	34	20	207	55
	8	16.8	9.0	3	19	3.2	2	192	55
Male 10-17 years	10	22	14.8	3.6	34	7.7	4	245	60
	10	20.8	21.1	3.7	34	35.6	14	467	81
	11	13.5	25.4	8.5	34	37.2	28	192	64
	11	19.8	42.0	6.5	34	33	12	295	46
	11	21.8	34.8	6.1	34	44	17	428	75
	13	23.6	45.9	5.3	34	37.4	10	165	38
	15	24.5	13.6	3.9	52	19.9	13	278	80
	16	21.3	15.8	4.2	52	21.4	13	301	80
	16	31.6	26.3	4.4	52	38.5	14	477	80
Female 10-17 years	10	19.3	17.5	3.3	34	18.6	8	422	78
	11	24.8	7.7	2.4	34	4.4	3	195	61
	13	29.3	14.6	3.7	34	20.7	12	309	78
	15	35.8	28.5	4.3	46	34.8	12	553	83
	15	36.5	14.8	4.0	46	9.8	6	325	89
	16	29.6	23.2	3.4	46	18.2	6	550	80

[a] Recommended Dietary Allowance,. [b]Carbohydrates

Table 22: Dietary content in relation to age and weight for adult study participants in Nkay-Kalengi (n=37).

	Age (years)	Weight (kg)	Average protein consumed (g)	Average protein consumed (E %)	RDA[a] protein (g)	Average fat consumed (g)	Average fat consumed (E %)	Average CHO[b] consumed (g)	Average CHO consumed (E %)
Male 18-61 years	22	49.1	12.5	2	56	12.8	5	522	91
	27	46.9	61.4	7	56	82.6	20	584	63
	27	48.4	13.0	2	56	20.4	8	261	68
	28	54.6	24.8	3	56	19.8	6	653	88
	28	53.2	15.0	3	56	20.6	8	284	48
	34	54.8	38.9	4	56	71.6	15	849	79
	35	44.8	14.8	3	56	18.2	8	343	66
	37	59.9	17.7	3	56	21.6	9	459	86
	39	47.6	28.7	4	56	26.3	8	666	86
	39	45.2	45.9	8	56	63.2	25	291	51
	39	54.7	15.9	2	56	26.5	9	577	87
	42	51.9	48.6	6	56	123.4	32	856	99
	51	45.7	11.1	2	56	19.8	9	422	87
	54	47	28.6	5	56	22	9	278	53
	56	49.5	52.4	5	56	68.4	15	796	78
	61	34.7	31.7	5	56	22.4	8	462	74
Female 18-61 (years)	19	35.9	15.0	4	46	15.7	9	339	85
	19	41.6	33.5	5	46	46.2	16	420	65
	21	34	15.6	4	46	19.9	10	372	85
	21	46.5	40.2	4	46	59.8	15	714	79
	22	59.9	25.2	4	46	35.4	14	431	73
	23	45.6	22.7	3	46	37.2	11	545	73
	24	39.8	13.7	2	46	13.8	5	566	91
	26	35.2	23.8	6	46	10.3	6	316	86
	28	38.9	37.4	8	46	54.8	27	292	65
	29	42.6	47.9	5	46	67	17	610	68
	29	41.7	11.1	3	46	17.2	9	381	87
	31	51.6	19.6	5	46	19.3	11	307	81
	34	47.3	16.2	3	46	20.5	9	426	86
	37	40.5	21.9	3	46	31.3	11	490	74
	38	53.8	42.2	7	46	54.7	21	411	70
	39	45.9	21.6	5	46	30.9	17	303	74
	45	40	24.1	5	46	15.5	7	402	85
	50	45.7	9.5	2	46	11.2	6	359	90
	53	53.3	25.9	4	46	34.5	11	588	84
	58	43.9	17.7	4	46	14.3	6	386	76
	60	44.9	32.7	4	46	44.4	13	543	73

[a] Recommended Dietary Allowance,. [b]Carbohydrates

I. Critically appraisal using STROBE checklist for articles selected in the review regarding assessment of dietary intake

Study 1: ***Feeding practices, nutritional status and associated factors of lactating women in Samre Woreda, South Eastern Zone of Tigray, Ethiopia***

1. Tittle and abstract:
   - Abstract gives clear description of the study's design i.e. community based cross-sectional survey.
   - Structured abstract: *Background, Objectives, design, setting, methods, results and conclusion.* It provided detailed and thorough information on study focus and findings.
2. Background/Rationale:
   - Gives good, general scientific background of the topic.
   - Cites and references previous studies in the text.
   - Rationale of the study was stated, although could be more clearly defined (e.g. why the study conducted in this area?)
3. Objectives: Both general and specific objectives were stated.
4. Main elements of the study were presented early in the paper and design was appropriate for aim of the study.
5. Setting, location and dates of the study were clearly described.
6. Eligibility criteria, sources and methods of selection were given.
7. Study clearly defined outcomes (intakes below recommended were considered as inadequate), potential confounder (land size, family size, length of marriage, education, age of the breastfeed child, growing maize, number of gravity, own farm animals and number of meals) were clarified.
8. Data sources and methods of assessment (1-day WFR and anthropometric measurements) were adequately explained.
9. Effort to address bias: study was community based approach, households and subjects were selected randomly, and thus sample was more likely to be representative of the entire population. Mothers were also well convinced not to change their normal feeding patterns and to eat separately. Besides these, calibrating of utensils and standardizing of anthropometric techniques were also performed. However data were collected for only one day that might affect the accuracy of the data (intakes patterns might change in that day, thus it lead to either underestimation or overestimation).

10. Sample size calculation for the whole study (400 lactating mother) was clearly explained (using single population proportion formula with a 95%CI, 5% margin of error, and 38% estimated prevalence of chronic intakes deficiency and considering 10% non-response rate.
    Dietary data was collected from randomly selected sub sample of the participants (60 women) using 1 day WFR.
11. Quantitative variables: data from WFR were changed to energy and nutrients using Ethiopian food composition table and ESHA food processor.
12. All statistical methods used in the analysis were described: socio-economic and demographic factors effects on the nutritional status of the women were investigated and mean difference in intakes among subjected were tested. BMI distribution of the entire sample (400) were also calculated. Median (25 th and 75 th percentile) of nutrient intake of the mothers were compared with recommended nutrient intakes.
13. Subject's numbers were reported and were 100% participation rate.
14. Demographic characteristics (age, educational status, religion, family size, household head and marital status) were described
15. Outcome numbers reported in relation to recommended dietary intakes
16. Adjustments were done to see the association between socio-demographic variable and nutritional status and 95% CI were tabulated ,crude and adjusted odds ratio were calculated.
17. Key finding of the study were summarized with reverence to study objectives.
18. Limitations of the study were discussed
19. Careful interpretation of results in consideration to objectives, limitations and results from other studies were given.
20. Generalizability of the study was discussed (external valid).
21. Sources of funding and role of the funder were discussed.

Study 2: ***Intakes and adequacy of potentially important nutrients for cognitive development among 5-year-old children in the Seychelles Child Development and Nutrition Study***

1. Tittle and abstract:
    - The abstract indicated study design with common term i.e. follow-up (longitudinal).
    - Structured abstract provided detailed and thorough information of what was done and what was found, without including too much information.
2. Background/Rationale
    - Gives general scientific background of the topic and cites previous findings.

- Rationale was stated clearly.

3. Objectives: Only the general objective is stated not the specific objectives.
4. Study design was appropriate for the aim of the study.
5. Setting, location and dates of the study were clearly described.
6. Eligibility criteria, sources and methods of selection were explained in other previous study and reference was provided for that study.
7. Source of data and method of assessment (4 days WF diaries) described clearly and UK EAR (Estimated Average Requirement) for children in aged 4-6 was used as standard.
8. No effort to address potential sources of bias: dietary intakes were assessed using two different weighed food diaries, one recorded by child's parent or caregiver and other by child's teacher, thus social desirability bias, measuring variation and miss to weigh could happen, which all could be sources of potential bias.
9. No information on how the sample size was calculated.
10. The way quantitative variables handled in the analysis were explained (data collected by WF diaries were converted to energy and nutrient using food composition table and then energy intake and energy expenditure were calculated using age -and -sex specific equation).
11. Statistical methods were described clearly, in order to correct intra- and inter-individual intake variability, adjustment was carried out and then adjusted nutrient intake were compared with EAR according to UK DRV (Dietary Reverence Value), which could help to control for confounding. There were subjects with underreporting food diaries, so assessment of the cohort was performed two times for both sex, first including under-reporter (270 subject) and second excluding them (180 subjects). After that comparison were done between the two assessments and underreporting did not show any effect in dietary intake.
12. Subjects' number reported for both sex. Reasons for underreporting were not mentioned and no flow diagram.
13. Demographic characteristics were given (age, sex, height and weight).
14. Summary of the findings were presented
15. Both unadjusted and adjusted dietary intake compared with the UK EAR as a cut-off point were presented.
16. Key results were summarized adequately with reference to study objective.
17. Limitations of the study were discussed, i.e. Weighing of all food was not possible and the absence of DRV for the Seychelles.
18. No discussion about external validity (generalizability).
19. Sources of funding and collaborators were acknowledged.

Study 3: ***Dietary intake, zincemia and cupremia of Cameroonian schoolchildren of Ngali II***

1. Tittle and abstract:
    - Study's design was not mentioned and even not clears in the title and abstract.
    - Abstract provided too short information and was unstructured.
2. Background/Rationale
    - Gives general scientific background of the topic and cites previous findings.
    - Rationale of the study was stated, but indirect way.
3. Objectives: Only the general objective was stated not the specific objectives.
4. Study design was not described appropriately even in the methods.
5. Setting and location were mentioned, but relevant dates were not described.
6. Eligibility criteria, methods of selection were not mentioned but study size was given.
7. Source of data and method of assessment (7 day measured inventory of food and drink).
8. Daily visit were made to subjects home to check that diaries were completing accurately and to keep them motivated which could minimize information bias.
9. No information on how the sample size was arrived at.
10. The quantitative variables were changed to nutrient using Ngali II food composition table and subjects were divided in to two age group (7-9 and 10-18) according to their nutrient need.
11. Statistical methods were described in a very short way and it was not adequately.
12. Results: Subjects' numbers were reported.
13. Demographic characteristics only age and sex were given.
14. Summary of the result were presented separately for dry and rainy season in comparison to reference value.
15. Key results were not summarized adequately with reference to study objective. Study results were compared with only few other results from similar studies.
16. Limitations of the study were not discussed.
17. No discussion about generalizability of study results.
18. Sources of funding and the role of authors were mentioned.

Study 4: ***Seasonal variation in food pattern but not in energy and nutrient intakes of rural Beninese school-aged children***

1. Tittle and abstract:
    - Study's design was not mentioned and even not clears in the title and abstract.

- Abstract was informative and balanced about what was done and what was found without too much information and was structured.

2. Background/Rationale
   - General scientific background of the topic was described well.
   - Rationale was stated clearly.
3. Objectives: General and specific objectives stated.
4. Study design was described in the early of the methods, i.e. longitudinal study.
5. Setting, location, dates (including time of follow-up) were described.
6. Participants eligibility criteria were not mentioned, but methods of selection and the source were mentioned (from the local birth registry randomly selected).
7. Source of data and method of assessment (3 day weighed records) were given.
8. Effort to address potential biases: participants were selected randomly from local birth registry, measurements were performed by well-trained local assistants every day from 07:00 to 21:00, and food consumed between 21:00-07:00 was also assessed by recall using local household measures. Mothers were also convinced to serve their children on a separate plate. Thus, all these efforts could help in accuracy of weighing the food intake.
9. No information on how the sample size was arrived at.
10. The way quantitative variables handled were explained .Energy and nutrient intake were calculated using Benin food composition table and mean intake values were obtained by averaging intake over three consecutive days.
11. Statistical methods were described well, energy and nutrient intake were presented for both sex in both post-and pre- harvest seasons. No information on how missed data handled.
12. Results: Subjects' numbers were reported. No information for those non-participants (5 subjects).
13. Demographic characteristics (age, sex and school attendance) were given.
14. Summary of the result were presented for both pre and post-harvest. And comparison of nutrient intake was done in relation to seasons and school attendance.
15. Key results were summarized in discussion adequately with the help of figures.
16. Limitations of the study were not mentioned.
17. Cautious interpretations of the overall findings were done and study findings were compared with other similar studies findings.
18. Generalizability of study results was not mentioned.
19. Sources of funding and the role of authors were mentioned.

Study 5: ***Inadequate feeding practices and impaired growth among children from subsistence farming households in Sidama, Southern Ethiopia***.

1. Tittle and abstract:

- Study design was not described in the tittle or in the abstract.
- Unstructured abstract summarized what was done and what was found in the study.

2. Background/Rationale: good scientific background information were given. Rationale of the study was stated clearly.
3. Both general and specific objectives of the study were mentioned.
4. Main elements of study design were presented. Study design was cross-sectional.
5. Setting, locations and dates of the study were mentioned
6. Eligibility criteria (children from mother with multiple pregnancies and children with evidence of chronic illness were excluded). Subjects aged 6-23 months were selected by convenience sampling.
7. Source of data and method of assessment were mentioned (for three communities' socio-demographic status, anthropometry, and breastfeeding, complimentary feeding practice using one-day WFR and motor development milestones.
8. To minimize potential bias:Training of data collectors prior the study started, continuous supervision during data collection and calibrating of equipment's and standardizing of techniques were done. But, convenience sampling was used to select participants, in which the method is criticized by sampling bias and sample might not represent for the entire population. Thus, external validity of the study become too low.
9. No information on sample size arrival.
10. The quantities of the WFR were changed in to nutrients. Samples of the complimentary food were collected and analyzed in New Zealand using flame atomic absorption spectrometry for calcium, zinc and iron contents. Analysis of data for energy, protein, vitamin B and C were compiled from Ethiopian food composition tables. Breast milk were assumed an average intakes and composition, except for vitamin A was assumed.
11. Statistical methods used were described, children were classified in to two according Z-scores for length-for-age (LAZ) and differences in energy intake and millstone were assessed Mann-Whitney U test.
12. Individuals numbers were reported (97, (52 males and 45 females)), there were 100% response rate. However three children were excluded from the final sample and reasons were mentioned.

13. Anthropometrical measurement and Z-score, adequacy of energy and nutrient intakes and micronutrients densities for three age groups were calculated. The energy and nutrient intakes were compared with FAO\WHO \UNU recommended need.
14. Demographic characteristics of the children were mentioned.
15. Children were classified in two groups (stunted and non-stunted) based on LAZ, then 95% CI or *P* value were tabulated to see if there were differences in anthropometric indices, energy intakes and milestones of these groups, together with maternal anthropometric and socio-economic status variables.
16. Key finding of the study were summarized well according to study objectives and findings were compared with other similar studies.
17. Limitations of the study were discussed (sample was not representative).
18. Results were carefully interpreted, by considering objectives, limitations and findings from other study.
19. Generalizability of the study was discussed (study has no external validity).
20. Sources of funding and role of the funder were mentioned.

Study 6: ***A comparison of weighed and recalled intakes for schoolchildren and mothers in rural Kenya. Public health nutrition***

1. Tittle and abstract:
   - The abstract indicate study's design and was structured.
   - Abstract provided adequate information of what was done and what was found.
2. Background/Rationale: Too short and less informative background. Rational of the study stated fairly good.
3. Objectives of the study were stated (both general and specific).
4. Study design is appropriate for the aim of the study
5. Setting, location and dates of data collection were described
6. Source and methods of selection were mentioned but not eligibility criteria.
7. Source of data and method of assessment (24 h recall and 1 day WFR) described clearly. Validity comparison between two assessment methods were done
8. Some efforts to address potential biases were done like training of enumerator and calibrating of scales and using validated protocol of WFR (proved by other studies). But there were also problems which causes bias like the sampling method used i.e. convenient sampling which is less likely to get representative population and hard to generalize) and

during schooling time food consumed by the children during were estimated by recall methods not by WFR.

9. All grade one students were used as a sample size, no calculation was done.
10. The way quantitative variables handled were explained. Amount from WFR and 24 were changed to energy and nutrients using food composition table for use in Kenya.
11. Statistical analysis used were described clearly, difference between two methods and the presence of any systematic bias were examined using statistical methods.
12. Numbers of subjects were reported separately for children and mothers.
13. Demographic characteristics were not reported all (only age of the children). There were no missing data.
14. All the results regarding the validity comparisons of the two methods were presented in the form of tables and figures.
15. Key results were summarized with reference to aims of the study.
16. Limitations of the two methods were discussed by putting in consideration for potential bias.
17. Good interpretations of the study findings were presented and comparison was made with other studies findings.
18. No discussion about generalizability of the study.
19. Sources of funding and collaborators were acknowledged.

Study 7: ***Nutritional status and dietary adequacy in rural communities of a protected area in Gabon***

1. Tittle and abstract:
   - Pointed out study's design i.e. community based survey.
   - Structured abstract presented summary information of the study.
2. Background/Rationale: Explained general background information of the topic and cites previous studies findings. Rationale of the study was stated.
3. Specific objective including pre-specified hypothesizes were stated.
4. Study design was presented and was appropriate for the aim of the study.
5. Setting, location and relevant dates (data collection) were described adequately.
6. Eligibility criteria: villages were selected using non-randomly sampling and selected villages were assigned to four strata, within each stratum, most populated were selected.
7. Source of data and method of assessment (7 days WFR) were given.

8. A numbers of efforts were done to avoid potential bias: Like, the principal investigator had spent some time prior the study in order to inform (not to change their way eating in the study) the population and to invite the households to participate. Training of surveyors and standardization of data collection instruments were done. The survey was carried out for 7 days in two major seasons (14 days in total). But, villages were selected using non-randomly sampling methods which could be sources for biases and made the study not to have external validity.
9. No sample size calculation was done; all residents of the villages were included.
10. The way quantitative variables handled in the analysis were explained (anthropometric measurements were taken, and prevalence of inadequacy intake, satisfaction of nutrient requirement were and nutrient adequacy were estimated from the WFR data.
11. Statistical methods were described clearly, finding in each strata (continental and coastal villages) were presented separately in both seasons.
12. Subjects number were presented in each of the study and reason for no-participation were given (those unwilling to weighed their intakes were excluded and left before the survey the completion of the survey).
13. Demographic characteristics were given (age, sex, village, and schooling).
14. Summary of the findings were presented, prevalence of inadequate intake, nutrient intake and satisfaction of requirements and nutrient adequacy were estimated by adjusting their age, sex and location.
15. Analysis was also performed to see the association between nutritional status, nutrient adequacy and health status.
16. The limitations of the study were discussed in relation to source of bias (non-random sampling)
17. Good interpretations of the study results were present by putting a consideration to the objectives and drawbacks of the study.
18. No discussion about generalizability of the study.
19. Sources of funding and role of funders were presented.

Study 8: ***A culture-sensitive quantitative food frequency questionnaire used in an African population: 2. Relative validation by 7-day weighed records and biomarkers***

1. Tittle and abstract:
    - Study design described in the abstract i.e. cross-sectional.

- Structured abstract described what was done and what was found in the study.

2. Background/Rationale: scientific background information was given. Rationale of the study was stated in indirect way (lack of stringent procedures for testing validity of dietary assessment instrument for use in Africa).
3. Objective of the study was mentioned.
4. Key elements of the design were described.
5. Only the location of the study was mentioned, no information on setting and relevant dates.
6. Eligibility criteria and methods of selection were not mentioned, the only information was that participants were recruited from other study (THUSA).
7. Source of data and method of assessment (quantitative food frequency questionnaire, 7-day WF diaries and 24-hour urinary nitrogen) were given.
8. Efforts to address potential bias were done: Subjects recorded intakes for 7 consecutive days, instructions were given on how to complete the diaries and how to use measuring scaled equipment. But in selecting of participants no efforts were done to make them representative (volunteers without any sampling method were included). Diaries were completed by participant themselves, thus more likely to have social desirability bias.
9. No sample size calculation was done, 85 for WR diaries and 104 for 24-hour urinary nitrogen volunteers were recruited.
10. The way quantitative variables handled were explained (nutrient analyses were done by the Food Finder program and PABA content of the urine specimens was analyzed by chromatography).
11. All statistical methods used were described; average energy and nutrient intakes from quantitative food frequency questionnaire (QFFQ) were compared with WR diaries.
12. Subjects number with complete 7-day weighed food diaries were presented (74 subject). No information was on those 11 no-participants.
13. Demographic characteristics (sex, income level, place of residence) were mentioned.
14. Summary of the findings were presented.
15. Main results obtained from QFFQ and WR were compared for their difference (95% CI were tested if the difference is statically significant). Bland-Altman plot was also used to describe the level of agreement and the presence of proportional bias between the two assessment methods. None of the plot showed proportion bias.
16. Under reporters were identified by a ratio of EI: BMR of less 1.2 or a UN: NI of greater than one.

17. Key findings of the study were summarized well according to study objectives and findings were compared with other similar studies.
18. No discussion about limitations of the study.
19. Good interpretation of the study finding was given in relation to other study findings.
20. Generalizability of the study was discussed, but not clears enough.
21. Sources of funding and role of the funder were mentioned.

Study 9 and 10: ***Assessment of dietary intake in rural communities in Africa: experiences in Kenya***

1. Tittle and abstract: Study design was not mentioned either in tittle or in abstract.
2. Unstructured abstract with inadequate summary of the study.
3. Background/Rationale: scientific background information was given and rationale of the study stated broadly.
4. Objectives of the study were mentioned (both general and specific objectives).
5. The study design was not mentioned throughout the entire paper.
6. Setting, location and relevant dates (including period and duration) of the study were described.
7. Sources and methods of selection of subjects (randomly selected) were mentioned, but eligibility criteria were not described.
8. Source of data and method of assessment (24- h recall and 3 day WFR) were given.
9. Efforts to address potential bias: A pilot study was carried out for three months for identifying, standardizing and coding of local utensils. Besides this training of data collectors were carried out. In the main study, data were collected in the some way of the pilot study.
10. No clues on how sample size was arrived at.
11. The weights of foods consumed by subjects were converted to nutrients using food composition table for use in Africa.
12. Statistical methods were not described adequately (too very short).
13. The study was conducted in three periods (two lean seasons and one harvest seasons) and in all periods, numbers of subjects were reported. These with incomplete three days food records were excluded and no information was given for why they didn't complete the WFR.
14. Energy and nutrient intakes of both preschoolers and elderly were reported in three periods.
15. No demographic characteristics of the subjects were given.
16. Energy and nutrient intakes were adjusted in three periods of seasons.

17. Limitations of the study were not discussed.
18. No results interpretation.
19. No discussion on the external validity of the study.
20. No information about funding of the study.

Note: we gave the last study two number (9 and 10) because it presented intakes of the preschool children and elderly separately.

II. Critically appraisal using STROBE checklist for articles selected in the review regarding BMI assessments

Study 11: ***Body mass index and waist circumference in Mozambique: urban/rural gap during epidemiological transition***

1. Tittle and abstract:
   - Study design was not descried either in the tittle or in the abstract.
   - Unstructured abstract provided a summary of the study without including too much information.
2. Background/Rationale:
   - Gives short general scientific background of the topic.
   - Cites and references previous studies in the text.
   - General rationale of the study was stated, but not specifically for the study (due to nutritional transition, obesity and overweight were increased worldwide).
3. Objectives: Both general and specific objectives were stated.
4. Main elements of the study were presented early in the paper and design was appropriate for aim of the study.
5. Setting, location and dates of the study were clearly described.
6. Eligibility criteria, sources and methods of selection were clearly presented.
7. Outcomes of the study (underweight, overweight, obesity and waist circumference) were defined using the WHO categories for BMI assessment, potential confounder (age, sex, residence place, education, family income) were adequately defined.
8. Source of data (WHO STEP wise approach to surveillance) and methods of assessment (anthropometrical measurements) were clearly explained.
9. Effort to address bias: study was community based approach, subjects were selected randomly from sampling frame of the 1997 census, which was designed to be representative at a national level and by place of residence (urban and rural). Anthropometrical measurements were also measured using calibrated utensils and standardized techniques.
10. Sample size calculation: 95 geographical clusters, among which all the households were listed and 25 randomly selected and visited, and then all eligible subjects were invited. 55 subjects refused and 3323 were included in the study.
11. Quantitative variables: BMI was calculated as weight (kg) divided by square height (m^2). And waist circumference was analyzed; subjects were categorized using the WHO standard used

for BMI assessment. Waist circumference was evaluated by the cut-off point (women>88 cm and men>102 were classified as abdominal obesity).

12. All statistical methods used in the analysis were described, including those used to control for confounding (stratification were done by gender, sex, residence place and education, besides this age-, family income-and –adjusted prevalence ratios, computed using multiple regression model). Thus in the analysis both stratification and multiple regression were used to control for confounding. 397 subjects with incomplete information were excluded from the analysis.
13. Numbers of subjects were reported in the percentage and reasons for those excluded from the study were given.
14. Demographic characteristics (age, sex, residence place, education and their annual income) were given. Information regarding potential confounders were presented.
15. Prevalence of BMI categories and abdominal obesity and average waist circumference, among women and men from rural and urban areas were presented in % (95%CI).
16. The main results give both unadjusted and adjusted estimates. Adjustment were done according to their age, education, annual income and residence place, 95% CI were calculated to test for cofounding. Odds ratios and linear regression coefficients were tabulated to check the association between residences of place and the outcomes among both sexes.
17. Other analysis: BMI vs waist circumference analysis was done to see the magnitude of their association.
18. Key finding of the study were summarized with reference to study objectives.
19. Limitations of the study were not discussed
20. Careful interpretation of results in consideration to objectives and results from other studies were given.
21. Generalizability of the study was not discussed.
22. Sources of funding and role of the funder were not discussed.

Study 12: ***Association between body mass index and blood pressure across three populations in Africa and Asia***

1. Tittle and abstract:
   - Study design was indicated in the abstract i.e. was cross-sectional descriptive design.
   - Unstructured abstract was informative about what was done and what was found.
2. Background/Rationale:

- Background explained general scientific information of the topic. It also explained and cited the finding of other studies.
- Rationale of the study was stated (correlation between BMI and blood pressure in very lean population was less explored).

3. Objectives: Both general and specific objectives were stated was also mentioned.
4. Key elements were presented early in the paper and design was appropriate for aim of the study. Data were generated from DSS (demographic surveillances sites) of three country.
5. Setting, location and dates of the study were clearly described.
6. Eligibility criteria (all adults aged 25-64 years in the DSS, excluding pregnant and subject with gross physical problem, sources and methods of selection were also mentioned.
7. Outcomes of the study (BMI defined according the conventional cutoff recommended by WHO and WHO cutoff for blood pressure was used for BP), potential confounder (age, education, occupation, residence place and sex) were mentioned.
8. Source of data (from DSS of Ethiopia, Vietnam and Indonesia) and methods of assessment (anthropometrical measurements, blood pressure measuring and questionnaires) were clearly explained.
9. Effort to address bias: Study was conducted in nationwide and anthropometrical measurements were taken using the WHO STEP instruments (calibrated instruments and standardized techniques). Blood pressure (BP) was also measured according the WHO guidelines. Training of the data collectors were carried out in order to make them familiar with survey instruments (questionnaire and anthropometric measurements) .Subjects were also randomly selected from the DSS database of each country.
10. Sample size was calculated using the formula for single population proportion.
11. Quantitative variables: BMI was calculated as weight (kg) divided by square height (m^2) and conventional BMI cutoff points were applied to classified subjects in to different nutritional status. Three BP measurements were taken, average BP were determined from the second and third measurements.
12. All statistical methods used in the analysis were described. To control for confounding subjects were stratified by age, sex, residence place, education, BMI categories and occupation and logistic regression analysis were carried out to determine odds ratio of hypertension and BMI across the two sexes and different age groups.

13. Number of subjects were reported (8014 subjects, where 4050 from Ethiopia, 2020 from Vietnam and 1944 from Indonesia. For BMI 7675 subjects were included, 339 subjects were excluded either due to pregnancy or subject's weight or height was not measured.
14. Demographic characteristics (age, sex, residence place, education, BMI categories and occupation) were given. Information regarding potential confounders was presented.
15. Outcome data: Prevalence of underweight, normal weight, overweight and obesity were presented for all country and mean value of both diastolic and systolic BP were presented.
16. The main results give both unadjusted and adjusted estimates. Correlation coefficients of age with BMI, BP for both sexes were calculated. Subjected were adjusted by their age, sex, education, occupation and BMI category, then adjusted OR (95% CI) were calculated using logistic regression to test for cofounding.
17. Key finding of the study were summarized with reference to study objectives.
18. Limitations of the study were not discussed.
19. Careful interpretation of the results in consideration study objectives, and results from other studies were given.
20. Generalizability of the study was not discussed (external valid).
21. Sources of funding and role of the funder were discussed.

Study 13: ***The association between the body mass index of first-year female university students and their weight-related perceptions and practices, psychological health, physical activity and other physical health indicators***

1. Tittle and abstract:
   - Study design was mentioned in the abstract i.e. cross-sectional.
   - Structured abstract provided adequate summary of the study methodology and findings.
2. Background/Rationale:
   - Explained adequate scientific background of the topic.
   - Rationale of the study was stated, (less is known about the association between weight status, health and lifestyle indicators, weight management practices and psychological parameters of the target group). But could be clarified more (why only first year student?).
3. Objectives: Both general and specific objectives were stated.
4. Key elements of the study were presented early in the paper and design was appropriate for aim of the study.

5. Setting and location (female residence at a South African university) of the study were clearly described. No information on relevant dates of the study.
6. Eligibility criteria, sources and methods of selection were presented (volunteers female university students in South Africa).
7. Outcomes of the study (BMI defined and categorized according the WHO guidelines, triceps skinfold were classified in to five categories, blood pressure SBP <130 and DBB<85 considered normal, physical activities divided in to three components, body shape, eating attitudes and self-concept) were defined. Other that could be as potential confounders (year of birth, weather, medication, accommodation, illness and smoking were also defined.
8. Source of data (baseline data of first year student participating in a weight-management intervention trial, from this data volunteers were selected for this study) and methods of assessment (anthropometrical measurements and all other mentioned outcomes) were clearly explained.
9. Effort to address bias: After an information session, volunteers were selected for participation. Anthropometric data was measured using calibrated instruments and standardized techniques. Thus, as only volunteers involved in the study the risk for potential bias was high.
10. Quantitative variables: BMI was calculated as weight (kg) divided by square height (m^2).
11. All statistical methods used in the analysis were described, including those used to control for confounding (stratification in to different categories).
12. Number of subjects (n=360) were reported and there were no no-participants.
13. Demographic characteristics (age, school, language, living with and self-reported prevalence of chronic diseases and smoking habit were collected
14. Summary reports of the outcome data were given: mean BMI, WC, triceps skinfold thickness, systolic BP and diastolic BP. In addition to those information regarding smoking habit, weight related perception and practice, psychological health and physical activity were reported.
15. In the main results, no adjustments were done. The association between BMI and weight related characteristics; weight related perception and practices were presented in tables. P value was tabulated to see if it was statistically significance.
16. Key finding of the study were summarized with reverence to study objectives, study was compared with other studies findings.
17. Limitations of the study were not discussed.
18. Cautious and broad interpretation of results in consideration to objectives and results from other studies were given.
19. Generalizability of the study was not discussed.

20. Source of funding was mentioned.

Study 14.1 and 14.2: ***The potential use of maternal size in priority setting when combating childhood malnutrition***

1. Tittle and abstract:
    - Study design was not described either in the tittle or abstract.
    - Abstract was structured and provided adequate summary of the study.
2. Background/Rationale:
    - Delivered broad scientific background of the topic.
    - Mentioned other studies findings in the text.
    - Rationale of the study was stated.
3. Objectives: Both general and specific objectives were stated.
4. Methods: Key elements of the study were presented early in the paper and design was appropriate for aim of the study (community-based survey).
5. Setting, location and dates of the study were clearly described.
6. The study used three different data (Ethiopia, India and Zimbabwe), subject's eligibility criteria was mentioned only for Ethiopia. Sources of the data were clearly presented for all. But methods of selection for India were not explained.
7. Outcomes of the study (underweight, normal, overweight and obesity) were defined using the WHO categories for BMI assessment and Z-score cut-off was used for children. No information was given on potential confounder, predictor and effect modifiers.
8. Source of data and methods of assessment (anthropometrical measurements) were clearly explained.
9. Effort to address bias: In both African nations, subjects were selected randomly. In all countries anthropometrical measurements were done according to internationally acceptable and standardized procedures.
10. There was no sample size calculation, 3865 adults women from three Ethiopian surveys, 801 adults women from Zimbabwe and 296 adults women from India were included in the study.
11. Quantitative variables: BMI was calculated as weight (kg) divided by square height (m^2). And nutritional status of the children was expressed as the mean of the z-score.
12. All statistical methods used in the analysis were described. The correlation between z-scores of children and their mother's BMI were estimated and tested for heterogeneity in relation

between the communities. Sensitivity and specificity analysis were also performed for suggesting children's appropriate z-score cut-off point.

13. Results: Number of subjects were reported for each country and the proportion of each group in different BMI categories (BMI<16, BMI<16-16.9, BMI 17-18.4, BMI18.5-24.9 and BMI 25-29.9) were also presented.
14. Descriptive data: Demographic characteristics (age, sex, and family size, country including residence area or region) for both children and mothers were mentioned. Adolescents were excluded from the study because of marked discrepancies in the timing of puberty and change in WFH in these groups compared with the reference population.
15. Outcome data: Prevalence of BMI in each categories and mean and standard deviation of the z-score for children in relation to the WHO reference pattern were reported. The concordance(c) between the anthropometry of siblings within a household and correlation(r) between mean z-score of children and the average BMI of all the adult women within each household were reported. At last classification of the households based on both adults and children's anthropometry were reported.
16. Main results: no adjustments were carried out, there was no statistically significant evidence of heterogeneity between the different countries in the relationship between maternal BMI and WFH (weight for height) z-score of the children aged <10 years.
17. Other analysis: Sensitivity and specificity analysis were used for suggesting the appropriate cut-off point of children's WFH z-score and -2 z-score cut-off point was suggested to be more appropriate.
18. Key results: finding of the study were summarized with reference to study objectives.
19. Limitations of the study were not discussed
20. Interpretation of results in consideration to objectives and results from other studies were given.
21. Generalizability of the study was not discussed.
22. Sources of funding and role of the funder were discussed.

Study 15: **Body mass index as indicator of standard of living in developing countries**

1. Tittle and abstract:
    - Study design was descried neither in the tittle nor in the abstract.
    - Structured abstract provided an informative summary of what was done and what was found without including too much information.
2. Background/Rationale:

- General scientific background of the topic was given.
- Rationale of the study was stated, (less is known about the suitability of BMI as an indicator of standard of living in developing countries.

3. Objectives: Both general and specific objectives were stated.
4. Key elements of the study were presented early in the paper and design was appropriate for aim of the study.
5. Setting, location and dates of the study were clearly described (data collected in the first round of the Ghana Living standard survey, held in 1987\88 (GLSS-I) and 1988\89 (GLSS-II).
6. Eligibility criteria (all adults in the age group 20-65 years, excluding pregnant, lactating ,individuals from households with total expenditures higher than 1 million cedis per year and individuals with BMI<10 and >40), sources (GLSS I and II), and methods of selection (proportionate sampling) were clearly presented.
7. Variables: Outcomes of the study (underweight, overweight, and obesity) were defined using the WHO categories for BMI assessment, other variables (potential confounders) such as income and expenditure, years of schooling of head of households, access to services, quality of housing, age, and nutritional of status children were also defined.
8. Source of data (GLSS I and II)) and methods of assessment (anthropometrical measurements) were clearly explained.
9. Effort to address bias: Study was nationwide approach and in both surveys over 3000 households proportionally distributed over Ghana were selected. To make the sample representative for both sex and households, one male and one female were selected in the analysis as subsample (4228 adults) from each household. Anthropometrical measurements were also measured using calibrated utensils and standardized techniques.
10. There was no sample size calculation, 9214 adults were selected in both surveys (male=4961 and female=4253) and BMI were calculated for all. In the analysis to reduce possible bias, only 4228 adults (2114 females and 2114 males) from 2114 households as subsample were used.
11. Quantitative variables: BMI was calculated as weight (kg) divided by square height (m^2) and were categorized using the WHO standard used for BMI assessment.
12. All statistical methods used in the analysis were described, sample was divided in to socio-economic groups on the basis of four criteria: first geographical location (coastal, forest), second, place (community <5000 inhabitants was considered as rural and these with over 5000 as urban and finally, rural households were divided on the basis of their economic activity and urban on the basis of record of training and experience of the head of the household (skilled

unskilled). These classification results 12 groups and mean BMI, weight, height and the various households' characteristics and correlation coefficient were obtained. Finally multiple regressions was carried out to see the effect of various socioeconomic characteristics on BMI, weight and height.

13. Results: Mean and distribution of the subjects were reported, separately for both sex and for the rural and urban population, and for the whole sample.
14. Demographic characteristics (age, sex, residence place, education and income and expenditure) were given. Information regarding potential confounders were presented.
15. Proportions of BMI for box sexes in urban and rural were reported. Correlation between adult BMI and household income expenditure, correlation coefficients between adults BMI and five household characteristics (electricity, treated water, educational level of the head of the household, quality dwelling and nutritional status) and mean BMI for the twelve socioeconomic groups were reported.
16. Main results: To evaluate BMI as an indicator of household wellbeing, multiple regressions were used. Regression included three variables: individual, household and community levels. *P*-value was calculated to check for statistically significance. In this model most selected households variable appeared to have significant effect on both BMI and weight, but not on height.
17. Other analysis: no other analysis was reported other than these mentioned.
18. Key finding of the study were summarized with reverence to study objectives.
19. Limitations of the study were not discussed
20. Interpretation of results in consideration to objectives and results from other studies were given.
21. Generalizability of the study was not discussed.
22. Sources of funding and role of the funder were not discussed.

Study 16.1, 16.2,16.3, 16.4 and 16.5: These studies were carried out by FAO. We retrived them from one article which reported a modified form of those FAO findings without describing the methods. Thus, we could not critically appraisal for them.

Study 17.1, 17.2 and 17.3: The findings in those studies were obtained from the WHO global database on BMI, therefore similar to the above studies, we could not do critically appraisal for those study either.