PREVALENCE AND CORRELATES OF OVERWEIGHT AND OBESITY AMONG PRIMARY SCHOOL CHILDREN IN ILALA AND MKURANGA DISTRICTS, TANZANIA

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ABSTRACT

Overweight and obesity are increasing among school children and are currently considered as significant public health problems. Therefore, this study aimed to determine the prevalence of overweight and obesity in school children (10-13 years) and their correlates, to inform policy for action in order to reduce the magnitude and consequences of the problems. A cross-sectional study design was conducted in Ilala and Mkuranga districts of Tanzania between July 2019 and December 2020 among 406 school children, 36 parents/guardians, and 9 teachers. Standardized questionnaires were used for data collection and laboratory analysis was performed to determine actual fatty acids and sugar contents of foods commonly consumed by school children in the study areas. Height and weight measurements were performed by using the World Health Organization standard procedures. The general prevalence of overweight and obesity based on BMI-for-age indicator was 22.6% higher in private than in public schools (32.4% vs. 14.8%, $p<0.001$). Dietary habits of school children were characterized by low fruit, vegetable, and milk intake. Overweight and obesity among school children correlated significantly with moderate consumption of soda/carbonated drinks (AOR 0.38, 95% CI 0.19-0.85), high consumption of fruit/fruit-flavored juices (AOR 0.21, 95% CI 0.07-0.67), local ice cream (AOR 0.41, 95% CI 0.17-0.95), and low dietary diversity (AOR 0.57, 95% CI 0.44-0.75). Other predictors were moderate consumption of potato chips (AOR 2.27, 95% CI 1.07-4.81) and having overweight/obese parent (AOR 10.11, 95% CI 2.72-37.65). In addition, sedentary behavior, such as listening to music and/or radio for >2 hours/week (OR 2.7, 95% CI 1.2-6.1) and low physical activity such as walking for exercise <2 hours/week (OR 2.1, 95% CI 1.1-4.1) were risk factors for overweight/obesity while rope skipping for >2 hours/week (OR 0.14, 95% CI 0.03-0.7) was protective. Saturated fatty acids, such as palmitic acid (C16:0), were found in abundance in all food samples while sucrose and saccharin concentrations varied considerably between products. Findings from this study showed that the food environment may be a contributing factor to overweight/obesity among school children. This study informs relevant authorities to take appropriate actions to minimize health risks associated with overweight and obesity in school children.

DECLARATION

I, Renatha Pacific, do hereby declare to the Senate of the Nelson Mandela African Institution of Science and Technology that this thesis is my original work and that it has neither been submitted nor being concurrently submitted for a degree award in any other institution.

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CERTIFICATION

The undersigned certify that, they have read and hereby recommend for acceptance by the Nelson Mandela African Institution of Science and Technology a thesis titled ***"Prevalence and correlates of overweight and obesity in primary school children in Ilala and Mkuranga Districts, Tanzania"*** in fulfilment of the requirements for the degree of Doctor of Philosophy in Life Sciences of the Nelson Mandela African Institution of Science and Technology.

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DEDICATION

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LIST OF ABBREVIATIONS AND SYMBOLS

AHA	American Heart Association
ANOVA	Analysis of Variance
BAZ	BMI-for-age Z-scores
BMI	Body Mass Index
BIA	Bioelectric Impedance Analysis
Cm	Centimeter
CREATES	Centre for Research, Agricultural, Advancement, Teaching Excellence and Sustainability in Food and Nutrition Security
DDS	Dietary Diversity Score
DHA	Docosahexaenoic acid
DPA	Docosapentaenoic acid
DXA	Dual-energy X-ray Absorption
EPA	Eicosapentanoic acid
ECL	Equivalent Chain Length
FAO	Food and Agriculture Organization
FGD	Focus Group Discussion
HAZ	Height-for-age Z-scores
HDL	High Density Lipoprotein
HPLC	High Performance Liquid Chromatography
IOTF	International Obesity Task Force
KII	Key Informant Interview
LDL	Low Density Lipoprotein
LMIC	Low and Middle-Income Countries
MoH	Ministry of Health
MUAC	Mid-Upper Arm Circumference
MUFA	Monounsaturated Fatty Acids
NCD	Non-Communicable Diseases
NNS	National Nutrition Survey
PAQ-C	Physical Activity Questionnaire for Children
PUFA	Polyunsaturated Fatty Acids
RDA	Recommended Dietary Allowance
RID	Refractive Index Detector

SBCC	Social Behavior Change Communication
SCT	Social Cognitive Theory
SES	Social Economic Status
SFA	Saturated Fatty Acids
SPSS	Statistical Product and Service Solution
TDHS	Tanzania Demographic and Health Survey
UMITASHUMTA	*Umoja wa Michezo Shule za Msingi Tanzania*
USA	United States of America
WHO	World Health Organization

CHAPTER ONE

INTRODUCTION

1.1 Background of the Problem

Overweight and obesity in children are currently a significant global public health problem (Mosha & Fungo, 2010; Adom *et al.,* 2019) which has exponentially increased in recent decades (Godakanda *et al.,* 2018; Corvalán *et al.,* 2017; Diouf *et al.,* 2016; Frignani *et al.,* 2015; Leech *et al.,* 2014). Globally 38.3 million (5.6%) children were reported to be overweight in the year 2018 (Development initiative, 2018). Overweight and obesity are also major risk factors for dietary- related chronic problems (Chomba *et al.,* 2019; Mosha *et al.,* 2021). Childhood obesity persists into adulthood life (Mosha *et al.,* 2021). Despite the heavy burden of under-nutrition, overweight and obesity rates are increasing, causing a double burden threat in developing countries (Mekonnen *et al.,* 2018).

Prior studies in Tanzania have indicated increased overweight and obesity prevalence among primary school children, rising from around 5% to more than 20% between 2010 and 2016 (Pangani *et al.,* 2016; Mwaikambo *et al.,* 2015; Muhihi *et al.,* 2013; Mosha & Fungo, 2010). In addition, a recent national representative study revealed the linkages between diet and nutrition status of school-age children and adolescents (Sauli *et al.,* 2021). However, this evidence is limited in terms of robust factors contributing to the rise of the problem. Moreover, Tanzania National Nutrition Survey (2018) shows an increase in the prevalence of overweight and obesity in the study regions among women of reproductive age. In Dar-es-Salaam, for example the prevalence was 24.6% and 24.0% for overweight and obesity, respectively, and, in Pwani, the prevalence was 26.0% for overweight and 17.1% for obesity. These levels are above the national average of 20.2% for overweight and 11.5% for obesity. This observation may translate into a similar trend among school children living in the respective districts and regions.

In children and adolescents, body mass index (BMI) is age- and sex-specific, and is referred to as BMI-for-age. It is calculated by dividing body weight in kilograms (kg) by height in meters squared (m^2) like in adults, but it is expressed in percentiles or Z-scores (Adesina *et al.,* 2012). These percentiles and Z-scores express a child's BMI in relation to other children of the same gender and age. In this study BMI-for-age, percentage body fat and Mid-upper arm circumference (MUAC) were used in assessing nutrition status of school children.

Many studies have defined obesity as an excessive increase in body fat which may be linked to the occurrence of diet-related non-communicable diseases (NCDs) such as type 2 diabetes, hypertension and dyslipidemia, and cardiovascular diseases (Mekonnen *et al.,* 2018; Naeeni *et al.,* 2014; Wamba *et al.,* 2013; Mohammed & Vuvor, 2012; Musa *et al.,* 2012) which have been exclusively observed in adults and developed countries (Rao *et al.,* 2016; Ulbricht *et al.,* 2018).

There is limited information on dietary habits and their influence on overweight and obesity among school children in Tanzania. Therefore, this study sought to determine the prevalence of overweight and obesity in selected urban and peri-urban public and private schools in Tanzania. Living in urban areas is associated with high levels of overweight and obesity due to low participation in physical activity and unhealthy diets which are embedded in the interplay between individual behaviours on food choices and obesogenic environments (Chen & Antonelli, 2020). The study also compared BMI-for-age against dietary habits of school-aged children from 10 to 13 years of age as it is hypothesized that school children are increasingly overweight/obese as a result of poor dietary habits. This age group is selected because it is in upper classes of primary school education which was the focus of this study.

Obesity is caused by a change in behavioral and environmental factors, including increased intake of high energy-dense diets (Joy *et al.,* 2017; Hebestreit *et al.,* 2014) and sedentary lifestyle associated with reduced physical activity (Hanandita & Tampubolon, 2015). High energy-giving foods and sugar-sweetened drinks are readily available in the school environment (Vargas *et al.,* 2013). Such products promote excess consumption of excess sugar and fats by school children since they can increase perceived hunger (Neeley, 2011). Dietary habits of public and private school children may vary due to availability and accessibility of foods, therefore comparing their dietary behaviors may shed light on potential intervention strategies to improve their eating habits.

Due to rapid growth during adolescence, school children easily become nutritionally vulnerable because they spend more time in the school environment (Steyn *et al.,* 2016). Likewise, in the home environment, the evidence suggests that, in low and middle-income countries, meals are low in energy, animal products, and micronutrients (Ayogu *et al.,* 2018). Data exists among adults as shown in the 2012 Tanzania STEPS survey, where consumption of fruits and vegetables was suboptimal (WHO, 2012). Because nationally-representative data on food consumption among school children in Tanzania is still limited, (although there one national

study), general conclusion on intakes and habits is also limited. In addition, two recently conducted small studies have shed light on food consumption of primary school children (Chomba *et al.,* 2019) and boarding secondary school children (Nicholaus *et al.,* 2020) in Northern Tanzania. Majority of the primary school children from the studied areas had random eating habits whereas many of the adolescents in boarding schools consumed monotonous diets with limited animal sources, fruits and vegetables. However, these studies provide limited information on food consumption patterns for overweight/obese and normal weight children. Therefore, the current study also characterized nutrient intake, consumption patterns, and family factors of school children in Ilala and Mkuranga districts, and how they correlate with overweight and obesity. Identification of these factors will contribute to the development of relevant policy options and will influence set-up of interventions to reduce burden of NCDs among children and adolescents in Tanzania.

Dietary behaviours established early in life tend to persist into later life (Yee *et al.,* 2017; Peters *et al.,* 2014*;* Leech *et al.,* 2014). Therefore, understanding factors that influence children's food choice is fundamental in designing strategies to decrease consumption of unhealthy foods and increase consumption of healthy foods (Murimi *et al.,* 2016). Food choices are essentially determined by food preferences which continually change due to biological, social, cultural and environmental determinants (Scaglion *et al.,* 2018; Spronk *et al.,* 2014). Food preference is driven by the biological factor of 'taste'. Taste is a barrier in promoting health eating because people resist to try new foods and acquiring new taste preferences (Chadwick *et al.,* 2013). Studies that examined the influence of parents, socio-cultural and environmental factors on school children's food choice are scarce in Tanzania. Therefore, this study also investigated these factors for better development of feasible policy options.

High consumption of sugar is reported to increase worldwide (Sungur & Kilboz, 2016) and it is linked to poor health outcomes in children (Walker & Goran, 2015) including diabetes mellitus and increase in obesity (Damayanti *et al.,* 2012). There is evidence that increased intake of free sugars contributes more energy and reduces intake of more nutritious foods (WHO, 2015). Sucrose is a commonly used table sugar in food industry/preparation especially in soft drinks and other beverages, and it is also used at home (Bhowon *et al.,* 2015). Due to rapid increase in overweight and obesity epidemic WHO recommends reduction of free sugars intake to less than 10% of total energy intake (WHO, 2015). Reducing intake of sugars and carbohydrate-rich foods is a potential strategy in managing weight gain. On the other hand, the

use of artificial sweeteners, such as saccharin, a caloric-free sweeting agent, has been recommended in reducing overall intake of calories (Azeez *et al.,* 2019). Sugars can occur naturally in foods, such as fruits and dairy products, and can also be added to foods during processing (Erickson & Slavin 2015). There is limited laboratory data on actual sugar contents of commonly consumed foods by school children in Tanzania. Therefore, the current study determined the sucrose and saccharin contents of foods and drinks commonly consumed by school children in Tanzania by using High Performance Liquid Chromatograph (HPLC).

Dietary fat plays a significant role due to its highest energy density and least-satiating macronutrient (Suara *et al.,* 2020; Casas-Agustench *et al.,* 2014). Fats in food enhance taste, aroma, acceptability, slow digestion, and facilitate absorption of fat-soluble vitamins (Uauy & Dangour, 2009). Increased intake of PUFA compared to SFA decreases incidence of chronic diseases later in life and body mass index (Astrup *et al.,* 2019; Kutzner *et al.,* 2016; Rahmawaty *et al.,* 2013). Nevertheless, evidence shows that intake of PUFA is suboptimal among children across countries (Neufingerl *et al.,* 2016). Because school children commonly purchase and consume fried foods and snacks sold by food vendors, this study was undertaken to investigate the fatty acid content of foods and snacks sold around schools. The overall significance of this study is its revelation that foods mostly consumed in the school environment have abundant types of saturated fatty acids and low types unsaturated fatty acids.

Studies linking physical activity, sedentary behaviors, and occurrence of overweight and obesity in school children are scarce in developing countries including Tanzania. Some studies in Tanzania have reported associations between increase in prevalence of overweight and obesity and physical activity and sedentary behaviors among school children. A study which associated dietary factors, physical activity, and body mass index among secondary school adolescents in rural Manyara region found that unhealthy diet, vigorous physical activity and physical inactivity were independent predictors of overweight and obesity (Tluway *et al.,* 2018). A study in Kilimanjaro region among primary school children found that dietary factors, availability of playgrounds at school and home neighborhood, and presence of electronic devices at home were positively associated with overweight and obesity (Mosha *et al.,* 2021). Mwaikambo *et al.* (2015) related a few sedentary behaviors with overweight and obesity in school children in Dar-es-Salaam. The author found that use of private cars/school buses to and from school and computer/video games increased the risk of overweight and obesity in school children. A study by John *et al.* (2017) in northwest Tanzania reported that a big proportion

(96%) of adults had sufficient participation in physical, higher proportion in males (97.3%) than in females (94.8%). The Tanzania STEPS survey (WHO, 2012) also reported participation in physical activity among the adult population and revealed that three quarter of adults participated in vigorous physical activity.

Physical activity and healthy diet are modifiable factors in preventing childhood obesity and several NCDs and also improving life expectancy (Siong & John, 2021; Ferrari *et al.,* 2020; Mashili *et al.*, 2018; Diouf *et al.,* 2016). The World Health Organization (WHO) recommends children from 5-17 years old to participate in moderate to vigorous-intensity, mostly aerobic physical activity, for at least for 60 minutes per day across the week while limiting the amount of time spent in sedentary activities, especially recreational screen time (WHO, 2020). Nevertheless, around 80% of children aged 13-15 years globally do not meet this recommendation (Muntaner-Mas *et al.,* 2017) and physical inactivity is reported to increase in children and adolescents (Esht *et al.,* 2018; Micklesfield *et al.,* 2014), partly due to the use of electronics. In addition, the use of school buses to and from school lowered children's energy expenditures (Bhuiyan *et al.,* 2013; Mosha & Fungo, 2010).

A sedentary lifestyle behavior that involves less utilization of energy for a substantial amount of time (Godakanda *et al.,* 2018) has now been adopted by most citizens of low- and middle-income countries (McVeigh & Meiring, 2014). The traditional active lifestyle is replaced by more sedentary lifestyles, resulting in rapid increase in NCDs hence overload to the health care systems (Muthuri *et al.,* 2014). This research study also characterized physical activity and sedentary behaviors of school children based on their weight status.

Social, economic changes and environmental factors have led to overweight and obesity in children across all groups of socio-economic status in low and middle-income countries at the same rate as high income countries (Verstraeten *et al.,* 2014). Food choice and its outcomes form a vicious cycle as it has been noted that consumption of highly processed foods significantly increases likelihood of weight gain, and heavy weight people tend to select high-energy giving foods (Chen & Antonelli, 2017).

Generally, despite the numerous global calls to end childhood obesity and the availability of known interventions that can mitigate the rise of the burden of overweight and obesity, success stories in halting the increase in overweight and obesity are still scarce. The thesis thus addresses a pertinent research question to support governments in LMIC to better understand

the drivers of overweight and obesity in their context and support health and nutrition programming.

1.2 Statement of the Problem

Childhood is the most critical period of human life in which optimal nutrition plays key role in physical and mental development (El-Kassas & Ziade, 2017). Globally, childhood overweight and obesity among children and adolescents has increased significantly, with over 35% of 42 million living in developing countries (Sahoo *et al.,* 2015; Adamo & Brett, 2013). The *Global Nutrition Report* of 2018 showed that 2.5% of boys and 3.9% of girls aged between 10-19 years in Africa were obese in the year 2016 (Development Initiatives, 2018). In Sub-Saharan Africa, studies have shown an increase in overweight and obesity prevalence at an alarming rate ranging from 10% to > 30% in many countries, such as Ethiopia (Mekonnen *et al.,* 2018), Nigeria (Ofakunrin *et al.,* 2018), Kenya (Kyallo *et al.,* 2013), South Africa (Negash *et al.,* 2017; Baard & McKersie, 2014), Ghana (Annan-Assare *et al.,* 2017), Uganda (Chebet *et al.,* 2014) and Egypt (Hadhood *et al.,* 2017). Likewise, studies done in Tanzania showed an increased trend of the problem among school children, up to more 20% in 2016 (Pangani *et al.,* 2016; Mwaikambo *et al.,* 2015; Mosha & Fungo, 2010). Yet, there is inadequate regional and district data linking the prevalence, dietary habits, food consumption and physical inactivity. The high prevalence of overweight and obesity in children could be mitigated or prevented through policy and programs based on best practice informed actions.

Childhood obesity is attributed to imbalance between energy intake and energy expenditure and failure to meet daily minimum requirements of healthy diet and physical activity. Many studies (Ayogu *et al.,* 2018; Seid *et al.,* 2018; Ochalo & Masibo, 2014; Vargas *et al.,* 2013; Fitzgerald *et al.,* 2010) have reported poor dietary practices among children and adolescents. For instance, over 80% of school children in Malawi had high intake of carbohydrate and sugary foods. In Ghana, 56% and 48% of school children reported a rare consumption of fruits and vegetables respectively while dietary fat intake was high. Few studies in Tanzania (Chomba *et al.,* 2019; Nicholaus *et al.,* 2020) highlighted the preference of school children to more cereals and sweet foods. Thus, effective implementation of school-based interventions is reliant on sufficient evidence regarding dietary intake and food habits data of school children. Moreover, it is estimated that 80% of school children (13-15 years) globally do not meet the WHO recommendation for physical activity of at least 60 minutes per day (Muntanet-Mas *et al.,* 2017). Therefore, sufficient data on physical activity levels in Tanzanian school children is

required for planning of physical activity interventions among children. With poor dietary practices and physical inactivity, a child is likely to be overweight/obese and hence exposed to potential health risks including high cholesterol and high blood pressure, high risk of impaired glucose tolerance, insulin resistance, type 2 diabetes, breathing problems, and fatty liver disease (Center for Disease Control, 2016; Naeeni *et al.*, 2014; Lee, 2009). Moreover, obese children may experience psychological and emotional consequences caused by stigma, teasing, and harassment from their peers and surrounding community (Rankin *et al.*, 2016). The health risks associated with overweight and obesity in children demand for potential actions to be in place to alleviate the problem. Due to data showing increasingly high proportion of overweight/obesity in school children, planning of effective interventions requires determination of drivers of overweight and obesity in Tanzanian school children as little is available in this regard. This study thus determined the prevalence of obesity/overweight among school children aged between 10-13 years of age and assessed the linkage between obesity/overweight and dietary factors, physical activity. In addition, assessed determinants/drivers of overweight/obesity in the study population.

In this case, the problem of overweight and obesity is given consideration in the National Multi-sectoral Nutrition Action Plan (NMNAP) 2016-2021 which emphasized on addressing diet related NCDs earlier, thus issues related to overweight and obesity should receive adequate attention (URT, 2016). Again, in the effort to improve healthy food intake by school children, the government through Ministry of Education, Science and Technology has developed national guidelines on school feeding and nutrition services to basic education students (URT, 2020). On top of that, Ministry of Livestock and Fisheries has recently launched action plan for implementation of school milk program in Tanzania 2023-2028 (URT, 2023).

1.3 Rationale of the Study

Given the growing prevalence of overweight and obesity and its concomitant health risks, among school children in Tanzania, studying the prevalence, correlates and determinants of overweight and obesity is crucial. This topic has received little attention as health research in the Tanzania context as the focus has primarily been on undernutrition and other infectious diseases (Desalew *et al.*, 2017). Exploring dietary behavior, physical activity patterns, and duration in relation to their nutrition status is key. Studies investigating dietary practices among children and adolescents are scarce in Tanzanian context, thus it was important to characterize dietary patterns of school children by using a combination of tools such as; food habits

checklist, 24-hour dietary recall, and food frequency questionnaire. Studying dietary factors will help in modification of these factors thus potentially curbing the increase of excess body weight and averting serious health risks. Moreover, participation in physical activity among school children is reported to be low worldwide (Esht *et al.*, 2018; Micklesfield *et al.*, 2014) and data in this area are insufficiently studied in Tanzania. Little is known about overall levels, patterns, and duration of physical activities and sedentary behaviors. Therefore, understanding the frequency of participation, patterns, and details of specific types of physical activities and sedentary behaviors that children are involved in may help determine their contribution to health outcomes (Heitzler *et al.,* 2011). It is for these reasons that the study was conducted among school children (10-13years old), since the study targeted children in the upper level of primary school children with the aim of getting information that will inform policy and appropriate interventions to reduce and prevent incidences of overweight and obesity. Understanding factors that influence children's food choice is fundamental in developing better policy options and relevant school interventions in our setting. Furthermore, quantification of fats and sugars in foods consumed by school children may form basis for dietary guideline and recommendations. In addition, having enough local data on prevalence, determinants, and correlates of childhood obesity provide important contextual direction for health care provision and preventive strategies. The information will assist in creating evidence-informed health service planning and obesity management programs. Furthermore, the Sustainable Development Goal number 3 on promoting good health and wellbeing showed a slow progress in preventing the risk for pre-mature deaths resulting from NCDs (from 23% in 2000 to 19% in 2015) which calls for rapid investment in disease prevention and health promotion (WHO, 2015). Given that overweight and obesity is among the core risk factors for NCDs, it created a need to study correlates and/or determinants among school children in the selected districts.

1.4 Research Objectives

1.4.1 General Objective

To assess the prevalence, correlates, and determinants of overweight and obesity among primary school children (10-13 years) in public and private schools in Ilala and Mkuranga districts, Tanzania.

1.4.2 Specific Objectives

The study aimed to achieve the following specific objectives:

(i) To assess the nutrition status of primary school children aged 10-13 years using weight, height, MUAC and body fat measurements in the study areas.

(ii) To characterize dietary patterns and food consumption habits of primary school children aged 10-13 years in the study areas.

(iii) To evaluate physical activity level and patterns among primary school children aged 10-13 years in the study areas.

(iv) To investigate the influence of environmental, socio-cultural and parental factors on primary school children's food choices among parents and school teachers in the study area.

(v) To characterize fat and sugar profiles of foods and beverages commonly consumed by school children and sold in school environment in the study area.

1.5 Research Questions

The study intended to answer the following questions:

(i) What is the nutrition status of target groups of primary school children in Ilala and Mkuranga districts, Tanzania?

(ii) What are the dietary patterns and food consumption habits of target groups of primary school children in Ilala and Mkuranga districts, Tanzania?

(iii) What are the physical activity levels and patterns of target groups of primary school children?

(iv) Do environmental, socio-cultural and parental factors have influence on target groups of primary school children's food choices?

(v) What are levels of sugar and fats in foods and beverages commonly consumed by children in school environment?

1.6 Significance of the Study

The study determined the prevalence of overweight and obesity among children from public and private schools in Ilala and Mkuranga districts, Tanzania using different diagnostic criteria unlike previous studies which used BMI as the only indicator. The Predictors of overweight and obesity such as diet, physical activity, and family factors were also studied. The study provided data on dietary habits, nutrient intake, food consumptions patterns, and physical activity patterns. The study also provided information on environmental, socio-cultural, and parental influences on children's food choices. This multi-level exploration created more understanding and reduced a knowledge gap when developing school-based interventions targeting parents. Through this study quantification of sugars and fatty acids levels of foods commonly consumed by school children was done. Data obtained can help in reviewing and setting recommendations based on accepted levels of sugars and consumption of "healthy" dietary fats on the types of foods to be sold to children in the school environment. The study developed policy brief which suggested potential policy options and recommendations needed to advance the necessary changes to be undertaken by stakeholders in the education system.

The findings obtained from this study are evidence for policy makers to facilitate potential actions for prevention and mitigation of the effects of overweight and obesity among primary school children. The findings of this study are useful to governments in LMIC to modify multi-level factors which will provide access to affordable healthy foods and environment that encourage physical activities to school children. Thus, our results are important in policy implications that nutrition investment in young ages can be effective in reducing future burden of diseases and poor health outcomes.

1.7 Delineation of the Study

This mixed methods study was conducted to determine prevalence of overweight and obesity among primary school children. The study covered the urban and peri-urban areas of Ilala and Mkuranga district respectively, which were chosen based on high (above the national average) prevalence of overweight and obesity in the adult population. The study was conducted between July 2019 and July 2020 and involved 406 randomly selected school children who participated in the cross-sectional survey. Out of 406 children, 207 were drawn to participate in the comparison between overweight and normal weight children. The qualitative phase of this research focused on studying the influence of environment, socio- cultural, and parental

factors on school children's food choices. This was done through Focus Group Discussion (FGDs) among parents and Key Informant Interview (KII) among teachers. The study also determined the levels of sugars and fatty acids in foods commonly consumed by school children through laboratory analysis. Findings from this study are expected to inform policy options.

CHAPTER TWO

LITERATURE REVIEW

2.1 Global Nutrition of School Children

The shifting of diets from traditional to western foods together with limited research regarding the nutritional status of school children is a global nutrition knowledge gap. The world is currently undergoing a nutritional contradiction where undernutrition (e.g., stunting) and over-nutrition (e.g., obesity) co-exist, even in developing countries. One study found that under- and over-nutrition co-exist in rural China, while the risk for overweight is highest in urban areas (Zhang *et al.,* 2016). Similar findings were found in poor urban setting of Kenya where stunting, underweight, and obesity co-exist (Kimani-Murage *et al.,* 2015). A systematic review simultaneously reported both high prevalence of underweight among school children, especially in rural areas of developing countries, and high prevalence of overweight and obesity in urban areas (Best *et al.,* 2010). Prevalence of overweight and obesity in resource poor countries is increasing (Kimani-Murage *et al.,* 2015). The differences in prevalence of overweight and obesity between rural and urban areas, and in resource poor countries is a knowledge gap that require further investigation. Increased prevalence (over 20%) of childhood overweight and obesity has been reported in Latin America, Mexico (39.7%), (Barquera *et al.,* 2010), and among Canadian school children (31%) (Vine & Elliot, 2013). In addition, 36.6% of Saudi Arabian (Collison *et al.,* 2010), 32% of southern Appalachia (Wang *et al*., 2013) and in San Diego, 26.6% (Couch *et al.,* 2014) of school children were also reported to be overweight or obese. The increase in prevalence is linked to high intake of foods that are high in energy and poor in nutrients together with sedentary lifestyle (Corvalán *et al.,* 2017).

2.2 Overweight and Obesity Prevalence among School Children in African Context

Evidence from studies showed a diverse trend of overweight and obesity among school children across African countries. In many countries (such as South Africa, Nigeria, Ghana, Cameroon, Lesotho, Zimbabwe, and Ethiopia) prevalence ranged between 10-20% (Baard & McKersie, 2014; Pukree *et al.,* 2011) except in Egypt (Taha & Marawan, 2015) reported a high prevalence of > 40% for overweight and obesity while three studies (Hadhood *et al.,* 2017; Talat & El Shahat; 2016; Badawi *et al.,* 2013) found a prevalence > 30%.

In East Africa evidence shows that childhood overweight and obesity trends have increased at

an alarming rate and it ranges between 10-30% in Kenya (Rapando *et al.,* 2017; Kyallo *et al.,* 2013; Muthuri *et al.,* 2014) while, in Uganda, a prevalence of >30% was reported by Chebet *et al.* (2014). Tanzania, like other East African countries, is not immune to the growing problem of overweight and obesity in school-children as reflected in studies done across the country. Studies by Mosha and Fungo (2010) found prevalence below 10% for overweight and obesity in children in the Dodoma and Dar-es-Salaam regions, while Tluway *et al.* (2018) found the same trends in Manyara region among adolescents. In Dar-es-Salaam region, studies by Muhihi *et al.* (2013) and Mwaikambo *et al.* (2015) found an increased prevalence (>10%) for overweight and obesity in both children and adolescents. Prevalence ≥ 20% was reported by Kimario (2015) in the Kilimanjaro region and by Pangani *et al.* (2016) in Dar-es-Salaam region.

Many studies across countries reported a higher prevalence of overweight and obesity in girls compared to boys (Ofakunrin *et al.,* 2018; Annan-Assare *et al.,* 2017; Baard & McKersie, 2014; Van den Berg *et al.,* 2014; Kyallo *et al.,* 2013; Mohammed & Vuvor, 2012). This may be attributed to differences in gender roles where boys are more active than girls, therefore girls tend to accumulate more body fat than boys (Umar *et al.,* 2018; Musa *et al.,* 2012). Early-onset of menarche in girls is also associated with an increase in body fat and body weight (Tluway *et al.,* 2018).

Some evidence showed that cultural and environmental factors may explain variation in obesity data among study subjects (Umar *et al.,* 2018; Pangani *et al.,* 2016; Musa *et al.,* 2012). The difference in socio-economic status also contributed to these variations, as children from higher socio-economic status (SES) are reported to be more obese than children from lower SES (Mekonen *et al.,* 2018; Baard & McKersie 2014; Nagwa *et al.,* 2011). This is because children from high social economic status are more likely to consume energy-dense foods than children from low socio-economic status, given the low participation in physical activity, subject them to more vulnerability to obesity. Children from urban areas were found to be more obese (Hadhood *et al.,* 2017; Zhang *et al.,* 2016) than children from rural areas (Tluway *et al.,* 2018; Tathiah *et al.,* 2013). This can be attributed to the fact that children in urban areas are more likely to adopt sedentary lifestyle which influence them to have low energy expenditure hence more accumulation of body fat (Kurnia *et al.,* 2016; Muhihi *et al.,* 2013). In addition, children below 10 years were more likely to be obese than children/adolescents above 10 years (Badawi *et al.,* 2013; Musa *et al.,* 2012; Mosha & Fungo, 2010). This pattern may be attributable to faulty feeding during early childhood. Children from private schools, who had sedentary

lifestyle behaviors, were also found to be more obese than children from public schools (Desalew *et al.,* 2017; Rapando *et al.,* 2017; Pangani *et al.,* 2016). In addition, different cut-off values used to define overweight and obesity may attribute to variation in obesity prevalence in school children. For example, in a study with Iranian adolescents, CDC reference values obtained a higher rate of obesity by 3.2% than International Obesity Task Force reference values in children aged 12–15 years of both sexes (Hajian-Tilaki & Heidari, 2013). Similarly, in Saudi Arabian adolescents, the WHO reference values showed a higher rate of obesity (almost by 6%), but lower rates of overweight (almost by 5%) than IOTF (Alqahtan & Scott, 2015).

2.3 Etiology and Metabolic Consequences of Childhood Obesity

Obesity risk in children can be a result of both behavioral and biological factors (WHO, 2016). Behavioral factors occur based on a child's socio-economic status, cultural perspectives, eating norms and physical activity behaviors (WHO, 2016). Biological factors occur when there is mismatch between fetal and child nutrition. For example, if there was poor maternal nutrition it results in epigenic effects, such that gene function is altered and may result into low birth weight or short stature (Hanson & Gluckman, 2014). When a child is faced with energy-dense diets (which could be an intervention to undernutrition) they are at great risk of overweight and obesity. Another pathway of obesity development in a child occurs when a mother enters pregnancy phase with obesity, diabetes or develops gestational diabetes (McPharson *et al.,* 2012). This situation disposes the child to increased fat deposition associated with metabolic conditions and obesity. Likewise, fathers who are obese are likely to contribute to obesity risk to their children (McPharson *et al.,* 2012). As obesity is a result of a combination of behavioral and biological factors, responsible authorities must address the problem by providing guidance on public health and develop regulatory frameworks to address these risk factors. Parents and educators can play a significant role in encouraging health behaviors.

Childhood obesity is associated with insulin resistance which later leads to glucose intolerance. Moreover, dyslipidemia and hypertension have been reported in children. Prevalence of overweight and obesity in children increases parallel with type 2 diabetes. A study in Singapore revealed that 10-25% of obese children were more likely to have impaired glucose intolerance while 4% had silent diabetes. Obese children are estimated to have threefold higher risk of hypertension than children who are not obese (Sorof & Daniels, 2002). The study reported that, 20-30% of obese children aged between 5-11 years have either elevated systolic or diastolic

blood pressure. Higher levels of total cholesterol, low density lipoprotein (LDL) and triglycerides in obese children is associated with insulin resistance (Lee, 2009). Obese children are at increased risk of insulin resistance (which later leads to glucose intolerance), diabetes mellitus, hypertension, dyslipidemia, cardiovascular disease, sleeping problems, and gallstones (Fortes *et al.,* 2020; Muhihi *et al.,* 2013; Erickson & Slavin, 2015; Musaiger & Hazzaa, 2012; Stuckler *et al.,* 2012; Lee, 2009). Obese girls often experience earlier menarche (often before 10 years) compared to normal weight girls, which links increased body weight and body fat (Yung, 2009). Dietary intake of lipids from childhood tracks the lipid profile to adulthood, thus, high levels of saturated fatty acids, with low levels of polyunsaturated fat acids and dietary fibre predispose children to a risk of chronic diseases such as cardiovascular, insulin resistance and body weight gain (Fowler *et al.,* 2021; Kmiecik *et al.,* 2016; Rauber *et al.,* 2014; Smpokos *et al.,* 2014). Hence, identification of sugars and fats in foods commonly consumed by school children could help in setting up of recommendations to reduce consumption of these foods and consequently reduction in weight gain. Analysis of secondary data among out of school children and adolescents in Tanzania revealed that a combination of factors such as unhealthy diet, physical inactivity and tobacco use are responsible for development NCDs in children and adolescents. This situation suggests urgent need multi-strategy intervention to address these risk factors (Shayo, 2019). Unhealthy diets contribute to approximately 12 million deaths out of 40 million non-communicable disease related deaths (Singh *et al.,* 2017).

2.4 Assessment Methods of Nutrition Status and Associated Factors among School Children

In the current study nutrition status of school children was assessed by different indicators namely; BMI-for-Age, MUAC and percentage body fat. Children and adolescents, body mass index (BMI) is age and sex-specific, and is referred to as BMI-for-age. It is calculated by dividing body weight in kilograms (kg) by height in meters squared (m2) like in adults, but it is expressed in percentiles or Z-scores (Adesina *et al.,* 2012). These percentiles and Z-scores express a child's BMI in relation to other children of the same gender and age. However, BMI-for-age cannot separate other parameters, such as lean mass, bone mass, and fat mass (Laurson *et al.,* 2011; Papandreou *et al.,* 2010); hence, other tools like bioelectric impedance analysis (BIA) can be used to assess body fat in children. The BIA analysis is low cost, easy to use, convenient, and more feasible to access than other complex methods (Laurson *et al.,* 2011; Papandreou *et al.,* 2010). The BIA has shown the same reliability compared to an expensive

method like dual-energy X-ray absorption (DXA) (Marques-Vidal *et al.,* 2008). Mid Upper Arm Circumference (MUAC) is a simple to use, inexpensive and non-invasive method. It helps study indicators of nutritional status across different age groups (Jeyakumar *et al.,* 2013) and can be applied in large populations (Mogendi *et al.,* 2015). Nevertheless, it measures mainly muscle mass and lacks reproducibility (Craig *et al.,* 2014). A structured and validated food habits questionnaire adapted from the study of Galinski *et al.* (2017) was used to collect information on the dietary habits of school children. The food consumption patterns were assessed by food frequency questionnaire. The questionnaire was adapted from FAO (2018) then modified to fit the study population. Nutrient intake data was estimated by a 24-hour dietary recall.

Physical activity levels for this study was assessed by physical activity questionnaire for children (PAQ-C). Other studies by Bailey *et al.* (1999) and Carter *et al.* (2001) used PAQ-C successfully with school children. The PAQ-C was selected because of its low cost and frequently use in epidemiological studies. It is an alternative to more expensive electronic devices, such as accelerometers, pedometers, and doubly labeled water techniques (Diouf *et al.,* 2016), and can apply to large groups of participants (Muntaner-Mas *et al.,* 2017). In addition, children ages 10 years and above can give valid answers to PAQ-C (Muntaner-Mas *et al.,* 2017).

2.5 Dietary Consumption Habits of School Children

Children and adolescents' dietary habits in developing countries do not meet recommended guidelines (Fitzgerald *et al.,* 2010). The dietary habits and interest in foods are embedded within cultural, social-demographic factors (such as child's gender and family size), economic, and social contexts (Seid *et al.,* 2018). These factors may contribute to unhealthy food intake and may result into overweight and obesity given that other factors are constant. Industrialization and urbanization have significant influence in dietary habits, partly, due to increased production of cheaper processed foods that have changed food preference and food habits. Processed foods are palatable due to high fat and sugar contents, thus over consumption of these foods leads to overweight and obesity (Durá-Travé *et al.,* 2014). Healthy eating habits that develop early in life are essential for school children as they form a holistic future relationship with food emotionally, physically, and mentally (Mukherjee & Chaturvedi, 2017). If a child develops poor eating habits at an early age is more likely to develop obesity which persists through adulthood. As children grow, they build more subjective food perceptions (acquired through senses) and

informed preferential food choices. School environments play an important role in shaping children's food choices (Alejandra *et al.*, 2016; Hoque *et al.*, 2016). A study done by Abrahams *et al.* (2011) in South African school children revealed that those who brought lunchboxes to school had healthier consumption habits and lower BMI compared to those who consumed foods purchased from school tuck shops indicating that foods in tuck shops are energy dense and contribute higher MBI. Studies have indicated that children and adolescents make poor decisions in terms of food choice that result in negative health outcomes (Banna *et al.,* 2016; Murimi *et al.,* 2016). For instance, a systematic review and meta-analysis study indicated that many children across the globe have increased consumption of sugary foods, such as sweetened beverages, while concomitantly consumption of healthy foods, such as fruits and vegetables, has decreased escalating the problem of overweight/obesity (Yee *et al.,* 2017; Holsten *et al.,* 2012). This was also revealed by few studies conducted in Tanzania (Chomba *et al.,* 2019; Nicholaus *et al.,* 2020) that school children and adolescents have poor dietary habits. This can be explained partly by availability of high-energy dense giving foods around school environment. It was revealed by a study of Itatiro (2014) in Morogoro region, that food vendors in the school environment supply mainly snacks and soft drinks while the supply of fruits, vegetables and dairy products was very low.

In a Mediterranean-based study, intake of sugar and meat among school-aged children was relatively high, while intake of cereals and dairy products were low. This behavior is highly associated to etiology of overweight and obesity. Unhealthy eating habits of hydrogenated fats and preference to white bread contributed to more energy intake by school children and adolescents in Mediterranean region (Musaiger & Hazzaa, 2012). A study done by El-Kassas and Ziade (2017) in Lebanon revealed that consumption of sweet snacks was high among school children and had significant association with the likelihood of overweight and obesity. A systematic review revealed that school children in developing countries have low dietary diversity, which is mainly characterized by high caloric processed foods and limited in animal foods, fruits, and vegetables (Ochala & Masibo, 2014) which leads to more energy intake. Similarly, studied Indian school children disliked milk, green vegetables, and fruits while preferring snacks, processed foods, and sweetened beverages (Mukherjee & Chatuverdi, 2017). A study in Bulgaria found low intake of dairy products, meat, fish, fruits, and vegetables, but high intake of simple sugars (Doichinova *et al.,* 2015). Some Pakistan school children reported to skip breakfast, which increases their risk of becoming overweight and obese (Mushtaq *et al.,* 2011).

In Tanzania, the country's nutrition profile showed that most of the diets are not diversified, mainly carbohydrate-based, and consumption of milk, meat, fruits, and vegetables is not adequate especially in low-income groups (FAO, 2008). This phenomenon explains why low-income groups are more likely to become overweight or obese. Wide changes in food habits and preferences have been contributed by increased production of processed foods and beverages, and a decrease in consumption of natural foods such as whole cereals, legumes, fruits, and vegetables (Vilchis-Gil *et al.,* 2015). Easy access to processed and unhealthy foods (high in fats and sugars) combined with social and technological changes have accelerated rates of childhood obesity (Brown *et al.,* 2011).

2.6 Environmental, Socio-Cultural and Parental Influences in Children's Food Choices

Eating habits during childhood may have long term implications; therefore, factors associated with children's food choices need to be identified and understood to enable the modification of these choices. African-based studies investigated the contributions of school and home environments on children's food choices and dietary habits. In schools, children face strong peer pressure which may alter their food preferences (Adamo & Brett, 2013) and children are more likely to opt for unhealthy foods (Neeley, 2011). A study in Malawi by Kalimbira and Gondwe (2015) reported that more than 80% of children had access to sugar-based soft drinks, especially home-made drinks in both home and school environments. When these foods are consumed in excess, it causes more energy intake, with reduced physical activity a child becomes more prone to overweight and obesity. Brown *et al.* (2015) through their study in Botswana revealed that parents have influence/control over children's food choice. Thus, interventions targeting parents may influence food behavior change in children. Studies in Tanzania (Itatiro, 2014), Mauritius (Sun *et al.*, 2009), and South Africa (Faber *et al.,* 2013) reported that most foods supplied in the school environment were high in energy, such as snacks, soft drinks, chocolates, biscuits, and sweets while fruits, vegetables, and dairy products were less available. Unhealthy foods are more preferred by children. Thus, it requires modification of school environment to provide more options for health and nutritious foods. If healthy food alternatives are available in the school environment, children may opt to consume nutritious foods (Bevans *et al.,* 2011), although the consumption may be lower compared to other unhealthy foods (Nollen *et al.,* 2007). Therefore, current study thought it is necessary to investigate factors contributing to food choices among Tanzanian school children that may

assist in planning of feasible interventions.

Perceptions towards healthy eating are influenced by both home and school environments (Sedibe *et al.,* 2018; Kupolati *et al.,* 2017). Provision of healthy foods in the home and school environment are necessary in the effort to prevent occurrence of overweight and obesity among children. Perceptions of healthy eating in the school and home environments suggest that the availability of healthy food options improves children's food choices (Bekker *et al.,* 2017).

Food preference in relation to texture, taste, appearance, and time involved in food preparation influence children's food choice regardless of knowledge they might have on healthy eating (Fitzgerald *et al.,* 2010). This indicates that knowledge alone will not impart food behavior change among children and it needs to be combined with attitude and practices. Advertisement of fast and unhealthy foods on television influence children's food choices by use of images of fast foods which target children as potential audiences (Boyland *et al.,* 2015). Therefore, children are likely to choose and consume fast foods that are advertised in the television. Many children are raised in obesogenic environment as a result of globalization and urbanization, in which cultural values and norms provide a perspective that overweight and obesity are perceived as indicative of good health status, especially in children and women (WHO, 2016).

Parents also have strong influence on children's food choices as based on their own food preferences and beliefs which impact their children's eating behavior. A child is more likely to try unfamiliar foods if parents consume them, and if parents dislike certain foods children are apt to do the same (Adamo & Brett, 2013). Savage *et al.* (2007) reported that women, who are primarily responsible for food preparation, are now overburdened with other tasks thus leaving less time to prepare food and eat together with their children or to pack school lunches for their children. This pattern might have contributed to poor decisions in food choice among children and adolescents that result in negative health outcomes (Banna *et al.,* 2016; Murimi *et al.,* 2016). Parental factors, such as parenting style (authoritative, permissive, and authoritarian), maternal portion size control, maternal pressure, and media exposure, were reported to influence children's food choice (Scaglioni *et al.,* 2018; Yee *et al.,* 2017). In addition, the authors outlined restrictive guidance, parental modelling, pressure to eat, using food as a reward, parental control of availability, active guidance of parents, and accessibility to foods as the key determinants to children's food choices. Feeding practices and parental nutrition knowledge are also listed by Peters *et al.* (2014) as influencing children's eating habits and preferences to food. This indicate that in obesity prevention strategies parents should be

included as potential key players.

In terms of cultural factors, Reddy and Anitha (2015) reported that nutritional values of foods are not considered in food choice, especially when foods are associated with social or ceremonial roles. Some foods are highly prioritized in special events like holidays and religious festivals. In different cultural contexts some foods can be highly prized, classified as edible or not edible, and heavy or light, depending on how they value a certain food (Freedman, 2016). Culture may influence consumers' attitude and beliefs, thus promotion of health eating behaviours, interventions should consider cultural-specific differences underlying the food choices. For instance, in some cultures, people may enjoy foods due to the experience they get from eating while others may be more concerned about health outcomes of the same food (Cunha *et al.,* 2017; Freedman, 2016).

A number of researchers associated the interplay between food choice and the four levels of influence (personal, interpersonal, physical environment and society). At the personal level, food preference and knowledge on eating may influence food choice (Banna *et al.,* 2016). At the interpersonal level, family and peers play a part on what someone chooses to eat (Salvy *et al.,* 2012; Savage *et al.,* 2007). In the school physical environment Fox *et al.,* (2009) found an association between availability of poor-nutrient energy-dense foods and energy intake of these foods. At the societal level, exposure to media, such as television, was associated with unhealthy eating which consequently may contribute to overweight and obesity (Rey-López *et al.,* 2011).

2.7 Physical Activity Patterns and Health Implications in School Children

As childhood obesity can be caused by low physical activity, there is a need to consider how school children engage in physical activity (Sigmund *et al.,* 2007). Engagement in sports and physical activity during young age improves mental and physical health (Cardon *et al.,* 2012); easy movement of joints, body control and improvement of a cardiovascular system (Pedroni *et al.,* 2019). Thus, it is among the best strategy to prevent obesity (Leech *et al.,* 2014) and reduce risk of chronic diseases including premature heart diseases, type 2 diabetes, stroke, and some types of cancer. One study in Tanzania reported that children who participated in physical activity for at least > 30 minutes per had a low likelihood of being overweight/obese (Mosha *et al.,* 2021). It is reported that physical inactivity is the fourth most common cause of global premature mortality contributing to approximately 3.2 million deaths (Mashili *et al.,* 2018; Muthuri

et al., 2014). Previous studies have reported that young people do not engage sufficiently in physical activity to meet suggested guidelines (Dobbins *et al.,* 2013; Mushtaq *et al.,* 2011) with adolescent girls being less physically active than their male counterparts (WHO, 2016). According to WHO recommendations children are required to spend at least 60 minutes in moderate to vigorous physical activity daily (WHO, 2020; Leech *et al.,* 2014). In a study done in almost 40 western countries, it was revealed that a less than one in four school children met daily recommendation for physical activity (Cardon *et al.,* 2012). Recently, studies from the United States, Czech Republic, and Saudi Arabia (Jalal *et al.,* 2021; S´tvera´kova´ *et al.,* 2021; Tulchin-Francis *et al.,* 2021; Dunton *et al.,* 2020) have reported a decrease in physical activity among school children and university students respectively due to Covid-19 pandemic. This situation is likely to exacerbate the rates of overweight and obesity in children. It is now necessary to promote physical activity in the home and school environments. Parents and school teachers/administrators should be guided to encourage children to participate in sports activities and reduce sedentary activities such as screen time (Tandon *et al.,* 2021). Parents play an important role in influencing children's active life through support and encouragement, thus preventing excess weight gain in their children (McMurray *et al.,* 2016; Gubbels *et al.,* 2013). At school, teachers are responsible in guiding children to participate in physical activity and ensuring availability of sports facilities, space and allocation of adequate time for sports. To meet the daily recommendation for physical activities children may also be encouraged to participate in common and unorganized games such as hide and seek, jogging, walking and running around.

2.8 School Based Interventions on Addressing Double Burden of Malnutrition

Behavioral based nutrition education can be applied in urban settings to reduce the prevalence of over nutrition in target groups. The WHO report (2016) for ending childhood obesity recommended implementation of programs/interventions that are comprehensive in promoting physical activity, intake of healthy foods, and reduce intake of unhealthy foods among children and adolescents. School environment is considered optimal for implementing interventions aimed at promoting daily physical activity in children (Singh *et al.,* 2017; Cardon *et al.,* 2012). A Social Ecological Model (theory-based model) helps to understand the interaction effect of personal and environmental factors that determine behavior. This theoretical model was used in South African studies to promote healthy eating habits and physical activity in school children and showed success (Villiers *et al.,* 2015; Draper *et al.,* 2010). A school-based

intervention in Norway was built on the Social Ecological Framework to investigate intake of fruits and vegetables among adolescents. The study was rooted in the belief that eating behaviors are influenced by interactions of multiple factors, such as physical, political, social, and psychological (Krølner *et al.*, 2012). The use of Social Cognitive Theory (SCT) in behavior change in women towards consumption of fruits and vegetables to reduce overweight and obesity and increase consumption of animal protein among children to alleviate problem of stunting (Mahmudiono *et al.*, 2016). Thavorncharoensap (2017) and Krølner *et al.* (2012) stated that interventions combining diet and physical activity coupled with family involvement are likely to show promising effects in reducing body weight among school children. However, school-based nutrition interventions are still scarce in low and middle-income countries. Therefore, planning and implementing the interventions in the area of overweight and obesity will help to alleviate the problem and their associated risks.

2.9 Strategies for Creating Enabling Healthful Food Environment for School Children

2.9.1 Conducting Informative Research

Effective implementation of optimal intervention strategies to prevent obesity needs sufficient evidence on current and periodic trends of obesity across countries (Adom *et al.*, 2019). Knowledge about food choice and dietary habits data among African school children is inadequate; therefore, more consumer research on the school and home food environment are required. There is a need to focus on the penetration of supermarkets that offer highly processed food varieties (Turner *et al.*, 2017). Nevertheless, before launching school-based interventions in low and middle-income countries, we need to establish culturally based evidence because of differences in values, norms, customs, and environmental influences on food choices for children (Verstraeten *et al.*, 2014). Context-specific school-based interventions, if implemented effectively, can improve the nutritional status of school children.

2.9.2 Designing Social-Ecological Frameworks for African Childhood Nutrition

The social-ecological perspective describes relationships between an individual and environment positing that individual behavior emerges from the interplay of multiple factors between the two entities (Golden & Earp, 2012). The social-ecological framework considers five levels of influence: Individual (knowledge, attitude, and self-concept); Interpersonal (family, peers, friends, social networks); Community (relationships between

organizations); Organizational (organizations and social institutions); and Policy/enabling environment (national, state, local). At the individual level, school children need to receive nutrition education to equip them with appropriate knowledge to make informed healthy food choices and change their attitudes and skills to build self-efficacy (Sedibe *et al.*, 2018; Oldewage-Theron & Napier, 2011). At the interpersonal/family level, training of parents and modification of the home environment is required (Scaglioni *et al.*, 2011). At the organization/school level, teachers are capacitated to deliver nutrition education and communication messages to pupils and create resources for physical activity.

2.9.3 Multisectoral Partnership/Coordination

Prevention of overweight/obesity in children is a shared responsibility between different sectors. Leaders should be willing to take responsibilities through preparation and enhancement of policies across all sectors (WHO, 2016). The health sector needs to initiate, implement, and innovate primary and secondary overweight/obesity preventive measures. The education sector needs to integrate and implement nutrition-related courses in primary school curriculum (FAO, 2005). The agriculture sector needs to emphasize the production of local nutrient-dense foods at an affordable cost and the periodic revision of import trade policies (WHO, 2016). Food regulatory bodies are tasked to set and enforce import requirements and regulations to ensure that imported foods meet agreed quality standards (GAIN, 2016).

2.9.4 Social Behavior Change Communication

One of the most promising strategies to prevent childhood obesity is social behavior change communications. This strategy includes individual counseling, mass media campaigns, and education sessions. If these are targeted to relevant audiences, like school children, schools, non- governmental organizations, and decision-makers, the expected outcomes may be achieved (Bundara *et al.*, 2013). The SBCC needs to be developed, pre-tested, and disseminated to the target population. A success in integrating social behavior change communication interventions with nutritional specific programs was reported by Kennedy *et al.* (2018) and Wilner *et al.* (2017).

2.10 Conceptual Framework of the Study

This study is guided by the following conceptual framework on determinants/correlates of overweight and obesity in school children (Fig. 1).

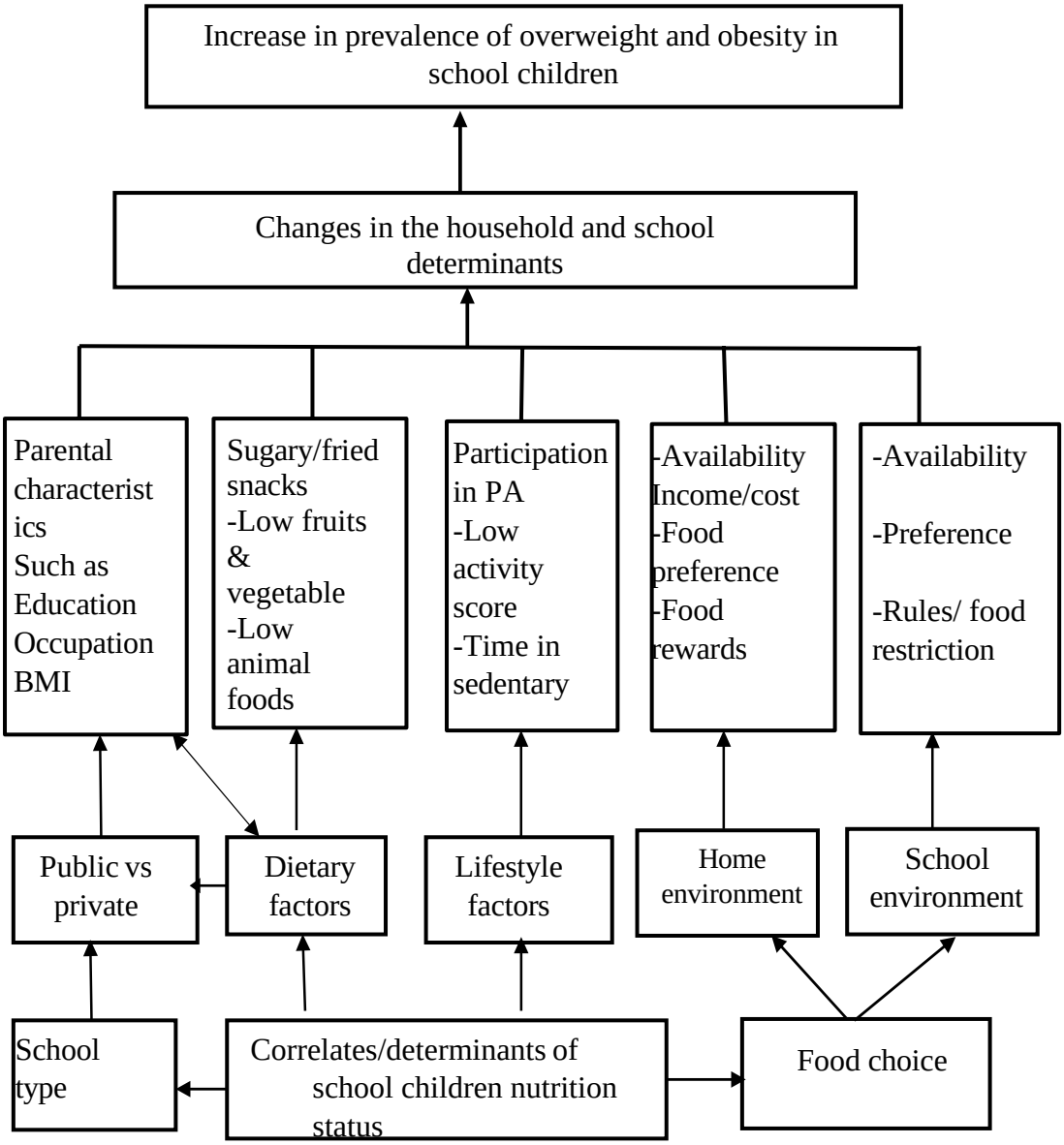


Figure 1: Conceptual framework of the study

CHAPTER THREE

MATERIALS AND METHODS

3.1 Description of the Study Area

The study was conducted in Ilala District, Dar-es-Salaam Region, and Mkuranga District, Pwani Region. These regions were selected due to previously reported high prevalence of overweight in the adult population which was above the national average (TNNS, 2018). In addition, large numbers of food vendors were found in Dar-es-Salaam city, including on school premises and 80% of school children purchased food from these vendors (Marras, 2018). Thus, the risk of being overweight or obese increases due to exposure and consumption of unhealthy foods. Dar-es-Salaam is the largest city in Tanzania with a population of 6.37 million in 2019 (https://www.macrotrends.net/cities/22894/dar-es-salaam/population) and Ilala district had 1.2 million inhabitants by the year 2012 (National Bureau of Statistics, 2013). The Indian Ocean borders it to the east and Pwani region to the South, West, and North. Pwani Region has a population of 1.1 million with Mkuranga district having 222 921 inhabitants (National Bureau of Statistics, 2013). Pwani shares borders with Lindi region to the South, Morogoro region on the West, Tanga region on the North. To the East Dar-es-Salaam region and the Indian Ocean. Major economic activities of the two areas include business, manufacturing companies, farming, livestock keeping, and fishing (National Bureau of Statistics, 2013).

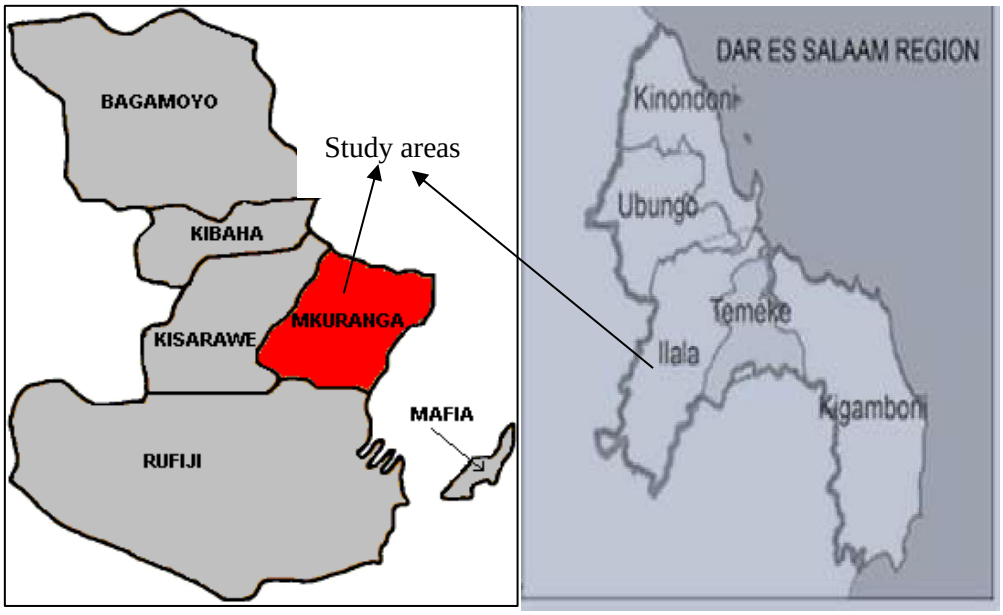


Figure 2: Pwani and Dar-es-Salaam maps showing the study areas

3.2 Study Design

The study used cross-sectional survey design. This design was used for the identification and analysis of the nutrition problem conducted between July and September, 2019 involving all children between the ages of 10 and 13 years and their parents and teachers in a qualitative study for investigating factors influencing food choices. It was also used to establish risk factors for overweight and obesity which was conducted from February to March, 2020 and July, 2020 among overweight/obese and normal weight children. In addition, a laboratory analysis was done for quantification of sugar and fatty acid profiles in foods commonly consumed by school children.

3.3 The Study Population

The study population involved school children aged 10-13 years recruited randomly from selected primary schools. School children were chosen because they spend significant periods of time in the school environment where they are exposed to a variety of unhealthy and inexpensive foods which may influence their eating habits. The age group of 10-13 years was selected as these children are in upper classes of primary school and are most likely to provide appropriate information compared to their younger counterparts. School children were involved in answering questions specific to objectives number one to three plus participating in the anthropometric measurements. Parents/guardians of school children and teachers in respective schools were involved in the qualitative study. In this study, teachers were involved in key informant interviews while parents were involved in focus group discussion with regard to specific objective number four.

3.3.1 Inclusion Criteria

All school children aged 10-13 years studying in selected districts and schools in grade five or six were eligible to participate in the cross-sectional survey. Thereafter, all overweight/obese children and normal weight children who met the specified criteria of age, sex and school type were compared to determine the risk of exposure. Selected parents and teachers who agreed to participate were included in the qualitative study. Willingness to participate and provision of the necessary consents.

3.3.2 Exclusion Criteria

Children with physical and mental disabilities, those with chronic diseases such as diabetes, boarding school children, and obese children already in weight management programs were excluded from the study. Children who were malnourished (i.e., wasted or stunted), unmatched criteria (difference in age, sex, school type) between overweight/obese and normal weight, and those who refused to participate were excluded from the study.

3.4 Sample Size Determination

3.4.1 Sample Size for Cross-Sectional Survey

The sample size was estimated using the WHO STEPwise Manual (2005).

$$n = \mathrm{Z}^2 \frac{P(1-P)}{e^2}$$

Whereby n = desired sample, Z = level of confidence (1.96) corresponding to 95% C.I, P= baseline level of indicators (proportion of target population 50% since no previous data which reflect reality), e = margin of error (recommended 0.05). Therefore n = (1.96)2*0.5(1-0.5)/(0.05)2 = **384**. Adjust for design effect of 1.0 and for non-response rate (10%) = 0.9, therefore 384*1.0/0.9= **426.6**

A sample size of 427 children is obtained after using the formula. By using a table of random numbers, a desired number of children were chosen from each of the 9 schools.

3.4.2 Sample Size for Comparison between Overweight/Obese and Normal Weight Children

For the purpose of this study, the sample size was calculated based on Charan and Biswas' (2013) formula

$$n = \frac{r+1}{r} * \frac{Sd^2(Z\beta + Z\alpha_2)^2}{d^2}$$

Whereby, n= minimum sample size, r = ratio of normal weight to overweight/obese children

Sd= standard deviation (Mean BMI for school children 16.6±4.0 kg/m^2 from a study of Muhihi *et al.*, 2013),

d = expected mean difference between overweight/obese and normal weight children =Sd/2

Zβ = standard normal variate for power for 80% power (equal to 0.84)

Zα = standard normal variate for level of significance of 1.96 corresponding to 95% C.I

$n = \frac{1+1}{1} * \frac{4^2(0.84+1.96)^2}{2^2}$ =62.72 = 63 overweight/obese children but the ratio was 1:2 (a ratio significant in increasing the statistical power), number for normal weight children = 63*2=126, therefore total sample size = **189**

To adjust for a non-response rate, 10% was added and a sample of 208 children was obtained. Finally, 207 children who assented to participate in the study were drawn from 406 children who participated in the cross-sectional survey. The criteria for matching overweight/obese children to normal weight children were age, gender, and school type. The random sampling method (also used by European Centre for Disease Control, 2009; WHO, 2014) was used to select control children from a list of normal weight children.

3.4.3 Sample Size for Qualitative Approach

Participants of the qualitative study were purposively selected teachers and conveniently selected parents (9 teachers and 36 parents) of school children in the two districts. Sample size selection for this approach was guided by the study of Moser and Korstjens (2018) based on the idea that adequate sample is determined when a saturation point is reached. The six-focus group discussion provided a rich discussion that no new analytical information arises. In addition, in practical terms, a sample for qualitative research should be as representative of the population as possible (Boddy, 2016). Thus, the participants for key informant interview and focus group discussions were selected from both the study districts and schools. Telephone calls and written requested were made few days before the interview to ask selected parents to participate in the study.

3.5 Sampling Techniques

The study involved multistage sampling, whereby sampling was done in stages from regional to individual level (Fig. 3). Purposive sampling was used to select two regions. Random sampling was used to select two wards in Ilala District; while in Mkuranga District, two wards were purposively selected based on their peri-urban characteristics. Stratified random sampling

was used to select a total of eight public and private schools, four schools per district, two schools per ward (one public, one private). Due to an inadequate number of children in private schools in Mkuranga ward an additional private school was added to obtain a desirable sample size. Eligible children from classes five and six were randomly selected by using a table of random numbers.

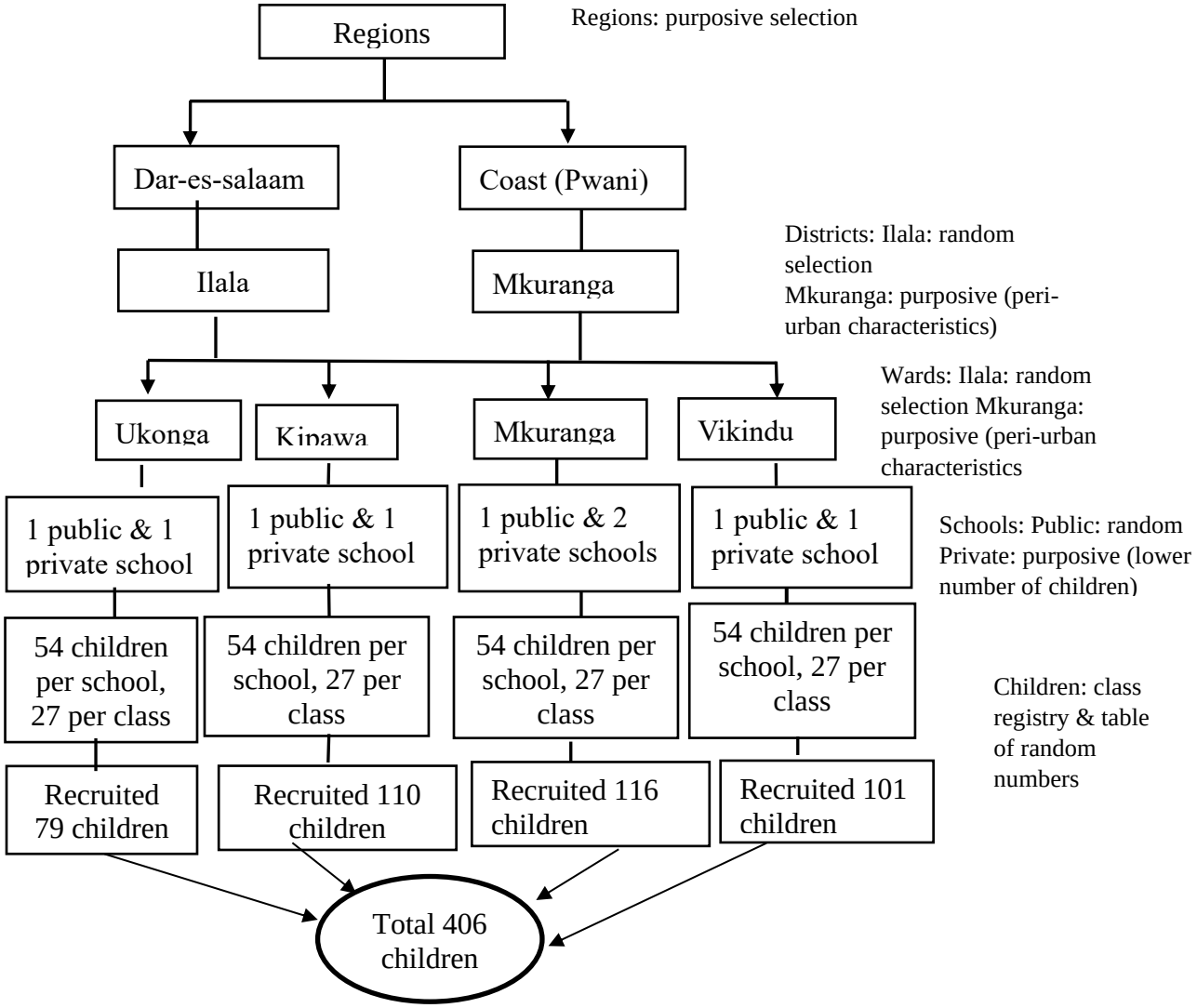


Figure 3: Sampling procedure of study participants for cross-sectional study

3.6 Data Collection

3.6.1 Pre-Testing, Training of Research Assistants, Study Tools, and Interviews

A comprehensive structured questionnaire was developed to collect information from

respondents, namely; demographic information of parents and school children, anthropometric and body composition assessments of children, and dietary habits. The questionnaire was written in English and translated to Swahili, a predominant local language for participants. Before data collection, two research assistants were trained on questionnaire administration and taking body measurements. The questionnaire was pre-tested in schools which had similar characteristics to study schools. The aim of pre-testing was to determine if participants understand the questions and can provide the needed information. The questionnaire was modified for clarification by adding some information on demographic characteristics, dietary habits and modifying the codes. Face-to-face interviews were conducted with parents who provided information on demographic characteristics, such as the age of the child, marital status, occupation, ward of residence, and maternal education level. Children provided information on their grade/class, dietary habits and participated in anthropometric measurements. The interviews of parents and children were done concurrently. Furthermore, children who participated in the comparison between overweight/obese and normal weight provided data on their nutrient intake, food consumption patterns and physical activity levels, patterns, and sedentary behaviors. The questionnaire was interviewer-administered and body measurements were performed during break times to avoid class interruption.

For the qualitative portion, a series of guides were developed based on findings of similar studies in school children. The guides were pre-tested in one focus group and key informant involving parents and teachers in other schools which had similar characteristics to study schools. After pre- testing the guides were modified for clarification of ambiguous questions and adding some questions which were thought to be missing. A focus group checklist guide developed contained three main parts; namely, parental factors, environmental factors, and socio-cultural factors influencing children's food choices. A checklist guide for key informant interviews contained two main parts which were food environment (availability and school rules) and facilities available for physical activities at school. Checklist guides were developed in English language then translated into Swahili language which was more convenient for participants and allowed for a rich discussion.

3.6.2 Assessment of Nutrition Status

Weight and height data were measured by trained researchers using standard procedures (WHO, 2008). Weight was measured using a weighing scale (Digital SECA^{TM}). Without shoes and with minimum clothes, children stepped onto a zero-calibrated weighing scale, and weight

was read and recorded to the nearest 0.1 kg. Height was measured by a SECA^{TM} mechanical stadiometer platform placed on a flat surface. Without shoes, children stood with their back, heels, buttocks, shoulders, and occiput touching the height board/stadiometer and hands hanging freely at the sides. The headpiece was then slowly lowered over the head of the child, and height was read and recorded to the nearest 0.1 cm. Fig. 4 shows anthropometric measurements. BMI-for-age (computed from weight and height data) and height-for-age were analyzed using the WHO's AnthroPlus software to determine the nutritional status of school children. The MUAC was measured using non-stretchable tape. The mid-point between the tip of the scapula and elbow was found and used as a center for circumference measurement. The child's left arm was allowed to hang freely at the side, then MUAC was measured and recorded to the nearest 0.1 cm.

Body fat mass was measured by a Bio-electric Impedance Analyzer (TANITA^{TM}-BF-350, America). In this instrument, the child's age, sex, and height were entered before the impedance measure. A single foot-to-foot BIA device was used and a drop of saline solution was regularly added to surface electrodes of the device maintain its accuracy. Without shoes and socks, children stood over the device with the feet directed into BIA foot sensors to ensure optimal contact. Percentage body fat was captured and then recorded. The device was zeroed before and after each measurement. The cut-off value (25% for boys and 30% for girls) has been used to define obesity in children (Marques-Vidal *et al.*, 2008).

Figure 4: Anthropometric assessment

3.6.3 Assessment of Dietary Habits of School Children

Dietary habits questionnaire was adapted by modified, some of the questions modified were; for example, common foods used in Tanzanian context were added and uncommon foods

omitted. It was then pre-tested with a subset of intended population. Questions included: the number of meals per day; main staple and relish (relish is a prepared side dish/food, mostly spiced food item from animal or vegetable source which serves to enhance palatability of staple) preferred most; preference to fruits and vegetables, snacks consumption; frequency of consumption of foods; foods preferred during school hours; and the number of times of eating during school hours. Other questions were on eating patterns, such as eating with other family members and while watching television. For further analysis, food varieties, such as fruits, vegetables, and snacks, were grouped to obtain one variable for each group. For example, fruits were recorded into one variable, which combined the most preferred fruits, such as mangoes, oranges, avocado, ripe banana, watermelon, and pineapple. The most preferred green leafy vegetables were recorded into labels of sweet potato leaves, spinach, amaranths, pumpkin leaves, and cassava leaves. Furthermore, most consumed foods at school were recorded into cereal foods; comprised of stiff porridge (a maize meal product in the African diet), rice and spiced rice (*pilau*), fried foods/snacks combined of fried cassava, potato samosa, and *kachori* (a deep-fried mashed round and colored potato ball). Sugary snacks were recorded as cookies, biscuits, cakes, soda, ice cream, and tea/coffee, and salty snacks as (i.e., potato/banana crips and popcorn). Frequencies of food consumption were computed as one of three categories, "did not consume", "consumed one to three times a week", or "consumed four or more times a week". Food types were computed into categories of "did not consume," "consumed one or less, "consumed two to three types," and "consumed three to four food types."

3.6.4 Assessment of Family History/Characteristics

Parents/guardians of overweight/obese and normal weight children who agreed to participate in the study that compared risk factors for overweight and obesity completed a checklist of questions. The questions covered various aspects, namely: (a) disease history in their families, such as diabetes, high blood pressure, cardiovascular and cancer; (b) parental perception on their weight and their child's weight status; (c) if their children usually consume breakfast in the morning before going to school; and (d) if they give money to their children for school use on food and place where their children normally take lunch. A checklist of questions for parents/guardians was given to children for their parents to fill at home and bring the forms back to school the next day. The telephone conversation was done to clarify any ambiguous questions for parents. Follow-up of the forms was facilitated by teachers in each school.

3.6.5 Assessment of Nutrient Intake and Food Consumption Patterns

By using a food frequency questionnaire (FFQ) and 24-hour dietary recall food consumption patterns and nutrient intake data were collected respectively. A standardized food frequency questionnaire consisted of 85 food items obtained from 11 food groups (i.e., cereals, roots and tubers, legumes, nuts and seeds, meat, poultry, fish, eggs, oils and fats, vegetables, milk and milk products, fruits, processed foods/snacks, and soft drinks). Each child was requested to recall the number of times (frequency) a certain food was consumed in the last month (30 days) before the survey date. Frequencies of consumption were recorded into daily, weekly, monthly, rarely, and never. The questionnaire was adapted from FAO (2018) then modified to fit the study population.

Usual food intake was determined by 24-hour recall. Children were asked to recall the food consumed in the past 24 hours during the school days from midnight to midnight. Trained fieldworkers recorded what each subject ate during breakfast at home/school, lunch, dinner, and all snacks between meals. A detailed description of foods and drinks consumed, and ingredients used were recorded. Estimations of liquid foods were done by household utensils, like cups, plates, bowls, and spoons, which were translated into gram equivalents. Solid foods were estimated by actual food samples and food pictures prepared by researchers before data collection. By using a kitchen digital food weigh scale, the child's estimated food portion size consumed at home and away from school was measured. Foods available in the school environment (like cassava, *kachori*, samosas, crips, banana, chips, chapatti, ugali, rice, beans, wheat burns, rice buns, and popcorn) were bought/requested from the school kitchen and its weight was measured. All food and drinks were recorded in grams served and net grams consumed. NutriSurvey™ software was used to calculate the mean nutrient intake of each food from 24-hour dietary recall and then data was transferred to SPSS™ software for further analysis as described in Section 3.7.2. Fig. 5 shows some of the pictures taken during dietary assessment.

Information of dietary diversity was recorded from 24-hour dietary recall which involved asking children to recall all foods and beverages consumed in the previous 24 hours inside and outside home. FAO (2010) guidelines were used to construct a dietary diversity score (DDS). Dietary diversity score (DDS) was calculated from reported food items categorized into 10 food groups including: (a) starchy staples; (b) dark green leafy vegetables; (c) other vitamin A rich fruits and vegetables; (d) other fruits and vegetables; (e) organ meat; (f) meat and fish; (g) eggs;

(h) legumes, nuts and seeds; (i) milk and milk products; and (j) sweets. Consumption of individual food items was dichotomized into 1=Yes, if the food was consumed, and 0=No, to indicate the food was not consumed. Total DDS was obtained by summing up number of food groups consumed by each child (between 0-10 food groups). Then two categories of DDS were formed as: (a) ≤ 4 food groups and (b) ≥ 5 food groups which were similar to scores classified in a study by Khamis *et al.* (2021).

Figure 5: Dietary assessment

3.6.6 Assessment of Physical Activity and Sedentary Behaviors by PAQ-C

A previously standardized validated and used physical activity questionnaire for older children and adolescents (PAQ-C) was adapted from Kowalski *et al.* (2004) and used for this study. The PAQ-C was modified as necessary by adding and omitting some games to ensure relevance in our context. Games like netball, rope skipping, household chores, walking to and from school were added because these are common in Tanzania and uncommon games in our setting like ice- skating and ice hockey were omitted. The first item of the questionnaire was on physical and sedentary activities. It included type of activity, place of the activity (home or school), as well as frequency and duration of each physical and sedentary activity in the last seven days before the survey. Physical activity included games like football, netball, dancing, rope skipping.

Sedentary activities involved watching television, listening to music, artwork, doing homework, computer games, and telling stories. Patterns of physical and sedentary activities were assessed in frequency (number of times) per week and minutes spent on each day of the week. A child was asked to recall in the last seven days, the type of physical and sedentary activities, place of activity, frequency, and duration of each activity. Each physical and sedentary activity was expressed as continuous (minutes/week) then categorized further for later analysis. The mean hours of physical and sedentary activities were obtained from the summation of time spent in various activities then divided by days of the week. Items 2 through 8 of the PAQ-C considered what they did most and the frequency of participating in activities done on different occasions in a typical week (during recess, lunch, right after school, evenings, and during weekends). Scores of 1-5 were assigned for each item, 1 being least active and 5 being most active. A higher score indicates an increased frequency of being active on a particular occasion. Item 9 was the mean of all days of the week. The mean activity score of each item was computed and compared between overweight/obese and normal weight children.

3.6.7 Assessment of the Environmental, Socio-Cultural and Parental Factors on Children's Food Choice

Data collection was conducted between July and September 2019. A total of 36 parents/guardians were interviewed across a total of 6 focus groups of six participants each in the two districts (i.e., three groups in each district). Out of the six focus groups, four involved parents/guardians of public-school children and two groups involved parents/guardians of private school children. Key informant interviews (KII) involved nine teachers, of which four were from Ilala district and five from Mkuranga district. The teachers were not involved in focus group discussions. Focus group discussions lasted approximately 60 minutes, while KII took around 20-25 minutes. The FGD and KII were conducted on the school premises during school hours. Specific locations were selected to enhance convenience and comfort for participants to freely give their ideas and views (Mbwana, 2019). For example, during the FGD, participants were seated in positions that enabled them to see each other that indicated sense of togetherness and each person participated equally in the discussion. Both FGD and KII were conducted in the Swahili language, audio-recorded, and transcribed verbatim in Microsoft™ Word by the researcher. The interviewer and a moderator were available to lead discussions, operate the recorder, and take short notes respectively. All participants in the FGD and KII received small monetary incentives to assist them for transport to and from school premises.

Focus group discussions collected information on parental factors on their children's food choices, eating together with their children, common cooking methods, and foods used as rewards for their children. Furthermore, parents were asked on variations in food choice during different seasons and special events, as well as food available in the home environment. Other information collected reflected on the gender differences consideration in food provision, food taboos, whose opinion matters most in food choice in the household, their perceptions and cultural beliefs on child's weight status, and foods mostly preferred by children and by adults in the household. Also, parents were asked about availability of physical activities facilities in their households.

Information collected in the KII included types of foods available in the school environment, providers of food services in the school, eating timetable, if children come with lunch boxes to school, and availability of school food policy. Again, teachers were asked to give their views on school food environment and nutrition aspects of foods available. Also, teachers were asked about availability of physical activities and facilities in the school, including space, sports schedule, and availability of teachers to run physical education classes. This qualitative component of the study aided in complementing the quantitative component of the study especially on dietary habits and partly on physical activity.

3.7 Statistical Analysis

Data were compiled, cleaned, coded, and analyzed using the Statistical Package and Service Solution (SPSS)™ Version 20.

3.7.1 Analysis of Anthropometric Measurements and Dietary Habits

Descriptive statistics (i.e., frequencies, percentages, medians, mean, and standard deviation) were used to describe sample characteristics (i.e., gender, age, type of school, education level, marital status, parent's occupation) and compute mean intake of fruits, vegetables, and snacks. The chi- square test was used to find out if there is any association between demographic characteristics and nutrition status among public and private school children. The distribution of BMI-for-age data (dependent variable) was skewed (Shapiro-Wilk test $p<0.05$), thus, the non-parametric test Kruskal-Wallis for comparison of more than two group categories and Mann-Whitney U-test for comparison of two group categories were used to associate BMI-for-age with dietary habits (independent variables). Other skewed continuous variables were age, weight, MUAC, and percentage body fat. With non-parametric tests, median values are

presented instead of mean values except for height values. BMI-for-age was categorized as thinness=1, normal=2, overweight=3, and obese and severe obese=4 (Z-scores classified under Table 5). Height-for-age was categorized into severe stunting=1, moderate stunting=2, and normal height=3. Similarly, gender (i.e., male=1, female=2) and type of school (i.e., public=1 and private=2) were categorized. Pearson's correlation coefficient was used to associate median BMI-for-age, median percentage body fat, and median MUAC. Multivariable binary logistic regression was further used to associate overweight and obesity with selected dietary habits. BMI-for-age was further dichotomized into 1=non-overweight/obese and 2=overweight/obese (dependent variable) and dietary habits variables were considered as independent variables. Univariate analysis was performed to assess the association between each of the independent variables and being overweight/obese. Independent variables (dietary habits) that showed a probability value of <0.30 in the univariate analysis were entered into a regression model. Three tertiles were made for dietary habits i.e., “did not consume", "consumed one to three times a week", or "consumed four or more times a week". Food types were computed into categories of "did not consume", "consumed 1 or less, "consumed 1-3 or 2-3 types," and "consumed 3-4 food types". Furthermore, in each regression model, the first dietary habits were considered as a reference category. The significance level was considered at $p<0.05$.

3.7.2 Analysis of Nutrient Intake, Food Consumption Patterns and Family Factors

Differences between overweight/obese children and normal weight children were performed by the following tests; Pearson’s chi- square test compared the socio-demographic and anthropometric categorical data and associated family history factors and dietary diversity between overweight/obese children and normal weight children. Data on nutrient intake from a 24-hour dietary recall (calculated by NutriSurvey™) was skewed (Shapiro-Wilk test <0.05); therefore, the Mann-Whitney’s U test was used to compare the differences in median values of nutrient intake (energy, macro- and micro-nutrients) between overweight/obese and normal weight children.

Association between family factors, nutrient intake, consumption patterns and dietary diversity, and overweight or obesity were evaluated by multivariable logistic regression. The odds ratio and 95% confidence interval were estimated. The univariate analysis involved four different models. The first regression model evaluated the association between overweight/obesity (dependent variable) with each of the independent (predictor) variables of consumption pattern of different foods. The second model used nutrient intake predictors and the third model used

family history factors and the last model involved dietary diversity. Information from the univariate analysis was used to build another model which included different variables (multivariate analysis). Independent variables that showed a probability value of <0.30 in the univariate analysis were entered into a regression model. A p-value was accepted to be statistically significant at the level $p<0.05$. Food frequency questionnaire variables were recorded into the following frequencies of consumption; 0=never/rarely; 1=once a month; 2=2-3 times a month; 3=1-2 times a week; 4=3-4 times a week; 5=5-6 times a week; 6=once and/or several times a day. Furthermore, categories one and two were recorded as less consumed; categories 3 and 4 were recorded as moderately consumed; and categories 5 and 6 were recorded as highly consumed. In the regression analysis, three categories of food consumption were recorded as 1=consumed ≤ 3 times a month, 2= consumed 1-4 times a week, and 3= consumed daily or 5-6 times a week and the first category was considered as a reference category.

3.7.3 Analysis of Physical Activity Levels and Sedentary Behaviors

Descriptive statistics, such as frequency and percentage, were used to classify the sample. The differences in socio-demographic and anthropometric data between overweight/obese children and normal weight children were tested using the independent sample t-test for normally distributed data and Mann-Whitney U-test for skewed data. The independent sample t-test was also used to compare the mean activity score between the two groups. To predict the association between physical activity patterns, sedentary behaviors, and overweight/obesity, multivariable binary logistic regression models were used to estimate the odds ratios (ORs) at 95% confidence intervals. Overweight/obesity was considered as a dependent variable while physical activities and sedentary behaviors were considered as independent variables. Univariate analysis was performed to assess the association between each of the independent variables and being overweight/obese. Independent variables that showed a probability value of <0.30 in the univariate analysis were entered into a regression model. Three tertiles were made for physical activities and sedentary behaviors as reported as: 0=none, 1= <2 hours per week, 2= ≥ 2 hours per week. Total physical activity had 2 tertiles which were reported as: 0= <1 hour per day or 1= ≥1 hour per day. Total sedentary level was reported as 0 <4 hours per day and 1= ≥4 hours per day. Furthermore, in each regression model, the first tertile of physical activity and sedentary behavior was considered as reference categories. The significance level was considered at $p<0.05$.

3.7.4 Analysis of Environmental, Socio-Cultural and Parental Factors on Children's Food Choice

Descriptive statistics (using SPSS version 20) was used to analyze demographic characteristics of participants. Qualitative information from FGD and KII were analyzed by thematic content analysis by considering themes and content from topics discussed (Mbwana, 2019). The themes of this study were based on a deductive approach in which data are collected based on pre-determined themes that are expected to be found based on existing knowledge. Transcribed data of FGD and KII were checked for quality by the researcher who was fluent in both languages (English and Swahili) to ensure that translated information was correct. Short notes written during FGD and KII were used to complement the transcribed information. Analysis was further done by Microsoft™ Excel. All responses of the questionnaire from audio records and notebooks were first typed into Microsoft™ word, and were then imported into Excel spreadsheets where common themes were identified and grouped depending on their occurrence. Qualitative analysis by Excel was also suggested by other studies (Bree & Gallagher, 2016; Ose, 2016) as a cost-effective method to analyze qualitative data.

3.7.5 Laboratory Analysis of Food Samples

(i) Sample collection for sugar and fatty acids analysis

A set of 13 food samples and drinks were tested for sugars (5 local ice creams, 3 local juices, 2 artificial juices, 3 *kashata*) and a total of 20 food samples (6 potato samosa, 5 *kachori,* 7 cassava, 2 *kashata*) were tested for fatty acids. These foods were purchased from different food vendors in school premises in Ilala and Mkuranga Districts. The food samples were taken from food vendors using chopping stick/fork and placed in safe zipper freezer bags. The samples were named by codes assigned to each school. Then the samples were transported in a cool box filled with ice cubes to the laboratory for analysis. Prior to sample collection, a survey was conducted to identify foods mostly consumed by school children. The survey showed that sugary foods (i.e., local ice creams, local juices, artificial juices and *kashata*) and fatty foods (i.e., potato samosa, cassava *kachori*, and *kashata*) were mostly consumed by children in the school environment. Samples of the same product from different food vendors were analyzed separately. Product names and assigned codes are presented in Table 1. In this study, local ice cream is made up of frozen water, sugars, and food colors. It is different from industrial made ice cream which contains other nutrients like calcium, phosphorous, vitamins like A, C, D, E

and the B-group vitamins which are from milk products and flavourings (Ndu & Ejikeme, 2017) Local juices are made at home involving mixture of one or more ripe fruits, water, and sugars. Artificial juices are industrial made and mostly contain added sugars, fruit flavoured concentrates, and preservatives that are mixed with water and sugars. *Kashata* is prepared using groundnuts, sugar and cooking oil, and others are made of grated coconut flesh, sugar, and cooking oil. Potato samosa is made of round potato, wheat flour, salt and cooking oil. *Kachori* is made of mashed round potato, wheat flour, salt and cooking oil, the same ingredients with potato samosa but differ in preparation. The letter abbreviations in the sample code represents initials for school names from which the samples were taken (that is MK-Mkuranga, KS-Kisemvule, MN-Minazi mirefu, UK-Ukonga).

Table 1: Description of food samples

Food type	Sample code
Local ice cream	MK 4A, MK 4B, KS 4A, KS 4B, MN 4
Artificial juice	MK 5, KS 5
Locally made juice	KS 7, UK 7, MN 7
Kashata	MK6, MN 6, KS 6
Potato samosa	MK 1A, MK 1B, KS 1A, KS 1B, MN 1A, MN 1B
Fried cassava	MK 2A, MK 2B, KS 2A, KS 2B, MN 2A, MN 2B, UK2
Kachori	MN 3, MK 3, KS 3, UK 3A, UK 3B

(ii) Sample preparation/extraction

Kashata solid samples were blended for five minutes at a maximum speed using a laboratory homogenizer (Ika, Germany) to obtain 3g of finely grounded and homogenised sample. Ice creams were defrozen at room temperature and diluted, filtered, and applied directly. All solid and liquid samples were diluted before HPLC analysis. The homogenate was filtered in a vacuum through whatman filter paper No. 1. Then 12.5 mL of each filtrate was diluted with acetonitrile and distilled water (75:25) in a 50 mL volumetric flask to the mark. The diluted mixtures were filtered through Sep-Pak C18 cartridge (Waters, Milford, MA). Sugars were contained in the eluate. The eluate was then filtered through 0.45 µm nylon filter before HPLC analysis.

(iii) Preparation of sucrose and saccharin standards

One gram of sucrose was weighed and dissolved in 50 % acetonitrile in 100ml volumetric flask (10 mg/ml) and 8 ml, 6 ml, 4 ml, 2 ml and 1 ml and top to 10 ml to make concentrations of 8 mg/ml, 6 mg/ml, 4 mg/ml, 2 mg/ml and 1 mg/ml which 20 µl of standard was injected in the 20 series coupled with Refractive Index Detector (RID).

The standard stock solution of saccharin was prepared through dissolving the required amount of pure standard in water. The final concentration of standard was around 1.0 mg/L. The calibration solutions were prepared by mixing and diluting the stock solutions with mobile phase to give five different concentrations of saccharin 0 mL, 0.5 mL, 1 mL, 2 mL, 3 mL and 4 mL. All solutions were stored at 40℃ and kept in a room temperature before use.

(iv) Detection of Sucrose and saccharin contents

The individual sugars were analyzed using a high-performance liquid chromatography (HPLC) (Model LC-20A Series, Shimadzu Corp., Kyoto, Japan) fitted with a refractive index (RI) detector and running under the following conditions: Oven temperature: 30℃, the flow rate of mobile phase was: 0.5-1.0 ml/min, Injection volume of each of the standard solutions of the two sugars into the HPLC to prepare calibration curves was 20 µl. The mobile phase was, Acetonitrile: water (75:25). Finally, the sugars present were identified and their individual concentrations were calculated using the sucrose and saccharin standards. Sugars concentration was calculated based on peak area measurements.

(v) Fatty acid analysis

Total lipid extraction

The extraction of the lipids was done by a modification of the Bligh and Dyer method (1959). Samples of each 2-3 g, were crushed and placed in a glass stoppered centrifuge tube and denatured at 100℃ for 3 minutes. Then 2 ml of water and 7.5 ml of methanol-chloroform (3:2 v/v) was added and the mixture shaken for 20 minutes at room temperature. The samples were centrifuged and the supernatant decanted and the residue resuspended in 15 ml of chloroform. Then 5 ml each of cold water was added to the supernatant and the mixture centrifuged. The chloroform phase was extracted and dried in a vacuum rotary evaporator at 40℃. The residue was completely dried. Then the lipid was methylated by placing 2 mg of the sample in a flask

and refluxing with 6 ml of 95% methanol-HCl for 1 hour at 60℃. The methyl esters were extracted with 3 portions of hexane (1 ml) and then washed with distilled water (3 ml). The hexane layer was dried in vacuum rotary evaporator and the residue re-dissolved in a small drop of hexane.

Fatty acid analysis

Fatty Acids Methyl Esters were analyzed by gas chromatography in Varian model CP-3380 equipped with a flame ionization detector (FID) and a fused silica capillary column (100 m × 0.25 mm i.d. × 0.39 µm 100% bonded cyanopropyl, Varian, EUA). The gas flow rates (White Martins) used were the carrier gas (H_2) 1.4 mL min-1, make-up gas (N_2) 30 mL min-1 and flame gases, (H_2) 30 and 300 mL min-1 and flame synthetic air, respectively. The sample injection rate (split) was 1/100. The injector and detector temperatures were 235℃. The temperature of the column was programmed to 65℃ for 4 min, followed by a ramp of 16℃ min-1 up to 185℃, which was kept for 12 minutes. A second ramp of 20℃ min-1 was run up to 235℃ for 14 minutes. The analysis took a total of 40 minutes. The peak areas were determined using Software Star (Varian). Injections of 2 µL into the GC were performed in triplicate. Then 0.2 ul was injected (Shimadzu 2010 Plus series) with a capillary column, supelcowax 30 m x 0.53 mm; injection temperature of 240℃ and detection temperature, 260℃ under a flame ionization detector.

Determination of fatty acid

The determination of fatty acids was by comparison of retention times of standard methyl esters containing linoleic acid geometric isomers c9t11 and t10c12 (189-19 and O-5626, Sigma, USA) and on equivalent chain length (ECL). The ECL of fatty acid esters were determined according to Semionato *et al.* (2010) based on ECL values determined for standard 189-9 (Sigma, USA). The internal standard methyl tricosanoate (23:0) from Sigma quantified the fatty acids in mg g-1 total lipids. Before transesterification, about 1.00 mL of internal standard solution (1 mg mL-1) was added to the samples and the solvent was evaporated under N_2 flow. After the verification of the agreement between the theoretical and experimental response factors the sample fatty acids were quantified. The sample fatty acid concentrations were calculated similar to the study of Simionato *et al.* (2010).

(vi) Statistical analysis for sugars and fatty acids

For further analysis, Microsoft™ Excel and SPSS (descriptive statistics) were used to compute means and standard deviation of each sugar and total sugars contained in the products. For fatty acids, data were entered into Microsoft™ Excel spreadsheet then transferred and analyzed by SPSS for Windows Version 20.0. Data were reported as mean ± standard deviation. Differences between means were determined using one-way analysis of variance (one-way ANOVA) with Tukey's highest significant difference (HSD) post hoc test, according to the equal variance of different groups. Independent sample t-test was used to determine mean differences between the two districts. A p value <0.05 was considered statistically significant.

3.8 Ethical Clearance

The ethical certification was given by the Kibong'oto Infectious Diseases Hospital (KIDH), the Nelson Mandela African Institution of Science and Technology (NM-AIST), and the Centre for Educational Development in Health, Arusha (CEDHA) Health Research Ethics Committee (KNCHREC0016). District educational authorities granted permission to conduct the study in selected primary schools. Parents and/or guardians consented for themselves and their children participation. School children assented to participate in the study.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Results

4.1.1 Nutrition Status and Dietary Habits of School Children

(i) Socio-demographic characteristics of parents/guardians

A total of 427 school children were recruited for the study and 406 participated in the study**.** Out of 406 children, 207 participated in the comparison between overweight/obese and normal children. Socio-demographic information was collected from 406 child-parent/guardian pairs (response rate was 95%) with 189 parents/guardians from Ilala and 217 from Mkuranga districts and 224 were from public schools while 182 were from private schools. All demographic variables (Table 2) differed significantly between parents/guardians of school children in public and private schools ($p<0.05$). A majority of mothers from public schools had primary school education, while a large proportion of mothers with children in private schools had attained higher education. Most (86.3%) parents of private school children were married. Nearly half of the mothers from private school children were employed in formal or informal sectors, while 48.2% of mothers of children in public school were self-employed.

Table 2: Socio-demographic characteristics of parents/guardians of study children

Parameter	Total sample	Parents from public schools n (%)	Parents from private schools n (%)	p-value
Maternal education level	N=406	224 (55.2)	182 (44.8)	<0.001
Never went to school	16 (4.0)	15 (6.7)	1 (0.6)	
Primary school	185 (45.6)	143 (64.1)	42 (23.1)	
Secondary school	95 (23.5)	47 (21.0)	48 (26.4)	
College/university	109 (26.9)	18 (8.1)	91 (50.0)	
Marital status				
Never married	7 (1.8)	5 (2.3)	2 (1.1)	<0.001
Married	298 (74.7)	141 (64.7)	157 (86.7)	
Separated	18 (4.5)	17 (7.8)	1 (0.6)	
Divorced	39 (9.8)	30 (13.8)	9 (5.0)	
Widowed	19 (4.7)	14 (6.4)	5 (2.8)	
Cohabitating	18 (4.5)	11 (5.0)	7 (3.9)	
Occupation of mother				
Employed (formal/informal)	114 (28.1)	20 (9.1)	90 (49.5)	<0.001
Self-employed	163 (40.2)	108 (49.3)	55 (30.2)	
Farmer	18 (4.4)	17 (7.8)	1 (0.6)	
Business	43 (10.6)	27 (12.3)	16 (8.8)	
Homemaker	50 (12.4)	34 (15.5)	16 (8.8)	
Not applicable	17 (4.2)	13 (5.9)	4 (2.2)	0.015
Family size				
1-4 people	116 (28.6)	75 (33.5)	41 (22.5)	
Above 4 people	290 (71.4)	149 (66.5)	141 (77.5)	

p-values are from Chi-square test for comparison between groups

(ii) Median anthropometric measurements by gender and school type

The total sample had 188 (46.3%) boys and 218 (53.7%) girls with a median age of 12 years (Table 3). Boys had higher median age and higher mean height than girls. Girls had higher

median values for MUAC, percentage body fat, and BMI-for-age than boys. There was no difference in median weight values between boys and girls. Children from private schools had higher median values for weight, MUAC, percentage body fat, and BMI-for-age, and mean height than their counterparts in public schools ($p<0.001$).

Table 3: Comparison of anthropometric measurements by gender and school type

Parameter[1]	Overall n=406	Gender			Public n=224	Private n=182	p-value
		Boys	Girls	p-value			p-value
Age (years)	12	12	11	0.006	12	11	<0.001
Weight (kg)	36.7	35.5	37	0.381	34.7	39.2	<0.001
Height (cm)[2]	143.6±7.9	144.5±8.3	142.9±7.6	0.049	142.4±8.0	145.2±7.7	0.001
MUAC (cm)	21.2	20.6	21.5	0.006	20.6	22.4	<0.001
Body fat (%)	16.1	12.4	19.4	<0.001	14.6	18.4	<0.001
BMI (kg/m^2)	17.5	17.1	17.8	0.021	17.1	18.1	0.002

[1]All values are medians except for height [2]Mean ± standard deviation

(iii) Cut-off values for body fat and correlations between BMI-for-age, MUAC and body fat

Using the cut-off value of 30% and 25% for girls and boys, respectively, 14.2% of girls and 10.7% of boys (Table 4) exceeded the cut-off value for percentage body fat. In the Ilala district (urban), 15.5% and in Mkuranga district (peri-urban), 13% of girls had a percentage body fat that exceeded the cut-off value of 30% for obesity, but their difference was not significant ($p>0.05$). Girls in private schools had slightly higher percentage of body fat that exceeded the cut-off value than girls in public schools. Boys in Ilala district had 12.8% of body fat that exceeded the cut-off value of 25% for obesity slightly higher than boys in Mkuranga district. Boys in private schools had significantly higher percentage of body fat that exceed cut-off values than boys in public schools. There was a positive and strong association between BMI-for-age and percentage body fat (Table 4), BMI-for-age and MUAC and percentage body fat and MUAC. The correlation coefficient for BMI-for-age, MUAC, and percentage body was significant at level 0.01 after adjusting for the age and gender of children.

Table 4: Cut-off values for percentage body fat, and correlation between BMI-for-Age, MUAC and percentage body fat

Proportion of children exceeded cut-off value for percentage body fat n=406				
	Boys n=188,	p-value	Girls n=218,	p-value
	>25%		>30%	
Overall	20 (10.7)		31 (14.2)	
Public schools	4.0 (4.0)	0.001	14 (11.3)	0.117
Private schools	16 (18.4)		17 (17.9)	
Ilala district	11 (12.8)	0.268	16 (15.5)	0.360
Mkuranga district	9 (8.9)		15 (12.9)	
Correlation between body fat, BMI-for-age and MUAC among school children n=406				
	Pearson's correlations		p-value[2]	
BMI-for-age and percentage body fat	0.811		<0.001	
BMI for age and MUAC	0.878		<0.001	
Percentage body fat and MUAC	0.820		<0.001	

p-values are from chi-square test for comparison between groups, and [2]Pearson's correlations

(iv) Nutrition status of school children

Table 5 shows the distribution of BMI-for-age and height-for-age based on school type. The overall prevalence of overweight and obesity was 14.5% and 8.1%, respectively. Children in private schools had a significantly higher prevalence of overweight and obesity compared to children in public schools ($p<0.001$). The overall prevalence of thinness (wasting) in the general sample was 3.9%. Children in public schools were significantly thinner than children in private schools $p<0.001$). The proportion of children with normal weight status was higher in public school children than in private schools. The prevalence did not differ between districts (urban and peri- urban) and between gender ($p>0.05$).

The general prevalence of stunting in school children was 10.1% of which 1.0% of children were severely stunted. Most children from both public and private schools had the normal height for their ages. Children in public schools were found to be more moderately or severely stunted than children in private schools ($p=0.003$). No significant gender and district differences in the prevalence of stunting were observed in this study ($p>0.05$).

Table 5: Nutritional status of public and private school children in percentage

Variable	BMI-for-age[1] n(%)					Height-for-age[2] n(%)			
	Thin/wasting	Normal	Over-weight	Obese	p-value	Severe stunting	Moderate stunting	Normal	p-value
Public schools n=224	10(4.5)	181(80.8)	23(10.3)	10(4.5)	<0.001*	4(1.8)	29(13.0)	191(85.2)	0.003*
Private schools n=182	6(3.3)	117(64.3)	36(19.8)	23(12.6)		0(0.0)	8(4.4)	174(95.6)	
Total n=406	16(3.9)	298(73.4)	59(14.5)	33(8.1)		4(1.0)	37(9.1)	365(89.9)	

[1]BMI-for-age Z-scores classification: Thinness ≤-3SD to -2SD; Normal ≥-2SD to +1SD; Overweight ≥+1SD to <+2SD; Obese ≥+2SD to +3SD; Severe obese ≥+3SD. p-values are from Chi-square test for comparison between groups. *Indicates significant

[2]Height-for-age Z-scores classification; severe stunting-HAZ-score:<-3SD; moderate stunting:>-3SD to -2SD; normal height: <-2SD to <+2SD; p-values are from chi-square test for comparison between groups.

(v) Dietary patterns of school children

Generally, the majority (70%) of children from both public and private schools had three to four meals per day (excluding snacks), although some (15.6%) children from public schools had one to two meals a day and 25.8% of children in private schools had five to six meals a day (p<0.001). During school days, the frequency of consumption of foods by many children (70% in public and 68% in private) was two or more times a day. Foods mostly consumed at public schools were potato samosa, fried cassava, and kachori and in private schools, the most consumed foods were rice and beans. More than half of the children (57%) in public schools ate together with other family members. On the other hand, 43% of children from private schools ate less often with other family members and the difference between public and private schools was significant (p<0.001). More children from private schools (48.4%) versus public (36%) preferred to eat while watching television (p=0.013). The most preferred foods during television viewing by both children included rice, ugali, and chips. Other foods like popcorn, biscuits, cakes, sweets and soft drinks were least preferred. However, the study found no associations between the eating patterns and BMI-for-age (p>0.05).

(vi) Preference and consumption frequencies of most liked fruits, vegetables, and snacks

The distribution of children by preference and consumption frequencies of mostly liked fruits, vegetables, and snacks are shown in Table 6. More than half of school children from public and private schools preferred mangoes and oranges more than other fruits. Likewise, the most preferred dark green leafy vegetables by public school children were sweet potato leaves (>70%),

and private schools preferred mostly spinach (>60%). Amaranths were almost equally preferred by both groups. In terms of snacks, many children in public schools preferred fried snacks such as potato samosa, fried cassava, and kachori. Children from private schools preferred mostly sugary snacks such as soda/carbonated drinks, ice cream, and cookies, biscuits, cakes. Other snacks were moderately preferred. Preference for milk or yogurt was relatively lower in public schools (12%) than in private schools (29%).

Regarding consumption frequencies, daily consumption of fruits was < 20% and vegetables ≤ 10% in both public and private schools. A large proportion of children in both groups consumed preferred fruits and vegetables less than once a week. In terms of snacks, children in public schools had a higher daily frequency of consumption of potato samosa and fried cassava compared to children in private schools. Likewise, children in private schools had a higher daily consumption of soda/carbonated drinks and sugared tea; meanwhile, many consumed cookies, biscuits, and cakes one to three times per week. Daily consumption of milk was low in both groups (<2% in public and 11% in private). Many children in both groups consumed milk less than once a week.

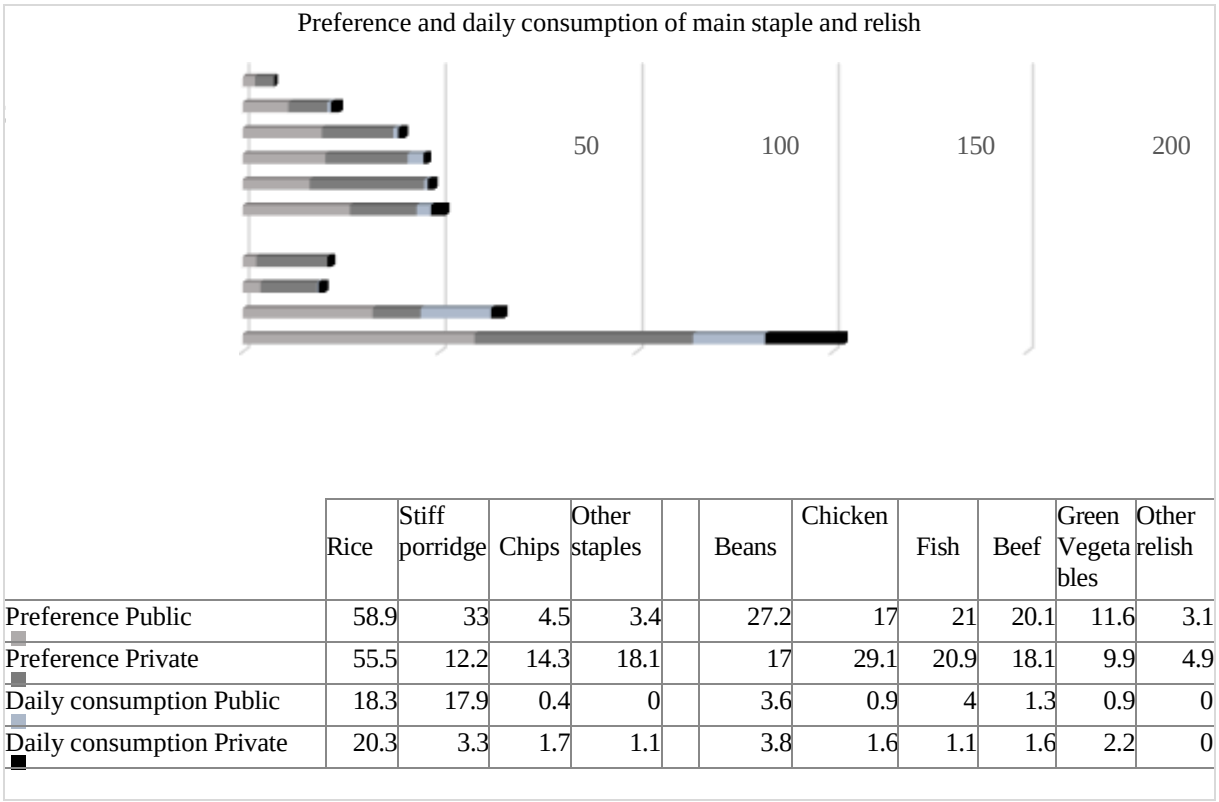
The mean intake of fruits and vegetables was ≥ four times a week with an average of ≤ one fruit and ≤ one vegetable servings per day in both public and private schools. The mean intake of sugary snacks was more than four times per week in private school children with an average of > one snack a day and one to three times a week in public school children with the average intake of < one snack a day. The mean intake of fried snacks was ≥ four times per week with an average of more than one snack a day, while for private schools, the mean intake was one to three times a week with an average intake of less than one snack a day.

The most preferred staple by both public and private school children (>55%) was rice (Fig. 6). Stiff porridge (33%) was mostly preferred by public school children. Chips and other staples were least preferred (Fig. 6). Regarding relish, public school children preferred more beans (27%) and children in private schools preferred more chicken (29%). Fish and beef were equally preferred (around 20%). Green vegetables and other relish were least preferred. The daily consumption frequency of rice was 18% and 20% for public and private schools, respectively. Public school children had a higher daily consumption of stiff porridge than children in private schools. Daily consumption of beans was slightly higher than beef, chicken, and green vegetables in both groups. However, children in public schools had a slightly higher (4%) daily consumption of fish than children in private schools (1.1%).

Table 6: Comparison of preference and consumption frequencies of most liked fruits, vegetables, and snacks among public and private school children

Food item	% Preference		% Frequency of consumption							
	Yes		Daily		4-6 times/week		1-3 times/week		< once/week	
	Publ. n=224	Priv. n=182	Publ. n=224	Priv. n=182	Publ. n=224	Priv. n=182	Publ. n=224	Priv. n=182	Publ. n=224	Priv. n=182
Fruits										
Mangoes	65.2	59.9	12.9	7.7	15.2	14.3	37.1	37.9	34.8	40.1
Oranges	54.2	51.1	16.5	17.0	14.7	14.8	23.7	19.2	45.1	48.9
Banana	29.9	40.1	9.4	4.9	5.8	7.7	14.7	14.3	70.1	59.9
Watermelon	21.0	30.2	5.8	7.1	4.0	8.2	11.2	14.8	79.0	69.8
Green vegetables										
Sweet potato leaves	73.2	58.2	8.9	4.9	29.8	17.6	37.5	35.7	26.8	41.8
Spinach	55.8	68.1	6.3	13.7	19.6	18.1	29.9	36.3	44.2	31.9
Amaranths	55.4	57.7	5.4	11.0	13.4	14.3	36.6	32.4	44.6	42.3
Pumpkin leaves	20.1	13.7	1.8	2.7	6.3	2.7	12.1	8.2	79.9	86.3
Snacks										
Soda/carbonated drinks	26.8	52.9	8.0	14.8	5.8	7.1	12.9	30.2	73.2	47.8
Ice cream	24.6	38.5	6.7	7.1	5.4	6.6	12.5	24.7	75.4	61.5
Potato samosa	68.3	47.8	38.4	18.1	12.9	8.8	17.0	20.9	31.7	52.2
Fried cassava	57.1	15.4	40.6	5.5	7.6	4.4	8.9	5.5	42.9	84.6
Kachori	35.7	18.1	10.7	6.0	8.9	1.6	16.1	10.4	64.3	81.9
Milk/yoghurt	11.6	28.6	1.8	11.0	3.6	7.1	6.3	10.4	88.4	71.4
Sugared tea/coffee	17.4	33.5	12.8	27.5	2.2	3.3	3.1	2.7	82.6	66.5
Cookies, biscuits, cakes	25.0	53.8	5.8	6.6	3.6	8.8	15.6	38.5	75.0	46.2

Publ=public school; Priv= private school



	Rice	Stiff porridge	Chips	Other staples		Beans	Chicken	Fish	Beef	Green Vegetables	Other relish
Preference Public	58.9	33	4.5	3.4		27.2	17	21	20.1	11.6	3.1
Preference Private	55.5	12.2	14.3	18.1		17	29.1	20.9	18.1	9.9	4.9
Daily consumption Public	18.3	17.9	0.4	0		3.6	0.9	4	1.3	0.9	0
Daily consumption Private	20.3	3.3	1.7	1.1		3.8	1.6	1.1	1.6	2.2	0

Figure 6: Preference and daily consumption of main staple and relish

(vii) Association between BMI-for-age and dietary habits of school children

The current study did not identify an association (Table 7) between the type of school (public and private) and all dietary habits variables (all $p>0.05$). Significant differences were found in gender and the results indicated that boys consumed more cereal foods and had higher median BMI-for- age than non-cereal eaters ($p<0.05$). Furthermore, boys who consumed less fried foods had a higher median BMI for age than consumers of fried foods. Likewise, boys who consumed milk/yogurt had a higher BMI-for-age value than non-milk consumers. Again, in boys, increased frequency of consumption of sugary snacks to more than four times a week was associated with high median BMI-for-age. In girls, less fruit intake was associated with high median BMI-for-age ($p<0.05$). Surprisingly, a higher frequency of consumption of fried snacks was associated with low median BMI-for-age in girls. Other dietary habit variables did not associate with median BMI-for-age in all participants ($p>0.05$).

Table 7: Association between BMI-for-age and dietary habits of school children by type of school and gender

Characteristics/food intake		Public n=224	Private n=182	Boys n=187	Girls n=219
		Median BMI-for-age	Median BMI-for-age	Median BMI-for-age	Median BMI-for-age
Number of meals/day	1-2	16.9	17.9	17.0	17.1
	3-4	17.2	18.1	17.0	18.3
	5-6	16.5	17.8	17.7	17.1
Cereal foods eaten at school	Eat None	17.1	19.4	16.6†	17.7
	Eat 1	17.2	17.6	17.2	17.7
	Eat 2-3	-	18.2	18.0	18.3
Fried foods/snacks eaten at school	Eat None	16.8	17.7	17.9†	18.3
	Eat 1	17.4	18.1	16.4	18.4
	Eat 2-3	17.1	18.2	16.6	17.4
Sugary snacks	Eat none	16.9	17.5	16.6	18.1
	Eat 1-2	17.1	18.2	17.2	17.7
	Eat 3-4	17.2	18.3	17.5	18.3
Milk/yoghurt	Yes	16.9	18.2	17.8†	17.7
	No	17.1	17.7	16.9	17.9
Eating together with others often	More	17.2	18.1	17.2	18.0
	Sometimes	16.7	17.7	16.8	17.7
	Less often	16.6	18.3	17.2	18.2
Eating while watching TV	Yes	17.1	18.1	17.4	18.1
	No	17.1	18.0	17.0	17.7
Eating preferred vegetable	Eat ≤1	17.1	17.7	17.1	17.7
	Eat 2-3	17.1	18.1	17.1	18.0
Eating preferred fruits	Eat ≤1	18.5	17.5	16.4	20.2†
	Eat 2-3	17.0	18.1	17.1	17.7
FFQ of sugary snacks consumed	Not	16.9	17.5	16.6†	18.1
	1-3/week	16.8	18.2	17.0	17.3
	≥ 4/week	17.2	18.1	17.5	17.5
FFQ of fried snacks consumed	Not	16.8	17.7	17.1	17.7†
	1-3/week	17.5	18.3	17.4	19.1
	≥ 4/week	17.1	17.7	16.9	17.4
FFQ preferred fruits consumed	Not	17.2	26.0	16.9	23.6
	1-3/week	17.3	17.6	16.4	19.5
	≥ 4/week	17.1	18.1	17.1	17.7
FFQ preferred vegetables consumed	Not	17.6	17.4	16.9	17.9
	1-3/week	18.1	18.9	18.5	18.6
	≥ 4/week	17.1	18.1	17.1	17.1

†indicates significant, p-value derived from Kruskal-Wallis test and Mann-Whitney U-test, $p<0.05$

(viii) Logistic regression analysis of selected dietary habits variables and overweight/obesity in school children

Table 8 shows an association between overweight and obesity with selected dietary habits by multivariable binary logistic regression. In univariate analysis, crude odds ratios for consuming more cereal foods at school (OR 2.8, 95% CI 1.7-4.6, p<0.001), fried foods/snacks at school and away (OR 0.3), and intake of milk (OR 1.7) were significantly associated with overweight and obesity. In the multivariate analysis (final model), after adjusting for other factors, only the intake of fried foods/snacks (AOR 0.3. 95% CI 0.4-1.1, p<0.05)) was significantly associated with overweight and obesity.

Table 8: Logistic regression analysis of selected dietary habits variables and overweight/obesity among school children (n=406)

Characteristics/food intake		Crude OR[a]	95% CI	p-value	Adjusted OR[b]	95% CI	p-value
Cereal foods eaten at school	Eat None	Ref			NA		
	Eat 1	2.2	0.8-5.6	0.11			
	Eat 2-3	2.8	1.7-4.6	**≤0.001***			
Fried foods/snacks eaten at school	Eat None	Ref			Ref		
	Eat 1	0.4	0.2-0.8	**0.007***	0.4	0.2-0.8	**0.013***
	Eat 2-3	0.3	0.2-0.5	**≤0.001***	0.3	0.4-1.1	**≤0.001***
Sugary snacks	Eat none	Ref			NA		
	Eat 1-2	1.7	0.9-3.1	0.10			
	Eat 3-4	1.7	0.8-3.6	0.15			
Milk/yoghurt	No	Ref			NA		
	Yes	1.7	1.0-2.9	**0.04***			
Eating while watching TV	No	Ref			NA		
	Yes	0.6	0.4-1.0	0.06			
Eating preferred fruits	Eat ≤1	Ref			NA		
	Eat 2-3	1.8	0.9-3.7	0.09			
FFQ of sugary snacks	Not consumed	Ref			NA		
	1-3x/week	1.5	0.8-3.2	0.24			
	≥ 4 x/week	1.8	0.9-3.3	0.07			
FFQ preferred fruits	Not consumed	Ref			NA		
	1-3x/week	0.33	0.8-1.4	0.13			
	≥ 4 x/week	0.34	0.1-1.1	0.08			

OR, odds ratio; CI, confidence interval; FFQ, frequency of consumption; *indicates significant. [a]Crude odds ratios also included age, gender, school type, number of meals, number of preferred vegetables, number of sugary snacks, FFQ of fried foods/snacks, FFQ of preferred vegetables with no significant association with overweight and obesity [b]Odds ratios have been adjusted for age, gender, school type, number of meals per day, school food cereals, number of sugary snacks, intake of milk, eating while watching television, frequencies of consumption of sugary snacks, fried foods/snacks, preferred fruits and vegetables

4.1.2 Nutrient Intake, Food Consumption Patterns and Family Factors

(i) Demographic characteristics of overweight/obese and normal weight children

The study also compared further overweight and normal weight children to determine the risk of exposure to overweight and obesity. Social demographic and anthropometric data of overweight/obese children and control children are presented in Table 9. Out of the 207 children, 126 (60.9%) were girls and from the total sample, 108 (52.2%) children were from private schools and more than a half of the total sample were from class V. The mean age of children was 11.4 years (SD: 0.8). The mean sleeping hours per day were 8.4 hours (SD: 1.1). Overweight/obese children had higher weight, height, and percentage body fat than normal weight children ($p<0.001$). There was no statistically significant difference in age, school type, grade/class, number of sleeping hours per day, and average time spent in sedentary and physical activities per day between overweight/obese children and normal weight children.

Table 9: Background characteristics of school children[4] n=207

Characteristic	All	Ov/obese	Normal	p-value
n	207	69	138	
[1]Sex, girls %	60.9	60.9	60.9	0.48
[1]School type, private %	52.2	52.2	52.2	0.558
[1]Class/grade, class V %	57.5	52.2	60.1	0.172
[2]Age in years, mean±SD	11.4 ± 0.8	11.3 ± 0.9	11.4 ± 0.8	0.25
[3]Weight (kg)	38.2	49.5	34.6	<0.001*
[2]Height (cm), mean±SD	143 ± 7.7	146 ± 7.7	142 ± 7.4	<0.001*
[3]BMI kg/m^2	18.2	23.0	16.9	<0.001*
[3]BMI Z-scores	0.26	1.76	-0.35	<0.001*
[3]Body fat (%)	18.4	30.5	14.7	<0.001*
[2]Sleeping hours/day, mean±SD	8. 4 ± 1.1	8.3 ± 1.0	8.4 ± 1.1	0.52
[3]Sedentary hours/day	3.7	3.7	3.6	0.99
[3]Physical activity hours/day	2.4	2.5	2.4	0.86

p-value derived from chi-square test[1], p-values are from independent sample t-test[2], p-value derived from Mann-Whitney U-test[3] indicates significant* $p<0.001$, mean ± standard deviation, BMI= Body Mass Index, all values are medians except age, height and sleeping hours[4,] Ov- overweight

(ii) Energy and Nutrient Intake among School Children

The 24-hour dietary recall was used to capture data on energy and nutrient intake of school children and results were expressed in median values in Table 10. The findings showed that the overall median for energy intake was 1370 kcal and children in the normal weight arm had consumed about 8 kcal more than overweight/obese children. The median intake for protein

was 45 g with overweight/obese children having an intake slightly above the normal weight children. Normal weight children had a slightly higher intake of fat compared to overweight/obese children. The overall median intake of carbohydrates was around 260 g and overweight/obese children had consumed 25 g extra in comparison to normal weight children. The median intake of micronutrients, such as iron, zinc, folic acid, vitamin A, vitamin C, calcium, and phosphorus, was similar between overweight/obese and normal weight children. Regardless of the small variations in energy and macro- and micro-nutrient intake, there was no significant difference found between overweight/obese and normal weight children ($p>0.05$).

Table 10: Median energy and nutrient intake in overweight/obese and normal weight children

Nutrient	RDA for 10-13 years old	All, n=207	OV/OB children, n=69	Normal children, n=138	p-value
Energy (kcal)	1600 girls, 1800 boys	1370.0	1368.9	1376.6	0.994
Protein (g)	34	45.0	46.9	43.0	0.388
Fat (g)	25	24.6	23.3	25.1	0.399
Carbohydrate (g)	130	261.6	279.6	254.2	0.234
Dietary fibre (g)	>25	22.0	23.7	21.7	0.247
Iron (mg)	8	10.1	10.5	9.7	0.127
Zinc (mg)	8	6.7	7.3	6.5	0.322
Folic acid (µg)	300	108.1	110.7	107.7	0.828
Vitamin A (µg)	600	251.0	223.7	257.9	0.756
Vitamin C (mg)	45	47.1	49.8	47.2	0.522
Calcium (mg)	1300	234.0	248.6	228.9	0.295
Phosphorous (mg)	1250	789.2	844.0	770.3	0.189

p-values are from Mann-Whitney U test for comparison between two independent groups, RDA= Recommended Daily Allowances. RDAs are based on Institute of Medicine (2005) Dietary Reference Intakes, OV/OB-overweight/obese

Results in Table 11 compare the recommended daily allowance between overweight/obese and normal weight children based on the Institute of Medicine's (2005) recommended dietary allowances. More than 70% of overweight/obese and normal weight children were below the recommendation for energy and >70% were above the recommended intake for protein. Intake of carbohydrate was high (>95%) in both overweight/obese and normal weight children. However, about 50% of children in both groups had an intake of fat below recommended levels. A majority of children had micronutrient intakes below the recommendations except for iron and vitamin C. Also, all children did not meet the RDA for calcium. Again, there was no significant difference in micronutrient intake between overweight/obese and normal-weight children.

Table 11: Energy and nutrient intake based on RDA among OV/OB and normal children

	All, n (%) n=207	Overweight/obese children n (%) n=69	Normal weight children n (%) n=138	p-value
Energy (kcal)				0.525
<RDA	149 (70.0)	50 (72.5)	99 (71.7)	
≥RDA	58 (28.0)	19 (27.5)	39 (28.3)	
Protein (g)				0.437
<RDA	54 (26.1)	17 (24.6)	37 (26.8)	
≥RDA	153 (73.9)	52 (75.4)	101 (73.2)	
Fat (g)				0.403
<RDA	104 (50.2)	36 (52.2)	68 (49.3)	
≥RDA	103 (49.8)	33 (47.8)	70 (50.7)	
Carbohydrate (g)				0.627
<RDA	9 (4.3)	3 (4.3)	6 (4.3)	
≥RDA	198 (95.7)	66 (95.7)	132 (95.7)	
Iron (mg)				0.139
<RDA	72 (34.8)	20 (29.0)	52 (37.7)	
≥RDA	135 (65.2)	49 (71.0)	86 (62.3)	
Zinc (mg)				0.320
<RDA	135 (65.2)	43 (62.3)	92 (66.7)	
≥RDA	72 (34.8)	26 (37.7)	46 (33.3)	
Vitamin A (µg)				0.252
<RDA	163 (78.7)	52 (75.4)	111 (80.4)	
≥RDA	44 (21.3)	17 (24.6)	27 (19.6)	
Folic acid (µg)				
<RDA	157 (75.8)	52 (75.4)	105 (76.1)	0.519
≥RDA	50 (24.2)	17 (24.6)	33 (23.9)	
Calcium (mg)				
<RDA	207 (100)	69 (100)	138 (100)	
≥RDA	-	-	-	
Vitamin C (mg)				0.403
<RDA	94 (45.4)	30 (43.5)	64 (46.4)	
≥RDA	113 (54.6)	39 (56.5)	74 (53.6)	

p-values are from chi-square test for comparison between groups, RDA= Recommended Daily Allowances, ≥RDA= above or equal to the RDA, and <RDA= below the RDA. RDAs are based on Institute of Medicine (2005) Dietary Reference Intakes

(iii) Dietary diversity of school children

Table 12 presents dietary diversity and consumption of different food groups by children in the two groups. The mean dietary diversity is higher in normal weight children than in overweight/obese children. A big percentage of normal weight children consumed five or more food groups compared to overweight/obese children and the difference was significant (p=0.005) indicating that low dietary diversity is associated with overweight and obesity. Consumption of vitamin A rich fruits and vegetables, other fruits and vegetables and sweets

was significantly higher in normal weight children than in overweight/obese children. These food groups and consumption of more than five food groups were also inversely associated with overweight and obesity in the univariate analysis (data not shown in the table) and only consumption of more than five food groups was significant in the multivariate analysis (AOR 0.57, 95% CI 0.44-0.75, p<0.001).

Table 12: Dietary diversity score and consumption of food groups by overweight/obese and normal weight children

Variables	Overweight/obese n=69	Normal weight n=138	p-value
Dietary diversity Mean ±SD	4.68±1.13	5.41±1.16	
DDS score			
≤ 4 food groups	29 (42.0)	32 (23.2)	0.005*
≥ 5 food groups	40 (58.0)	106 (76.8)	
Food groups			
Starchy	69 (100)	138 (100)	1.000
Dark green leafy vegetables	25 (36.2)	68 (49.3)	0.075
Other vitamin A rich fruits/vegetables	46 (66.7)	111 (80.4)	0.029*
Other fruits and vegetables	28 (40.6)	81 (58.7)	0.014*
Organ meat	0 (0)	6 (4.3)	0.079
Meat and fish	40 (58.0)	92 (66.7)	0.220
Eggs	5 (7.2)	14 (10.1)	0.496
Legumes, nuts and seeds	57 (82.6)	109 (79.0)	0.538
Milk and milk products	5 (7.2)	17 (12.3)	0.269
Sweets	47 (68.1)	112 (81.2)	0.036*

p-values are from chi-square test for comparison between groups, *indicates significant

(iv) Frequency of consumption of mostly consumed cereals, roots and tubers, legumes, nuts and animal source protein

The most consumed cereal foods included maize, wheat, and rice (Table 13). More than a half of overweight/obese and normal weight children consumed maize-based foods daily or five to six times a week (a high consumption category). More than 60% of overweight/obese and >50% normal weight children consumed rice and wheat-based foods daily or 5-6 times a week. Beans were consumed daily or five to six times a week by more than 40% of overweight/obese and normal weight children and the other >40% had moderate consumption of beans (i.e., one to four times a week). Other types of legumes had similar pattern of consumption in both overweight/obese and normal weight children. Data on consumption frequency of beef revealed that only small percentage of overweight/obese and normal weight children consumed beef daily or five to six times a week. A large percentage (>50%) of children in both groups

had moderate consumption of beef (i.e., one to four times a week). Consumption of eggs, poultry, and fish on a daily basis or five to six times a week was below 15% in both overweight/obese and normal weight children. The majority had moderate consumption of poultry and eggs, while more than half had a low frequency of fish consumption (i.e., one to three times a month). The frequency of consumption of milk was not adequate in both groups. Only 20% of overweight/obese and 25% of normal weight children consumed milk daily or 5-6 times/week. A nearly half of overweight/obese children (46%) and 38% of normal weight children did not consume fresh milk.

Table 13: Frequency of consumption of mostly consumed cereals, roots and tubers, legumes, nuts, and animal-source protein

		OV/OB n=69	Normal n=138	OV/OB n=69	Normal n=138	OV/OB n=69	Normal n=138	OV/OB n=69	Normal n=138
Cereals	Maize	52.2	59.4	36.2	37.0	5.8	2.2	5.8	1.4
	Wheat	60.9	52.2	21.7	33.3	2.9	2.2	14.5	12.3
	Rice	66.7	58.0	27.5	37.0	2.9	2.9	2.9	2.2
Roots and tubers	Cassava	30.4	24.6	14.5	34.1	26.1	18.8	29.0	22.5
	Green banana	11.6	8.0	30.4	27.3	24.6	26.1	33.3	38.4
	Round potatoes	14.5	14.5	44.9	42.8	20.3	18.1	20.3	24.6
Legumes	Beans	47.8	43.5	43.5	43.5	4.3	8.7	4.3	4.3
	Other legumes	1.4	1.4	13.0	10.1	55.1	58.0	30.4	30.4
Nuts	Groundnuts	23.2	26.1	18.8	37.0	26.1	21.0	31.9	15.9
	Coconut	46.4	45.7	33.3	32.6	11.6	10.9	8.7	10.9
Animal sources	Beef	23.2	17.4	50.7	53.6	13.0	18.1	13.0	10.9
	Poultry	10.1	11.6	40.6	44.2	36.2	36.2	13.0	8.0
	Eggs	13.0	14.5	37.7	36.2	30.4	27.5	18.8	21.7
	Fish	10.1	7.2	20.3	28.3	59.4	50.7	10.1	13.8
	Sardines	18.8	15.2	37.7	40.6	15.9	20.3	27.5	23.9
	Fresh milk	20.3	25.4	27.5	21.7	5.8	15.2	46.4	37.7
	Other milk products	49.3	46.4	4.3	3.6	2.9	5.8	43.5	44.2
Oils	Sunflower	49.3	46.4	4.3	3.6	2.9	5.8	43.5	44.2
	Korie	49.3	50.0	5.8	6.5	2.9	3.6	42.0	39.9

Highly consumed= Daily + 5-6 times a week; moderately consumed= 3-4 times a week +1-2 times a week; Less consumed= 2-3 times a month + once a month; Never= not consumed + rarely consumed, OV/OB – Overweight/obese

(v) Mostly consumed vegetables, fruits, snacks, and drinks

Table 14 presents the frequency of consumption of vegetables, fruits, snacks, and drinks. Findings showed that consumption of green leafy vegetables and fruits was not adequate in both overweight/obese and normal weight children as many children had low consumption of these food items. In terms of consumption of snacks, many normal weight children had a higher frequency (consumed daily or five to six times a week) consumption of fried and sweet foods

than overweight/obese children. For instance, consumption of potato chips, crips, popcorn, samosa, and kachori was higher in normal weight children than in overweight/obese children. Likewise, consumption of cookies, cakes, biscuits, sweets, candy, chocolate, soda and/or carbonated drinks, local ice cream, and local and/or fruit-flavored juices were higher (i.e., consumed daily or five to six times a week) in normal weight children than in overweight/obese children. Many overweight/obese children had moderate consumption (i.e., between one and four times a week) of potato chips.

Table 14: Frequency of consumption of mostly consumed vegetables, fruits, snacks, and drinks between overweight/obese and normal weight children

Food items	Highly consumed		Moderately consumed		Less consumed		Never	
	OV/OB n=69	Normal weight n=138	OV/OB n=69	Normal weight n=138	OV/OB n=69	Normal weight n=138	OV/OB n=69	Normal weight n=138
Green leafy vegetables	24.6	18.8	24.6	32.6	40.6	42.0	10.1	6.5
Other vegetables	26.1	31.9	55.1	54.3	18.8	13.8	-	-
Fruits	13.0	18.8	30.4	38.4	55.1	42.0	1.4	0.7
Potato chips	8.7	19.6	53.6	42.0	24.6	27.5	13.0	10.9
Potato crisp	5.8	13.0	21.7	18.8	17.4	19.4	55.1	48.6
Popcorn	1.4	11.6	21.7	24.6	18.8	25.4	58.0	38.4
Cookies, cakes	7.2	13.8	26.0	29.0	27.5	33.3	39.1	23.9
Kashata	7.2	10.1	14.7	17.4	20.3	18.1	58.0	54.3
Processed baobab	18.8	21.7	17.4	31.9	27.7	19.6	36.2	26.8
Biscuits	13.0	21.0	33.3	39.9	26.1	23.2	27.5	15.9
Sweets, candy, chocolate	20.3	31.9	27.5	27.5	17.4	17.4	34.8	23.3
Wheat burns	30.4	32.6	50.7	49.3	10.1	8.7	8.7	9.4
Pancakes	14.5	20.3	39.1	39.9	17.4	18.1	29.0	21.7
Samosa	30.4	39.9	27.5	34.1	17.4	10.1	24.6	15.9
Kachori	14.5	23.9	11.6	12.3	7.2	6.5	66.7	57.2
Soda and/or carbonated drinks	17.4	18.1	27.5	46.4	21.7	18.8	33.3	16.0
Local ice cream	17.4	29.7	20.3	26.8	26.1	17.4	36.2	26.1
Local/fruit flavored juices	10.1	27.5	34.8	37.0	17.4	22.5	37.7	13.0

Highly consumed= Daily + 5-6 times a week; moderately consumed= 3-4 times a week +1-2 times a week; Less consumed= 2-3 times a month + once a month; Never= not consumed + rarely consumed, OV/OB – overweight/obese

(vi) Family history/characteristics and parental perception on overweight and obesity in school children

Table 15 presents results of the family history/characteristics. Findings showed that disease history was not significantly different between overweight/obese children and normal weight children. Significant differences were found on parents' assessment of their children weight

status. More parents (16.9%) of overweight/obese children assessed their children as being overweight or obese than parents from the normal weight children (2.7%). Likewise, more parents from overweight/obese children (24.1%) assessed themselves as being overweight or obese than parents from normal weight children. More parents of overweight/obese children had a negative perception that overweight or obesity is normal or represents good health although results are not statistically significant. A majority of parents of the normal weight children equated overweight and obesity to a bad situation (66.4% vs 54.2%). A large proportion of school children (>50% for overweight/obese children and >60% for normal weight children) were given money regularly to buy something to eat at school. Furthermore, giving money to children to use at school for food and place of taking lunch by children did not differ significantly between overweight/obese and normal weight children ($p>0.05$). In addition, more than 30% of children in both groups did not take breakfast in the morning before going to school. There was no significant difference in taking breakfast at home between overweight/obese children and normal weight children.

Table 15: Family history/characteristics and parental perception on overweight and obesity in school child

Characteristics	Parents of OV/OB children	Parents of normal children	p-value
Family history of diseases	n=69	n=138	0.466
Disease present	11 (15.9)	20 (14.5)	
Disease absent	58 (84.1)	118 (85.5)	
Parents assessments of their children's weight status	n=59	n=102	0.005*
Normal	43 (72.9)	87 (77.7)	
Overweight or obese	10 (16.9)	3 (2.7)	
Underweight	0 (0)	1 (0.9)	
Comfortable with child's weight	6 (10.2)	21 (18.8)	
Parents self-assessment of own weight status	n=58	n=113	<0.001*
Normal	39 (67.2)	90 (79.6)	
Overweight or obese	14 (24.1)	3 (2.7)	
Underweight	1 (1.7)	3 (2.7)	
Comfortable with own's weight status	4 (6.9)	17 (15.0)	
Parents' perception on overweight and obesity	n=59	n=110	0.257
Normal	15 (25.4)	18 (16.4)	
Bad	32 (54.2)	73 (66.4)	
Good	12 (20.3)	19 (17.3)	
Children take breakfast before going to school	n=68	n=135	0.686
No	21 (30.9)	46 (34.1)	
Yes, usually	26 (38.2)	55 (40.7)	
Yes, sometimes	21 (30.9)	34 (25.2)	
Give money for school use on food	n=69	n=138	0.366
No	26 (37.7)	42 (30.4)	
Sometimes	7 (10.1)	10 (7.2)	
Yes	36 (52.2)	86 (62.3)	
Place of lunch	n=69	n=138	
Home	28 (40.6)	53 (38.4)	
School	28 (40.6)	58 (42.0)	
Both home and school	13 (18.8)	27 (19.6)	

p-values are from chi-square test for comparison between groups, *indicates significant

(vii) Association between food consumption, nutrient intake, family factors, and overweight/obesity among school children

In the univariate analysis (Table 16), high consumption (daily or five to six times a week) of some energy-giving food items, such as maize-based products including popcorn, potato samosa, fruit juices and/or fruit-flavored juices, and local ice cream, were significantly associated with overweight/obesity ($p<0.05$). In addition, consumption of processed baobab one to four times a week also was significantly associated with overweight and obesity ($p=0.015$). Intake of energy and other nutrients did not associate with overweight/obesity (all $p>0.05$). Family factors, such as the parental perception of their children's weight status and parental self-assessment of being overweight/obese, were significantly associated with overweight and obesity in their children ($p<0.05$). Other family factors were not associated with overweight/obesity ($p>0.05$). In the multivariate analysis (Table 16), results showed that

consumption of potato chips up to four times a week was significantly associated with overweight and obesity (AOR 2.27, 95% CI 1.07-4.81) while consumption of soda and/or carbonated drinks up to four times a week (AOR 0.38, 95% CI 0.19-0.85) was inversely associated with overweight and obesity. High consumption (daily or 5-6 times a week) of maize based foods (AOR 0.19, 95% CI 0.05-0.77), juices (fruit or fruit-flavored) (AOR 0.21, 95% CI 0.07-0.60), and local ice cream (AOR 0.41, 95% CI 0.17-0.95), were also inversely associated with overweight/obesity. However, among family factors, parental assessment on their own overweight/obese status (AOR 10.11, 95% CI 2.72-37.65) predicted overweight/obesity in school children.

Table 16: Logistic regression analysis of select risk factors associated with overweight and obesity among school children

Characteristics/food consumption		[a]COR	95% CI	p-value	[b]AOR	95% CI	p-value
Maize-based	≤ 3/month	1					
	1-4/week	0.31	0.09-1.03	0.056	0.22	0.05-0.92	0.057
	Daily/5-6/wk	0.27	0.08-0.89	0.032	0.19	0.05-0.77	0.020*
Potato chips	≤ 3/month	1			1		
	1-4x/week	1.30	0.69-2.43	0.410	2.27	1.07-4.81	0.032*
	Daily/5-6/wk	0.45	0.17-1.23	0.121	1.07	0.33-3.46	0.907
Popcorn	≤ 3/month	1			NA		
	1-4/week	0.73	0.37-1.47	0.381			
	Daily/5-6/wk	0.10	0.01-0.81	0.030			
Processed baobab	≤ 3/month	1			NA		
	1-4/week	0.40	0.19-0.84	0.015			
	Daily/5-6/wk	0.63	0.30-1.34	0.231			
Samosa	≤ 3/month	1			NA		
	1-4/week	0.50	0.24-1.03	0.062			
	Daily/5-6/wk	0.47	0.24-0.96	0.037			
Local/fruit flavoured juices	≤ 3/month	1			1		
	1-4x/week	0.60	0.32-1.16	0.128	0.66	0.32-1.32	0.237
	Daily/5-6/wk	0.24	0.09-0.59	0.002	0.21	0.07-0.67	0.004*
Local ice cream	≤ 3/month	1			1		
	1-4/week	0.53	0.26-1.09	0.086	0.59	0.27-1.30	0.143
	Daily/5-6/wk	0.41	0.19-0.87	0.020	0.41	0.17-0.95	0.038*
Soda/ carbonated drinks	≤ 3/month	1			1		
	1-4/week	1.62	0.72-3.63	0.245	0.38	0.19-0.85	0.018*
	Daily/5-6/wk	0.62	0.26-1.46	0.272	0.82	0.32-2.06	0.670
Parental self-assessment of own weight	Normal	1			1		
	Overweight/ obese	10.77	2.93-39.61	<0.001	10.11	2.72-37.65	0.001*
	Underweight	0.77	0.08-7.63	0.823	0.78	0.08-7.73	0.830
	Comfortable with child's weight	0.54	0.17-1.72	0.299	0.55	0.17-1.75	0.310

COR, crude odds ratios; AOR, adjusted odds ratios; CI, confidence interval, the first model involved consumption pattern variables, second model involved nutrient intake variables and a third model involved family factors variables. *****indicates significant

[a]Crude odds ratios also included energy, protein, carbohydrate and fat intake, individual foods from FFQ such as beef, poultry, fish, milk, kashata, sweets, candy chocolate, biscuits, fruits, vegetables with no significant association with overweight and obesity, family factors such as the history of dietary-related diseases, giving money to children to use for food at school, and taking breakfast at home before going to school

[b]Odds ratios have been adjusted for foods such as popcorn, processed baobab, biscuits, sweets, candy, chocolate, samosa, soda/carbonated drinks, fruits, parental assessment of their children's weight status.

4.1.3 Physical activity levels and sedentary behaviors and their association with overweight and obesity in school children

The mean score for being active on different occasions is presented in Table 17. Besides lunch (over the lunch break) normal weight children had a higher mean score of being active (p=0.012) than overweight and obese children. Mean scores for being active during break

times/recess, right after school, during weekends and, evenings were not significantly different between overweight/obese and normal weight children (p>0.05). Although not statistically significant, overall mean scores of being active were slightly higher in normal weight than in the overweight/obese children.

Table 17: Comparison of mean activity scores among overweight/obese children and normal weight children

	OV/OB	n=69	Normal,	n=138	
Activity level in different occasions	**Mean**	**SD**	**Mean**	**SD**	**p-value**
Participating in physical education	2.7	1.9	2.7	1.2	0.97
During recess/ break times	1.9	0.9	1.9	1.0	0.96
Beside lunch	1.9	0.8	2.3	0.9	0.012*
Right after school	2.0	1.0	2.1	0.98	0.62
During evenings	2.3	1.1	2.5	1.1	0.31
During weekends	2.2	0.9	2.4	1.0	0.29
Being active in the last 7 days	2.0	0.9	2.2	0.98	0.28
Overall mean activity score	2.2	0.5	2.3	0.6	0.12

p-value is from independent sample t-test, indicate significant* p<0.05, scores are numbers 1-5, 1=less active, 5=most active, SD = Standard deviation

Results for univariate analysis (Table 18) showed that rope skipping for > 2 hours per week was associated with overweight and obesity (OR 0.2, 95% CI 0.05-0.9) which is a protective effect OR <1. Other sports activities were not associated with overweight/obesity. However, odds ratios showed that those who were running, swimming for <2 hours/week, and/or riding a bike for > 2 hours/week were less likely to be overweight and obese (OR<1). On the other hand, those who were dancing, walking for exercise, and doing household tasks were more likely to be overweight and obese than those who did not participate in these activities (OR>1). Although not significant, more percentage of normal weight children met the WHO recommendations for physical activity than overweight/obese children.

Table 18: Association of physical activity with overweight/obesity among school children

Physical activity		OV/OB N=69	Normal weight N=138	Crude OR (95% CI)	p-value
Dancing	none	35 (50.7)	79 (57.2)	1	
	< 2 hours/week	27 (39.1)	47 (34.1)	1.3 (0.7-2.4)	0.41
	> 2 hours/week	7 (10.1)	12 (8.7)	1.3 (0.5-3.6)	0.60
Running/jogging	none	29 (42.0)	41 (29.7)	1	
	< 2 hours/week	29 (42.0)	76 (55.1)	0.5 (0.3-1.0)	0.05
	> 2 hours/week	11 (15.9)	21 (15.2)	0.7 (0.3-1.8)	0.50
Swimming	none	54 (78.3)	120 (87.0)	1	
	< 2 hours/week	9 (13.0)	12 (8.7)	0.5 (0.1-1.5)	0.18
	> 2 hours/week	6 (8.7)	6 (4.3)	0.8 (0.2-3.1)	0.69
Bike riding	none	42 (60.9)	77 (55.8)	1	
	< 2 hours/week	20 (29.0)	37 (26.8)	0.9 (0.5-1.9)	0.97
	> 2 hours/week	7 (10.1)	24 (17.4)	0.5 (0.2-1.3)	0.18
Doing household chores	none	23 (33.3)	45 (32.6)	1	
	< 2 hours/week	24 (34.8)	50 (36.2)	0.9 (0.5-1.9)	0.86
	> 2 hours/week	22 (31.9)	43 (31.2)	1.0 (0.5-2.1)	0.99
Play on the ground	none	41 (59.4)	74 (53.6)	1	
	< 2 hours/week	12 (17.4)	31 (22.5)	0.7 (0.3-1.5)	0.36
	> 2 hours/week	16 (23.2)	33 (23.9)	0.9 (0.4-1.8)	0.71
Skipping rope	none	36 (52.2)	68 (49.3)	1	
	< 2 hours/week	31 (44.9)	52 (37.7)	1.1 (0.6-2.1)	0.70
	> 2 hours/week	2 (2.9)	18 (13.0)	0.2 (0.05-0.9)	0.044*
Walking as part of exercise	none	37 (63.6)	93 (67.4)	1	
	< 2 hours/week	23 (33.6)	30 (21.7)	1.9 (0.9-3.7)	0.05
	> 2 hours/week	9 (13.0)	15 (10.9)	1.5 (0.6-3.7)	0.37
Total physical activity	< 1 hour/day	16 (23.2)	26 (18.8)	1	
	>1 hour/day	53 (76.8)	112 (81.2)	1.3 (0.6-2.6)	0.46

OR odds ratios, CI confidence interval, indicates significant*p<0.05, p value is from univariate analysis, crude odds ratios also included playing football, netball, walking on foot to and from school with no significant association with overweight/obesity

Univariate analysis (Table 19) showed that listening to music and/or radio for >2 hours/week was significantly associated with overweight/obesity (OR 2.7, 95% CI 1.2-6.1). Other sedentary behaviors were not significantly associated with overweight and obesity (p>0.05). However, those who watched television/video, travel to and from school by bus/car, and talk on a telephone for >2 hours/week were more likely to be overweight and obese than those who were not involved in those activities (OR>1). In addition, those who were doing artwork and homework <2 hours/week had odds ratios >1 which indicates they are more likely to be overweight/obese.

Table 19: Association of sedentary activities and overweight/obesity among school children

Factors		Overweight/obese children N=69	Normal weight children N=138	OR (95% CI)	p-value
Listening to music	none	15 (21.7)	52 (37.7)	1	
	< 2 hours/week	32 (46.4)	58 (42.0)	1.9 (0.9-3.9)	0.07
	> 2 hours/week	22 (31.9)	28 (20.3)	2.7 (1.2-6.1)	0.014*
Watching TV/video	none	11 (15.9)	29 (21.0)	1	
	< 2 hours/week	13 (18.8)	36 (26.1)	0.9 (0.4-2.4)	0.92
	> 2 hours/week	45 (65.2)	73 (52.9)	1.6 (0.7-3.6)	0.23
Arts work	none	36 (52.2)	79 (57.2)	1	
	< 2 hours/week	29 (42.0)	45 (32.6)	1.4 (0.7-2.6)	0.27
	> 2 hours/week	4 (5.8)	14 (10.1)	0.6 (0.2-2.0)	0.44
Doing homework	none	12 (17.4)	24 (17.4)	1	
	< 2 hours/week	29 (42.0)	55 (39.9)	1.1 (0.5-2.4)	0.90
	> 2 hours/week	28 (40.6)	59 (42.8)	0.9 (0.4-2.2)	0.90
Playing computer games	none	51 (73.9)	97 (70.3)	1	
	< 2 hours/week	9 (13.0)	23 (16.7)	0.7 (0.3-1.7)	0.49
	> 2 hours/week	9 (13.0)	18 (13.0)	0.9 (0.9-2.3)	0.91
Reading	none	3 (4.3)	5 (3.6)	1	
	< 2 hours/week	24 (34.8)	43 (31.2)	0.9 (0.2-4.2)	0.93
	> 2 hours/week	42 (60.9)	90 (65.2)	0.8 (0.2-3.4)	0.74
Travel by bus to and from school	none	33 (47.8)	74 (53.6)	1	
	< 2 hours/week	9 (13.0)	18 (13.0)	1.1 (0.5-2.8)	0.80
	> 2 hours/week	27 (39.1)	46 (33.0)	1.3 (0.7-2.5)	0.39
Talk on phone	none	36 (52.2)	74 (53.6)	1	
	< 2 hours/week	32 (46.4)	62 (44.9)	1.1 (0.6-1.9)	0.84
	> 2 hours/week	1 (1.4)	2 (1.4)	1.0 (0.1-11.7)	0.98
Total sedentary	< 4 hours/day	41 (59.4)	75 (54.3)	1	
> 4 hours/day		28 (40.6)	63 (45.7)	0.8 (0.5-1.4)	0.49

OR odds ratios, CI confidence interval, indicates significant* $p<0.05$, p value is from univariate analysis, crude odd ratios also included telling stories with no significant association with overweight/obesity

In the multiple logistic regression analysis (Table 20), rope skipping for >2 hours/week (AOR 0.14, CI 95% 0.03-0.7) was significantly associated with overweight and obesity, indicating that it was protective against overweight/obesity. Walking for exercise <2 hours/week (AOR 2.1, 95%CI 1.1-4.1) and listening to music and/or radio (AOR 2.7, 95% CI 1.2-6.1) for > 2 hours/week significantly predicted overweight and obesity among school children.

Table 20: Logistic regression analysis of selected physical activity and sedentary behaviors and overweight and obesity among school children

Factor	β	SE(β)	Adjusted OR	95% CI for OR	p-value
Skipping rope >2 hours/week	-2.0	0.8	0.14	0.03-0.7	0.014*
Walk as part of exercise <2 hour/week	0.7	0.4	2.1	1.1-4.1	0.034*
Listening to music/radio >2 hours/week	0.9	0.7	2.7	1.2-6.1	0.014*

β-Regression coefficient; SE (β) standard error of β; CI, confidence interval; OR, adjusted odds ratio, indicates significant*, p value is from multivariate analysis, p<0.05, odds ratios are adjusted for playing netball, running/jogging, bike riding, rope skipping, walking as part of exercise, listening to music/radio, watching television/video and arts work.

Regarding places of physical activities most children engaged more in physical activities in their home environments compared to school. The most common games played at home included dancing (39%), running (46.4%), bike riding (40.1%), and rope skipping (32.3%). At school, less than 10% of children reported playing these games. Most of the sedentary activities also took place at home except reading (57.5%) and telling stories (43%) which took place in both home and school environments. There were no reported popular games for school and home differently. There was no significant difference in places of physical activities and sedentary behaviors (home or school) between overweight/obese children and normal weight children. Frequencies of performing physical and sedentary activities in the two groups were not statistically significant (p>0.05).

4.1.4 Influence of Environmental, Socio-cultural, Parental Factors on Children's Food Choice

(i) Description of participants of the key informant interview and focus group discussion

Participants in KII were mostly men (66.7%), with a mean age of 34.3 ± 4.5 (range: 29 to 42) years, and had completed secondary school education. A majority of participants in the FGDs were females (88.9%) with a mean age of 37.1±6.4 (range: 29 to 55) years. Additional description of participants is presented in Table 21.

Table 21: Demographic information of teachers and parents for the KII and FGD

	Variable	Category	N (%)
Key informants	Gender	Males	6 (66.7)
		Females	3 (33.3)
	Age in years (mean ± SD)	Males	34.3±4.5
		Females	35.0±5.6
	Education	Primary	0 (0)
		Secondary	9 (100)
	School type	Public	5 (55.6)
		Private	4 (44.4)
Focus Groups	Gender	Males	4 (11.1)
		Females	32 (88.9)
	Age in years (mean ± SD)	Males	36.3±9.3
		Females	37.3±6.1
	Education	Primary	13 (36.1)
		Secondary	23 (63.9)
	School type	Public	24 (66.7)
		Private	12 (33.3)

(ii) Overall themes influencing food choice in KII and FGD

Thematic analysis of this study revealed the factors influencing children's food choices and consumption categorized into school and home environments (Fig. 7). In the school environment, children's food choice and consumption were influenced by two main themes; the first theme was on environmental factors influencing children food choices and the second theme was on school rules governing food consumption. At home three main themes are identified which include; (a) parental factors influencing children's food choices, (b) environmental factors governing food choices and (c) socio-cultural influences of food choices. Sub-themes emanated from the main themes (see details in Fig. 7)

A food choice model

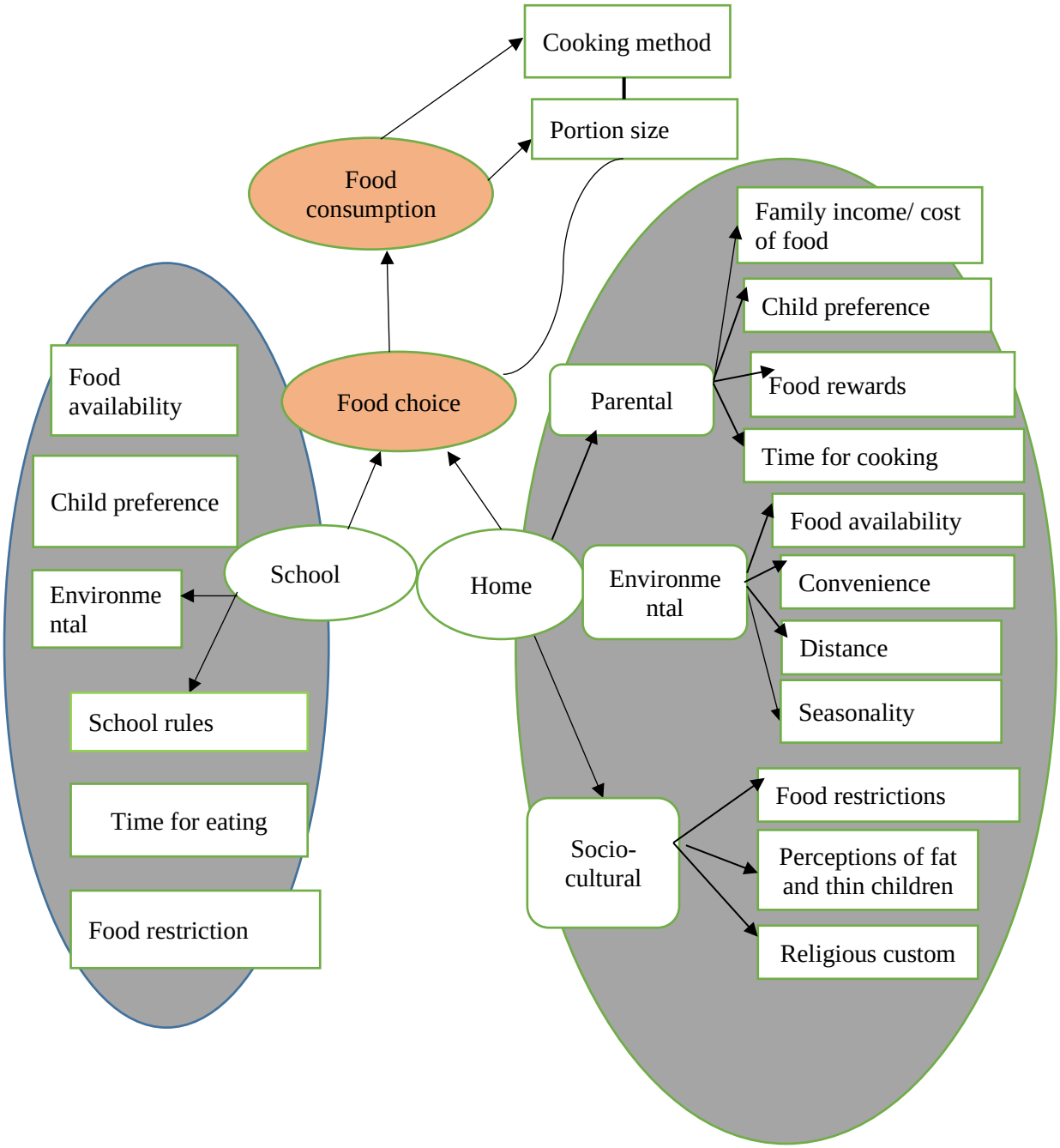


Figure 7: A model representing factors influencing children's food choice derived from key informant interview and focus group discussion

(iii) Key Informant interview results

Food availability in the school environment

Food availability in school environments varies between public and private schools. The most common foods consumed in private schools were rice, *pilau* (spiced rice), *ugali*, *kande* (cereals)

and beans. Beef was the main source of animal protein consumed in private schools at least once a week and boiled eggs were sold in one public school. Roasted groundnuts (i.e., peanuts) were common snacks in two public schools. Common fruits available in schools were mangoes, oranges, watermelon, and ripe banana, although some fruit, like oranges, depends on the season. In public schools, fruits are bought by individual children upon interest, while in private schools fruits are served with lunch at least three times a week. Green vegetables, such as amaranth, cabbage, and spinach, are commonly served in private schools at least one to three times a week, except one private school did not include fruits and green vegetables in their meals. In public schools, green vegetables are less available. Processed foods, like fried foods/snacks, and sweet snacks, including beverages, were found in abundance in public schools. Plain tea with sugar was available in three private schools as a part of breakfast and sometimes milk tea was served in one of those schools at least once a week.

School setting and food services

Contacted schools (n=8) had three sessions for classes and extracurricular activities. The first session starts at 0600 h or 0700 h to around 1000 h. The second session runs between 1030 or1100 h to 1230 h and the last session is between 0130 h or 1400 h to 1600 h. Both schools had a break for breakfast ranging from 20-40 minutes and lunch break of between 40-90 minutes. In private schools (n=4), food services are provided in the school kitchens. In public schools (n=4), food services are provided mainly by food vendors. One school had a canteen operated by outsiders and a school shop, while another school had an addition of nearby shop. In addition, two public schools provide food services occasionally upon agreement with parents during special events such as national exams. In private schools, children preferred *pilau,* rice, beans, and meat while, in public schools, children preferred to consume fried foods/snacks, such as cassava, potato samosa, kachori, sweets, local juices, and local ice creams. In all schools, children are allowed to eat twice a day during break times.

"*What a child chooses to eat is not enough just for the sake of minimizing hunger, for example ice cream it is just for comforting children, if someone is hungry we advise them to buy something else like a wheat burn and not an ice cream but they don't agree"* (Health teacher in a public school).

Concerning food policy, teachers from public school responded that they do not have a specific food policy, whereas private schools had a common policy on food restrictions.

A private school teacher reported that "*All children should eat food at school and no one is allowed to bring food from outside". In addition, no food vendor is allowed to sell food in the school premises***.**

With regard to food environments, private school teachers claimed to have satisfactory environments in terms of cleanliness and food safety but nutritionally food was less diverse and in most overweight/obese children starch-based foods were served. Fruits, vegetables, and dairy products were not served regularly. However, one school reported that their foods have adequate nutrients covering a broad array of food varieties. Nevertheless, after a visit to school kitchen during lunch time, very small portions of fruits and vegetables were served to children (just a thumb of fruit and a table spoon of vegetable). In public schools, teachers complained that they have no control related to food cleanliness and food safety. Most of the foods sold by vendors are prepared at home, but due to lack of refrigeration and cupboards, foods are kept in containers on the ground and sometimes foods are served cold.

Physical activity facilities available at schools

Most of the school teachers reported availability of various types of physical activities, such as playing football, netball, athletics, and skipping ropes. In addition, two private schools also have basketball. Many teachers also reported that they have adequate space for all types of sports except in three schools (two public and one private) which indicated insufficient space and were required to request the use of nearby school grounds. Physical activity schedules are available in all schools and with frequency of sports varying between one to two times per week for a duration of one to two hours each but, at one school, the schedule is not followed consistently. Each school has at least two teachers for running physical education classes. Inter-school sports competitions are organized at least four times per year in many schools and a national competition called "*Umoja wa Michezo kwa Shule za Msingi Tanzania"* (UMITASHUMTA) conducted on a yearly basis.

(iv) Focus group discussions results

When parents were asked to identify factors that influence them in choosing food for their children, all groups mentioned income/cost of food and child preference. In four groups mention was made of considering food nutrients (i.e., nutritional value of the food), with one parent from one group adding on food availability and another mentioning cultural aspects and location. In addition, health reasons, like high blood pressure, diabetes, allergy, and food safety (for example, broiler chicken are believed not to be safe) were also mentioned to

influence food choices. For example one participant highlighted that,

"To me when I give food to my child, I consider 6 groups of food…like body building, energy-giving, protective foods like vitamins, bone strengthening, water..

(Father of private school child in group 5).

Time spent by the mother/caregiver in food preparation

More than two thirds of participants reported that the work schedule of the mother/caregiver affected food preparation. Respondents argued that inadequate time leads to untimely food preparation and feeding, which may cause some children go to bed hungry, food monotony, and eating unintended (unhealthy) foods. In addition, some preferred foods, like *kande* (tradition food which is a mixture of maize and beans), cannot be cooked because needs more time. Quality control becomes difficult when food is prepared by a house maid. In addition, some may opt to go for convenience foods which may lead to food monotony. Less than one quarter of participants said that time has no effect on food preparation as they are able to balance their working and cooking schedules, and others were full-time housewives. For example one parent reported that "*If I wanted to include green vegetables in the diet, I can't manage because of time, so I end up cooking ugali and meat only"* (Mother of private school child in group 3). The other one added that *"To me time has no effect because I plan well in advance even my housemaid is well informed"* (Mother of public-school child in group 2).

Family income and cost of food

Most of the parents mentioned that low family income is a barrier to access food varieties leading to food monotony, low food diversity, limited number of meals eaten per day, eating undesirable food, and eating less than normal. *We eat mainly starch-based foods and beans and sometimes we need protein from other sources like meat, because beans do not have enough amino acids, but we cannot afford to buy meat* (father of private school child in group 3).

You wish to have food varieties like fish, green leafy vegetables, fruits, milk for children, but the budget is low, so you cook ugali with sardines and the day is over… you wished to have fruits, vegetables, juice but you cannot afford (Mother of public school child in group 2)

On the other hand, participants mentioned that when family income rises, they purchase desired foods, buy more fat foods, processed foods, and convenient/ready to eat food. In addition, one

member stated that you can also buy other types of foods, such as milk, meat, and green vegetables, when you have a better income. Overall, both low and high income affects purchasing power of consumers.

Seasonality and special events

In Ilala district, most parents stated that seasonality has minimal effect on food choice, because of the constant flow of foods throughout the year, except for some fruits like pears and pineapples. In Mkuranga district, many participants said that there are food variations especially during harvesting season (e.g., from June to August consume more rice and pigeon peas, cassava, and sweet potatoes). During special events, such as birthdays and religious festivals different food are eaten, such as more energy-dense foods like cakes, *pilau*, chips, fried meat and chicken, and soft drinks. During the holy month of Ramadhan, consumption changes to more roots, tubers, and legumes, such as cassava, yams, banana, and beans. One parent reported that *"During special events like birthdays we cook or buy foods mostly preferred by children like chips, pilau, cakes, soda, biscuits or juice"* (Father of private school child in group 5).

"During festivals, at least you slaughter a chicken, eat pilau, soda, but in normal days you cook rice and beans, but during festivals you can't feed children with rice and beans" (Mother of public-school child in group 4).

Regarding food outlets around their home environments, most parents mentioned that foods are readily available from outlets such as retail shops, food groceries *(magenge)*, food vendors, and few have access to vegetable gardens. For many parents, markets and supermarkets are located far from their households. In addition, many parents from Mkuranga district (peri-urban) obtained food from farms. The distance from the household to the closest fruit and vegetables outlet for most participants was estimated to be within 500 m and for few participants it was between 1000- 2000 m.

For most of the parents, the distance from households to meat and meat products outlets was within 500 m and for fish within 1000 m. To some parents, distance to the food outlet limited their consumption of preferred foods, affect time to go for shopping, untimely eating, and piling up of household chores. All groups of parents admitted that food vendors are readily available and sell diverse types of foods including legumes, green vegetables, other vegetables such as tomatoes and onions, fish, milk, offal (intestines), and composite flours, with limited cereals.

Culture

All parents/guardians in the FGD reported that there are no gender differences in food distribution between boys and girls. Most of them claimed that there are no food taboos governing food consumption in their families except specific food restrictions. For example, foods like ugali, rice, beans, and green vegetables are restricted in post-partum women because they reduce milk production, and chicken tail is not consumed by men and pregnant women. Another restriction was on eating gizzard by women and jute mallow by men. These restrictions were mainly for adults but can also impact eating preferences in children. Some members from two groups pointed out that familiarity with certain foods motivates selection of particular foods. For example one parent said that *"I used to cook banana at least after every two days it is our cultural food… although my children do not like banana, they were born here in Coast region"* (Mother of private school child in group 6). Thus, parenting styles and modeling may influence children to follow parents' eating pattern. Furthermore, religious beliefs were seen to impact food choices and consumption; for example, a Christian living in a Muslim household cannot cook and eat pork.

Participants were also asked to whose opinion is important in food choice in the household, many participants in all groups pointed out that mothers' opinion was most important because she knows the budget, meal planning, and food selection. Few of them advised that fathers are prioritized in food selection because they are the bread winners. Participants were also asked how they feel when their children look fat or thin. Most of them preferred their children to be average/moderate, not too fat not too thin, but a few of them feel good when their children look fat. Culturally, thin children are believed to be sick, such as HIV infected, exposed to poor nutrition, poverty, and receiving inadequate care. On the other hand, society believes that fat children are in good health, good life, well fed, and receive good care.

> *Even for health practitioners when you go to the clinic they admire fat children and praise the mother, they are much more concerned with thin children for advice…but for the fat ones they keep on congratulating the mother without knowing that they subject the child into health problems.* (Mother of a public-school child in group 1)

Food availability in the home environment

In the home environment, food commonly served to children are cereal-based and legumes especially beans. Two groups of parents also served animal source foods like meat, fish, and

eggs, but very few give milk. Green leafy vegetables were served by the majority of parents, although portion sizes were not enough. Almost half of the participants reported seldom giving fruits to their children. Processed foods, like fried foods and sweet beverages, are commonly served to children in all groups of participants.

Food consumption norms

Most (>60%) parents in four groups reported to eat together with their children evening meals every day, on the weekends all meals, and during holidays. Participants in the other two groups mentioned they always eat together with their school children.

Most parents in all groups mentioned that choice of cooking method depends on type of food to be cooked, but mostly boiling, frying, and stewing are most common methods. Also, parents were asked about which foods they normally used as rewards for their children, most of them mentioned giving processed foods, like chips, *pilau,* sausage, fried chicken, cakes, soda, juices, biscuits, and sweets. Very few parents mentioned offering meat and milk as food rewards. In most overweight/obese children, the foods given to children in the morning for breakfast before going to school were porridge (maize- based or mixed cereals), plain tea, breads, and rice or wheat buns. A few parents mentioned giving eggs and milk occasionally. Many parents reported that their children prefer processed and energy dense foods and few reported their children preferred milk, fruits, and vegetables.

On control of portion sizes of foods given to children, many parents said that they do control the portions served to children. However, some mentioned that they do control when specific foods served to children, such as sugary foods and chips; others mentioned that they control portion size to small children but not to the older ones. One of the parents stated that "*I control portion size for sugary foods like chocolate, biscuits, sweets and chips, I seldom prepare chips at home"* (Mother of private school child in group 3).

Physical activity and sedentary behavior at home environment

Many participants reported having enough space for physical activities, such as skipping ropes, playing with toys/dolls, swinging game, running and *rede* game (a traditional game for East African children featuring two children at the end of each side who throw the ball to one or more children in the centre). However, these games were not formal. Only three parents reported having inadequate spaces for physical activities at their homes. Most of the participants

reported that school children assisted their families in household chores, such as washing, sweeping, fetching water, cooking, gardening, and some were involved in farming. During leisure time, many children were involved in activities like watching television, playing games, doing homework, reading, and a few children were going for extra studies after normal class time (tuition).

4.1.5 Sucrose and Saccharin Levels of Foods Commonly Consumed by School Children

Sucrose and saccharin contents are presented in Table 22. Results for sucrose are expressed in grams (g) while for saccharin are expressed in milligrams (mg). Findings of the current study show that sucrose concentration varied between similar samples investigated. Local ice creams were bought from five different food vendors and for example, KS 4A from one food vendor, had a higher amount of sucrose (6 g/100g of food) than other samples (MK 4B, MK 4A, KS 4B, and MN 4) of local ice cream. This amount is above one teaspoon while sample MN 4 had the smallest amount of sucrose. Sucrose concentration in local ice cream samples ranged from 0.002 to 6.4 g/100 g.

In artificial juice, there were two samples from two different vendors. Artificial juice MK 5 had higher amount of sucrose concentration than artificial juice KS 5. Among the three tested samples of *kashata* sample MK 6 had the highest concentration (14.353±0.589 g/100 g) of sucrose than other samples of *kashata* (MN 6 and KS 6). This amount is approximately, three teaspoons of sugar. In addition, sucrose was not detected in *kashata* sample KS 6; hence, the range of sucrose in *kashata* samples was 0 to 14.4 g/100 g. All the three samples of locally made juices had small amounts of sucrose <0.05 g/100 g. Generally, among the samples tested high for concentration of sucrose were kashata (MK 6) and local ice cream (KS4 A), while the lowest concentrations were found in locally made juice (MN 7) and artificial juice (KS 5).

Results of saccharin concentration also varied between the same food samples. When comparing saccharin concentrations, local ice cream MN 4 had the highest amount of saccharin (533.317 ± 18.582 mg/100 g) compared to other local ice cream samples (MK 4A, MK 4B, KS 4A, and KS 4B).

Table 22: Sucrose and saccharin contents of foods/drinks mostly consumed by primary school children (mg/g/100 g of food)

			Parameters	
			Sucrose (g/100g)	Saccharin
S/No	Sample ID	Sample name		(mg/100g)
1	MK 4A	Local ice cream	1.398±0.089	6.836±0.145
2	MK 4B	Local ice cream	2.188±0.084	7.911±0.199
3	KS 4A	Local ice cream	6.356±0.017	11.400±0.103
4	KS 4B	Local ice cream	0.031±0.001	10.906±0.496
5	MN 4	Local ice cream	0.022±0.002	533.317±18.582
6	MK 5	Artificial juice	3.580±0.090	4.328±0.170
7	KS 5	Artificial juice	0.011±0.001	19.935±0.664
8	MN 6	*Kashata*	0.064±0.001	328.309±10.342
9	MK 6	*Kashata*	14.353±0.589	127.467±2.050
10	KS 6	*Kashata*	ND	372.020±1.077
11	KS 7	Locally made juice	0.021±0.001	6.495±0.038
12	UK 7	Locally made juice	0.035±0.001	7.729±0.097
13	MN 7	Locally made juice	0.010±0.001	89.702±0.288

Local ice cream MK 4A had the smallest concentration (6.836 ± 0.145 mg/100 g). The remaining ice cream samples almost had small variations in saccharin concentration. Therefore, saccharin concentration in local ice cream ranged from 6.6 to 533 mg/100 g. Artificial juice KS 5 had a higher concentration (20 mg/100 g) of saccharin than sample MK 5 (4.3 mg/100 g). Results also show that levels of saccharin were higher in all *kashata* samples ranging from 127.5 mg to 372.0 mg/100 g. The highest amount was found in *kashata* KS 6 followed by *kashata* MN 6. In locally made juices a higher concentration of saccharin (89.702 ± 0.288 mg/100 g) was found in sample MN 7. Locally made juices KS 7 and UK 7 had lower concentration of saccharin (<10 mg/100 g). The range of saccharin in locally made juices was between 6.5 to 89.7 mg/100 g. Among the samples tested, the highest amount of saccharin was found in local ice cream MN4 and kashata samples KS 6 and MN 6 and the lowest concentration was found in artificial juice MK 5.

When comparing the levels of sucrose and saccharin in samples, it shows that some samples had small concentrations of both sugars, while others had higher concentration of one sugar in comparison to the other. For example, locally made juice KS 7 had small concentration of both sucrose and saccharin; however, local ice cream MN 4 and kashata MN 6 had higher amounts of saccharin and low sucrose. In *kashata* sample KS 6 sucrose was not detected, and saccharin was used in high amount. In a sample *kashata* MK 6 high levels of both sucrose and saccharin were found. In locally made juice MN 7 saccharin concentration was higher than sucrose concentration.

Results in Table 23 compares concentrations of sucrose and saccharin in product analyzed in this study to international standards. Sucrose content was found to be lower in the tested products compared to Canadian standards. In terms of saccharin content our samples especially the *kashata* product showed higher saccharin content >100 mg/100 g than recommendation of WHO and European Union (5 mg/kg/BWT/day). The figure was computed based on median weight of school children.

Table 23: Comparison of Sucrose and saccharin contents of mostly consumed foods/drinks to international regulations/recommendations (mg/g/100 g of food)

Sample name (code)	Sample weight (g)	Sucrose content g/100	Canadian regulation[1] g/100g	Saccharin content mg/100g	WHO &EU regulation[2] 5mg/kg/BWT/day
Kashata (MK 6)	40	14.35	35	127.47	180mg/bwt/day
Kashata (MN 6)	40	0.064	35	328.31	180mg/bwt/day
Kashata (KS 6)	40	ND	35	372.20	180mg/bwt/day
Local ice cream (MN 4)	115	0.022	8	533.32	180mg/bwt/day
Local fruit juice (MN 7)	400	0.010	10	89.7	180mg/bwt/day

Sources; References[1], Canadian Food database, Reference[2,] WHO and EU regulation on sweeteners, ND-not detected, bwt- body weight

4.1.6 Fatty Acid Profile of Foods Mostly Consumed by School Children

A total of 17 fatty acids were identified and quantified in foods consumed in the school environment. The saturated fatty acids were relatively higher in number (10) than unsaturated fatty acids (7). Among the seven unsaturated fatty acids, four were monounsaturated fatty acids (MUFA) and three were the polyunsaturated fatty acids (PUFA).

The fatty acid composition of foods consumed in the school environment (Table 24) consisted of the total Saturated Fatty Acids (SFA) ranging between 37-52.5%, total MUFA and PUFA ranging between 14.47-28.6% and 18.4-38.9% respectively. Of the SFA, palmitic (C16:0) was found in abundance and constituted 20.89 to 41.20% of the total lipid content. Behenic and lignoceric saturated acids were less abundant in all products. Oleic acid (C18:1) was the highest MUFA in the four food types and ranged between 8.93-19%, while the least abundant MUFA were the Heptadecenoic (C17:1) and Nervonic acid (C24:1). Among the PUFAs, levels of linoleic (C18:2) and linolenic acid (C18:3) were almost similar and ranged from 5.23%-25.0% and 13-20.75% respectively. Arachidonic acid (C20:4) was the least available PUFA. Although palmitic acid was higher in all samples, significant difference was found between products.

Palmitic acid was higher in *kashata* than fried cassava and kachori ($p<0.05$), it was also higher in fried cassava than kachori. Stearic acid was significantly lower in kachori than in fried cassava and samosa. Arachidic acid levels were significantly higher in fried cassava than kachori and samosa. Heptadecenoic acid was significantly different between kachori and samosa, and between *kashata* and samosa. Oleic acid was significantly higher in kachori than in samosa ($p<0.001$). Nervonic acid was higher in samosa than other products. Fried cassava had the lowest level of linoleic acid compared to kachori, *kashata*, and samosa. On the other hand, linolenic acid was higher in kachori than in fried cassava and samosa.

In the current work, significant differences were also found between similar products from the two districts (Table 25). Total SFA in fried cassava were higher in Mkuranga district (57.78%) than in Ilala district (39.51%). Percentage of SFA in kachori (44.87%) was higher in Ilala district than in Mkuranga district. Likewise, kashata from Mkuranga district had higher SFA than similar products from Ilala district. Again, samosa from Mkuranga district had higher total SFA than samosa from Ilala district. In case of total MUFAs, fried cassava and samosa from Ilala district had higher amount than fried cassava and samosa from Mkuranga district (26% versus 17%) and (19% versus11%) respectively. Total PUFAs in fried cassava in Ilala district were higher than total PUFAs in Mkuranga district (26%vs15%). Likewise, total PUFAs in kachori in Mkuranga district were two times higher than in kachori found in Ilala district. With regard to individual fatty acids, palmitic acid, stearic acid and oleic acid levels were significantly higher in kachori from Ilala district ($p<0.05$) than kachori from Mkuranga district. Palmitoleic acid was significantly higher in fried cassava and samosa from Ilala district than in fried cassava and samosa from Mkuranga district. Linolenic acid was significantly higher in fried cassava from Ilala district than fried cassava in Mkuranga district. On the other hand, kachori from Mkuranga district had significantly higher level of linolenic acid than kachori from Ilala district ($p<0.05$).

Table 24: Fatty acid profile of foods commonly consumed in the school environment (g fatty acid/100 g oil sample)

Fatty acid	Fried cassava	*Kachori*	*Kashata*	Samosa
C8:0	1.8±4.5	0	0	0
C10:0	0.9±1.45	5.40±9.995	0	0.76±1.756
C12:0	1.08±2.08	1.26±2.078	0.04±0.003	3.36±4.01
C14:0	0.85±0.39	0.595±0.59	0.79±0.054	0.69±0.46
C15:0	0.003±0.006	0.001±0.002	0	0.008±0.015
C16:0	27.19 ± 11.04^{a}	20.89 ± 10.95^{b}	41.20 ± 2.54^{ab}	27.71±12.64
C18:0	13.70 ± 5.64^{ab}	5.94 ± 5.36^{ac}	0.75 ± 0.30^{bc}	14.84 ± 9.51^{c}
C20:0	6.04 ± 6.69^{ab}	2.19 ± 1.37^{a}	1.56±0.08	1.12 ± 0.94^{b}
C22:0	0.01±0.03	0	0	0
C24:0	0.99±1.17	0.81±1.01	0.33±0.03	1.65±1.71
Total SFA	**52.57±13.01**	**37.09±12.63**	**44.68±2.80**	**49.99±15.85**
C16:1	4.14±9.64	8.66±11.25	0.04±0.002	2.71±4.55
C17:1	0.49±0.41	0.21 ± 0.21^{a}	0^{b}	0.92 ± 1.02^{ab}
C18:1	14.34±8.80	19.07 ± 9.55^{a}	17.89±0.51	8.93 ± 8.50^{a}
C24:1	0.90 ± 1.15^{a}	0.66 ± 0.74^{b}	0^{c}	1.91 ± 1.57^{abc}
Total MUFA	**19.89±14.91**	**28.60±11.80**	**17.93±0.51**	**14.47±12.64**
C18:2	5.23 ± 4.59^{abc}	13.65 ± 8.98^{ad}	25.022 ± 0.48^{bdc}	14.64 ± 12.22^{c}
C18:3	13.02 ± 6.28^{a}	20.75 ± 12.196^{ab}	13.14±0.88	12.87 ± 5.47^{b}
C20:4	0.16±0.15	0.097±0.13	0.22±0.21	0.08±0.12
Total PUFA	**18.43±6.32**	**34.50±15.43**	**38.39±1.27**	**27.59±12.63**
Undetected	9.12 ± 7.89^{ab}	0.19 ± 3.38^{ac}	0.99 ± 3.45^{b}	7.59 ± 10.08^{c}

Values in the table are presented as mean±standard deviation
Means with similar superscript letters in the same row are significantly different

Table 25: Fatty acid composition of foods commonly consumed in the school environment based on district

Fatty acid	Cassava		*Kachori*		*Kashata*		*Samosa*	
	Mkuranga	**Ilala**	**Mkuranga**	**Ilala**	**Mkuranga**	**Ilala**	**Mkuranga**	**Ilala**
C8:0	2.5±5.2	0.03±0.03	0	0	0	0	0	0
C C10:0	1.26±1.61	0	0.04±0.041	8.98±11.78	0	0	0	2.29±2.51*
C12:0	1.51±2.34	0*	0	2.11±2.36*	0.41±0.001	0.04±0.005	4.93±4.099	0.22±0.24*
C14:0	0.78±0.38	1.03±0.38	0.59±0.51	0.59±0.66	0.80±0.78	0.78±0.03	0.67±0.49	0.34±0.37
C15:0	0.002±0.004	0.007±0.008	0	0.002±0.003	0	0	0.003±0.00	0.02±0.02*
C16:0	29.86±7.4	20.52±16.1	17.57±8.99	41.20±2.54*	42.81±1.90	39.59±2.16	30.50±12.6	22.13±11.51
C18:0	13.42±6.69	14.41±1.04	2.24±1.58	8.41±5.63*	0.92±0.36	0.58±0.11	15.84±11.21	12.83±4.76
C20:0	7.05±7.75	3.52±0.42	3.15±0.44	1.55±1.42*	1.59±0.11	1.53±0.02	0.70±0.69	1.96±0.83*
C22:0	0.02±0.04	0	0	0	0	0	0	0
C24:0	1.38±1.16	0*	1.85±0.82	0.12±0.18*	0.31±0.009	0.35±0.05	2.36±1.69	0.22±0.25*
Total SFA	**57.78±6.71**	**39.51±16.39**	**25.43±12.21**	**44.87±3.96**	**46.48±2.42**	**38.53±1.29**	**54.99±12.08**	**40.01±18.79**
C16:1	0.34±0.28	13.66±14.81*	13.32±14.6	5.55±7.79	0.42±0.003	0.04±0.001	0.89±0.88	6.34±6.70*
C17:1	0.29±0.26	1.00±0.24*	0.99±0.11	0.29±0.23	0	0	0.74±0.95	1.28±1.13
C18:1	15.37±8.74	11.77±9.21	10.13±3.54	25.03±7.21*	18.00±0.7	17.76±0.96	8.06±9.22	10.68±7.30
C24:1	1.27±1.18	0*	1.50±0.26	0.99±0.15*	0	0	2.05±1.51	1.64±1.81
Total MUFA	**17.27±9.49**	**26.44±23.80**	**25.05±17.99**	**30.97±5.07**	**18.05±0.77**	**17.81±0.94**	**11.74±9.64**	**19.93±16.90**
C18:2	4.41±5.08	7.31±2.16	21.33±1.89	8.52±8.06*	25.99±0.50	25.05±0.52	13.88±15.1	16.17±1.28
C18:3	10.44±5.54	19.48±1.36*	30.39±5.86	14.33±11.1*	13.02±1.06	13.27±0.86	12.46±6.73	13.67±0.86
C20:4	0.17±0.16	0.15±0.16	0	0.16±0.14*	0.23±0.02	0.21±0.12	0.073±0.14	0.87±0.009
Total PUFA	**15.02±3.16**	**26.94±3.12**	**51.72±7.50**	**23.01±3.25**	**38.25±1.53**	**38.53±1.29**	**26.42±15.5**	**29.93±1.09**
Undetected	9.93±6.54	7.11±11.06	2.20±3.29	1.15±2.86	2.77±4.46	0.76±0.72	7.53±12.46	7.69±3.77

Values in the table are presented as mean±standard deviation, *in the same row indicates significant difference

4.2 Discussion

4.2.1 Nutrition Status and Dietary Habits of School Children

The current study aimed to determine the prevalence of overweight and obesity in public and private school children, examine their dietary habits, and assess the association between dietary habits and BMI-for-age. The BMI-for-age, percentage body fat, and MUAC correlated significantly with overweight and obesity and girls had higher values than boys. This implies that if resources are limited, one indicator may be used to identify presence of overweight and obesity among study population. Two studies (Ulbricht *et al.*, 2018; Mosha & Fungo, 2010) also reported higher body fat percentages in girls than in boys. This finding may be related to the propensity for girls to accumulate more fat mass than fat-free mass during the pubertal stage, which is a period accompanied by rapid growth and fat deposition (Umar *et al.*, 2018;

Mosha & Fungo, 2010;). Gender difference in body fat composition was also reported by de Cintra *et al.* (2013), which described boys gaining more muscle mass while girls are gaining more fat mass. The MUAC, which is also used for screening acute malnutrition, was associated with higher BMI-for- age and higher percentage body fat among school children. This means, in obesity studies, MUAC can also be used to detect over-nutrition, although cut-offs values for school children need to be established. However, a single cut-off value of 25% for boys and 30% for girls has been used in one study to define overweight and obesity in school children (Marques-Vidal *et al.,* 2008). A study by Craig *et al.* (2014) in South African school children and adolescents revealed that MUAC was an effective tool in measuring over-nutrition.

Findings from the current study showed a high prevalence of overweight and obesity in primary school children. The overall prevalence of overweight and obesity was 22.6%, which is higher than what was reported in previous studies in Tanzania (Mwaikambo *et al.,* 2015; Muhihi *et al.,* 2013; Mosha & Fungo, 2010), but equals the 22.6% reported by Pangani *et al.* (2016). Children from private schools had a higher prevalence of overweight and obesity than children in public schools. In the current study more mothers of private school children had higher education level and were employed compared to mothers of public-school children. This finding is consistency with a study conducted among Chinese school children which found that higher maternal education had greater odds of overweight and obesity in children than in mothers with lower levels of education (Feng *et al.,* 2019). However, it is expected that high maternal education should improve nutrition status of children including consumption of healthy food (Abuya *et al.,* 2012). This may imply that high education may not be associated with nutrition knowledge. Thus, interventions for mothers with different levels of education is required to manage children nutrition status effectively. If there is a delay in taking immediate actions the risk for non-communicable diseases increases in children, quality of life decreases and more burden may be experienced by the health care system.

The obesity prevalence of above 20% is similar to reports from Ghana (Annan-Assare *et al.,* 2017), Uganda (Chebet *et al.,* 2014), Egypt (Taha & Marawan, 2015), and Latin America (Corvalán *et al.,* 2017). Our findings are consistent with studies in school-age children by Kyallo *et al.* (2013) in Kenya, Pangani *et al*. (2016) in Tanzania, and Adom *et al.* (2019) in Ghana. The mentioned studies reported the prevalence of overweight and obesity in children aged 8 to 15 years. These studies showed that attendance at private schools was linked to high social-economic status (SES), thus a driving force of overweight and obesity among school

children. Since this challenge is reported in many studies more effort with regard to obesity prevention strategies need to be directed to private schools. Other studies also linked overweight and obesity in children to maternal employment (Adom *et al.*, 2019), high education level of mothers (Maddah & Nikooyeh (2009), and inadequate outdoor space for physical activities (Umar *et al.*, 2018).

The current study found no significant difference in the prevalence of overweight and obesity between boys and girls ($p>0.05$), indicating that boys and girls are equally affected. This finding is in contrast with studies among Saudi Arabian school children (El-Mouzan *et al.*, 2010; Collison *et al.*, 2010) and Nigerian school children (Musa *et al.*, 2012), which found that boys were more likely to be obese than girls while girls were more likely to be overweight. However, the reason for this variance could not be substantially explained and needed further investigation. Other studies found that girls were significantly more obese than boys (Umar *et al.*, 2018; Annan- Asare *et al.*, 2017; Baard & McKersie, 2014; Wamba *et al.*, 2013; Adesina *et al.*, 2012; Ene-Obong *et al.*, 2012; Mohammed & Vuvor, 2012). Again, in the African context, females having a large body size are regarded as prestigious and a symbol of wealth.

This situation may cause girls not to bother to lose weight and tend to participate less in vigorous physical activities. This could also be associated with high social economic status of parents, which encourage the purchase of highly processed foods. Based on the literature, other reasons for the differences in overweight and obesity could be due to differences in the age group of children under investigation and area of residence (rural versus urban). However, the current study found no difference in the prevalence of overweight and obesity in the two districts (one in urban and the other in peri-urban), which may be attributable to the geographic proximity of these two districts. Thus, the children are likely to share numerous social, geographical, and economic attributes.

The findings of this study also showed some degree of undernutrition. Children from public schools were significantly thinner and more stunted than children from private schools. This can be associated with the low education levels of mothers in public schools which could also be associated with low social economic status, thus could affect their dietary intake. To some extent, these findings may explain the existence of the double burden of malnutrition among school children wherein both undernutrition (e.g., stunting) and over-nutrition (e.g., overweight) occur together in the same population (FAO, 2006). This was observed in other studies in South Africa (Modjadji & Madiba, 2019; Puckree *et al.*, 2011) and the rates of undernutrition were

higher in rural compared to urban areas. Having double burden of malnutrition among school children emphasize the need to address parallel both under and over nutrition.

The current study found a good preference for fruits and vegetables among public and private school children, but their frequency of consumption was below recommendations. Fruits, such as mangoes and oranges were preferred compared to other fruits, probably because they are readily available and accessible on the school premises. Less preferred fruits such as avocado and pineapple are not available on school premises and are also likely to be affected by seasonality. Thus, increasing availability of preferred fruits in the school environment may attract children to increase consumption of these fruits. Sweet potato leaves were the most preferred vegetable by public school children as it was reported to be more available at home. Private school children preferred spinach and amaranths because they were frequently served during lunch. The WHO recommends an intake of five portions (400g) of fruits and vegetables per day, equivalent to ≥ 2 servings of fruits and ≥ 3 servings of vegetables per day to reduce the risk of dietary-related conditions (Ziaei *et al.,* 2020; Okop *et al.,* 2019). However, in the current study, intake of fruits and vegetables on average was less than one serving a day. It is important to sensitize children to meet this recommendation which may reduce the chances of developing NCDs at younger ages. Some studies (Peltzer & Pengpid, 2012; Peltzer & Pengpid, 2010) conducted in seven African and five Asian countries revealed related results showing intake of fruits and vegetables among adolescents was low (less than once a day). In addition, intake of fruits and vegetables at least three times a week was associated with lower BMI in school children (Wall *et al.,* 2018).

Furthermore, results of the current study showed that milk intake by school children was also low but lower in public school children than in private school children. This could be due to low education level and income of mothers in public schools. Similar studies by Larson *et al.* (2006) and Naserirad and Akbari (2018) among school children and adolescents in Minneapolis and north-eastern Iran, respectively, reported low milk intake. Larson and colleagues (2006) stated that low milk intake could be due to milk taste preference, especially in girls, poor socioeconomic status, and high body weights of adolescents. Children in public schools had higher preference and consumption of fried foods than private school children, which could be linked to the presence of food vendors who prepare these snacks in the public school premises, unlike in private schools where no food vendors are allowed. Although daily consumption was moderate, children in private schools had a higher preference for sugary foods/snacks. This can

be linked to availability and accessibility to these foods with regard to the SES of their mothers. Rice and stiff porridge were the most preferred and consumed staple foods in public and private schools because they are typical staple foods available in Tanzania and the most frequently served foods during lunch breaks in private schools.

In the current study, boys who preferred milk had higher BMI-for-age than those who did not. This could be due to small number of children who consumed milk to make a reasonable comparison. The study of Larson *et al.* (2006) reported that being overweight was associated with low milk intake among middle and high school students from Minneapolis. In the current study, BMI-for- age was related to the intake of more cereal foods and sugary snacks in boys and fewer fruits in girls. Thus, early precautions need to be considered as the evidence suggests linkages between energy-dense snacks and increased overweight and obesity (Alangea *et al.*, 2018), particularly when there is an increase in portion size (Govender *et al.*, 2018). Boys who consumed fried foods/snacks at school had lower median BMI-for-age than those who did not consume. This outcome can be explained by the fact that children from public schools tend to use fried foods as both main meals and snacks while at school, which is likely that the portion sizes were not adequate. This is so because many children from these schools do not go home for lunch.

Furthermore, regression analysis found that consumption of fried foods/snacks at school was inversely associated with overweight/obesity, which can be related to inadequate portion size.

4.2.2 Nutrient Intake, Food Consumption Patterns and Family Factors as Predictors of Overweight and Obesity among Primary School Children

The current study assessed nutrient intake, food consumption patterns, and characterize family factors among overweight/obese and normal weight school children. Then, the work assessed the association between consumption patterns, nutrient intake, family factors and dietary diversity with overweight/obesity among school children. Findings of the current study showed that demographic characteristics were not statistically different between overweight/obese and normal weight children. This may be due to resemblances in selection criteria of overweight/obese children and normal weight children which were age, sex, and school type. However, overweight/obese children were significantly taller and heavier than normal weight children.

In the current study, intake of energy was low in both overweight/obese and normal weight

children similar to a study among adolescent girls in Kilolo district (Bakar, 2016) and a study by Nicholaus *et al.* (2020) with school adolescents in northern Tanzania, but lower than the study reported by Seid *et al.* (2018) in Ethiopian school children. Lower energy intake compared to intake of protein found in the current study was also reported by a study of Gitika (2014) with Kenyan school children and adolescents. The lower intake of energy reported in many African studies indicate that increased prevalence of overweight and obesity in children may be caused more by low participation in physical activity than by dietary intake. In addition, school children are in a period of rapid growth therefore have increased demand for nutrient requirements. A review of studies in South Africa on dietary intake showed that the mean energy intakes were lower than the estimated energy requirement (Steyn *et al.,* 2016). In the current study a large proportion of both overweight/obese and normal weight children had high carbohydrate intake above recommendation which is linked to high intake of cereal foods such as maize, wheat, and rice. Cereals are main staple foods in many African countries. Similarly, a South African study reported that most school children consumed more carbohydrates rich staples compared to animal sources, vegetables, and fruits which was linked to low socio-economic status (Nyathela & Oldewage, 2017).

In the current study intake of animal source foods, such as beef, poultry, eggs, fish and milk, were low and is consistent with studies by Ronoh *et al.* (2017) among pre-school children in Kenya, Naserirad and Akbari (2018) among 6-18 years children in north-east Iran and Alsubaie (2018) among 7-12 years in Saudi Arabia. These findings indicate more reliance on plant-based sources which have reduced bioavailability, which was also confirmed by the current study that a large proportion of both overweight/obese and normal weight children consumed beans daily or several times a day. Animal source foods are expensive for low-income families to afford, and those who are keeping livestock may have other priorities that just consumption. Low fish and milk intake in the current study can be linked to low calcium intake by the children. Evidence suggests that there is a strong association between consumption of milk/dairy products with calcium intake (Alsubaie, 2018). Low fish consumption in the study area is questionable due to the study's location near the Indian Ocean, and fishing is among the economic activities taking place in the area. Perhaps this situation could be related to low SES given that fish is more expensive compared other relish.

Similar to our findings, Alsubaie (2018), Al-Jawaldeh *et al.* (2020), and Naserirad and Akbari (2018) reported low fruit and vegetable intakes among school children. The Tanzanian STEPS

survey (2012) revealed low consumption of fruits on average of 2.5 days in a week in the adult population and vegetable consumption on average of 4.5 days in a week. This finding indicates that children may be following adults' trends in fruits and vegetables consumption. Fruits and vegetables are considered protective foods since they are the best sources of vitamins, minerals, and antioxidants (Naserirad & Akbari, 2018). Low consumption is suggestive of the potential for low intake of micronutrients, such as zinc, vitamin A, and folic acid in the current study.

In the current study, high frequency (daily or five to six times a week) of consumption of maize-based foods, local/fruit flavoured juices, and local ice cream was inversely associated with overweight and obesity. The findings show that normal weight children (i.e., normal weight children) reported higher frequencies of consumption of these foods but portion sizes could be low. Other evidence suggests that most fruit drinks may promote weight gain when consumed in large amounts (WHO, 2003). Another reason could be overweight/obese children underreported the frequency of consumption or they have become more conscious of weight gain and are trying to watch what they consume. In a study by Skinner *et al.* (2012) overweight and obese children were found to consume less energy than healthy weight children. The authors associated the finding with high energy intake which might occur during childhood and perpetuates to adolescence thus contributing to the early onset of obesity. Likewise, moderate intake of potato chips (up to four times a week), was significantly associated with overweight/obesity indicating that the trend might have perpetuated from childhood. Essentially, if there is energy balance, an obese child will remain obese while a normal weight child will remain normal weight (Skinner *et al.* 2012). Also, obese children may find themselves too heavy to participate in physical activities thus requiring less energy to maintain balance.

Findings from the current study revealed that moderate consumption of soda/carbonated drinks (up to four times a week) was not associated with overweight and obesity. Other studies by Nasreddine *et al.* (2014) in Lebanon, Vilchis-Gil *et al.* (2015) in Mexico, Godakanda *et al.* (2018) in Sri-Lanka, Alangea *et al.* (2018) in Ghana, and Al-Jawaldeh *et al.* (2020) in the Eastern Mediterranean region reported that high consumption of beverages such as soda/carbonated drinks and other sugary drinks were significantly associated with the increased risk for overweight and obesity among school children. This may depend on the amount of drink consumed and level of physical activity, since evidence have suggested that low consumption of soda does not cause increased weight. In a longitudinal study with European

school children, a dietary pattern classified as energy-dense (i.e., snacking, sweets, fat) was not associated with overweight and obesity among children (Pala *et al.,* 2013). This finding however was associated with the weakness of the tool used to collect data being unable to correctly capture the food-frequency of children.

Furthermore, our results showed that low dietary diversity significantly predicted overweight and obesity, which was reflected in more children in the normal weight group reporting consumption of more dark green leafy vegetables, vitamin A rich fruits and vegetables, and other fruits and vegetables which are known to have low energy density, thus a decrease in weight gain. However, a study by Khamis *et al.* (2021) found conflicting results in the association between dietary diversity and overweight/obesity in Tanzania that some anthropometric indicators were associated with dietary diversity and others did not. In addition, Gicevic *et al.* (2018) reported that dietary diversity failed to predict obesity and coronary diseases in women and children in low and middle-income countries.

Many parents of overweight/obese children self-assessed as being overweight or obese (perceived overweight/obese) which is consistent with the finding that an obese parent is likely to have an obese child (Pala *et al.,* 2013). This indicated obesity can be passed on from parents to children given that enabling environment is provided. Our results are in line with a case-control study in Bangladesh which revealed that having an overweight/obese parent was a risk factor for overweight or obesity in children (Bhuiyan *et al.,* 2013). Both studies with Cameroonian university students by Niba *et al.* (2017) and a Mexican study by Vilchis-Gil *et al*. (2015) found that skipping breakfast was associated with overweight and obesity, which varied from the current study where skipping breakfast (by >30% of children) was not a significant factor for overweight/obese. Skipping breakfast was caused by fear of children being late for school and low preference to eat early in the morning. Other reasons for skipping breakfast among school children according to Katungwe *et al.* (2015) in Malawian school children included lack of motivation to prepare breakfast, lack of knowledge among parents on the importance of breakfast, priority for other household chores like fetching water, going to the farm, and lack of food in the household.

4.2.3 Physical Activity and Sedentary Behaviors Associated with Overweight and Obesity among Primary School Children

The current study characterized physical activity and sedentary behaviors of school children, and their association with overweight/obesity. Data revealed that listening to music and/or radio for >2 hours per week and walking for <2 hours per week were significantly associated with overweight/obesity. This finding indicates that more overweight/obese children had access to music devices and walked less frequently. There is a need to modify lifestyle behaviors by reducing in sedentary time for obese children to prevent the risks associated with increased weight. Rope skipping for >2 hours/week was protective against overweight/obesity as it involves vigorous jumping as a result more energy is used. Obese children may feel too heavy to participate in rope skipping. Promotion of physical activity that involves utilization of high amount of energy can be an effective strategy to reduce more weight in school children. Current findings suggest that children who spend >2 hours/week in television viewing were 1.6 times more likely at risk of being obese/overweight than children who did not watch television, However, the finding was not significant which is in contrast with the study by Bhuiyan *et al.* (2013) who found that watching television for >4 hours/day was significant risk factors for overweight and obesity.

In the current study mean score of being active over the lunch break was significantly higher in normal weight than in overweight/obese children. This may be attributable to the fact that obese children preferred more sedentary behaviors such as reading following a lunch session. The overall mean activity score did not differ between overweight/obese and normal weight children but slightly higher in normal weight children which aligned with Thasanasuwan *et al.* (2016). In addition, participation in physical education classes was moderate in both groups and only 16.9% of children were active. This figure is lower than Micklesfield *et al.* (2014) findings among South African school children. Physical education classes promote physical activity through access to knowledge and stimulation of physical activity practice (Ferrari *et al.,* 2020) and prepare young people to adopt a physically active future and a healthy lifestyle (Walter, 2011).

Results of the current study showed that overweight/obese children were significantly taller than normal weight children of the same age. Similar findings were found in Mexico City by Vilchis-Gil *et al.* (2015) who reported overweight and obese children to be taller compared to their counterparts, which was suggestive that their increase in height might have been

accelerated by imbalances of growth hormones causing rapid bone maturation. Our results found no difference in sleeping time between overweight/obese children and normal weight children which differs from findings revealed in Thailand (Amini *et al.,* 2009; Thasanasuwan *et al.,* 2016) which reported that obese children slept fewer hours than non-obese children. The reasons discussed by the authors suggested that (a) children with normal weight were more active than obese children, thus requiring more time to sleep, (b) low sleep quality results from being obese due to sleep apnea; and (c) obese children played more electronic games thus shorten their sleeping time.

In the current study over 70% of overweight/obese children and over 80% of normal weight children met the WHO daily recommendation for physical activities in children indicating that many children from both groups participated in physical activities. This finding may account for other factors associated with overweight/obesity differing from other extant evidence. In addition, evidence from the literature showed that there is a possibility of overestimation of physical activity level through a self-report questionnaire (Mindell *et al.,* 2014). The levels reported in the current study are higher than those found in Sao Paulo in Latin America by Ferrari *et al.* (2020).

Based on the finding that many children in both groups reported participating in physical activity, it may account for the current study's finding not associating with previous studies on overall physical activity and sedentary behaviors with overweight/obesity. This was also revealed in studies by Keane *et al.* (2017), Godakanda *et al*. (2018), and Wiersma *et al.* (2019) who found that total sedentary behaviors were not the risk factors for overweight/obesity. Conversely, many studies revealed a significant relationship between sedentary behaviors or physical inactivity with overweight/obesity (Muntaner-Mas *et al.,* 2017; Vilchis-Gil *et al.,* 2015; McVeigh & Meiring, 2014; Bhuiyan *et al.,* 2013; Mushtaq *et al.,* 2011). There is a scarcity of data in Sub-Saharan Africa including Tanzania that link physical activity patterns and sedentary behaviors with weight status. One study from South Africa reported an association between BMI and physical activity in high schools (McVeigh & Meiring, 2014). However, other studies (Ferrari *et al.,* 2020; Esht *et al.,* 2018; Micklesfield *et al.,* 2014; Walter 2011) have compared differences in physical activity among boys and girls and not weight status.

Findings of the current study showed that most physical activities were conducted in the home environment which may indicate that adequate space is available. This finding was revealed

through focus group discussion with parents of school children of the current study. Most indicated that at home there is adequate space for informal and local games. This is contrary to what was expected in large cities which are normally faced with reduced space for physical activity. In addition, games, such as dancing, running, rope skipping, and walking, may not require a well-defined/structured space. Therefore, the promotion of participation in physical activity by school children at the family level is potential to achieve greater levels of physical activities. Nevertheless, children spend a considerable amount of time in the school environment, therefore, schools should be accountable for at least half of the time to meet the daily recommendation for physical activities (Walter, 2011).

4.2.4 Influence of Environmental, Socio-Cultural and Parental Factors on School Children's Food Choices, Consumption and Physical Activities

Parental, environmental, and socio-cultural determinants of children's food choices by using a qualitative approach were examined in the current study. Key informant interviews involved persons who had influence at schools and know the school environment. Our results showed that most KII participants were males. This might reflect that most males are likely to hold senior positions in institutions, such as head teacher, assistant head teacher, and health teachers. A majority of participants in the FGD were females, which could be due division of labour, in which females are more involved in shopping, food preparation, and meal planning at home. Therefore, they are likely to have more knowledge on factors influencing food choice in the home environment.

Current results shed light on school and home environments in determining food choices for school children. Food availability and food preference were the basic drivers of food choice in both school and home environments. Family income/cost of food, time for food preparation, and food for rewards, were potential food choice influencers in the home environment. Food choice determinants play a great role in obesity epidemic especially if the choice is skewed to high-energy giving foods as it has been observed in the current study.

From the current results, the environments which children are exposed to force them to select foods available. For example, in private schools, there were a few food options, including cereal-based foods with limited fruits and vegetables. Given that no child is allowed to bring food from outside, children had to eat whatever was offered by the school. However, most children preferred '*pilau'* (spiced rice) often cooked with more oil compared to normal rice. In

public schools, there were plenty of energy-dense foods and children consumed more of these food items. This was consistent with the study of Bevans *et al.* (2011) who found that low-nutrient energy-dense foods were abundant in school environment and were frequently consumed by children. On the other hand, healthy foods, such as fruits, vegetables, and whole grains, were also available but infrequently consumed (Bevans *et al.*, 2011). Thus, promotion of healthy eating in school children is likely to influence positive behaviour change. In the current study schools provide limited varieties of healthy foods like dairy products, fruits, vegetables, eggs, and whole grains. Therefore, schools may expose children to the risk of becoming overweight or obese given that the timetable for physical activity and facilities are not adequate to compensate for energy expenditure. Likewise, in the home environment available foods were mainly cereal-based with limited options for healthy foods like fruits, milk, nuts, and seeds.

The findings from a review paper revealed that the diets of school children are limited in diversity (Ochalo & Masibo 2014). Most parents reported to eat less frequently with their children because of their busy schedules and children spending most of the day at school. However, in most overweight/obese children, they eat supper together. Eating supper together with the family reduces the risk of becoming overweight or obese (Mushtaq *et al.,* 2011). Studies by Chadwick *et al.* (2013) and Scaglioni *et al.* (2018) highlighted the association of eating more regular family meals with increased consumption of healthy foods.

The current study showed that many children prefer processed foods and drinks and parents prefer to give these foods as rewards for being "good". Yee *et al.* (2017) in their review reported that 6 out of 10 studies found a positive association between using food as a reward and unhealthy food consumption indicating that unhealthy foods are commonly used as reward items. Parents need to be informed on dangers of preferring energy-dense food selection for their children, as this may expose their children to overweight and obesity and increase their risk for dietary related chronic diseases later in life. It is evident that preference to energy-dense foods is genetically determined, as human infants are born with preference to sweet taste which normal weight children food selection in children (Vabø & Hansen, 2014). However, as a person grows older food preference is guided more by experiences (Vabø & Hansen, 2014).

In the current study, many parents reported that time for food preparation impaired food quality and undesired eating in families with working mothers. This is in line with what was reported by Nazzaro *et al.* (2018) who found that longer working hours of employed mothers outside

home lead to insufficient time for mothers to prepare healthy meals at home. However, parental understanding on negative health impact of unhealthy foods needs further investigation. A study with Australian kids reported that parents were motivated to choose food liked most by their children and nutritionally adequate, but did not consider price of food (Russell *et al.*, 2014). In the current study, parents considered children preference and cost of food/family income, but nutritional aspects were seldom considered. A study in the USA also revealed that nutrition quality of foods and drinks were lower in low-income households and higher in high-income households (French *et al.*, 2019). A rise in income was associated with increased purchase of healthy foods, such as milk and fruits (Muhammad *et al.*, 2017). Studies with Finnish school children (Roos *et al.*, 2012) and Norwegian school children (Oellingrath *et al.*, 2012) demonstrated that healthy, natural food, and sensory appeal were the most influential parental factors for food choices. It should be noted that studies done in economically affluent countries might not be similar to studies conducted in less affluent countries. To some extent in the current study food choice was affected by seasonality especially for fruits, roots, and tubers. In Tanzanian culture there is no tradition of preserving these foods, thus there are certain food groups less available during off-season perhaps we need to adapt relevant preservation methods to increase shelf-life. Findings of the current study showed that most participants were surrounded by food outlets, such as retail shops (mostly selling cereal-based foods, legumes, oils and fat and non-food items), small food groceries *(magenge)*, and street food vendors which are dominated by fruits and vegetables. These places may not always supply fresh and healthy foods which might impact unhealthy eating patterns (Lind *et al.*, 2016), given that customers develop behaviours based on what is available nearby (Caspi *et al.*, 2017).

4.2.5 Sucrose and Saccharin Contents in Foods Commonly Sold and Consumed in the School Environment

The current study characterized sugar (sucrose and saccharin) levels in foods consumed by school children. The average sucrose content in the analyzed samples varied from 0 to 14 g/100 g of food/drink while for saccharin varied from 4 to 533 mg/100g of food/drink. *Kashata* (MK 6) had the highest amount of sucrose and local ice cream (MN 4) had the highest amount of saccharin. Findings of this study show varying concentration of sucrose and saccharin in both samples. Some samples had high amount of both sugars while others had low amount of both sugars. However, when sucrose content was compared to Canadian regulation it was found that samples of the current study had lower concentration indicating that food vendors do not prefer

to use sucrose may be due to cost implications. From these findings, it is suggested that saccharin is used mostly by food vendors because smaller amount is required to give the required sweet taste at low and affordable cost than when using sucrose (table sugar). This amount of saccharin is above the WHO recommendation of 5 mg/kg/BWT/day. However, given the dangers of high saccharin contents in foods, food vendors need to be guided on proper and safe amounts to be added in foods during preparation, because even at small concentration of sugars a desired sweet taste can be achieved.

From the survey, the median body weight of school children was 36.7 kg with a range from 22.7 to 104 kg. According to WHO recommendation of saccharin is 5 mg/kg of body weight per day (Ndu & Ejikeme 2017), therefore, these children should not consume more than 184 mg of saccharin per day based on their median body weight. In this study, some analyzed samples had high saccharin content (up to > 500 mg/100 g in local ice cream and > 300/100 g in *kashata*) which is likely to cause health problems including weight gain. For example, local ice cream (measured from 24 hour dietary recall) weighed 115-150 g and frequency of consumption of majority of school children was one to two times a day, which means increased consumption leads to more intake of saccharin.

A study conducted in rats found a predictive relationship between sweet taste and caloric content of foods thus normal weight children energy homeostasis. However, the predictive relationship is impaired when eating sweet and artificial sweetener such as saccharin and leads to compensation in energy intake or a reduction in basal metabolic rate. The study concluded that saccharin resulted in increased caloric intake, body weight, and adiposity (Cabral *et al.*, 2018). The sweetness of saccharin may stimulate preference for sweet taste, desire for sweet foods, and favouring increased consumption of those foods (Liem & de Graaf, 2004).

Another study administered in rats revealed that intake of sodium saccharin at 5 mg/kg and 10 mg/kg body weight per day was associated with increased body weight in the treatment group than in the control group after 60 and 120 days of experiment (Azeez *et al.*, 2019). The reason given by the study was that saccharin and other non-nutritive sweeteners tend to induce microbial communities in the digestive system thus caused glucose intolerance in the treatment group. Findings from Davidson and Swithers (2004) reported that intense sweeteners are likely to be responsible for obesity epidemic as it is hypothesized that absence of calories results in ambiguous signals that confuse the regulatory mechanism of the body, resulting in a loss of control over appetite hence contributing to a person's tendency to overeat.

In a study with obese adults it was revealed that high intake of non-nutritive sweetener was associated with increased intake of fatty foods, proteins, and sugars while intake of some vitamins was low (Winther *et al.,* 2017). Review of literature across a period of 40 years found conflicting results among studies on association between saccharin intake and adverse health effect in experimental animals and humans. Some studies found positive relationship while others found inverse association. Hence it is important that a reconsideration be undertaken regarding intake of saccharin based on acceptable daily intakes (Uçar & Yilmaz, 2015).

In a study with school children in Spain it was observed that overweight and obesity was associated with greater daily intakes of energy, total sugars, added sugars, and free sugars (Heras-Gonzalez *et al.,* 2020). Liem and DeGraaf, (2004) found that 6-11 year old children in the Netherlands had increased preference to sweet taste after an 8-day repeated exposure to a drink with high sucrose concentration. Hypothetically, this can also be applicable to children in the current study who prefer to consume sugary foods/drinks as after a repeated exposure they become used to these types of foods and beverages. Thus, reduction of sugars is recommended to achieve the desired body weight. One author added that foods that are normally consumed by children in the school or around school premises may make substantial contributions to total amount of sugars (Fox *et al.,* 2021). Over consumption of added sugars in children has been associated with more weight gain, poor dietary quality, and other diet-related problems, therefore, can present a potential danger to health (Fox *et al.,* 2021). Therefore, it is crucial for schools to recognize the importance of influencing dietary changes positively. When children are well informed on negative effects of high sugar intake, they are likely to reduce consumption of sugary food items and drinks (Joo *et al.,* 2017).

Recommended amounts of sugars per day is <10% of total energy (WHO, 2015) which is equivalent to 25 g of sugar per day (Sewwandi *et al.,* 2020) and, according to American Heart Association, 25-40 g is recommended per day in adolescents (Damayanti *et al.,* 2012). Data on nutrient intake from survey of the current study showed that median intake of carbohydrate among school children was 262 g per day which was twice as much as recommended level of 130 g per day. This finding indicates that added sugars in foods and drinks are likely to contribute to the total and high amount of carbohydrate intake by school children. The current study provided new information on presence of sugars (sucrose and saccharin) in foods/drinks found in school environment, which could provide some cues in setting guidelines and recommendations for sugars.

4.2.6 Fatty Acids Composition of Fried Foods Commonly Consumed by Primary School Children

In the current study, fatty acid composition of fried foods commonly consumed by school children around school environment were evaluated. These foods were identified during a cross-sectional survey and, thereafter, samples were collected for laboratory analysis. Results showed that these foods contained high levels of SFA with PUFA constituting the lowest level of fatty acids. The most common fatty acids found in the current study were palmitic (41%), oleic (19%), linolenic (21%), and stearic acid (14.8%). This profile reflects the most common cooking oil used in Tanzania which is *Korie* brand, with its main ingredient being palm oil. Results from a similar study done with bean cakes fried with palm oil showed that palm oil had the highest percent of palmitic acid (42%), followed by oleic acid (30.9%), linolenic acid (9.23%) and stearic acid (8.13%) (Abiona *et al.,* 2011). Palm oil is the mostly consumed fat worldwide; however, its highly saturated fatty acid (especially C16:0) content rises a concern in obesity-related diseases (such as type 2 diabetes, hyperlipidemia, hypertension) and cardiovascular diseases (Kasmin *et al.,* 2015). Palm oil contains 50% of saturated fatty acids mainly palmitic (44%), it contains 40% MUFA mainly oleic and 10% PUFA in which linolenic acid constitutes the main part (Kasmin *et al.,* 2015). A diet rich in palm oil has been linked to weight gain and lipid accumulation when compared to unsaturated fat diets, due to the high SFA concentration. It is reported that in the adipose tissues SFA undergo inflammatory processes resulting in insulin resistance (Mancin *et al.,* 2015). The same author and colleague further postulated that consumption of SFA from palm oil during pregnancy and breastfeeding induces fat retention in the young offspring hence predisposing the offspring to obesity development later in life (Mancin *et al.,* 2015). Among the samples, *kashata* which was shallow fried, it was noted that they contained higher levels of palmitic acids than the deep-fried products (fried cassava, *kachori* and samosa). This finding suggests that deep frying might be altering the levels of palmitic acids, which merits further research consideration.

From the cross-sectional survey and follow up-survey data showed that intake of animal source protein including fish and *dagaa* was low among school children. Given that fish is the major source of polyunsaturated fatty acids, such as Omega-3 and Omega-6, it means that school children are less likely to compensate for these essential fatty acids from the diet, thus they are more likely to become obese. A study by Rahmawaty *et al*. (2013) revealed that lower intake of PUFA, such as Omega-3, EPA and DHA, was associated with insulin resistance in obese

school age children. Literature review reported results from prospective cohort longitudinal studies to show linkages between dietary intake of fat and weight gain. The first study (done over 8 years) found that the intake of SFA and trans-fatty acids were positively associated with weight gain compared to intake of MUFAs and PUFAs (Monnard & Dulloo, 2021). Another study which used data from National Health and Nutrition Examination survey in America found that BMI was positively associated with intake of carbohydrate, protein, total fat, total saturated fatty acids and MUFA, but not to total and individual PUFAs (Raatz *et al.,* 2017). In both studies control of potential confounders was considered. A study by Liu *et al.* (2018) investigated the changes in intake of varying types of dietary fat over a period of 20 years. After controlling for confounders, results indicated that increased consumption of n-3 and n-6 PUFA and MUFA from plant sources were associated with less weight gain at the expense of carbohydrate. Likewise, increased consumption of SFA, trans- fats, and animal based MUFA was associated with greater weight gains. On the other hand, other studies linked consumption of omega 3 fatty acids rich foods (n-3 PUFAs) with reduction in overweight and obesity but results are controversial and challenging thus proposed further investigation (Lorente-Cebrián *et al.,* 2012; Young *et al.,* 2020).

When linking these results to cross-sectional survey the median intake of energy among school children was 1370 kcal and median intake for fat was 225 kcal which is 16.4% of the total energy coming from fat. It can be assumed that fat intake by school children is not likely to cause overweight and obesity in children as it is within recommended levels. However, after prolonged use may accumulate in the body and result in overweight/obesity and associated health risks (Monnard & Dulloo, 2021). Therefore, the promotion of right consumption (in terms of quality and quantity) of dietary fat is required.

A study by Abiona *et al.* (2011) revealed that as palm oil was used repeatedly in frying for six days new fatty acids were observed. These new fatty acids included butryric, caprylic, palmitoleic, linolenic, eicosenoic, docosadienoic, lignoceric and nervonic. In the current study, some fatty acids also found included: caprylic, palmitoleic, linolenic, lignoceric, nervonic, and pentadecanoic. This profile is likely the result of the oil being repeatedly used for frying. In many societies with low SES, it is common to re-use the same oil for cooking and frying. It also a way of maximizing profit for small food vendors but is dangerous for consumers' health. Formation of new fatty acids could be associated with oxidation, thermal, and hydrolysis reactions occurring during the frying process (Abiona *et al.,* 2011).

Results from the current study also showed that levels of fatty acids in the same product differed significantly in the two districts. Several studies have stipulated numerous factors contributing to variation in fatty acid composition in the same product even if the same type of oil is used for frying. In an experiment with French fries (potato chips) done over a two-day duration at 4, 8, 12, and 16 hours, levels of linoleic acid (C18:2) decreased while levels of palmitic acid (C16:0), stearic acid (C18:0) and oleic acid (C18:1) increased and general levels of PUFA decreased while SFA increased (Sharoba & Ramadan, 2012). Flores *et al.* (2018) found that frying tends to decrease PUFAs, such as linoleic and linolenic acids, as a result of chemical processes taking place during frying. This could also be explained in our results that in some products like kachori linoleic and linolenic acids were lower in Ilala district than in Mkuranga district. During frying, amount of oil absorbed by the food depend on frying time, temperature, food composition, and oil quality (Marques de Lima *et al.,* 2019).

Frying oil undergoes numerous changes during frying namely: hydrolysis, oxidation, and thermal polymerization resulting in the formation of many oxidative products in the fried food, with repeated use the oil becomes harmful for human consumption. In addition, food absorbs more oil when it is reused (Goswami *et al.,* 2015), which means the same food prepared by the same oil type may have different fatty acid composition. During sample collection for the current study, food vendors admitted to reuse frying oil several times before discarding or mixing with new oil and through observation (because the foods are prepared within school premises) the oil used seemed to be foamy, highly viscous, and dark coloured. Therefore, from a nutrition point of view a number of factors must be considered in order to create strategies to reduce oil intake from fried foods.

4.2.7 Limitation of the Study and Methodological Challenges

The study faced numerous limitations. It was conducted in a small population of school children in four wards in the two districts, which may limit the generalization of findings to a larger segment of children in urban and peri-urban areas. However, random sampling employed helped to obtain a representative sample.

This study relied on self-reported data in which participants had to recall information on dietary habits, nutrient intake, and food frequency which is subject to memory bias. However, observation of foods available in the school environment and information on the number of times a child is allowed to eat during school hours aided in the recall.

There might be some challenges in remembering accurately the time spent in physical and sedentary activities across the reference period. However, probing questions asking the daily schedule of each child helped to minimize these biases.

In addition, the current study was limited to foods sold and consumed in and around school environment, food eaten at home could not be captured as the focus of this study was to concentrate on school environment. However, levels of sugars (sucrose and saccharin) and fats founds in foods/drinks could provide highlights in restrictions on selling sugary and fat foods in the school premises. In addition, Covid-19 pandemic jeopardized data collection exercise in 2020, thus to some extent delayed the study progress.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

The prevalence of overweight and obesity was high among school children in the study areas (Ilala and Mkuranga districts). The prevalence was higher among children from private schools than public schools, and was significantly correlated with increased body fat, and MUAC. Consumption of unhealthy foods such as biscuits, cookies, cakes, and local ice cream were associated with high median BMI-for-age and intake of fruits, vegetables, and milk was low. Predictors of overweight or obese were having overweight/obese parent, listening to music and/or radio and less walking exercise, while rope skipping for >2 hours/week was found to be protective. Normal weight children were significantly more active over the lunch break than overweight/obese children. Food preference, food availability, family income/cost of food, and time for food preparation were potential determinants for food choices in school children. The current study found that foods which are sold by vendors at schools contained significant levels of saturated fatty acids (especially the palmitic and stearic) compared to MUFA and PUFA which is linked to the type of oil used for frying. Moreover, some food products had higher amount of sugar and children preferred to consume those foods. Therefore, school children are likely to be exposed to the risk of overweight/obesity and other dietary-related chronic problems. Considering the findings from this study, it recommended that, the government needs to address to address the high prevalence of overweight and obesity among school children by taking possible interventions such as promoting consumption of fruits and vegetables in schools, promoting regular/routine physical activities (e.g sports) in schools and reducing the sales of high sugar and/or fat food by food vendors to curb and mitigate the effect of the problem.

5.2 Recommendations

Overweight and obesity is a growing health problem among school children in Tanzania although there is little attention in addressing the problem. This study recommends the following:

(i) At national level, it is advised to conduct a periodic national nutrition survey that will include school children since this group receives less attention in nutrition research and more focus should be paid to private schools especially in increasing availability of

adequate fruits and vegetables. The national survey should also explore the linkage between increased obesity (and all herein studied associate factors) and NCDs in the country.

(ii) In the home environment, parents are advised to increase availability of locally available healthy foods, and at schools, teachers should teach children the importance of choosing and consuming healthy foods. This can be an effective strategy in promoting healthy eating among school children.

(iii) The government needs to implement the WHO adopted recommendations "best buys" for preventing NCDs, mainly focusing on healthy eating habits, improving physical activity and awareness creation/education to school children and their caregivers/parents.

(iv) Possible interventions, by district nutritionists at school level, such as providing nutrition education and strategies to schools to modify behaviors and improve intake of healthy diets.

(v) Continuous surveillance/monitoring of snacks sold in school environment is necessary to minimize the risk related to high sugar intake by school children.

(vi) Multi-sectoral approach by different parties such as government, parents, producers, and manufactures is required to modify home and school environments to provide healthy diets and promote physical activities for school children.

(vii) Future research is recommended to investigate the contribution of biological factors on increased prevalence of overweight and obesity.

(viii) Interventions/programs targeting school children, parents, food processors and school administrators should be monitored and evaluated for the best performance of the interventions/programs.

REFERENCES

Abiona, O. O., Awojide, S. H., Anifowoshe, A. J., & Babalola, O. B. (2011). Comparative study on effect of frying process on the fatty acid profile of vegetable oil and palm oil. *E-International Scientific Research Journal,* 3(3), 210-218.

Abrahams, Z., deVilliers, A., Steyn, N. P., Fourie, J., Dalais, L., Hill, J., Draper, C. E., & Lambert. E. V. (2011). What's in the lunchbox? Dietary behaviour of learners from disadvantaged schools in the Western Cape, South Africa. *Public Health Nutrition,* 14(10), 1752–1758.

Adesina, A. F., Peterside, O., Anochie, I., & Akan, N. A. (2012). Weight status of adolescents in secondary schools in Port Harcourt using body mass index (BMI). *Italian Journal of Pediatrics*, 38(31), 1-7.

Adom, T., Kengne, A. P., DeVilliers, A., & Puoane, T. (2019). Association between school-level attributes and weight status of Ghanaian primary school children. *BMC Public Health,* 19(577), 1-10

Adamo, K. B., & Brett, K. E. (2013). Parental perceptions and childhood dietary quality. *Maternal and Child Health Journal*. doi:10.1007/s10995-013-1326-6.

Alangea, D. O., Aryeetey, R. N., Gray, H. L., Laar, A. K., & Adanu, R. M. K. (2018). Dietary patterns and associated risk factors among school age children in urban Ghana. *BMC Nutrition,* 4(22), 1-9.

Alejandra, N. M., Paula, C. M., & Patricia, A. M. (2016). Study of nutrition habits in primary school students. *Journal of Clinical Nutrition and Dietetics*, 2(4), 1-5.

Al-Jawaldeh, A., Taktouk, M., & Nasreddine, L. (2020). Food consumption patterns and nutrient intakes of children and adolescents in the Eastern Mediterranean Region: A call for policy action. *Nutrients,* 12, 3345.

Alqahtan, N., & Scott, J. (2015). Childhood obesity estimates based on WHO and IOTF reference values. *Journal of Obesity and Weight Loss Therapy*, 5(1), 1-3.

Alsubaie, A. S. R. (2018). Intake of fruit, vegetables and milk products and correlates among school boys in Saudi Arabia. *International Journal of Adolescent Medicine and Health*, 0(0), doi:10.1515/ijamh-2018-0051.

Amini, M., Alavi-Naini, A., Doustmohammadian, A., Karajibani, M., Khalilian, A., Nouri-Saeedlo, S., Salimi, M., & Shafaghi, K. (2009). Childhood obesity and physical activity patterns in an urban primary school in Thailand. *Rawal Medical Journal*, 34 (2), 203-206.

Annan-Assare, J., Asante, M., & Amoah, A. G. B. (2017). Obesity and its correlates among junior high school children in the Accra Metropolis. *Journal of Nutrition and Health Sciences* 4(2), 206. https://doi.org/10.15744/2393-9060.4.206.

Astrup, A., Bertram, H. C., Bonjour, J., deGroot, L. C., deOliveira O. M. C., Feeney, E. L., Garg, M. L., Givens, I., Kok, F. J., Krauss, R. M., Jordan, D., Lamarche, B., Lecerf, J., Legrand, P., McKinley, M., Micha, R., Michalski, M., Mozaffarian, D., & Soedamah-Muthu, S. S. (2019). WHO draft guidelines on dietary saturated and trans-fatty acids: Time for a new approach? *British Medical Journal*, 366, doi: 10.1136/bmj.14137.

Ayogu, R. N. B., Eme, P. E., Anyaegbu, V. C., Ene-Obong, H. N., & Amazigo, U. V. (2018). Nutritional value of school meals and their contributions to energy and nutrient intakes of rural school children in Enugu and Anambra States, Nigeria. *BMC Nutrition*, 4(9), 1-9.

Ayogu, R. (2019). Energy and nutrient intakes of rural Nigerian schoolchildren: Relationship with dietary diversity, *Food and Nutrition Bulletin*, 40(2), 241-253.

Azeez, O. H., Alkass, S. Y., & Persike, D. S. (2019). Long-term saccharin consumption and increased risk of obesity, diabetes, hepatic dysfunction, and renal impairment in rats. *Medicina*, 55, 681, 1-15.

Baard, M. L., & McKersie, J. (2014). Obesity in 7-10-year-old children in urban primary schools in Port Elizabeth. *South African Journal of Sports Medicine*, 26(2), 55-58.

Badawi, N. E., Barakat, A. A., El-Sherbini, S. A., & Fawzy, H. M. (2013). Prevalence of overweight and obesity in primary school children in Port Said city. *Egyptian Pediatric Association Gazette*, 61, 31–36.

Bailey, D. A., McKay, H. A., Mirwald, R. L., Crocker, P. R. E., & Faulkner, R. A. (1999). A six-year longitudinal study of the relationship of physical activity to bone mineral accrual in growing children: The University of Saskatchewan bone mineral accrual study. *Journal of Bone and Mineral Research*, 14, 1672-1679.

Bakar, S. M. (2016). Nutritional Inadequacies and Determinants among Adolescent School Girls in Rural Tanzania (Master's thesis, Michigan State University), 42-44.

Banna, J. C., Buchthal, O. V., Delormier, T., Creed-Kanashiro, H. M., & Penny, M. E. (2016). Influences on eating: A qualitative study of adolescents in a periurban area in Lima, Peru. *BMC Public Health*, 16-40.

Barquera, S., Campirano, F., Bonvecchio, A., Hernández-Barrera, Rivera, A. J., & Popkin, B. M. (2010). Caloric beverage consumption patterns in Mexican children. *Nutrition Journal*, 9(47), 1-10.

Bekker, F., Marais, M., & Koen, N. (2017). The provision of healthy food in a school tuck shop: does it influence primary-school students' perceptions, attitudes and behaviors towards healthy eating? *Public Health Nutrition*, 20(7), 1257–1266.

Best, C., Neufingerl, N., Van-Geel, L., Van-den-Briel, T., & Osendarp, S., (2010). The nutritional status of school-aged children: Why should we care? *Food and Nutrition Bulletin*, 31(3), 400-417.

Bevans, K. B., Sanchez, B., Teneralli, R., & Forrest, C. B. (2011). Children's eating behavior: The importance of nutrition standards for foods in schools. *Journal of School Health,* 81(7), 424–429.

Bhowon, M. G., Ramsurn, D. D., & Jhaumeer- Lau-Loo, S. (*2015*). Determination of artificial sweeteners in liquid foods by high performance liquid chromatography. *International Journal of Pharmaceutics and Drug Analysis,* 3(10), 311 – 321.

Bhuiyan, M. U., Zaman, S., & Ahmed, T. (2013). Risk factors associated with overweight and obesity among urban school children and adolescents in Bangladesh: A case–control study. *BMC Pediatrics,* http://www.biomedcentral.com/1471-2431/13/72.

Bligh, E. G., & Dyer, W. J. (1959). A rapid method of total lipid extraction and purification.

Canadian Journal of Biochemistry and Physiology, 37(8), 911–917.

Boddy, C. R. (2016). Sample size for qualitative research. *Qualitative Market Research,* 19(4), 426-432.

Boyland, E. J., Kavanagh-Safran, M., Halford, J. C. G. (2015). Exposure to 'healthy' fast food meal bundles in television advertisements promotes liking for fast food but not healthier choices in children. *British Journal of Nutrition,* 113, 1012–1018.

Bree, R., & Gallagher, G. (2016). Using Microsoft Excel to code and thematically analyze qualitative data: A simple, cost-effective approach. *All Ireland Journal of Teaching and Learning in Higher Education,* 8(2), 2811-2819.

Brown, C., Shaibu, S., Maruapula, S., Malete, L., & Compher, C. (2015). Perceptions and attitudes towards food choice in adolescents in Gaborone, Botswana. *Appetite*, 95, 29-35.

Brown, J. E., Nicholson, J. M., Broom, D. H., & Bittman, M. (2011). Television viewing by school-age children: associations with physical activity, snack food consumption and unhealthy weight. *Social Indicators Research: An International and Interdisciplinary Journal for Quality-of-Life Measurement, Springer,* 101(2), 221-225.

Buja, A., Grotto, G., Brocadello, F., Sperotto, M., & Baldo, V. (2020). Primary school children and nutrition: Lifestyles and behavioral traits associated with a poor-to-moderate adherence to the Mediterranean diet. A cross-sectional study. *European Journal of Pediatrics, 179,* 827-834.

Bundara, N., Mwanri, L., & Masika, J. (2013). Addressing childhood undernutrition in Tanzania: Challenges and opportunities. *African Journal of Food, Agriculture, Nutrition and Development,* 13(1), 7288-7306.

Cabral, T. M., Pereira, M. G. B., Falchione, A. E. Z., de-Sá, D. A. R., Correa, L., Fernandes, D., de-Sá, L. B. P. C., & Arbex, A. K. (2018). Artificial sweeteners as a cause of obesity: Weight gain mechanisms and current evidence. *Health,* 10, 700-717.

Cardon, G. M., Van-Acker, R., Seghers, J., DeMartelaer, K., Haerens, L. L., DeBourdeaudhuij, I. M. M. (2012). Physical activity promotion in schools: Which strategies do schools

(not) implement and which socioecological factors are associated with implementation? *Health Education Research*, 27(3), 470–483.

Carter, L. M., Whiting, S. J., Drinkwater, D. T., Zello, G. A., Faulkner, R. A., & Bailey, D. A. (2001). Self-reported calcium intake and bone mineral content in children and adolescents. *Journal of the American College of Nutrition*, 20, 502-509.

Casas-Agustench, P., Arnett, D. K., Smith, C. E., Lai, C., Parnell, L. D., Borecki, I. B., Frazier-Wood, A. C., Allison, M., Chen, Y. I., Taylor, K. D., Rich, S. S., Rotter, J. I., Lee, Y., & Ordovás, J. M. (2014). Saturated fat intake modulates the association between an obesity genetic risk score and body mass index in two US populations. *Journal of Academy of Nutrition and Dietetics*, 114(12), 1954-1966.

Caspi, C. E., Lenk, K., Pelletier, J.E., Barnes, T. L., Harnack, L., Erickson, D. J, & Laska, M. N. (2017). Association between store food environment and customer purchases in small grocery stores, gas-marts, pharmacies and dollar stores. *International Journal of Behavioral Nutrition and Physical Activity*, *14*, 76.

Center for Disease Control (2016). Childhood obesity, causes & consequences, division of nutrition, physical activity, and obesity. National Center for Chronic Disease Prevention and Health Promotion [cdc.gov/obesity/childhood/causes.html] site visited on 26/03/2019.

Chadwick, P. M., Crawford, C., & Ly, L. (2013). Human food choice and nutritional interventions. *British Nutrition Foundation Nutrition Bulletin*, 38, 36–42.

Chan, S. M., Lalsing, Y., & Subratty, A. H. (2009). Primary school food environment in Mauritius. *Food Science and Nutrition*, 39(3), 251-259.

Charan, J., & Biswas, T. (2013). How to calculate sample size for different study designs in medical Research? *Indian Journal of Psychological Medicine*, 35, 121-126.

Chebet, M., Nsibambi, C., Otala, J., Goon, D. T. (2014). Prevalence of overweight and obesity among primary school children in Kampala central, Uganda. *African Journal for Physical Health Education, Recreation and Dance*, 20(4), 1365-1378.

Chen, P., & Antonelli, M. (2020). Conceptual models of food choice: Influential factors related

to foods, individual differences, and society, *Foods,* 9, 1898, 1-21.

Chomba, H., Martin, H. D., & Kimywe, J. (2019). Prevalence and predictors of obesity among 7- to 17-year-old schoolchildren in urban Arusha, Tanzania. *Journal of Nutrition and Metabolism,* https://doi.org/10.1155/2019/3106597.

Cintra, I., Ferrari, G.L., Soares, A. C. S. V., Passos, M. A. Z., Fisberg, M., & Vitalle, M. S. (2013). Body fat percentiles of Brazilian adolescents according to age and sexual maturation: A cross-sectional study. *BMC Pediatrics,* 13, 96, 1-8.

Collison, K. S., Zaidi, M. Z., Subhani, S. N., Al-Rubeaan, K., Shoukri, M., & Al-Mohanna, F. A. (2010). Sugar-sweetened carbonated beverage consumption correlates with BMI, waist circumference, and poor dietary choices in school children. *BMC Public Health*, 10, 234, 1-13.

Corvalán, C., Garmendia, M. L, Jones-Smith, J., Lutter, C. K., Miranda, J. J., Pedraza, L. S., Popkin, B. M., Ramirez-Zea, M., Salvo, D., & Stein, A. D. (2017). Nutrition status of children in Latin America. *Obesity Reviews,* 18(S2), 7–18.

Couch, S. C., Glanz, K., Zhou, C., Sallis, J. F., & Saelens, B. E. (2014). Home food environment in relation to children's diet quality and weight status. *Journal of Academy of Nutrition and Dietetics*, 114, 1569–1579.

Craig, E., Bland, R., Ndirangu, J., & Reilly, J. J. (2014). Use of mid-upper arm circumference for determining overweight and overfatness in children and adolescents. *Archives of Disease in Childhood,* 99, 763–766.

Cunha, L. M., Cabral, D., Moura, A. P., & de-Almeida, M. D. V. (2018). Application of the Food Choice Questionnaire across cultures: Systematic review of cross-cultural and single country studies. *Food Quality and Preference, 64*, 21-36.

Damayanti, S., Permana, B., & Weng, C. C. (2012). Determination of sugar content in fruit juices using high performance liquid chromatography. *Acta Pharmaceutica Indonesia*, 37(4), 139-145.

Davidson, T. L., & Swithers, S. E. (2004). A Pavlovian approach to the problem of obesity. *International Journal of Obesity,* 28, 933–935.

De-Onis, M., Onyango, A. W., Borghi, E., Siyam, A., Nishida, C., & Siekmann, J. (2007). Development of a WHO growth reference for school-aged children and adolescents. *Bulletin of the World Health Organization,* 85, 660-667.

Desalew, A., Mandesh, A., & Semahegn, A. (2017). Childhood overweight, obesity and associated factors among primary school children in Dire Dawa, eastern Ethiopia; A cross-sectional study. *BMC Obesity,* 4(20), 1-10.

Development Initiatives. (2018). 2018 Global Nutrition Report: Shining a light to spur action on nutrition. Bristol, UK: Development Initiatives.

Diouf, A., Thiam, M., Idohou-Dossou, N., Diongue, O., Mégné, N., Diallo, K., Sembène, P. M., & Wade, S. (2016). Physical activity level and sedentary behaviors among public school children in Dakar (Senegal) measured by PAQ-C and accelerometer: Preliminary results. *International Journal of Environmental Research and Public Health*, 13(10), 998, doi: 10.3390/ijrph13100998.

Dobbins, M., Husson, H., DeCorby, K., & LaRocca, R. L. (2013). School-based physical activity programs for promoting physical activity and fitness in children and adolescents aged 6 to 18. *Cochrane Database of Systematic Reviews*, (2), CD007651.

Doichinova, L., Bakardjiev, P., & Peneva, M. (2015). Assessment of food habits in children aged 6-12 years and the risk of caries. *Biotechnology and Biotechnological Equipment*, 29(1), 200-204.

Draper, C. E., de-Villiers, A., Lambert, E. V., Fourie, J., Hill, J., Dalais, L., Abrahams, Z., & Steyn, N. P. (2010). Study protocol HealthKick: A nutrition and physical activity intervention for primary schools in low-income settings. *BMC Public Health, 10*(398), 1-12.

Dunton, G. F., Do, B., & Wang, S. D. (2020). Early effects of the COVID-19 pandemic on physical activity and sedentary behavior in children living in the US. *BMC Public Health*, 20(1351), 1-13.

Durá-Travé, T., Gallinas-Victoriano, F., & Durá-Gúrpide, B. (2014). Dietary habits in school children (9-12 years old) with normal nutritional status in a Mediterranean area. *Journal of Nutritional Disorders Therapy*, *4*, 133.

El-Kassas, G., & Ziade, F. (2017). The dual burden of malnutrition and associated dietary and lifestyle habits among Lebanese school age children living in orphanages in North Lebanon. *Journal of Nutrition and Metabolism*, 2017, doi 10.1155/2017/4863431.

El-Mouzan, M. I., Foster, P. J., Al Herbish, A. S., Al Salloum, A. A., Al-Omer, A. A., Qurachi, M. M., & Kecojevic, T. (2010). Prevalence of overweight and obesity in Saudi children and adolescents. *Annuals of Saudi Medicine*, 30(3), 203-208.

Ene-Obong, H., Ibeanu, V., Onuoha, N., & Ejekwu, A. (2012). Prevalence of overweight, obesity, and thinness among urban school-aged children and adolescents in southern Nigeria. *Food and Nutrition Bulletin*, 33(4), 242-250.

Erickson, J., & Slavin, J. (2015). Total, added, and free sugars: Are restrictive guidelines science-based or achievable? *Nutrients*, 7, 2866-2878.

Esht, V., Midha, D., Chatterjee, S. & Sharma, S. (2018). A preliminary report on physical activity patterns among children aged 8–14 years to predict risk of cardiovascular diseases in Malwa region of Punjab. *Indian Heart Journal*, 70, 777–782.

European Centre for Disease Prevention and Control. (2009). Protocol for case-control studies to measure influenza vaccine effectiveness in the European Union and European Economic Area Member States. Stockholm.

Faber, M., Laurie, S., Maduna, M., Magudulela, T., & Muehlhoff, E. (2013). Is the school food environment conducive to healthy eating in poorly resourced South African schools? *Public Health Nutrition*, 17(6), 1214–1223.

Feeley, A. B., & Norris, S. A. (2014). Added sugar and dietary sodium intake from purchased fast food, confectionery, sweetened beverages and snacks among Sowetan adolescents. *South African Journal of Child Health, 8*(3), 88-91.

Ferrari, G., Rezende, L. F., Wagner, G. A., Florindo, A. A., & Peres, M. F. T. (2020). Physical activity patterns in a representative sample of adolescents from the largest city in Latin America: a cross-sectional study in Sao Paulo. *BMJ Open, 10*(9), e037290.

Fitzgerald, A., Heary, C., Nixon, E., & Kelly, C. (2010). Factors influencing the food choices of Irish children and adolescents: A qualitative investigation. *Health Promotion*

International, 25(3), 289-298.

Flores, M., Meyer, L., Orellana, S., Saravia, C., Galdames, C., & Perez-Camino, C. M. (2018). Quality of lipid fractions in deep-fried foods from street vendors in Chile. *Journal of Food Quality*, 2018, 1-9.

Food and Agriculture Organization. (2005). Nutrition education in primary schools. The activities. Notes for facilitators and workshop organizers. *Food and Nutrition Division, 2*, 1-32.

Food and Agriculture Organization. (2006). The double burden of malnutrition: Case studies from six developing countries, *FAO-Food and Nutrition*, 84.

Food and Agriculture Organization. (2008). Tanzania Nutrition Profile: Nutrition and Consumer Protection Division, FAO, 17-24.

Food and Agriculture Organization (2010). Guidelines for Measuring Household and Individual Dietary Diversity. Food and Agricultural Organization.

Food and Agriculture Organization/World Health Organization. (2010). Fats and fatty acids in human nutrition. Report of an expert consultation. Food and Nutrition Paper. Food and Agriculture Organization of the United Nations, Rome.

Food and Agriculture Organization. (2018). Dietary assessment: A resource guide to method selection and application in low resource settings. FAO.

Fortes, F. S., de-Almeida, A. P., Rosa, C. O. B., Silveira, B. K. S., Reis, N. A., & Hermsdorff, H. H. M. (2020). Dietary fat intake and its association with adiposity and inflammatory markers in individuals at cardio metabolic risk. *International Journal of Cardiovascular Science*, 33(5), 447-456.

Fowler, L. A., Powers, A. D., Williams, M. B., Davis, J. L., Barry, R. J., D'Abramo, L. R., & Watts, S. A. (2021). The effects of dietary saturated fat source on weight gain and adiposity are influenced by both sex and total dietary lipid intake in zebrafish. *PLoS One* 16(10): e0257914.

Fox, M. K., Dodd, A. H., Wilson, A., & Gleason, P. M. (2009). Association between school food environment and practices and body mass index of US public school children.

Journal of American Dietetic Association, 109(2), S108–117.

Fox, M. K., Gearan, E. C., & Schwartz, C. (2021). Added sugars in school meals and the diets of school-age children. *Nutrients,* 13(2), 471, doi:10.3390/nu13020471

Freedman, I. (2016). Cultural specificity in food choice: The case of ethnography in Japan. *Appetite,* 96, 138-146.

French, S. A., Tangney, C. C., Crane, M. M., Wang, Y., & Appelhans, B. M. (2019). Nutrition quality of purchases varies by household income: The SHoPPER study. *BMC Public Health,* 19, 231, doi:.org/10.1186/s12889-019-6546-2.

Frignani, R. R., Passos, M. A., Ferrari, G. L., Niskier, S. R., Fisberg, M., & de Pádua Cintra, I. (2015). Reference curves of the body fat index in adolescents and their association with anthropometric variables. *Journal of Pediatric,* 91, 248-55.

Galinski, G., Przybylowicz, K., Wawrzyniak, A., Gawecki, J., Roszkowski, W., Kollajtis-Dolowy, A., Wadolowska, L., Niedzwiedzka, E. Slowinska, M. A., Krusinska, B., Czarnocinska, J., Jezewska-Zychowicz, M., & Hawrysz, I. (2017). Dietary habits and nutrition beliefs. Questionnaire for people 15-65 years old, version 1.1. Interviewer administered questionnaire. In Dietary Habits and Nutrition Beliefs Questionnaire and the manual for developing of nutritional data: Technical report, Polish Academy of Sciences.

Gicevic, S., Gaskins, A. J., Fung, T. T., Rosner, B., Tobias, D. K., Isanaka, S., & Willett, W. C. (2018). Evaluating pre-pregnancy dietary diversity vs. dietary quality scores as predictors of gestational diabetes and hypertensive disorders of pregnancy. *PLoS One, 13* (4), e0195103.

Gitika, A. W. (2014). Food Consumption Patterns, Nutrient Intakes, Nutritional Status and School Attendance among Children from HIV/AIDS Affected Households in Kiambu Municipality (Master Thesis, Kenyatta University).

Global Agricultural Information Network (2016). Food and Agricultural Import Regulations and Standards – Narrative, FAIRS Country Report-Tanzania.

Godakanda, I., Abeysena, C., & Lokubalasooriya, A. (2018). Sedentary behavior during leisure time, physical activity and dietary habits as risk factors of overweight among school children aged 14–15 years: Case control study. *BMC Research Notes, 11*(1), 1-6.

Golden, S. D., & Earp, J. A. L. (2012). Social ecological approaches to individuals and their contexts: Twenty years of health education and behavior health promotion interventions. *Health and Education Behavior*, 39(3), 364–372.

Goswami, G, Bora, R., & Rathore, M. S. (2015). Oxidation of cooking oils due to repeated frying and human health. *International Journal of Science Technology and Management*, 4(1), 495-501.

Govender, K., Naicker, A., Napier, C. E., & Singh, D. (2018). School snacking preferences of children from a low socioeconomic status community in South Africa. *Journal of Consumer Sciences, Special Edition Food and Nutrition Challenges in Southern Africa,* 3, 1-10.

Gubbels, J. S., van Assema, P., & Kremers, S. P. J., (2013). Physical Activity, Sedentary Behavior, and Dietary Patterns among Children. *Current Nutrition Report,* 2:105–112.

Hadhood, S. E. S. A., Ali, R. A. E., Mohamed, M. M., & Mohammed, E. S. (2017). Prevalence and correlates of overweight and obesity among school children in Sohag, Egypt. *Open Journal of Gastroenterology*, (7), 75-88.

Hajian-Tilaki, K., & Heidari, B. A. (2013). Comparison between International Obesity Task Force and Centre for Disease Control References in assessment of overweight and obesity among adolescents in Babol, Northern Iran. *International Journal of Preventive Medicine*, 4(2), 226-232.

Hanandita, W., & Tampubolon, G. (2015). The double burden of malnutrition in Indonesia: Social determinants and geographical variations. *SSM-Population Health,* 1, 16–25.

Hanson M.A, & Gluckman, P. D. (2014). Early developmental conditioning of later health and disease: Physiology or pathophysiology? *Physiological Reviews*, 94, 1027–1076.

Harika, R. K., Eilander, A., Alssema, M., Osendarp, S. J. M., & Zock, P. L. (2013). Intake of fatty acids in general populations worldwide does not meet dietary recommendations to

prevent coronary heart disease: A systematic review of data from 40 countries. *Annals of Nutrition and Metabolism, 63*, 229–238.

Heitzler, C., Lytle, L., Erickson, D., Sirard, J., Barr-Anderson, D. & Story, M. (2011). Physical activity and sedentary activity patterns among children and adolescents: A latent class analysis approach. *Journal of Physical Activity and Health,* 8(4), 457–467.

Hebestreit, A., Börnhorst, C., Pala, V., Barba, G., Eiben, G., Veidebaum, T., Hadjigergiou, C., Molnár, D., Claessens, M., Fernández-Alvira, J. M., & Pigeot, I. (2014). Dietary energy density in young children across Europe. *International Journal of Obesity,* 38, S124–S134.

Heras-Gonzalez, L., Latorre, J. A., MartinezBebia, M., Gimenez-Blasi, N., Olea-Serrano, F., & Mariscal-Arcas, M. (2020). Sugar consumption in schoolchildren from southern Spain and influence on the prevalence of obesity. *PLoS One*, 15(11), e0242602.

Hoffman, D., Cacciola, T., Barrios, P., & Simon, J. (2017). Temporal changes and determinants of childhood nutritional status in Kenya and Zambia. *Journal of Health Population and Nutrition*, 36:27.

Holsten, J. E., Deatrick, J. A., Kumanyika, S., Pinto-Martin, J., Compher, C. W. (2012), Children's food choice process in the home environment. A qualitative descriptive study. *Appetite*, (58), 64–73.

Hoque E. K., Kamaluddin, M. A., Razak, A. Z. A., & Wahid, A. A. A. (2016). Building healthy eating habits in childhood: A study of the attitudes, knowledge and dietary habits of schoolchildren in Malaysia. *Peer Journal 4*, e2651.

Hussein, A. E. (2018). Overweight and obesity among primary school children in Misurata City- Libya: Prevalence and associated risk factors. *International Journal of Pediatric Health Care and Advancements,* 5(2), 74-78.

Hussein, M. D., Alonazi, N. A., & Mohamed, S. (2018). Prevalence of obesity, overweight, underweight and stunting among school children in Argo city, Northern Sudan. *Sudan Journal of Paediatrics*, 18(2), 15–19.

Institute of Medicine. (2005). Dietary Reference Intakes for Energy, Carbohydrate, Fiber, Fat,

Fatty Acids, Cholesterol, Protein, and Amino Acids. Washington, DC: The National Academies Press. https://doi.org/10.17226/10490.

Itatiro, J. (2014). The association of school food environment with eating habits of school going adolescents in Tanzania (Master Dissertation, University of Ghent), 19-28.

Jalal, S. M., Beth, M. R. M., Al-Hassan, H. J. M., & Alshealah, N. M. J. (2021). Body mass index, practice of physical activity and lifestyle of students during COVID-19 lockdown. *Journal of Multidisciplinary Healthcare,* 14, 1901–1910.

Jeyakumar, A., Ghugre, P., & Gadhave, S. (2013). Mid-Upper-Arm Circumference (MUAC) as a simple measure to assess the nutritional status of adolescent girls as compared with BMI ICAN. *Infant, Child, and Adolescent Nutrition,* 5(1), 22-25.

John, B., Todd, J., Mboya, I., Mosha, M., Urassa, M., & Mtuy, T. (2017). Physical activity and associated factors from a cross-sectional survey among adults in northern Tanzania. *BMC Public Health,* 17-588.

Joo, N., Kim, S., & Yoon, J. (2017). High school students' sugar intake behaviors and consumption of sugary processed food based on the level of sugar-related nutrition knowledge in Seoul area. *Korean Journal of Community Nutrition,* 22(1), 1-12.

Joy, E. J. M., Green, R., Agrawal, S., Aleksandrowicz, L., Bowen, L., Kinra, S., Macdiarmid, J. I., Haines A., & Dangour, A. D. (2017). Dietary patterns and non-communicable disease risk in Indian adults: Secondary analysis of Indian migration study data. *Public Health Nutrition*, 20(11), 1963–1972.

Kalimbira, A., & Gondwe, E. (2015). Consumption of sweetened beverages among school-going children in a densely populated township in Lilongwe, Malawi. *Malawi Medical Journal*, 27(2), 55-59.

Kambondo, G., & Sartorius, B. (2018). Risk factors for obesity and overfat among primary school children in Mashonaland West Province, Zimbabwe. *International Journal of Environmental Research and Public Health,* 15(249), 1-14.

Kasmin, H., Lazim, A. M., & Awang, R. (2015). Determination of fatty acid composition and quality characteristics of oils from palm fruits using solvent extraction. *AIP Conference*

Proceedings 1678, 050002 https://doi.org/10.1063/1.4931281.

Katungwe, P., Mwangwela, A., & Geresomo, N. (2015). Dietary adequacy of rural school children among Bambara groundnut growing farmers in Ntchisi District of Malawi. *African Journal of Food, Agriculture, Nutrition and Development,* 15(1), 9620-9634.

Keane, E., Li, X., Harrington, J. M., Fitzgerald, A. P., Perry, I. J. & Kearney, P. M. (2017). Physical activity, sedentary behavior and the risk of overweight and obesity in school-aged children. *Pediatric Exercise Science,* 29(3), 408-418.

Kennedy, E., Strickland, J., Kershaw, M., & Biadgilign, S. (2018). Impact of social and behavior change communication in nutrition specific interventions on selected indicators of nutritional status. *Journal of Human Nutrition,* 2(1), 34-46.

Khamis, A. G., Ntwenya, J. E., Senkoro, M., Mfinanga, S. G., Kreppel, K., Mwanri, A. W., Bonfoh, B., & Kwesigabo, G. (2021). Association between dietary diversity with overweight and obesity: A cross-sectional study conducted among pastoralists in Monduli District in Tanzania. *PLoS One,* 16(1), e0244813.

Kimani-Murage, E. W., Muthuri, S. K., Oti, S. O., Mutua, M. K., Van-de-Vijver, S., & Kyobutungi, C., (2015). Evidence of a double burden of malnutrition in urban poor settings in Nairobi, Kenya. *PLoS One, 10*(6), e0129943.

Kimario, J. T. (2015). Prevalence of obesity and overweight among school children in Moshi Municipality, Kilimanjaro, Tanzania (Master Dissertation, Ghent University), 21-39.

Kmiecik, D., Kobus-Cisowska, J., Kotecka, K., Przeor, M., & Kulczyński, B. (2016). Evaluation of the fat content and fatty acid profile including Trans fatty acids (TFA) in confectionery products available on the Polish market. *Nauka Przyroda Technologies*, 10(4), 52.

Kowalski, K. C., Crocker, P. R. & Donen, R. M. (2004). The Physical Activity Questionnaire for Older Children (PAQ-C) and Adolescents (PAQ-A) Manual. College of Kinesiology, University of Saskatchewan, Canada.

Krølner, R., Jørgensen, T. S., Aarestrup, A. K., Hjøllund, A., Christensen, A. M. & Pernille Due, P. (2012). The Boost study: Design of a school- and community-based randomised

trial to promote fruit and vegetable consumption among teenagers. *BMC Public Health, 12*:191.

Kupolati, M. D., Gericke, G. J., & MacIntyre, U. E. (2015). Teachers' perceptions of school nutrition education's influence on eating behaviours of learners in the Bronkhorstspruit District. *South African Journal of Education,* 35(2), 1-10.

Kurnia, P., Wardhani, D. T. K., & Hariyani, R. (2016). Consumer attitudes, nutrition knowledge, and use of nutrition information on the labels of packed drinks among adolescents in Surakarta. Indonesia. *International Conference on Health and Well-Being, 2016,* 253-264.

Kutzner, L., Ostermann, A. I., Konrad, T., Riegel, D., Hellhake, S., Schuchardt, J. P., & Schebb, N. H. (2017). Lipid class specific quantitative analysis of n-3 polyunsaturated fatty acids in food supplements. *Journal of Agricultural and Food Chemistry, 65*(1), 139-147.

Kyallo, F., Makokha, A., & Mwangi, A. M. (2013). Overweight and obesity among public and private primary school children in Nairobi, Kenya. *Health*, 5(83A), 85-90.

Larson, N. I., Story, M., Wall, M., & Neumark-Sztainer, D. (2006). Calcium and dairy intakes of adolescents are associated with their home environment, taste preferences, personal health beliefs, and meal patterns. *Journal of the American Dietetic Association,* 106(11), 1816- 1824.

Lassibille, Â. G, & Tan, J. (2001). Are private schools more efficient than public schools? Evidence from Tanzania, *Education Economics, 9*(2), 145-172.

Laurson, K. R., Eisenmann, J. C., & Welk, G. J. (2011). Body fat percentile curves for U.S. children and adolescents. *American Journal of Preventive Medicine,* 41(4S2), S87–S92.

Leech, R. M., McNaughton, S. A., Crawford, D. A., Campbell, K. J., Pearson, N., & Timperio, A. (2014). Family food involvement and frequency of family dinner meals among Australian children aged 10–12 years. Cross-sectional and longitudinal associations with dietary patterns. *Appetite,* 75, 64–70.

Leech, R. M., McNaughton, S. A., & Timperio, A. (2014). The clustering of diet, physical activity and sedentary behavior in children and adolescents: A review. *International Journal of Behavior, Nutrition and Physical Activity,* 11(4), 1-9.

Lee, Y. S. (2009). Consequences of childhood obesity. *Annals Academy of Medicine Singapore, 38*(1), 75-81.

Liem, D. G., & de-Graaf, C. (2004). Sweet and sour preferences in young children and adults: Role of repeated exposure. *Physiology and Behavior,* 83, 421 – 429.

Lind, P. L., Jensen, P. V., Glumer, C., & Toft, U. (2016). The association between accessibility of local convenience stores and unhealthy diet. *European Journal of Public Health,* 26(4), 634–639.

Liu, X., Li, Y., Tobias, D. K, Wang, D. D., Manson, J. E., Willett, W. C., & Hu, F. B. (2018). Changes in types of dietary fats influence long-term weight change in US women and men. *Journal of Nutrition,* 148(11), 1821-1829.

Lorente-Cebrián, S., Costa, A. G. V., Navas-Carretero, S., Zabala, M., Martínez, J. A., & Moreno-Aliaga, M. J. (2013). Role of omega-3 fatty acids in obesity, metabolic syndrome, and cardiovascular diseases: A review of the evidence. *Journal of Physiology and Biochemistry,* 69, 633–651.

Maddah, M., & Nikooyeh, B. (2009). Factors associated with overweight in children in Rasht, Iran: Gender, maternal education, skipping breakfast and parental obesity. *Public Health Nutrition,* 13(2), 196-200.

Mahmudiono, T., Nindya, T. S., Andrias, D. R., Megatsari, H., & Rosenkranz, R. R. (2016). The effectiveness of nutrition education for overweight/obese mothers with stunted children (NEO-MOM) in reducing the double burden of malnutrition in Indonesia: Study protocol for a randomized controlled trial. *BMC Public Health*, *16*:486.

Mancini, A., Imperlini, E., Nigro, E., Montagnese, C., Daniele, A., Orrù, S., & Buono, P. (2015). Biological and nutritional properties of palm oil and palmitic acid: Effects on health. *Molecules*, *20*(9), 17339-17361.

Marques-de-Lima, K. C., Barros, H. D. F., Passos, T. S., & Maciel, B. L. L. (2019). The effect

of using different oils and paper towel in vegetable oil absorption of fried recipes. *Journal of Culinary Science & Technology*, 17(4), 373-384.

Marques-Vidal, P., Marcelino, G., Ravasco, P., Ermelinda, M. C., & Oliveira, J. M. (2008). Body fat levels in children and adolescents: Effects on the prevalence of obesity. e-SPEN, *The European e-Journal of Clinical Nutrition and Metabolism,* 3, e321-e327.

Marras, S. (2018). Street Food in Tanzania. A Literature Review. Food and Agriculture Organization of the United Nations. Dar-es-Salaam, Tanzania.

Mashili, F. L., Kagaruki, G. B., Mbatia, J., Nanai, A., Saguti, G., Maongezi, S., Magimba, A., Magamba, J., Kamugisha, M., Mgina, E., Mweya, C. N., Kaushik, R., & Mayige, M. T. (2018). Physical activity and associated socioeconomic determinants in rural and urban Tanzania: results from the 2012 WHO-STEPS survey. *International Journal of Population Research, 2018.*

Mbwana, H. A. (2019). Consumer behavior and consumption practices towards less documented wild leafy vegetables among rural households in Dodoma Region, Tanzania. *International Journal of Environment, Agriculture and Biotechnology*, 4(4), 1005-1011.

McMurray, R. G., Berry, D. C., Schwartz, T. A., Hall, E. G., Neal, M. N., Li, S., & Lam, D. (2016). Relationships of physical activity and sedentary time in obese parent-child dyads: a cross- sectional study. *BMC Public Health,* 16:124.

McPherson, N. O., Fullston T, Aitken R. J., Lane, M. (2014). Paternal obesity, interventions, and mechanistic pathways to impaired health in offspring. *Annals of Nutrient Metabolism*, 64, 231–238.

McVeigh, J., & Meiring, R. (2014). Physical activity and sedentary behavior in an ethnically diverse group of South African school children. *Journal of Sports Science and Medicine,* 13, 371-378.

Mekonnen, T., Tariku, A., & Abebe, S. M. (2018). Overweight/obesity among school aged children in Bahir Dar City: Cross sectional study. *Italian Journal of Pediatrics,* 44,

Micklesfield, L. K., Pedro, T. M., Kahn, K., Kinsman, J., Pettifor, J. M., Tollman, S., & Norris,

S. A. (2014). Physical activity and sedentary behavior among adolescents in rural South Africa: Levels, patterns and correlates. *BMC Public Health, 14,*1-10.

Mindell, J. S., Coombs, N., & Stamatakis, E. (2014). Measuring physical activity in children and adolescents for dietary surveys: Practicalities, problems and pitfalls. *Proceedings of the Nutrition Society*, *73*(2), 218-225.

Ministry of Health, Community Development, Gender, Elderly and Children (MoHCDGEC), [Tanzania Mainland, Ministry of Health (MoH) [Zanzibar], National Bureau of Statistics (NBS), Office of the Chief Government Statistician (OCGS) and ICF. 2016. 2015-2016 TDHS-MIS Key Findings. Rockville, Maryland, USA: MoHCDGEC, MoH, NBS, OCGS and ICF.

Ministry of Health, Community Development, Gender, Elderly and Children (MoHCDGEC) [Tanzania Mainland], Ministry of Health (MoH) [Zanzibar], Tanzania Food and Nutrition Centre (TFNC), National Bureau of Statistics (NBS), Office of the Chief Government Statistician (OCGS) [Zanzibar] and UNICEF. 2018. Tanzania National Nutrition Survey using SMART Methodology (TNNS) 2018. Dar es Salaam, Tanzania: MoHCDGEC, MoH, TFNC, NBS, OCGS, and UNICEF.

Modjadji, P., & Madiba, S. (2019). The double burden of malnutrition in a rural health and demographic surveillance system site in South Africa: A study of primary schoolchildren and their mothers. *BMC Public Health*, 19, 1087.

Mogendi, J. B., De-Steur, H., Gellynck, X., Saeed, H. A., & Makokha, A. (2015). Efficacy of mid- upper arm circumference in identification, follow-up and discharge of malnourished children during nutrition rehabilitation. *Nutrition Research and Practice,* 9(3), 268-277.

Mohammed, H., & Vuvor, F. (2012). Prevalence of childhood overweight/obesity in basic school in Accra. *Ghana Medical Journal,* 46(3), 124-127.

Monnard, C. R., & Dulloo, A. G. (2021). Polyunsaturated fatty acids as modulators of fat mass and lean mass in human body composition regulation and cardio metabolic health. *Obesity Reviews*, 22(S2), e13197.

Moser, A., & Korstjens, I. (2018) Series: Practical guidance to qualitative research. Part 3:

Sampling, data collection, and analysis. *European Journal of General Practice*, 24 (1) 9–18.

Mosha, T. C. E., & Fungo, S. (2010). Prevalence of overweight and obesity among children aged 6-12 years in Dodoma and Kinondoni Municipalities, Tanzania. *Tanzania Journal of Health Research,* 12(1), 6-16.

Mosha, M. V., Msuya, S. E., Kasagama, E., Ayieko, P., Todd, J., & Filteau, S. (2021). Prevalence and correlates of overweight and obesity among primary school children in Kilimanjaro, Tanzania. *PLoS One,* 16 (4), e0249595.

Muhammad, A., D'Souza, A., Meade, B., Micha, R., & Mozaffarian, D. (2017). How income and food prices influence global dietary intakes by age and sex: Evidence from 164 countries. *BMJ Global Health*, 2, e000184.

Muhihi, A. J., Mpembeni, R. N. M., Njelekela, M. A., Anaeli, A., Chillo, O., Kubhoja, S., Lujani, B., Maghembe, M., & Ngarashi, D. (2013). Prevalence and determinants of obesity among school children in Dar es Salaam, Tanzania. *Archives of Public Health*, 71, 26.

Mukherjee, R., & Chaturvedi, S. (2017). A study of the dietary habits of school children in Pune City, Maharashtra, India. *International Journal of Community Medicine Public Health*, *4*, 593-597.

Muntaner-Mas, A., Vidal-Conti, J., Cantallops, J., Borràs, P. A., & Palou, P. (2017). Obesity and physical activity patterns among Balearic Islands children and adolescents: A cross-sectional study. *Journal of Human Sport and Exercise,* 12(2), 333-348.

Murimi, M. W., Chrisman, M., McCollum, H. R., & Mcdonald, O. A (2016). Qualitative study on factors that influence students' food choices. *Journal of Nutrition and Health,* 2(1), 6.

Musa, D. I., Toriola, A. L., Monyeki, M. A., & Lawal, B. (2012). Prevalence of childhood and adolescent overweight and obesity in Benue State, Nigeria. *Tropical Medicine and International Health,* 17(11), 1369–1375.

Musaiger, A. O., & Hazzaa M. H., (2012). Prevalence and risk factors associated with nutrition-related non-communicable diseases in the Eastern Mediterranean region. *International*

Journal of General Medicine, 5, 199–217.

Mushtaq, M. U., Gull, S., Mushtaq, K., Shahid, U., Shad, M. A., & Akram J. (2011). Dietary behaviors, physical activity and sedentary lifestyle associated with overweight and obesity, and their socio-demographic correlates, among Pakistani primary school children. *International Journal of Behavioral Nutrition and Physical Activity*, 8:130.

Muthuri, S. K., Wachira, L. M., Leblanc, A. G., Francis, C. E., Sampson, M., Onywera, V., & Tremblay, M. S. (2014). Temporal trends and correlates of physical activity, sedentary behaviour, and physical fitness among school-aged children in sub-Saharan Africa: A systematic review. *International Journal of Environmental Research and Public Health,* 11, 3327-3359.

Mwaikambo, S. A, Leyna, G. H., Killewo, J., Simba, A., & Puoane, T. (2015). Why are primary school children overweight and obese? A cross sectional study undertaken in Kinondoni district, Dar-es-Salaam. *BMC Public Health,* 15(1269), 1-10.

Naeeni, M. M., Jafari, S., Fouladgar, M., Heidari, K., Farajzadegan, Z., Fakhri, M., Karami, P., & Omidi, R. (2014). Nutrition knowledge, practices, and dietary habits among school children and adolescents. *International Journal of Preventive Medicine,* 5(Suppl 2), S171-S178.

Nagwa, M., Elhussein, A., & Azza, M. (2011). Alarming high prevalence of overweight/obesity among Sudanese children. *European Journal of Clinical Nutrition,* (65)**,** 409–411.

Naserirad, M., & Akbari, H. (2018). Food group consumption pattern of school-aged children and adolescents inside and outside the school setting: A cross-sectional study of a community in north-eastern Iran. *Journal of Nutritional Sciences and Dietetics,* 4(4), 139- 146.

Nasreddine, L., Naja, F., Akl, C., Chamieh, M. C., Karam, S., Sibai, A., & Hwalla N. (2014). Dietary, lifestyle and socio-economic correlates of overweight, obesity and central adiposity in Lebanese children and adolescents. *Nutrients,* 6, 1038-1062.

Nazzaro, C., Lerro, M., & Marotta, G. (2018). Assessing parental traits affecting children's food habits: An analysis of the determinants of responsible consumption. *Agricultural*

and Food Economics, 6, 23.

Ndu, D. A., & Ejikeme, D. L. (2017). Determination of the saccharin content in some ice creams consumed in Port Harcourt. *International Journal of Chemical Studies*, 5(5): 439-442.

Neeley, S. M. (2011). The influence of school eating environment on children's eating behaviors: An examination of the SNDA-III (Masters dissertation, Wright State University, Dayton, Ohio).

Negash, S., Matsha, T. E., Agyemang, C., Peer, N., Erasmus, R. T., & Kengne, A. P. (2017). Differential prevalence and associations of overweight and obesity by gender and population group among school learners in South Africa: A cross-sectional study. *BMC Obesity*, 4:29.

Neufingerl, N., Djuwita, R., Otten-Hofman, A., Nurdiani, R., Garczarek, U., Sulaeman, A., Zock, P.L., & Eilander, A. (2016). Intake of essential fatty acids in Indonesian children: Secondary analysis of data from a nationally representative survey. *British Journal of Nutrition*, 115, 687–693.

Niba, L.L., Atanga, M.B., & Navti, L.K. (2017). A cross sectional analysis of eating habits and weight status of university students in urban Cameroon. *BMC Nutrition*, (3), 55.

Nicholaus, C., Martin, H.D., Kassim, N., Matemu, A. O, & Kimiywe, J. (2020). Dietary practices, nutrient adequacy, and nutrition status among adolescents in boarding high schools in the Kilimanjaro Region, Tanzania. *Journal of Nutrition and Metabolism*, 2020.

Nollen, N. L., Befort, C. A., Snow, P., Daley, C. M., Ellerbeck, E. F., & Ahluwalia, J. S. (2007). The school food environment and adolescent obesity: Qualitative insights from high school principals and food service personnel. *International Journal of Behavioral Nutrition and Physical Activity*, 4, 18.

Nyathela, T., & Oldewage-Theron, W. (2017). Nutritional status and food consumption patterns of primary school children in Orange Farm. *African Journal of Food, Agriculture Nutrition and Development*, 17(1), 11497-11517.

Ochalo, S., & Masibo, P. K., (2014). Dietary intake of schoolchildren and adolescents

in developing countries. *Annals of Nutrition and Metabolism,* 64(Supplement 2), 24–40.

Oellingrath, I. M., Hersleth, M., & Svendsen, M.V. (2012). Association between parental motives for food choice and eating patterns of 12- to 13-year-old Norwegian children. *Public Health Nutrition,* 16(11), 2023–2031.

Ofakunrin, A. O. D., Obayomi, J. I., Afolaranmi T. O., Dialaa, U. M., John C., Toma, B.O., Envuladu. E. A., & Okolo, S. N. (2018). Prevalence of overweight and obesity among school-age children in Jos, North Central, Nigeria. *International Journal of Biomedical Research,* 9(6), 208-213.

Okop, K. J., Ndayi, K., Tsolekile, L., Sanders, D., & Puoane, T. (2019). Low intake of commonly available fruits and vegetables in socio-economically disadvantaged communities of South Africa: Influence of affordability and sugary drinks intake. *BMC Public Health,* 19, 940.

Oldewage-Theron, W. H., & Napier, C. E. (2011). Nutrition education tools for primary school children in the Vaal region. *Development South Africa,* 28(2), 283-292.

Ose, S. O. (2016). Using Excel and Word to Structure Qualitative Data. *Journal of Applied Social Science*, 10(2), 147–162.

Pala, V., Lissner, L., Hebestreit, A., Lanfer, A., Sieri, S., Sian, A., Huybrechts, I., Kambek, L., Molnar, D., & Tornaritis M. (2013). Dietary patterns and longitudinal change in body mass in European children: A follow-up study on the IDEFICS multicenter cohort. *European Journal Clinical Nutrition,* 67, 1042–1049.

Pangani, I. N., Kiplamai, F. K., & Onwera V. O. (2016). Prevalence of overweight and obesity among primary school children aged 8-13 in Dar-es-salaam City, Tanzania. *Advances in Preventive Medicine,* 2016, 1-6.

Papandreou, D., Malindretos, P., & Rousso, I. (2010). First body fat percentiles for 607 children from Thessaloniki-Northern Greece. *Hippokratia,* 14(3), 208-211.

Pedroni, C., Dujeu, M., Moreau, N., Lebacq, T., Méroc, E., Godin, I., & Castetbon, K. (2019). Environmental correlates of physical activity among children 10 to 13 years old in

Wallonia (Belgium). *BMC Public Health* 19:187, https://doi.org/10.1186/s12889-019-6509-7.

Peltzer, K., & Pengpid, S. (2010). Fruits and vegetables consumption and associated factors among in-school adolescents in seven African countries. *International Journal of Public Health,* 55, 669–678.

Peltzer, K., & Pengpid, S. (2011). Overweight and obesity and associated factors among school- aged adolescents in Ghana and Uganda. *International Journal of Environmental Research and Public Health,* 8, 3859-3870.

Peltzer, K., & Pengpid, S. (2012). Fruits and vegetables consumption and associated factors among in-school adolescents in five Southeast Asian countries. *International Journal of Environmental Research and Public Health,* 9, 3575-3587.

Peters, J., Parletta, N., Campbell, K., & Lynch, J. (2014). Parental influences on the diets of 2- to 5-year-old children: Systematic review of qualitative research. *Journal of Early Childhood Research,* 12(1), 3–19.

Puckree, T., Naidoo, P., Pillay, P, & Naidoo, T. (2011). Underweight and overweight in primary school children in eThekwini district in KwaZulu-Natal, South Africa. *African Journal of Primary Health Care and Family Medicine,* 3(1), 1-6.

Raatz, S. K., Conrad, Z., Johnson, L. K, Picklo, M. J., & Jahns, L. (2017). Relationship of the reported intakes of fat and fatty acids to body weight in US Adults. *Nutrients*, 9, 438.

Rahmawaty, S., Charlton, K., Lyons-Wall, P., & Meyer, B. J. (2013). Dietary intake and food sources of EPA, DPA and DHA in Australian Children, *Lipids*, 48, 869–877.

Rankin, J., Matthews, L., Cobley, S., Han, A., Sanders, R., Wiltshire, H.D., & Baker, J.S. (2016). Psychological consequences of childhood obesity: Psychiatric comorbidity and prevention. *Adolescent, Health and Therapeutics,* 7, 125-146.

Rao, D. P., Kropac, E., Do, M. T., Roberts, K. C., & Jayaraman, G. C. (2016). Childhood overweight and obesity trends in Canada: Health promotion and chronic disease prevention in Canada. *Research, Policy and Practice 36*(9), 194-198.

Rapando, C., Nyagero, J., & Wakhu, F. (2017). Feeding habits associated with overweight and

obesity amongst secondary school students in private and public schools in Langata Nairobi Kenya**.** *International* Journal *of Scientific and Research Publications*, 7(5), 498-505.

Rauber, F., Campagnolo, P. D. B., Hoffman, D. J., & Vitolo, M. R. (2014). Consumption of ultra- processed food products and its effects on children's lipid profiles: A longitudinal study. *Nutrition, Metabolism and Cardiovascular Diseases*,

Reddy, S., & Anitha, M. (2015). Culture and its influence on nutrition and oral health. *Biomedical and Pharmacology Journal,* 8.

Rey-López, J. P., Vicente-Rodríguez, G., Répásy, J., Mesana, M. I., Ruiz, J. R., Ortega, F. B., Kafatos, A., Huybrechts, I., Cuenca-García, M., León, J. F., González-Gross, M., Sjöström M., de Bourdeaudhuij, I., & Moreno, L. A. (2011). Food and drink intake during television viewing in adolescents: The Healthy Lifestyle in Europe by Nutrition in Adolescence (HELENA) study. *Public Health Nutrition,* 14(9), 1563–1569.

Ronoh, A. K., Were, G. M., Wakhu-Wamunga, F., & Wamunga, J. B. (2017). Food consumption patterns among pre-school children 3-5 years old in Mateka, Western Kenya. *Food and Nutrition Sciences*, 8, 801-811.

Roos, E., Lehto, R., & Ray, C. (2012). Parental family food choice motives and children's food intake. *Food Quality and Preference,* 2011, 24 85–91.

Russell, C. G., Worsley, A., & Liem, D. G. (2014). Parents' food choice motives and their associations with children's food preferences. *Public Health Nutrition,* 18(6), 1018–1027.

Sagbo, H., Ekouevi, D. K., Ranjandriarison, D. T., Niangoran, S., Bakai, T. A., Afanvi, A., Dieudonné, S., Kassankogno, Y., Vanhems, P., & Khanafer, N. (2018). Prevalence and factors associated with overweight and obesity among children from primary schools in urban areas of Lomé, Togo. *Public Health Nutrition,* 21(6), 1048–1056.

Sahoo, K., Sahoo, B., Choudhury, A. K., Sofi, N. Y., Kumar, R., & Bhadoria, A. S. (2015). Childhood obesity: Causes and consequences. *Journal of Family Medicine and Primary Care*, *4*(2), 187–192.

Salman, Z., Kirk, G. D., & DeBoer, M. D. (2011). High rate of obesity-associated hypertension among primary schoolchildren in Sudan. *International Journal of Hypertension*, 2011.

Salvy, S. J., De-la-Haye, K., Bowker, J. C., & Hermans, R. C. J. (2012). Influence of peers and friends on children's and adolescents' eating and activity behaviors. *Physiology and Behavior,* 106 (3), 369–378.

Savage, J. S., Fisher, J. O., & Birch, L. L. (2007). Parental influence on eating behavior: Conception to adolescence. *Journal of Law and Medical Ethics.* 35(1), 22–34.

Scaglioni, S., DeCosmi, V., Ciappolino, V., Parazzini, F., Brambilla, P., & Agostoni, C. (2018). Factors influencing children's eating behaviours. *Nutrients,* 10, 706.

Scaglioni, S., Arrizza, C., Vecchi, F., & Tedeschi, S. (2011). Determinants of children's eating behavior. *American Journal of Clinical Nutr*ition, 94(supplement), 2006S–2011S.

Sedibe, M. H., Pisa, P. T., Feeley, A. B., Pedro, T. M., Kahn, K., & Norris, S. A. (2018). Dietary habits and eating practices and their association with overweight and obesity in rural and urban black South African adolescents. *Nutrients,* 10(145), 1-18.

Seid, E., Derseh, L., Derso, T., Assefa, M., Gonete, K. A., & Tariku A. (2018). Nutrient consumption and associated factors among school age children in Dewa Chefe District, northeast Ethiopia: A cross-sectional study. *BMC Research Notes,* 2018, 11:669.

Sewwandi, S. D. C., Arampath, P. C., Silva, A. B. G., & Jayatissa, R. (2020). Determination and comparative study of sugars and synthetic colorants in commercial branded fruit juice products. *Journal of Food Quality*, https://doi.org/10.1155/2020/7406506.

Sharoba, A. M., & Ramadan, M. F. (2012). Impact of frying on fatty acid profile and rheological behaviour of some vegetable oils. *Journal of Food Processing and Technology*, 3:161.

Shayo, F. K. (2019). Co-occurrence of risk factors for non-communicable diseases among in-school adolescents in Tanzania: An example of a low-income setting of sub-Saharan Africa for adolescence health policy actions. *BMC Public Health,* 19:972. https://doi.org/10.1186/s12889-019-7320-1.

Sheriff, D. S. (2016). A perspective on childhood obesity in general and Libya in particular. *Asian Journal of Pharmacy, Nursing and Medical Sciences*, 4(5), 52-64.

Sigmund, E., Croix, M. D. S., Mikla´nkova, L., & Fromel, K. (2007). Physical activity patterns of kindergarten children in comparison to teenagers and young adults. *European Journal of Public Health, 17*(6), 646–651.

Simionato, J.I., Garcia, J. C., Dos-Santos, G. T., Oliveira, C. C., Visentainer, J. V. & De-Souza, N. E. (2010). Validation of the Determination of Fatty Acids in Milk by Gas Chromatography. *Journal of the Brazilian Chemical Society*, 21, (3), 520-524.

Singh, A., Bassi, S., Nazar, G. P., Saluja, K., Park, M., Kinra, S., & Arora, M. (2017). Impact of school policies on non-communicable disease risk factors – A systematic review. *BMC Public Health, 17*, 292.

Siong, C. N., & John, J. F. (2021). Goal content and attitudes toward physical activity among primary school students during COVID-19 conditional movement control order. *Asian Journal of Sport and Exercise Psychology,* 1, 103–107.

Skinner, A. C., Steiner, M. J., & Perrin, E. M. (2012). Self-reported energy intake by age in overweight and healthy-weight children in NHANES, 2001–2008. *Pediatrics*, 130(4), e936–42.

Smpokos, E. A., Linardakis, M., Papadaki, A., Theodorou, A.S., Havenetidis, K., & Kafatos, A. (2014). Differences in energy and nutrient-intake among Greek children between 1992/93 and 2006/07. *Journal of Human Nutrition and Dietetics*, 27 (Suppl. 2), 230–238.

Spronk, I., Kullen, C., Burdon, C., & O'Connor, H. (2014). Relationship between nutrition knowledge and dietary intake. *British Journal of Nutrition*, 111, 1713–1726.

Steyn, N., Eksteen, G., & Senekal M. (2016). Assessment of the dietary intake of schoolchildren in South Africa: 15 years after the first national study. *Nutrients*, 8(509), 1-14.

Stuckler, D., McKee, M., Ebrahim, S., & Basu, S. (2012). Manufacturing epidemics: The role of global producers in increased consumption of unhealthy commodities including processed foods, alcohol, and tobacco. *PLoS Medicine,* 9(6), e1001235.

S´tvera´kova, T., Jačisko, J., Busch, A., Safa´řova, M., Kola´ř, P., & Kobesova, A. (2021). The impact of COVID-19 on physical activity of Czech children. *PLoS One*, 16(7),

e0254244.

Suara S. B., Siassi, F., Saaka, M., Foroshani, A. R., Asadi, S., & Sotoudeh, G. (2020). Dietary fat quantity and quality in relation to general and abdominal obesity in women: a cross-sectional study from Ghana. *Lipids in Health and Disease* 19:67.

Sungur, S., & Kilboz, Y. (2016). Determination of sugar profiles of sweetened foods and beverages. *Journal of Food and Nutrition Research*, 4(6), 349-354.

Taha, A. A., & Marawan, H. M. (2015). Socio-behavioral determinants of overweight and obesity in Egyptian primary school children. *Journal of Child and Adolescent Behavior*, 3, 236.

Talat, M. A., & El-Shahat, E. (2016). Prevalence of overweight and obesity among preparatory school adolescents in Urban Sharkia Governorate, Egypt. *Egyptian Pediatric Association Gazette*, 64, 20–25.

Tandon, P. S., Zhou, C., Johnson, A. M., Gonzalez, E. S., Kroshus, E. (2021). Association of Children's Physical Activity and Screen Time with Mental Health during the COVID-19 Pandemic. *JAMA Network Open.* 4(10), e2127892.

Tathiah, N., Moodley, I., Mubaiwa, V., Denny, L., & Taylor, M. (2013). Overweight, obesity, underweight and stunting in female primary school learners in rural KwaZulu-Natal, South Africa. *South African Medical Journal*, 103(10), 718-723.

Thasanasuwan, W., Srichan, W., Kijboonchoo, K., Yamborisut, U., Wimonpeerapattana, W., Rojroongwasinkul, N., Khouw, I. T., & Deurenberg, P. (2016). Low sleeping time, high TV viewing time, and physical inactivity in school are risk factors for obesity in pre-adolescent Thai children. *Journal of Medical Association of Thailand*, 99(3), 314-321.

Thavorncharoensap, M. (2017). Effectiveness of obesity prevention and control. *Asian Development Bank Institute, Working paper series No.* 654.

Tluway, F. D., Leyna, G. H., & Mmbaga, E. J. (2018). Magnitude and factors associated with overweight and obesity among adolescents in semi-rural area of Babati District, Tanzania. *Tanzania Journal of Health Research,* 20 (2), 1-9.

Trattner, S., Becker, W., Wretling, S., Öhrvik, V., & Mattisson, I. (2015). Fatty acid

composition of Swedish bakery products, with emphasis on trans-fatty acids. *Food Chemistry*, 175, 423–430.

Tulchin-Francis, K., Stevens, W., Gu, X., Zhang, T., Roberts, H., Keller, J., Dempsey, D., Borchard, J., Jeans, K., & Vanpelt, J., (2021). The impact of the coronavirus disease 2019 pandemic on physical activity in U.S. children. *Journal of Sport and Health Science,* 10, 323-332.

Turner, C., Kadiyala, S., Aggarwal, A., Coates, J., Drewnowski, A., Hawkes, C., Herforth, A., Kalamatianou, S., & Walls, H. (2017). Concepts and methods for food environment research in low- and middle-income countries. Agriculture, Nutrition and Health Academy Food Environments Working Group (ANH-FEWG). Innovative Methods and Metrics for Agriculture and Nutrition Actions (IMMANA) programme. London, UK.

Uauy, R., & Dangour, A. D. (2009). Fat and fatty acid requirements and recommendations for infants of 0–2 years and children of 2–18 years, *Annals of Nutrition and Metabolism,* 55, 76–96.

Uçar, A., & Yilmaz, S. (2015). Saccharin genotoxicity and carcinogenicity: A review. *Advances in Food Sciences*, 37(3), 138-142.

Ulbricht, L., De-Campos, M. F., Esmanhoto, E., & Ripka, W. L. (2018). Prevalence of excessive body fat among adolescents of a south Brazilian metropolitan region and State capital, associated risk factors, and consequences. *BMC Public Health*, 18, 312.

Umar, I. U., Kakale, I. M., Gwarzo, G. D., & Muutassim, I. (2018). Prevalence of childhood and adolescent overweight and obesity in Kano State, Nigeria. *EC Paediatrics,* 7(4), 231-238.

United Republic of Tanzania. *National Nutrition Social and Behavior Change Communication Strategy July 2013 – June 2018*, Ministry of Health and Social Welfare, Tanzania, 85pp

United Republic of Tanzania. (2020*). National Guidelines on School Feeding and Nutrition Services to Basic Education Students*. Ministry of Education, Science and Technology, Tanzania.

United Republic of Tanzania. (2023). *Action Plan for Implementation of School Milk Program*

in Tanzania, 2023-2028. Ministry of Livestock and Fisheries. Tanzania, 40pp

Vabø, M., & Hansen, H. (2014). The relationship between food preferences and food choice: A theoretical discussion. *International Journal of Business and Social Science,* 5(7), 145-157.

Van-den-Berg, V. L., Seheri, L., & Raubenheimer, J. (2014). Body mass index of 16-year olds in urban Maseru, Lesotho. *African Journal of Primary Health Care and Family Medicine*, 6(1), 14.

Vargas, L., Jime´nez-Cruz, A., & Bacardı´-Gascon., M. (2013). Unhealthy and healthy food consumption inside and outside of the school by pre-school and elementary school Mexican children in Tijuana, Mexico. *Journal of Community Health*, 38(6), 1166–1174.

Verstraeten, R., Van-Royen, K., Ochoa-Avile´s, A., Penafiel, D., Holdsworth, M., Donoso, S., Maes, L., & Kolsteren, P. (2014). A conceptual framework for healthy eating behavior in Ecuadorian adolescents: A qualitative study. *PLoS One*, 9(1), e87183.

Verstraeten, R., Roberfroid, D., Lachat, C., Leroy, J. L., Holdsworth, M., Maes, L., & Kolsteren, P. W. (2012). Effectiveness of preventive school-based obesity interventions in low- and middle-income countries: A systematic review. *American Journal of Clinical Nutrition*, 96, 415-438.

Vilchis-Gil, J., Galván-Portillo, M., Klünder-Klünder, M., Cruz, M., & Flores-Huerta, S. (2015). Food habits, physical activities and sedentary lifestyles of eutrophic and obese school children: A case–control study. *BMC Public Health,* 15:124.

Villiers, A., Steyn, N. P., Draper, C. E., Hill, J., Dalais, L., Fourie, J., Carl Lombard, C., Barkhuizen, G., & Lambert, E. V. (2015). Implementation of the HealthKick intervention in primary schools in low-income settings in the Western Cape Province, South Africa: A process evaluation. *BMC Public Health, 15*(818), 1-12.

Vine, M. M., & Elliott, S. J. (2013). Examining local-level factors shaping school nutrition policy implementation in Ontario, Canada. *Public Health Nutrition*, 17(6), 1290–1298.

Walker, R. W., & Goran, M. I. (2015). Laboratory determined sugar content and composition of commercial infant formulas, baby foods and common grocery items targeted to

children. *Nutrients*, 7, 5850-5867.

Wall, C. R., Stewart, A. W., Hancox, R. J., Murphy, R., Braithwaite, I., Beasley, R., & Mitchell, E.A. (2018). Association between frequency of consumption of fruits, vegetables, nuts and pulses and BMI: Analyses of the International Study of Asthma and Allergies in Childhood (ISAAC). *Nutrients*, 10, 316.

Walter, C. M. (2011). In-school physical activity patterns of primary school learners from disadvantaged schools in South Africa. *African Journal of Physical, Health Education, Recreation and Dance,* 17 (4:2), 780-789.

Wang, L., Dalton, W. T., Schetzina, K. E., Fulton-Robinson, H., Holt, N., & Ho, A. (2013). Home food environment, dietary intake, and weight among overweight and obese children in Southern Appalachia. *Southern Medical Journal,* 106(10), 550–557.

Wamba, P. C. F., Oben, J. E., & Cianflone, K. (2013). Prevalence of overweight, obesity, and thinness in Cameroon urban children and adolescents. *Journal of Obesity*. 737592.

Watts, A. W., Barr, S. I., Hanning, R. M., Lovato, C. Y., & Mâsse, L. C. (2018). The home food environment and associations with dietary intake among adolescents presenting for a lifestyle modification intervention. *BMC Nutrition*, *4*(1), 1-9.

Wiersma, R., Lu, C., Hartman, E., & Corpeleijn, E. (2019). Physical activity around the clock: objectively measured activity patterns in young children of the GECKO Drenthe cohort. *BMC Public Health*, 19, 1647.

Wilner, L., Suri, D. J., Langlois, B. K., Walton, S. M., & Rogers, B. L. (2017). Effective delivery of social and behavior change communication through a care group model in a supplementary feeding program. *Journal of Health Population and Nutr*ition, 36:34.

Winther, R., Aasbrenn, M., & Farup, P. G. (2017). Intake of non-nutritive sweeteners is associated with an unhealthy lifestyle: A cross-sectional study in subjects with morbid obesity. *BMC Obesity*, 4, 41.

World Health Organization. (2003). Diet, Nutrition and the Prevention of Chronic Diseases. Report of a Joint WHO/FAO Expert Consultation, WHO Technical Report Series, no 916: i-viii, 1–149, Geneva, 18.

World Health Organization. (2005). Non-communicable Diseases and Mental Health Cluster. WHO STEPS surveillance manual: The WHO STEPwise approach to chronic disease risk factor surveillance / Non-communicable Diseases and Mental Health, World Health Organization. https://apps.who.int/iris/handle/10665/43376.

World Health Organization. (2008). WHO *child growth standards: Training course on child Growth assessment.*

World Health Organization. (2009). *AnthroPlus for personal computers Manual. 2009. Software for assessing growth of the world's children and adolescents*. Geneva. http://www.who.int/growthref/tools/en/.

World Health Organization. (2014). *Case-control study to assess potential risk factors related to human illness caused by Middle East Respiratory Syndrome Coronavirus* (MERS-CoV)", Protocol version 6.

World Health Organization. (2015a). *Guideline: Sugars intake for adults and children*. WHO Geneva.

World Health Organization (2015b). *Health in the 2030 Agenda for Sustainable Development*, available at: http://apps.who.int/gb/ebwha/pdf_ files/EB138/B138_14-en.pdf. Accessed on 20th January, 2023.

World Health Organization. (2016). *Report of the Commission on ending childhood obesity*; WHO document Production Services, Geneva, SWZ, 68pp.

World Health Organization. (2020). WHO guidelines on physical activity and sedentary behaviour, Geneva. World Health Organization, 104.

World Health Organization. (2012). WHO STEPwise approach to chronic disease risk factor surveillance, STEPS-instrument v2.1. The Tanzanian Steps survey report, 490.

Yee, A. Z. H., Lwin, M. O., & Ho, S. S. (2017). The influence of parental practices on child promotive and preventive food consumption behaviors: A systematic review and meta-analysis. *International Journal of Behavioral Nutrition and Physical Activity*, 14, 47. Doi:10.1186/s12966-017-0501-3.

Young, I. E., Parker, H. M., Cook, R. L., O'Dwyer, N. J., Garg, M. L., Steinbeck, K. S., Cheng,

H.L., Donges, C., Franklin, J.L., & O'Connor, H.T. (2020). Association between obesity and omega-3 status in healthy young women. *Nutrients,* 12, 1480.

Yusuf, S. M., Mijinyawa, M. S., Musa, B. M., Gezawa, I. D., & Uloko, A. E. (2013). Overweight and obesity among adolescents in Kano, Nigeria. *Journal of Metabolic Syndrome,* 2(1), 1-5.

Zhang, N., Bécares, L., & Chandola, T., (2016). Patterns and determinants of double-burden of malnutrition among rural children: Evidence from China. *PLoS One, 11*(7). e0158119.

Ziaei, R., Shahi, H., Dastgiri, S., Mohammadi, R., & Viitasara, E. (2020). Fruit and vegetable intake and its correlates among high-school adolescents in Iran: A cross-sectional study. *Journal of Public Health,* 28, 711-718.

APPENDICES

Appendix 1: Study tools (Questionnaires)

'UTION OF SCIENCE AND TECHNOLOGY (NM – AIST)

Questionnaire on Prevalence and correlates of obesity among School Children in eastern Tanzania

S/ N	Section A: Demographic information	Fill blanks/Tick where appropriate		
1	Interviewer's name			
2	Name of respondent (School Child)			
3	Gender of the child	Male	1	
		Female	2	
4	Region	Dar-es-salaam	1	
		Coast	2	
5	District	Ilala	1	
		Mkuranga	2	
6	Street/Ward of residence			
7	Name of School			
8	Type of School	Public	1	
		Private	2	
9	Grade/class of child	Class V	1	
		Class VI	2	
		Class VII	3	
10	Date of birth DD/MM/YYYY	……/……./…….		
11	Date of interview DD/MM/YYYY	……./……../……		
12	Consent has been obtained *	Yes	1	
		No	2	
13	Contact phone number of Parent/Guardian*			
14	Who is the owner of the phone number?	Father	1	
		Mother	2	
		Someone else (Mention)	3	
15	What is the highest level of education your mother/caregiver? *	Never went to school	1	
		Primary school	2	
		Secondary school	3	
		college/university	4	
16	Marital status of parents	Never married	1	
		Married	2	
		Separated	3	
		Divorced	4	
		Widowed	5	
		Cohabiting	6	
		Prefer not to mention	99	

17	Which of the following describes main work of your father? *	Employed (formal or informal	1	
		Self employed	2	
		Business	3	
		Home maker	4	
		Retired officer	5	
		Unemployed	6	
		Others (mention)	9	----
18	Which of the following describes main work of your mother? *	Employed (formal or informal	1	
		Self employed	2	
		Business	3	
		Home maker	4	
		Retired officer	5	
		Unemployed	6	
		Others (mention)	9	
19	Which of the following describes main work of your caregiver? *	Employed (formal or informal	1	
		Self employed	2	
		Business	3	
		Home maker	4	
		Retired officer	5	
		Unemployed	6	
		Others (mention)	9	
20	How many people live in your family?	**…….**		
21	Have you ever been sick in the past 4 weeks?	Yes	1	
		No	2	
22	If yes, which type of sickness did you experience?	Malaria	1	
		Diarrhea	2	
		Fever	3	
		Coughing/Flu	4	
		Typhoid	5	
		Worm infestation	6	
		Others (mention)	7	
23	Did the sickness reduced your food intake?	Yes	1	
		No	2	
Section B: Dietary habits of school children				
24	How many meals do you usually take per day during school days (including breakfast, lunch, dinner and snacks)?	1-2 meals	1	
		3-4 meals	2	
		5-6 meals	3	
		More than 6 meals	4	
		I don’t know	88	
25	How many meals do you usually take per day during weekends/ holidays (including breakfast, lunch, dinner and snacks)?	1-2 meals	1	
		3-4 meals	2	
		5-6 meals	3	
		More than 6 meals	4	
		I don’t know	88	
26	What type of main staple food do you mostly prefer?	Cereal based	1	
		Root and tuber based	2	
		None	3	
		I don’t know	4	

27	How often do you prefer to consume the main staple mentioned above?	Several times a day	1	
		Once a day	2	
		More than 3 times a week	3	
		Less than 3 times a week	4	
		Never	5	
28	What type of relish do you mostly prefer?	Meat and poultry relish	1	
		Fish and dagaa relish	2	
		Legumes relish	3	
		Green leafy vegetables	4	
		I don't know	5	
29	How often do you prefer to consume the type of relish mentioned above?	Several times a day	1	
		Once a day	2	
		More than 3 times a day	3	
		Less than 3 times a day	4	
		Never	5	
		Type of snack	code	frequency
30	What type of snacks do you mostly prefer? (multiple responses are allowed)	Soda/ carbonated drinks		1. Several times a day Once a day 3. >3 times a week 4. <3 times a week 5.Never
		Hot drinks (Tea and coffee)		
		Yoghurt/ fresh milk		
		Fruits		
		Cookies, cakes, biscuits		
		Popcorn		
		Potato Crips		
		Ice cream		
		None		
		Others (specify)		
31	How often do you eat during school hours?	Several times a day	1	
		Once a day	2	
		> 3 times a week	3	
		< 3 times a week	4	
		Never	5	
32	Which foods you normally eat during school hours? Mention at least 3 foods			
33	How often do you eat together with other family members	More often	1	
		Sometimes	2	
		Less often	3	
34	Do you usually eat while watching television?	Yes	1	
		No	2	
35	Which foods do you prefer to eat while watching television? Mention at least 3 foods			
36	Do you sometimes wake up at nights to eat?	Yes	1	
		No	2	
		Not sure	88	

37	If yes, why do you wake up at night to eat?			
38	Do you watch out for healthy diet?	Yes	1	
		No	2	
		Not sure	88	

***Parents may be consulted**

Section C: School child 24h Dietary Recall Form (Please recall all foods and drinks consumed in the past 24 hours (usually mid-night to midnight) including main meals and snack. Please describe the type of meal, ingredients used, and amount consumed)

Respondent's name …….			**Day of the week …….**		
Did you experience any form of discomfort or sickness yesterday? Yes ( ) No ( )			Was there anything different that changed your daily intake (e.g. festival or fasting) Yes ( ) No ( )		
Time food was eaten	**Type of food/drink**	**Description of ingredients used**	**Household measure**	**Amount served (grams)**	**Amount consumed (grams)**

Section D: Anthropometric Measurements

Respondent name		
SN	Variables Measured	
1	Weight (kg)	
2	Height (cm)	
3	Body fat (%)	

NELSON MANDELA AFRICAN INSTITUTION OF SCIENCE AND TECHNOLOGY (NM-AIST)

Questionnaire for comparison study between overweight/obese and normal weight children on correlates of obesity among school children in Ilala and Mkuranga districts, Tanzania

Introduction

The purpose of this study is to determine the factors that might put someone at risk of becoming overweight or obese. Overweight and obesity may be due to diet and physical activities or a number of other factors, but we do not know how likely each of these factors are to contribute to overweight and obesity. So, we will be asking questions of parents/guardians and children related to diet, physical activities, and family factors related to overweight and obesity. The study focuses on children who were identified as overweight or obese, in order to understand their history and risk factors. We are also including a comparison group of children found to be of normal weight. The study will help us to better understand the type of exposures or risks to each group of school children that might lead to overweight and obesity. Your answers are very important to making this study possible and helpful to children across Tanzania.

ID No. of the child…….Name…… School……..

Section A: Questions for parents/guardians.

1.In your family do you have a history of any of the following diseases/conditions?

Disease/ condition	1=Yes	2=No
Diabetes		
Hypertension (high BP)		
Cardiovascular diseases		
Cancer		
Overweight/Obesity		

2.Please pick the term that most reflects what you consider/perceive as your weight status
(1) Normal (2) Overweight (3) Obese (4) Underweight (5) I'm comfortable with my weight

3.How do you perceive someone who is overweight or obese?
(1) Good healthy (2) Normal (3) Wealthy/rich (4) Poor (5) Sick (6) Other
(mention)_____

4.What do you perceive of your child's weight status?
(1) Normal (2) Overweight (3) Obese (4) Underweight (5) I'm comfortable with his/her weigh

5. Does your child normally eat breakfast before going to school child before going to school,
1 = Yes, usually 2 = Yes, sometimes 3 = No……..

6.If yes, mention at least 3 foods/meals normally consumed during breakfast.

7. If no why your child is not given/consume breakfast? _____

8.Do you give money to your child to use at school?

1) Yes……., 2) No…..……, 3) Sometimes……..
9.What is the mode of transport to and from school for your child?

1) School bus 2) Public transport (eg Daladala) 3) Bicycle 4) Others (mention)_____

10. How many hours does your child sleep per day_____

Section B: Food Frequency Questionnaire
Name_____Age_____School_____
1. This section asks about frequency of consumption of foods in one month between the day of interview and 30 days back (please enter a number of the frequency of consumption in respective rows and column. For example, if you normally eat maize products two times per day you enter number 2 in the first column and row for maize). Put a tick if a food is consumed rarely or never consumed. Indicate also the source and seasonal availability of food in the respective column.

Food item		Frequency of consumption					Availability (Seasonal variation) 1=Rainy season 2=Dry season 3=Both rainy and dry season
	Per day	Per week	Per month	Rare √	Never √	Major source 1=own production 2=purchase 3= gift from friend 4=others- specify	
Cereals							
Maize							
Sorghum							
Finger millet							
Wheat							
Rice							
Others (Specify)							
Roots, tubers, plantain							
Cassava							
Sweet potatoes							
Round potatoes							
Yams							
Green bananas							
Ming'oko							
Others (Specify)							
Legumes							
Beans (Maharage)							
Peas (Njegere)							
Cowpeas (Kunde)							

Food item	**/day**	**/week**	**/month**	**rarely**	**never**	**major source**	**availability**
Pigeon peas (Mbaazi)							
Green grams (Choroko)							
Chickpeas (Dengu)							
Soybeans (Soya)							
Bambara nuts (Njugumawe)							
Others (specify)							
Nuts and seeds							
Groundnuts							
Coconut							
Cashew nut							
Other seeds (specify)							
Meat, poultry, fish, eggs							
Cow-beef							
Liver							
Other organ meats							
Goat							
Pork							
Wild game meat							
Poultry-chicken/duck							
Eggs							
Fresh-water fish							
Sea fish							
Dried fish							
Sardines							
Others (Specify)							
Oils and fat							
Sunflower oil							
Palm oil							
Korie, safi							
Butter							
Others(specify)							
Vegetables							
Cabbage							
Amaranth leaves							
Sweet potato leaves							
Cassava leaves							
Cowpea leaves							
Pumpkin leaves							
Okra							
Carrot							
Pumpkin fruit							
African eggplant							
Eggplant							
Tomato							
Others (Specify)							
Food item	**/day**	**/week**	**/month**	**rarely**	**never**	**major source**	**availability**
Milk and milk products							

Cow's milk (whole)							
Goat's milk (whole)							
Processed & packed milk							
Yoghurt							
Butter/ Lard (siagi)							
Ghee (samli)							
Cheese (jibini)							
Others (Specify)							
Fruits							
Citrus e.g. oranges							
Mangoes							
Passion fruit							
Water melon							
Bananas							
Pineapple							
Papaya							
Avocado							
Other (specify)							
Processed foods/snacks							
Potato chips							
Potato/banana crisps							
Popcorn							
Processed/colored baobab							
Cookies and cakes							
'Kashata'							
Biscuits							
Sweets, candy, chocolates							
Wheat burns (Maandazi)							
Doughnuts (Donati)							
Pancakes (Chapati)							
Samosa (Sambusa)							
Others (specify)							
Beverages							
Water							
Soda/carbonated drinks							
Energy drinks							
Fruit juices or Fruit-flavoured drinks							
Sugar cane juices							
Local ice cream (Flavoured-sweetened frozen water)							
Others (specify)							

2. Do you usually eat breakfast (1) Yes (2) No
3. Where do you usually eat lunch? (1) At home (2) At school

Section C: Child Physical Activity Questionnaire for school children 10-13 years old (Please complete every line in the questionnaire)

The aim of this questionnaire is to find out about your level of physical activity from ***the last 7 days*** (in the last week. Which of the following PHYSICAL activity did you do in the past seven days**.** This includes sports or dance that make you sweat or feel tired, or games that make you breathe hard, like skipping, running, climbing, e.t.c. Note: i). There are no right and wrong answers. It is not a test. Ii). Please answer all the questions accurately and honestly

Name……. Age……. Sex…….Grade……

To be completed in seven days from …….to……

1. Spare time activities

Did you do the following activities in the past 7 days (circle your response)				**Monday - Sunday**	
				How many times a day	**Time in minutes per day**
A. Sports activities	**At home**	**At school**			
Football			Yes No		
Netball			Yes No		
Basketball			Yes No		
Dancing			Yes No		
Cricket			Yes No		
Table tennis			Yes No		
Running or jogging			Yes No		
Swimming			Yes No		
Bike riding (not for school travel)			Yes No		
Household chores			Yes No		
Play on the ground			Yes No		
Skipping rope			Yes No		
Walk for exercise			Yes No		
Travel by bike to and from school			Yes No		
Travel by walking to and from school			Yes No		
Others (mention)					

B. Sedentary activities/ leisure time					
Listen to music			Yes No		
Watching TV/video			Yes No		
Arts work (drawing, sewing, pottery			Yes No		
Doing homework			Yes No		
Imaginary play			Yes No		
Playing cards			Yes No		
Playing with toys			Yes No		
Playing computer games			Yes No		
Playing music instruments			Yes No		
Reading			Yes No		
Telling stories			Yes No		
Talk on phone			Yes No		
Internet surfing			Yes No		
Travel to and from school by car or bus			Yes No		

2. In the last 7 days, during your physical education (PE) classes, how often were you very active (playing hard, running, jumping, throwing)? (Check one only.)

I don't do PE ..... [ ]
Hardly ever ..... [ ]
Sometimes ..... [ ]
Quite often ..... [ ]
Always ..... [ ]

3. In the last 7 days, what did you do most of the time *at recess/* break times? (Check one only.)

Sat down (talking, reading, doing schoolwork)…… [ ]
Stood around or walked around ..... [ ]
Ran or played a little bit ..... [ ]
Ran around and played quite a bit ..... [ ]
Ran and played hard most of the time ..... [ ]

4. In the last 7 days, what did you normally do *at lunch* (besides eating lunch)? (Check one only.)

Sat down (talking, reading, doing schoolwork)……..... [ ]
Stood around or walked around ..... [ ]
Ran or played a little bit ..... [ ]
Ran around and played quite a bit ..... [ ]
Ran and played hard most of the time ..... [ ]

5. In the last 7 days, on how many days *right after school*, did you do sports, dance, or play games in which you were very active? (Check one only.)

None ..... [ ]
1 time last week ..... [ ]
2 or 3 times last week ..... [ ]
4 times last week ..... [ ]
5 times last week ..... [ ]

6. In the last 7 days, on how many *evenings* did you do sports, dance, or play games in which you were very active? (Check one only.)

None ..... [ ]
1 time last week ..... [ ]
2 or 3 times last week ..... [ ]

4 or 5 last week ..... [ ]
6 or 7 times last week ..... [ ]

7. *On the last weekend*, how many times did you do sports, dance, or play games in which you were very active? (Check one only.)

None ..... [ ]
1 time ..... [ ]
2 — 3 times ..... [ ]
4 — 5 times ..... [ ]
6 or more times ..... [ ]

8. Which *one* of the following describes you best for the last 7 days? Read *all five* statements before deciding on the *one* answer that describes you.

A. All or most of my free time was spent doing things that involve little physical effort [ ]
B. I sometimes (1 — 2 times last week) did physical things in my free time (e.g. played sports, went running, swimming, bike riding, etc.) . [ ]
C. I often (3 — 4 times last week) did physical things in my free time [ ]
D. I quite often (5 — 6 times last week) did physical things in my free time [ ]
E. I very often (7 or more times last week) did physical things in my free time [ ]

9. Mark how often you did physical activity (like playing sports, games, doing dance, or any other physical activity) for each day last week.

	None	Little bit	Medium	Often	Very often
Monday					
Tuesday					
Wednesday					
Thursday					
Friday					
Saturday					
Sunday					

10. Were you sick last week, or did anything prevent you from doing your normal physical activities? (Check one.)

Yes .....…… [ ]
No ..... [ ]
If yes, did the sickness prevented you from being active? _____

Focus Group Discussion: Questions to parents about environmental, socio-cultural and parental factors affecting children food choices

Greetings, I would like to thank you for accepting to take part in this interview. We appreciate your willingness and time to participate. We are coming from Nelson Mandela African Institution of science and Technology. The purpose of this interview is to obtain information about parental, socio-cultural and environmental factors affecting your school children food choices. We would like to hear your ideas and opinions about different aspects related to foods available at home environment, common foods given to children and cultural aspects governing children food choice. We will appreciate if you will share your honest and open thoughts with us. Your responses to the questions will be kept confidential. The interview will take about one hour. You can choose whether or not to participate in the interview or stop at any time. The information learned will be used to inform stakeholders on current situation and identify possible measures to address the situation.

Parental factors

1. Which factors do you consider when choosing foods for your……
2. Which foods do you normally prefer to give to your school children?.....
3. Do you have control on portion size when food is served to children in your households?
4. How does the working time of the mother/caregiver affect food preparation for the family?

   _____
5. How does family income affect types of food to be purchased and consumed at the household?

   _____
6. How often do you eat together as a family with your school children?
7. What method of food preparation/cooking are most common in your households?
8. What types of foods do you use as rewards to your school child?

   _____
9. Which foods do you normally give to your children before they go to school in the morning?
10. What are household chores do children assist at home?
11. Do you normally give your children money for school use?

Environmental factors

12. What your children normally do during their leisure time?_____
13. How do your food choices vary in different season of the year?_____
14. What are your food choices in special events/occasions_____
15. Are there any factors that induce not to choose favorite food in the household? What are they?_____
16. Which foods are commonly available or sold around your home environment_____?
17. What type of food supply outlets is close to your households e.g supermarkets, big/main markets, small markets (magenge), food groceries e.t.c_____
18. What is the distance from your households (please estimate in meters) to fruits and vegetable outlets_____?
19. What is the distance from your households (please estimate in meters) to fish, meat and meat product outlets?_____
20. To what extent does the distance to food store/market/shop influence food

consumption?_____

21. Do you have small food vendors (street vendors, road stands) around your vicinity and what types of foods they normally sell?____
22. What is the effect of food price on purchasing power (are these foods affordable to children)?_____
23. How does location/area of residence determine types of food available
24. Do you have enough space for children physical activity at home? E.g space, tools like balls, ropes e.t.c

Socio-cultural factors

25. Which foods are normally given to boy children and which one are given to girls?
26. What are food taboos (if any) that govern food consumption in your family?_____

Whose opinion is important in food choice in the household and why?_____

27. What do you feel when your child looks fat? _____
28. What do you feel when your child looks slim? _____
29. What does your culture believe in fat and in thin children?_____
30. Which foods are mostly preferred by children in the household?_____
31. Which foods are mostly preferred by adults in the household?

_____

……..Thank you for your cooperation……

Key Informant Interview: Questions to school teachers about environmental factors influencing

children food choices and physical activity (Qualitative study)

Greetings, I would like to thank you for accepting to take part in this interview. We appreciate your willingness and time to participate. We are coming from Nelson Mandela African Institution of science and Technology. The purpose of this interview is to obtain information about this school with regard to food, nutrition aspects and physical activity program of school children. We would like to hear your ideas and opinions about different aspects related to foods available at school and nutrition in general as well as physical activity program at your school. We will appreciate if you will share your honest and open thoughts with us. Your responses to the questions will be kept confidential. The interview will take about 40 minutes. You can choose whether or not to participate in the interview or stop at any time. The information learned will be used to inform stakeholders on current situation and identify possible measures to address the situation.

1. Name of the school_____
2. Type of the school_____
3. School size 1= small_____2= large_____
4. Name of the responding person _____
5. Contact of the responding person _____

6. Which types of foods are available in school environment?

_____

7. Who provides food services in school environment? (Food outlets like canteen, school shop, food vendors e.t.c) _____
8. Does your school provide food to children? _____If yes what is the food timetable per week?_____
9. Do some of the children come with lunch boxes to school? If yes what are main foods contained in the lunch boxes?_____
10. What types of foods are preferred mostly by children in this school?_____
11. What are the school food policy or school food programs in your school?

_____

12. At what times do children eat during school hours? _____
13. What do you comment on food environment in your school? _____
14. What do you think of nutrition and safety aspects of foods sold at school environment?

_____

13. What type of physical activity are common in this school?

_____

16. Do you have enough space for physical activity in this school?_____
17. What is the schedule/time table for physical activity in this school?_____
18. Do you have teachers for physical running physical education in this school?

___

19. Does your school has inter school sports competitions?_____

Thank you for you cooperation…….

Appendix 2: Consent Form

Informed Consent for the participants of the study on prevalence and correlates of obesity among school children in eastern Tanzania: A basis for policy options.

Introduction

Child nutrition status is a key component for leading the child's health life and prevent risk for non-communicable diseases, thus optimal nutrition plays key role in physical and mental development of a child. However, in many studies conducted in developing countries nutrition situation of school children do not receive adequate attention. Therefore, this study will help to assess nutrition status of school children, their participation in physical activity and their dietary consumption habits (through cross-sectional survey and then develop multi- sectoral policy briefs to inform policy options. To complete this work, we will measure child's weight, height and body fat content and requesting child, parents and teachers to answer some questions in a questionnaire. These questions are about social demographics, dietary patterns and habits of children, their physical activity and parental, socio-cultural, environmental factors influencing children's food choices. The study will involve cross-sectional survey.

Procedure: If a child assent and parents' consent their children to participate in this study, they will be requested to participate in measurements and answering questions from the questionnaire. Child's measurements will be taken once and followed up of overweight/obese children on nutrition status of children. Food samples which are mostly consumed by school children will be taken for laboratory analysis to assess their fats and sugar profiles. The results of this study will be disclosed to you and will only be used for the purpose stated in this study.

Benefits: By participating in this study, child's measurements (weight, height and body fat) will be done free of charge and provided with advice and counseling if necessary. Causes of poor children's nutrition status will be established and communicated to influential stakeholders so that appropriate measures can be taken

Risks and Precautions: measurement which will done are non-invasive, thus no pain and risks will be involved. However, we are requesting children and parents to be patient during the period of study which is approximated to take about 3-6 months which will sometimes be inconvenient and you will have to postpone your activities.

Confidentiality: Any records relating to your participation will be strictly confidential. Your names will not be used in any reports from the study. The participation to this study is voluntary and you may withdraw from the study at any time. You are free to ask any questions or any clarification after you have read and understood the consent form explained to you.

Participant statement

I have understood the above information explained to me
by the researcher and I agree to take part in this study and I can withdraw at any time without giving reason.

Participants Name:……..Signature……

Date…….. Researcher's Name :……Signature

……....Date……..

Appendix 3: Ethical Certificate

Kibong'oto Infectious Diseases Hospital- Nelson Mandela African Institution of Science and Technology- Centre for Educational Development in Health, Arusha (KIDH-NM-AIST-CEDHA) -KNCHREC

RESEARCH ETHICAL CLEARANCE CERTIFICATE

Research Proposal No: KNCHREC0016 **3rd May 2019**

Study Title: **PREVALENCE AND CORRELATES OF OBESITY AMONG SCHOOL CHILDREN IN EASTERN TANZANIA**

Study Area: THE NELSON MANDELA AFRICAN INSTITUTION OF SCIENCE AND TECHNOLOGY

PI Name: RENATHA PACIFIC
Co-Invigilator:
Institutions: SCHOOL OF LIFE SCIENCES AND BIO-ENGINEERING

The Proposal has been approved by KNCHREC on 3rd May 2019

1. Subject to this approval you will be required to submit your progress report to the KNCHREC, National Institute of Research and Ministry of Health Community Development Gender Elderly and Children
2. Publication of your findings is subject to presentation to the KNCREC and NIMR Approval.
3. Copies of final publication should be made available to KNCHREC, National Institute of Research and Ministry of Health Community Development Gender Elderly and Children

Duration of Study Renewal: Subject to Renewal within ONE YEAR
Span From: 3rd May 2019 to 2nd May 2020.

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Mr. Simon Njeya
Secretary
KNCHREC

Chairperson
KNCHREC

RESEARCH OUTPUTS

(i) Research Papers

Pacific, R., Martin, H. D., Kulwa, K., & Petrucka, P. (2020). Contribution of home and school environment in children's food choice and overweight/obesity prevalence in African context: evidence for creating enabling healthful food environment. *Pediatric Health, Medicine and Therapeutics*, 283-295.

Pacific, R., Martin, H. D., Kulwa, K., & Petrucka, P. (2021). Nutritional status and dietary habits of urban and peri-urban primary school children (10-13 years) in Tanzania: A comparative study between public and private schools. *International Journal of Biosciences 19*(3), 12-30.

Pacific, R., Kulwa, K., Martin, H. D., & Petrucka, P. (2022). Physical activity and sedentary behaviors associated with overweight and obesity among primary school children in Tanzania: A case-control study. *Nutrition & Food Science*, *52*(5), 765-777.

(ii) Policy brief

(iii) Poster Presentation

Appendix 4: Poster Presentation

Prevalence and correlates of overweight and obesity among primary school children in Ilala and Mkuranga districts, Tanzania

Renatha Pacific, Haikael Martin, Pammla Petrucka, Kissa Kulwa

Introduction

- Overweight and Obesity is a major public health concern globally and particularly in LMIC.
- The rates are becoming double burden threats in developing countries.
- In many countries Tanzania the prevalence of OV & OB in school children is > 10% while in others is > 20%.
- Obesity (OB) is an excessive body weight in the form of fat caused by imbalance between energy intake and expenditure.
- Overweight (OV) is classified as value of +1SD and obesity as a value of +2SD.

Problem statement & justification

- OV & OB prevalence in children increase rapidly, & estimated to rise to 70 million by 2025.
- In Tanzania reported prevalence is > 20%.
- Poor dietary practices and physical inactivity are the major causes.
- Studies examining dietary intake, food habits, physical activity participation and drivers of food choices are scarce in Tanzania.
- Present study examined factors associated with overweight and obesity in children by using multiple methods.
- Data from this study forms basis to inform relevant authorities to take actions to minimize risks associated with OV & OB among school children.
- It also provide important contextual direction for health care provision and obesity preventive strategies.

Methodology

- Cross-sectional survey between 2019-2020.
- Study areas- Ilala and Mkuranga districts.
- Multi-stage sampling was used.

- A total of 406 children, 36 parents and 9 teachers participated in the study.

- A structured questionnaire was used to collect information.

- Samples of common foods were collected for sugar and fatty acids laboratory analysis.

Objectives

General Objective:
To assess prevalence, correlates and determinants of overweight and obesity among primary school children (10-13 years) in Ilala and Mkuranga districts.

Specific Objectives:

- To assess the nutrition status of primary school children.
- To characterize dietary patterns and food consumption habits of school children.
- To evaluate physical activity level and patterns.
- To investigate the influence of environmental, socio-cultural and parental factors on children's food choices.
- To characterize fat and sugar profiles of foods.

Anthropometric data collection

Data analysis

- SPSS version 20, with both qualitative and quantitative analysis.

- WHO AnthroPlus – nutrition status data.
- NutriSurvey - estimated nutrient intake.
- Descriptive statistics- describe sample characteristics.
- Inferential statistics were performed using Chi-square (X^2).
- Independent sample t-test and Mann Whitney – to compare means of different groups.
- Binary logistic regression – estimated odd ration at 95% CI.
- Thematic content analysis - FDG & KII.
- HPLC – Sugar analysis.
- GC – Fatty acids analysis.

Dietary data collection

Focus group discussion (FGD)

Collection of food samples

Sugar identification-

HPLC analysis - RID

Fatty acids detection-

GC analysis - FID

Results, conclusion and recommendation

- Prevalence of Overweight was 14.5% , and obesity 8.1%.
- Low fruit, vegetables and animal source intake.
- OV & OB children were less active than normal weight children.
- Having OV/OB parent significantly predicted the situation in children.
- Food sample analysed for sugars had higher amount of saccharin (>500 mg/100g).
- Saturated Fatty acids especially palmitic (41%) were found in abundance in tested samples.
- Interventions to modify behavior are recommended to increased intake of PUFA/MUFA and reduce intake of more sugars and SFA.
- Modification of home and school environment is necessary for promoting availability of healthy foods.