Chapter One

Introduction

1.1 Background to the Study.

Nigeria is currently experiencing a rapid urbanization process, accompanied by a quickly growing population [1]. This phenomenon has given rise to distinct food systems in urban and rural areas, leading to varying nutritional challenges and the need for targeted interventions. For example, the urban poor heavily rely on purchasing food, resulting in more diverse diets compared to their rural counterparts. While this may provide better access to quality food and nutrients, their vulnerability to market fluctuations and prices is notably higher. Additionally, urban households tend to consume a higher proportion of processed foods and eat out more frequently, which exposes them to health risks associated with such dietary habits. Furthermore, the urbanization of Nigeria has led to the emergence of urban health crises, including inadequate water supply, poor sanitation, and an increase in diseases. These factors compromise food safety within these urban environments [1]. The intricate nature of food systems arising from urbanization necessitates a holistic approach to addressing the multiple nutritional challenges. This approach should take into account spatial and socio-cultural factors when designing policies and interventions aimed at improving the nutritional well-being of the population [1].

Previous studies in Nigeria attempted to establish a statistical association between food and nutrition security (mainly using anthropometric indicators, total calorie intake, or household dietary diversity) and potential determinants [2]. Yet, these studies did so without examining the magnitude of nutrient and dietary gaps and not necessarily using the food system

perspective (for example, these studies did not link nutrient and dietary gaps and components of food systems such as access to/use of irrigation, mobile phone, electricity, water, health care, and markets). Further, these studies were drawn from samples which were not nationally representative. On the other hand, based on the rural subset of the 2010–2011 Nigeria General Living Standards Measurement Surveys (LSMS-ISA), dietary profiles and statistical association between household dietary diversity and the likelihood of adequate consumption of nutrients were established [3]. Relatedly, based on a country-wide sample survey from 2003/2004, evidence suggests that greater burden of nutritional deficiencies was borne by low-income household cohorts, and deficiency of micronutrients was diffused across urban-rural divides with deficiency of calcium, vitamin A, and vitamin C appearing to be more pronounced in rural areas while phosphorous, vitamin B_1, vitamin B_2, and vitamin B_3 deficiencies seem to be higher in urban settings [4].

Malnutrition is still a problem that is prevailing globally with the relationship of both over-nutrition and under-nutrition in developing countries affecting people of all ages[1]. Adolescents are particularly at risk of malnutrition due to rapid growth and development and changes in dietary habits that may have influenced their nutrient intake [5]. Being overweight and obesity are the main contributors to non-communicable diseases [2].

The change in the food systems is likely to create new nutritional challenges while opening opportunities. To unravel this complexity and identify entry points for interventions, this study adapts the conceptual framework of food systems for diets and nutrition by the High-Level Panel of Experts for Food Security and Nutrition HLPE [6]. Diets are shaped by the interactions of food supply chains, food environments, and consumer behavior [7].

Production, storage, distribution, processing and packaging, retail, and markets are activities that comprise the food supply chain. Many actors are involved along the supply chains, and their involvement may improve the nutritional value of food (e.g., fortification) and in some cases reduce the nutritional value of food due to losses or contamination. The actions of these actors may also affect the food environment. which comprises food availability and physical and economic access to food, promotion, advertising and information, and food quality and safety [8].

As noted before, the food environment in turn affects consumer choices and decisions including what food to acquire, store, prepare, cook, and eat. This is because, besides personal preferences, food prices, income, knowledge and skills, time and equipment, and social and cultural norms are some of the determinants of food choices with implications on nutrient acquisition [9]. The differences in nutrient acquisition corresponding to three cultural food customs from southwest, eastern, and northern Nigeria. Interactions between components of the food systems determine diets—quantity, quality, diversity, and safety. Nonetheless, dietary patterns may also act as drivers of change for future food systems [10]. This is because diets affect nutrition and health outcomes and have social, economic, and environmental impacts [11]. This and the growing demand for food would necessitate sustainability in production, consumption, and enabling conditions such as future behavior by the food systems actors [12] .

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1.2 Statement of the Problem

The food environment, nutrient adequacy, and physical activities of young adults are critical factors that impact their health and well-being. However, there are several challenges in promoting healthy dietary habits and physical activity levels in this population.

Firstly, the food environment plays a crucial role in shaping dietary practices and food choices. However, the food environment in LMICs is often characterized by an abundance of energy-dense foods which can lead to unhealthy dietary patterns and a gap between nutrient intake and requirements [15,16].

Secondly, nutrient adequacy is a concern among adolescents and young adults due to higher nutrient requirements for their developing bodies. However, the current gap between nutrient intake and requirements is a significant issue, and studies have shown that obesity in adolescents and young adults is the phenotypic expression of the interaction between polygenic inheritance with food intake and physical activity habits [17].

Thirdly, physical activity plays a vital role in keeping young adults healthy, and carbohydrate is an important energy source during exercise. However, the benefits of low-carbohydrate diets for athletic performance are not yet fully understood, and more research is needed to determine the optimal carbohydrate intake for different types of exercise [18].

1.3 Justification of the Study

- The food environment plays a significant role in shaping dietary patterns and physical activity levels, which in turn affect nutrient adequacy and health outcomes. According to the British Nutrition Foundation, physical activity is vital for keeping young adults healthy, and carbohydrate is an essential energy source during exercise [1].
- A recent study examining the contribution of food to nutrient intake, meal and dietary patterns among children aged 4-13 years in Ibadan highlights the importance of this research.
- The study found that the majority of children in Ibadan did not meet the recommended daily intake for several key nutrients, including calcium, iron, and vitamin A. This suggests that young adults in Ibadan may also be at risk for nutrient inadequacy, which can lead to negative health outcomes.

- Additionally, a study on the relationship between dietary habits and nutritional status among adolescents in Abuja, Nigeria, found that low intake of vegetables and fruits was associated with higher risk of developing cardiovascular diseases (CVDs) [2].
- This highlights the importance of understanding dietary patterns and nutrient adequacy among young adults in Ibadan, as low intake of vegetables and fruits can also lead to negative health outcomes.

1.4 Aim and Objectives of the Study

The aim of this study is to investigate the food environment, Nutrient Adequacy and Nutritional Status of the young adults living in Ibadan North Local Government, Ibadan.

The objectives were to:

- Determine the nutritional status of the young adults living in Ibadan North Local Government
- Assess the proportion of young adults' food environment living in Ibadan North Local Government
- Determine how the environment has affected their nutritional status

1.5 Research Questions

1. What is the nutritional status of the young adults living in Ibadan North Local Government, Ibadan. Oyo State?
2. What proportion of young adults living in Ibadan North Local Government has the food environment affected
3. How has the environment affected their health?

1.6 Hypothesis

(Null)

1. There is no relationship between Food Environment and Nutrient Intake in young adults living in Ibadan North Local Government.
2. There is no relationship between Food Environment and Nutritional Status in young adults living in Ibadan North Local Government
3. There is no relationship between Nutrient Intake and Nutritional Status

1.7 Significance of the Study

The food environment, nutrient adequacy, and nutritional status are all interconnected and play a crucial role in the overall health and well-being of young adults.

Food Environment: A healthy food environment makes it easier for young adults to make healthy choices by providing access to a variety of nutritious foods at affordable prices. The food environment refers to the sum of factors that influence people's eating habits and choices, including:

- **Availability:** The types of food available in the local area, such as grocery stores, restaurants, and vending machines.
- **Accessibility:** The ease with which healthy foods can be obtained, including factors like cost, transportation, and time.
- **Affordability:** The price of healthy foods compared to unhealthy options.
- **Marketing:** The promotion and advertising of food products, which can influence consumer choices [19].

Nutrient Adequacy: Nutrient adequacy refers to the consumption of enough nutrients to meet the body's needs for growth, development, and overall health. Essential nutrients include:

- **Protein:** Builds and repairs tissues
- **Carbohydrates:** Provides energy
- **Fats:** Provides energy and helps absorb vitamins
- **Vitamins and minerals:** Regulate various bodily functions

Nutrient adequacy is important for young adults because it supports:

- **Physical growth and development:** Adequate nutrition is essential for bones, muscles, and organ development.
- **Cognitive function:** Nutrients like iron and B vitamins support brain function and memory.
- **Immune function:** Vitamins and minerals help the body fight off infections.
- **Reproductive health:** Adequate nutrition is essential for healthy fertility and pregnancy outcomes.

Nutritional Status: Nutritional status refers to the body's overall health as a result of its nutritional intake. It can be assessed through:

- **Anthropometric measurements:** Height, weight, and body mass index (BMI).
- **Biochemical tests:** Blood tests to measure levels of nutrients like iron, vitamin D, and protein.

- **Clinical assessment:** Physical examination for signs of malnutrition, such as poor skin condition, muscle wasting, or edema.

Good nutritional status is associated with:

- **Reduced risk of chronic diseases:** Such as heart disease, stroke, diabetes, and certain cancers
- **Improved mental health:** Adequate nutrition supports brain function and mood regulation
- **Increased energy levels and physical performance**
- **Enhanced overall quality of life**

The food environment, nutrient adequacy, and nutritional status are closely linked. A healthy food environment promotes nutrient adequacy, which in turn leads to good nutritional status. Conversely, a poor food environment can limit access to nutritious foods, leading to nutrient deficiencies and poor nutritional status.

By addressing the food environment, nutrient adequacy, and nutritional status, It can help improve young adults achieve optimal health and well-being.

1.8 Scope of the Study

This study aims to investigate the relationship between the food environment and the nutritional adequacy of young adults. It will explore how factors within the food environment, such as the availability and accessibility of healthy food options, influence dietary choices and overall nutritional status in this population.

Specific areas of focus within this scope may include:

- **Food Environment Assessment:**
    - Mapping the availability and density of various food outlets (supermarkets, convenience stores, fast-food restaurants) in residential areas and near institutions frequented visited by young adults.
    - Assessing the affordability and quality of food options available in these outlets.
    - Evaluating the presence of food marketing and advertising targeting young adults, particularly for unhealthy foods and beverages [20].
- **Dietary Intake and Nutritional Status:**
    - Collecting dietary intake data through validated food frequency questionnaires or 24-hour dietary recalls.
    - Assessing nutritional adequacy using dietary analysis software to calculate nutrient intakes and compare them to recommended dietary allowances.
    - Measuring anthropometric indicators (e.g., BMI, waist circumference) to assess body composition and potential nutritional deficiencies [21].
- **Socio-demographic and Behavioral Factors:**
    - Collecting information on socio-demographic characteristics (age, sex, education, income, ethnicity) to identify potential disparities in food environment access and dietary behaviors.
    - Investigating factors influencing food choices, such as food preferences, cooking skills, time constraints, and social norms.

1.9 Limitations of the Study

Several limitations can be identified in the study examining the relationship between food environment, nutritional adequacy among young adults and also generally.

1. Measurement of Food Environment:

- **Data Sources:** Reliance on self-reported data or limited data sources can introduce biases and inaccuracies in assessing the food environment.
- **Temporal Variation:** Food environments are dynamic and can change over time, making it difficult to capture long-term effects on nutritional adequacy.

2. Measurement of Nutritional Adequacy:

- **Dietary Assessment Methods:** Self-reported dietary assessment tools, such as food frequency questionnaires or 24-hour recalls, can be prone to recall bias and underreporting, potentially underestimating dietary intake and nutritional adequacy.
- **Sample Selection:** Study focused on specific population or geographic region limiting the generalizability of findings to broader populations.
- **Cultural and Socioeconomic Context:** Food environments and dietary patterns vary across cultures and socioeconomic contexts, potentially impacting the applicability of study results to diverse populations.
- **Multiple Dimensions:** The food environment is a complex interplay of various factors, including the availability, affordability, and accessibility of healthy foods, as well as social and cultural influences on food choices.

- **Individual-Level Factors:** Individual-level factors, such as personal preferences, beliefs, and knowledge, can significantly influence dietary choices, even in the presence of a healthy food environment [22].

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Chapter Two

Literature Review

2.1 Conceptual Review

Food environment refers to the physical, economic, political, and socio-cultural context in which consumers engage with the food system to make their decisions about acquiring, preparing, and consuming food [1]. It is also a context that creates everyday prompts, shaping people's dietary preferences and choices as well as nutritional status It serves as an interface that mediates the acquisition of foods by people within the wider food system [2]. For many communities, the food environment consists of the foods they produce and those they purchase from their local markets. For others, the food environment is more global, with increasingly interconnected local, regional, and international markets[2.] The food environment consists of:

- "Food Entry Points" or the physical spaces where food is purchased or obtained [3].
- Features and infrastructures of the built environment that allow consumers to access these spaces
- Personal determinants of consumer food choices (including income, education, values, skills, etc.); and surrounding political, social, and cultural norms that underlie these interactions.

2.1.1 Elements that Influence Food Choices

The key elements of the food environment that influence consumer food choices, food acceptability and diets are:

1. Physical and Economic Access to Food (Proximity and Affordability)

2. Food Promotion, Advertising, and Information
3. Food Quality and Safety [4,5,6]

2.1.2 Availability and Physical Access (Proximity)

Food availability which means the adequate supply of food at the national or international levels, does not in itself guarantee FSN at community or household levels. Lack of access to food – in the dual sense of physical as well as economic access – can increase the risk of undernourishment as well as of obesity and diet-related NCDs, depending on the context [7,8.] Physical access to food depends first on the built environment (presence of food entry points and adequate infrastructures to access them).

2.1.3 Economic Access (Affordability)

Economic access to food (food affordability) reflects the relative cost of food compared with a household's income and purchasing power. People in LMICs tend to spend a greater proportion of their household budget on food, with people in Cameroon and Kenya spending almost half their budgets and people in Nigeria spending even more [8].

2.1.4 Promotion, Advertising and Information

Retail outlets and markets promote foods to consumers through various means, including advertising, branding, and social marketing. Simple signage, product placement, billboards, and radio and television advertisements all serve to impact food acceptability, consumer preferences, purchasing behavior, and consumption patterns, both negatively and positively.

2.1.5 Food Quality and Safety

Food quality describes the attributes of food that influence its value and that make it acceptable or desirable for the consumer [9]. This includes size, shape, color, texture, flavor, food composition (ingredients and nutrients), as well as the way food is produced or processed (i.e. “organic”, “cage-free”, and “without antibiotics”). This includes negative attributes such as spoilage, contamination with filth, discoloration, and off-odors, and positive attributes such as the origin, color, flavor, texture, and processing method of the food. Food safety describes the impact of food on human health and refers to “all those hazards, whether chronic or acute, that may make food injurious to the health of the consumer. It refers to ways to prevent food-borne diseases, arising from food contamination with pathogens or chemicals, during the production, processing, storage, transport, and distribution of food, as well as in the household. It also refers to the standards and controls that are in place to protect consumers from unsafe foods. Food safety is inextricably linked, with unsafe food creating a vicious circle of diseases (such as diarrhea) and malnutrition, affecting particularly the more vulnerable (including children, the elderly, and the sick) [10].

2.1.6 Improve the Quality of Food Environments to Enhance Good Nutrition

Cash and Food Security Advisors should consider the opportunity to elaborate voluntary guidelines on improved food environments for healthy diets. States, Intergovernmental Organizations, the private sector, and Civil Society Organizations should[11]:

a) Make nutritious foods more accessible and convenient in public places (schools, hospitals,

etc.), as well as in home and school gardens, and rural marketplaces to provide greater dietary diversity and quality.

b) Design and implement policies and regulations that improve the built environment to promote nutritious food, including zoning regulations and tax regimes to minimize food deserts and swamps.

c) Regulate health claims on food packaging and adopt a front-labeling system that is easy to interpret [12].

d) Strengthen national food safety standards and quality assurance and develop better global surveillance systems for real-time information.

e) Phase out advertising and promotion of unhealthy foods, especially to children and adolescents [13].

2.1.7 Home Food Environment

The dietary guidelines for Americans recommend all Americans have a role in creating and supporting healthy eating patterns and consuming varied, well-balanced diets to promote well-being and healthy weight and prevent disease [1]. Portion control and limiting added sugars are particularly important [1]. Yet, only 25% of children aged 6 to 11 years meet daily fruit recommendations and 20% meet recommendations for vegetable intake [2]. Consumption of sugar-sweetened beverages (SSBs) and foods prepared away from home, which are often less nutritious, have increasingly contributed to children's total energy intake over the past several decades [3,4]. Thus, efforts to decrease SSB consumption and increase healthful meals

prepared at home are needed. Children's dietary intake is influenced by both physical and social home environments (e.g home food environment) [5]. Parents and other caregivers contribute to children's eating habits and diet quality through physical environments by making healthful foods available in the home and serving them at meals and snacks [6,7]. Almost 70% of calories and 80% of snacks consumed by children are eaten at home [8,9,10].[11]. Similarly, the mealtime setting is also important concerning dietary intake. For example, eating meals while watching television is associated with poorer dietary quality among youth [12]. Moreover, family meals in the home provide an opportunity for parents to support healthy eating through role modeling, which is important for children's development [13,14]. Yet, research has shown parents often report barriers to healthful eating due to lack of time for meal preparation, children's characteristics and preferences [15,16,17].

Conflicts associated with children's food likes and dislikes are therefore, programs promoting healthful home food environments and social interactions may be useful to support children's dietary quality [18,19]. To support parents and caregivers in overcoming barriers to meal preparation and address children's food preferences, engaging families to work together to develop healthful home food environments and prepare healthful meals is critical. In particular, interactive, engaging nutrition education sessions focused on awareness and identification of appropriate portion sizes, meal planning, and preparation skills that build self-efficacy may help parents establish and/ or maintain healthful home food environments [20,21, 22]. These experiential activities may also foster healthful food preferences and eating behaviors in their children [23]. Consensus building is effective for empowerment and cooperation [24]. Thus, involving all children and adults in the household in activities and family goal setting may make behavior change easier and more effective [25]. Furthermore,

children may be more likely to accept more healthful foods at meals and snacks when they assist in food preparation[26,27,28]. Meal preparation training could also provide children with life skills to sustain healthful behaviors [29,30]. Efforts to reduce eating family dinners while watching television (i.e, reducing screen time by improving the mealtime setting) may also improve children's dietary quality [31,32].

2.1.8 School Food Environment

Diets of most children and adolescents (hereafter referred to as children) remain poor, with tremendous consequences for metabolic diseases, overweight and obesity, and other nutrition-related illnesses [33,34]. Childhood is also a critical period to establish lifelong eating habits which influence the future risk of obesity and cardio-metabolic diseases [5,6,7]. Youth consume between one-third to one-half of meals at school, making this a crucial setting for interventions that alter the food environment [8]. Considering that almost all children obtain some years of schooling, and of diverse ethnic and socio-economic groups, health promotion efforts in schools could have a broader impact on eating behaviors and future disease risk [9].

2.2 Empirical Review

Promising school food environment policies include direct provision of healthful foods/beverages such as fruits and vegetables (F&V), quality standards for competitive foods and beverages (foods and beverages sold outside of school meal programs), and quality standards (targets for foods, nutrients/energy) for school meals (lunch, breakfast) [35]. For example, in 2008, a US Fresh Fruit and Vegetable Program (FFVP) was expanded nationally for elementary schools with the highest low-income enrolments to provide free F&V to

students outside usual school meals and in 2007, a similar free school fruit program was implemented in Norway to provide daily a free piece of fruit or vegetable to all secondary school students. The Healthy, Hunger-Free Kids Act in 2010 introduced Smart Snack Standards for competitive foods and beverages in schools receiving federal meal funding, including restriction of sugar-sweetened beverages (SSBs) to be fully implemented by 2014–2015. In 2012, US National School Lunch and School Breakfast Programs nutrition standards were significantly updated to be more consistent with US Dietary Guidelines and in 2015 the UK Department of Education mandated revised standards for all food served in schools [36].

Yet, the effectiveness of these food environment policies for improving children's habitual dietary habits, adiposity, or metabolic risk is not well-established. Understanding these effects is critical to estimate the benefits of existing programs as well as the need for their expansion; to elucidate potential harms from their elimination as suggested by potential new federal priorities in the US [37]. Prior studies have reviewed whether a range of school dietary interventions increases F&V consumption but often without focusing on environmental policies while other systematic reviews have been qualitative assessed the efficacy of competitive food/beverage standards informed mainly by the cross-sectional studies or focused on educational (rather than environmental) interventions [38]. Other reviews have grouped highly varied programs, e.g., teacher training, child education, family components, labeling, pricing changes, behavioral techniques, and school gardens [39]. Thus, the effectiveness of school food environment policies remains unclear, including potential differences in in-school vs. habitual (within and outside school) intakes. To address these gaps in knowledge, we systematically investigated and quantified the effects of school food environment interventions -carefully exploring sources of heterogeneity, including provision

of healthful foods/beverages, competitive food/beverage standards, and school meal standards, on habitual and in-school dietary consumption, adiposity, and metabolic risk factors in children [40].

2.2.1 Improving School Food Environment

Making healthful food choices is an essential part of a healthy lifestyle [41]. However, diets that were consumed by most American children are not consistent with the Dietary Guidelines for Americans [42]. Children's consumption of vegetables, fruits, and whole grains is substantially less than recommendations, and consumption of discretionary calories from solid fats and added sugars exceeds recommendations by a wide margin [43]. Poor dietary habits, coupled with low levels of physical activity, have contributed to a dramatic increase in the prevalence of childhood obesity over the last 4 decades. In 2007-2008, the prevalence of obesity among children aged 6 to 11 years was five times what it was in 1971-1974 (20% and 4%), and the prevalence among adolescents aged 12 to 19 years was approximately 3.5 times higher (18% and 5%) [8,9]. Schools are in a unique position to influence children's food choices daily and to potentially contribute to the development of healthful dietary habits and preferences [44]. Indeed, schools have been identified as an important setting for implementing strategies to prevent and reduce childhood obesity. Given that the average child obtains more than one-fourth (26%) of total energy intake from foods that were both obtained and consumed at school, schools have the potential to promote substantial change in children's dietary intakes. There are two primary avenues through which schools can influence children's diets [45].

One is the federally sponsored school meal programs (the National School Lunch Program [NSLP] and the School Breakfast Program [SBP]).

The other is "competitive" foods, which are foods that are sold, served, or given to students in schools but are not part of the school meal. Ninety-four percent of all schools, both public and private, participate in the NSLP, and approximately 85% of all public schools that offer the NSLP also offer the SBP [46].

Every child in a participating school can obtain a school lunch or breakfast, and children from low-income families are eligible to receive meals for free or to purchase them at a reduced price. These programs serve meals to millions of children every school day (an average of 31.3 million lunches and 11.1 million breakfasts per day in fiscal year 2009), and a majority (62.5% of lunches and 82.1% of breakfasts) are served to children from low-income families, who are at greatest risk of obesity [47]. Using data from the third School Nutrition Dietary Assessment Study (SNDA-III), it was found that students who participated in the NSLP obtained 35% of their daily dietary energy from foods obtained and consumed at school, and those who participated in both the NSLP and SBP obtained 47% of their energy from such foods [14]. Since the mid-1990s, when findings from the first SNDA study (SNDA-I) indicated that school meals were high in total fat, saturated fat, and sodium relative to the Dietary Guidelines for Americans the US Department of Agriculture (USDA), which administers the school meal programs, has launched several initiatives to improve the quality of school meals. These included establishing new nutrition standards that require that meals meet the 1995 Dietary Guidelines' recommendations for total fat and saturated fat, providing training and technical assistance to help school food service personnel prepare healthier meals and promote healthy eating behaviors among children, and improving the healthfulness

of commodity foods offered to schools [48]. It was showed that meals were lower in total fat and saturated fat, relative to SNDA-I, but there was still substantial room for improvement [13,25].

Most recently, the USDA implemented the Healthier US Schools Challenge, a program that recognizes schools that provide healthy school environments through the promotion of good nutrition and physical activity [26,27]. In addition, the USDA commissioned the Institute of Medicine (IOM) to recommend revised meal requirements and nutrition standards for school meals [12]. The IOM report was released in early 2010 and the USDA is currently assessing the recommendations and developing new regulations. It was also demonstrated that a strong commitment to improving the nutritional quality of school meals, calling for increased funding of $10 billion over the next 10 years to ensure that schools have the resources they need to make necessary changes, including adequate kitchen equipment and federal reimbursement [16.] The IOM report suggested that the USDA increase the frequency with which states monitor the nutritional quality of meals offered by schools [28]. Such a change would increase the likelihood that schools will meet standards by providing needed support and technical assistance on a more timely basis. The SNDA studies, which USDA conducts approximately every 5 years, are an important tool in monitoring progress in improving the nutritional quality of school meals [49]. Currently, the USDA has little control over competitive foods. It has no authority over foods that are sold outside of the school cafeteria, and can only restrict sales of so-called “foods of minimal nutritional value” within school cafeterias during mealtimes.

The standards used to define foods of minimal nutritional value are conservative, from a nutrition point of view, and exclude a limited number of foods, including soft drinks,

water ices, gum, and some candy. Competitive foods may be sold on an à la carte basis in cafeteria lines or other locations on school campuses; purchased through vending machines, school stores, or fundraising events; or provided to children as rewards or snacks or through classroom parties, school celebrations, or other activities [49].

Research has shown that competitive foods are widely available in schools and tend to be high in energy from fat and/or sugar and low in nutrients [29-37]. On average, children who consume competitive foods take in more than 150 calories from such foods in a day. In addition, the availability of competitive foods has been shown to have a negative influence on the quality of children's dietary intake. For example, It was found that the availability of competitive foods was associated with decreased intakes of fruits and vegetables and increased intakes of total fat and saturated fat [50]. It was also found that fifth-grade students who had access to snack bars in middle schools consumed less fruit, non-fried vegetables, and milk and more sweetened beverages than they had as fourth graders in elementary school, where snack bars were not available. Congress required that school districts participating in the school meal programs develop school wellness policies [38]. These policies must include goals for nutrition education, physical activity, and other school-based activities, and nutrition guidelines for all foods available on school campuses during the school day. In addition, state legislatures across the country have been actively engaged in considering and enacting legislation designed to influence school food policies and environments. Despite widespread interest in leveraging school environments and policies to address the problem of childhood obesity, there is little information available about whether such policies are effective and, if they are, which ones have the greatest potential to affect children's diets and

thereby prevent or reduce obesity. school food practices that "supported frequent snacking and the consumption of foods and beverages high in calories and low in nutrients" [51].

These practices included allowing students to have food in the classroom, allowing students to have beverages in the classroom, allowing students to have snacks in the hallways, allowing students to have beverages in the hallways, using foods or food coupons as rewards or incentives, allowing classroom fundraising that included food sales, and having school-wide fundraising that included food sales. Data was combined on school food policies from the 2000 School Health Policies and Programs Study, aggregated to the county level, with student-level data from the National Longitudinal Study of Youth 1997 to examine the relationship between the availability of "junk food" (chocolate, candy, cakes, ice cream, or salty snacks available for purchase from a machine or school store), pouring rights contracts (a pouring rights contract grants exclusive permission to a beverage manufacturer or bottler to control beverage distribution in a school district or school), and soda or snack food advertisements and children's BMI [51, 4]. They found that a 10–percentage point increase in the proportion of schools in a county that allowed children access to "junk foods" was associated with a 1% increase in the average BMI among all children in the county. The effect was entirely driven by students who had an overweight parent; there was no effect among students with normal-weight parents. Children who attended middle schools that did not have school stores or snack bars, did not have pouring rights contracts, or did not have à la carte offerings in the school cafeteria consumed considerably fewer calories from sweetened beverages obtained at school than children who attended schools with these characteristics [42].

The relationship between the availability of school stores and snack bars and calories from sweetened beverages was also observed among high school students. The authors also found that children in elementary schools that did not offer French fries or similar potato products in school lunches consumed fewer total calories at school from low-nutrient, energy-dense foods extended this analysis to examine the relationship between school food environments and BMI [43]. They found that among elementary school children, offering french fries and similar potato products in subsidized school meals more than once per week and offering dessert more than once per week were each associated with a significantly higher likelihood of obesity. Among middle school children, the availability of low-nutrient, energy-dense foods in vending machines in or near the food service area was associated with a higher BMI z score, and the availability of such foods for a la carte purchase in the cafeteria was associated with a lower BMI z score. The impact of any policy directed at the school food environment is likely to be affected by how well the policy is written. The federal requirement for school wellness policies provides directives about the issues these policies must address but does not provide specific standards that must be met [32]. As pointed out, there are pros and cons to this inherent flexibility. On the positive side, local development of policies provides an opportunity for involvement and buy-in of key stakeholders, including parents, students, teachers, school food service staff, school and district administrators, and the broader community. On the negative side, the lack of minimum national standards creates wide variation across districts and has led to the creation of some extremely weak policies. Several tools have been developed to assess the relative strength and comprehensiveness of school wellness policies, including policies that target the availability and nutritional quality of competitive foods [44]. Researchers and other nutrition

professionals interested in assessing the effectiveness of policies targeting competitive foods should carefully examine the rigor of these policies to draw sound conclusions. The association between policy rigor and the availability of "junk" food in vending machines and school stores [49].

In the issue of the Journal, Bullock and colleagues describe the Food and Beverage Environment Analysis and Monitoring System (Food BEAMS), a Web-based tool can be used to conduct a comprehensive inventory of competitive foods available in schools [50].

The National Collaborative for Childhood Obesity Research (NCCOR) is working toward promoting the consistent use of common measures and methods across childhood obesity prevention and research at the individual, community, and population levels. As the first step in this process, NCCOR is developing a registry of existing measures and documenting information about their reliability and validity as well as information about cultural sensitivity and administration requirements. This will include information about tools used to assess food environments in a variety of settings, including schools. Making positive changes in the types of foods types of foods available would enhance this important area of research and should be encouraged [51].

2.2.2 Importance of Food Systems and the Environment for Nutrition

For clinical nutrition to be impactful, it is essential to consider how the broader food system affects the diets, nutrition, and health outcomes of populations [52]. There is considerable debate on how food systems can be better positioned to provide safe and healthy diets and support human health in a way that is environmentally sustainable and resilient to climate change, as well as other disruptions and shocks [1.] As The American Journal of

Clinical Nutrition (AJCN) embarks on new territories, it is only fitting that the Journal delves into the relationship between food systems and dietary, nutritional, and environmental outcomes. Food systems involve the production, processing, packaging, distribution, marketing, purchasing, consumption, and waste of food [22, 53]. There remain many research questions and gaps in evidence on how to transform food systems so that they benefit both human nutrition and health while protecting ecological resources, supporting livelihoods and affordable foods, and upholding social, cultural, and ethical values [54].

2.2.3 Impacts of Climate and Environmental Change on Health and Nutrition

Climate and environmental change are and will continue to affect human health on a grand scale. As climate change progresses, the environmental conditions needed for optimal human health will come under threat, including clean air, drinkable water, low pathogen exposure, and the ability to produce, raise, harvest, and gather crops, animals, seafood, and wild foods in sufficient and safe quantities and/or qualities. Climate change introduces instability into the food supply, raises prices of food, and ultimately reduces access to nutrient-dense and healthy foods for certain populations [55]. E.g: rising sea temperatures are affecting marine life and threatening fish populations, a major source of protein, essential fatty acids, and micronutrients for many around the world. The impacts of lost biomass from the oceans are expected to disproportionally affect countries in the global South [56]. Some models suggest that changes in food availability due to climate change, specifically reduced availability of fruit and vegetables, are estimated to result in an additional 529,000 deaths by 2050 [16]. Climate change will likely affect the nutritional status of all populations, but it will continue to have a disproportionate impact on poor and marginalized populations, widening

existing equity gaps in nutrition and health outcomes. Climate change has the potential to increase the prevalence of under nutrition by affecting the immediate, underlying, and basic causes outlined in UNICEF's conceptual framework for maternal and child nutrition [10]. Examples at each level include facilitating optimal conditions for infectious diseases; reducing household food security; and altering livelihoods, particularly of those in the agricultural sector [57]. Nutritionally vulnerable populations, including pregnant and lactating women, infants, and small children, are likely to be the most affected by these trends; the International Food Policy Research Institute's IMPACT model predicts that under conditions with limited intervention to mitigate climate change, there will be an additional 4.8 million undernourished children by 2050 [58].

2.2.4 Role of Food Systems, Agriculture, and Diet on the Climate and Environment

The relationship between food systems and the environment is complex because environmental changes are both a driver and an outcome of food systems [59]. Environmental inputs such as soil and water quality, weather patterns, and temperature influence food systems through their impact on the production, storage, and transportation of food. This, in turn, affects localized food environments—the place or places where consumers interact with the food system to buy and consume food (including markets, restaurants, and cafeterias, for example; by influencing food availability, quality, safety, and affordability [60]. Proximal outcomes of food systems include increased or minimized exposure to contaminants, diet quality, and food loss and waste. Each of these proximal outcomes affects both human and environmental health outcomes. Food systems exemplify the characteristics of complex systems, including the existence of feedback loops. One important feedback loop in the food

system is that environmental outcomes affect environmental inputs; for example, GHG emissions from food production and waste affect temperatures, and eutrophication from agricultural runoff affects water quality [61]. In the context of food systems, resilience has been characterized as the ability to provide safe and sufficient food to all, not only in times of normalcy but also in times of disturbance and shocks to the system [62]. Although shocks to the food system can include natural disasters, pandemics, economic instability, and political or social unrest, shocks can also include environmental stressors that push beyond the boundaries of the system.

The COVID-19 pandemic is demonstrating the fragility of certain parts of current food systems and underscoring the interconnectedness of each component of the food system [34]. Numerous reports have measured the impact of food systems on the environment. Globally, agriculture and livestock production utilize ~40% of arable land, account for ~70% of freshwater withdrawn for human purposes and are responsible for ~11% of GHG emissions (although some estimates range from 11% to 24% depending on what is counted). Of all GHG emissions from the food system, 80%– 86% come from agriculture (with the remaining food systems– related emissions coming from food processing, packaging, transportation, or retail) [63,34,12.]. Expanding agricultural land use is a major contributor to rising carbon dioxide concentrations in the atmosphere, biodiversity loss due to deforestation, and draining of wetlands. Furthermore, the use of synthetic fertilizers—which contain high concentrations of nitrogen and phosphorus—is a significant source of eutrophication globally [64]. Climate change puts the quantity, quality, stability, and safety of the global food supply at risk [14.]. Changes such as rising temperatures, increasing atmospheric carbon dioxide, rising sea levels, and changing weather patterns all affect the functionality and efficiency of food

supply chains [38]. Because optimal food production requires specific conditions (for example, certain crops or pests may thrive in a narrow band of temperatures), disruptions to environmental conditions can negatively affect crop yields, the nutrient content of crops, and the broader ecosystems that support food production and livelihoods [20]. Climate forecasting models estimate that average land temperatures will increase in the next 100 years [29]. As land temperatures increase, certain areas of the globe, particularly tropical low-latitude areas, will experience decreased crop yields, whereas higher-latitude areas may experience increased yields in the short term. Lower yields and instability of production, in turn, threaten food security and nutrition by increasing food prices, which can affect the dietary diversity of poor households. In addition, geospatial differences in crop yields may result in greater reliance on a global rather than on a local food supply, which in turn may affect the equity of food distribution, food sovereignty, and the sustainability of food systems. Although rising atmospheric carbon dioxide may stimulate photosynthesis and improve the water efficiency of crops simulation models suggest that potential gains in crop yields from rising carbon dioxide will not fully offset diminished crop yields due to rising temperatures and other environmental consequences of climate change [44,65].

The increased climate disruption, the protected purchasing power of wealthier populations could leave those who are poor more food insecure because of their inability to access and afford food. The impact of floods and heat stress will affect the health and welfare of animals as well [46]. In addition to affecting the quantity of food, rising atmospheric carbon dioxide concentrations may also diminish the quality of food. Certain staple crops such as rice and wheat have decreased protein, iron, and zinc content when grown under high carbon dioxide conditions [66]. Even if the decrements in micronutrient content are minor, they may

disproportionately affect populations of lower socioeconomic status whose diets rely predominantly on nutrient-poor staple grains. When combined with rising food prices, particularly for more nutrient-dense foods that are already out of reach, this may worsen the risk of micronutrient deficiencies among more vulnerable populations [67]. The effects of climate change on human health are not limited to impacts on crop yields and the nutrient content of those crops. Temperature increases will also result in the proliferation of pests and pathogens in ways that may harm both crop production and human health. For example, aflatoxins— carcinogenic and immunosuppressive pathogens produced by certain molds— afflict crops such as maize and peanuts in tropical regions of the world and their consumption may be associated with increased risk of morbidity and mortality, poor pregnancy outcomes, and child growth [68]. Researchers predict that aflatoxins may become a more prevalent food safety issue even in temperate regions where aflatoxin exposure has typically not been a concern, e.g for maize grown in Europe [69]. Finally, warmer weather and increased atmospheric carbon dioxide facilitate harmful algal blooms that produce toxins, which can have negative impacts on the ability to access blue (aquatic) foods for diets, human and marine health, and significant economic consequences [70].

2.2.5 Impact of Climate Change Control on Food Environment

National governments have been negotiating a response to climate change for nearly 3 decades, since the adoption of the UN Framework Convention on Climate Change [71]. Yet states have still not reached a binding international agreement with provisions to avert environmental disaster [54]. At the Paris climate conference in 2015, 196 states agreed on a goal to keep average global warming but national pledges added up to only one-third of the

emissions reductions required to meet the Paris deal's goal. However, over the years, it has been discovered that increased attention from both nutrition and environmental scientists on the relationship between food systems and the environment. Landmark reports on the causes and consequences of climate change have highlighted the importance of food systems and human diets for planetary health [72]. The cyclical nature of the relationship between the environment and nutrition demands that nutrition scientists engage in food systems transformation to improve the diets of the current population while conserving natural resources for the diets of future generations [73]. Nutrition scientists are in a unique position to contribute to collaborative efforts that support both human and planetary health. Nutrition is inherently a multidisciplinary science with a wide umbrella that includes expertise ranging from molecular biology to community-level behavior change communication. In addition to encouraging dietary shifts that support both human and planetary health, nutrition scientists can collaborate with other disciplines to connect the dots between human health and efforts to promote sustainable agricultural practices, reduce food loss and waste, improve food processing or packaging, and conserve resources in foodservice settings and food environments [56,57].

Nutrition scientists have been traditionally silted into those who study under-nutrition and food insecurity and those who study overweight, obesity, and diet-related non-communicable diseases (NCDs) [74]. There is a disconnection between those who work on nutrition within a humanitarian context and those who focus on prevention or long-term development issues related to under-nutrition [60]. Given that many of the challenges we face are global, and with rapid convergence in the type of diets being consumed and growing commonality in the type of disease burdens faced in both low- and middle-income countries

(LMICs) and high-income countries (HICs), these traditional boundaries may adversely affect our ability to identify and implement public health interventions relevant to the field [75]. Because of the nature of food systems complex and interconnected with multiple drivers, outcomes, and stakeholders, we cannot gain a better understanding of interventions and policies that will reduce all forms of malnutrition and mitigate environmental consequences without a systems approach that facilitates collaboration between experts in under-nutrition, overweight and NCDs, environment, climate, and agriculture. Many gaps in our knowledge persist on the relation between environmental factors, food systems, and nutritional outcomes [76]. Evidence is just beginning to gather as nutrition research embraces a more inter-and trans-disciplinary approach to improve diet quality and reduce all forms of malnutrition [77].

2.2.6 Environmental Inputs and Food System Processes

Thus far, most research on the connection between food systems and nutrition has focused on the "ends" of food systems: agricultural production and consumer dietary intake. However, a host of other activities exist between the farm and the fork that affect nutrition and health, which some have referred to as the "missing middle" of the food supply chain [2,78]. Issues such as food processing and packaging, postharvest loss along the supply chain, and food distribution mechanisms all have an important bearing on nutrition and health outcomes [79.] Most research on the impact of climate change on the nutrient content of crops has focused on staple crops; to date, very few studies have examined how climate change may influence changes in the production and consumption of non-staple food groups [80]. More research is needed on how different kinds of crops particularly those that are nutrient-dense such as fruits, vegetables, and legumes will fare in a +2◦C environment. Understanding how nutrient

content may differ in food grown under various climate change conditions will be vitally important for policies and interventions designed to promote diet quality and reduce the prevalence of micronutrient deficiencies. Similarly, there is a need to better understand the relationships between climate and food production more broadly. For example, how is climate resilience in agriculture affected by the scale of food production, the extent of trade, or the amount of bio-diversity. In addition, further research is needed to identify and measure sustainability within food environments. An individual's food environment influences the food they choose to purchase and consume [81].

Sustainability has not been incorporated within traditional food environment frameworks [74]. But as more research and policies consider the sustainability of dietary patterns, so therefore is a need to understand how food environments should be designed to address both health and sustainability. These measures include the ecological footprint of foods available within an environment (with metrics including water, land, and GHG emission footprints), the amount and type of packaging companies and retailers use, the availability of combined eco- and health labeling on food packages, the availability of consumer-facing information on food sourcing and origins, food safety labels and checks, and minimization of food waste in food environments [82.]. Governments may also prioritize the importance of sustainability relative to the food security of their populations very differently depending on the dominant problem they are trying to solve, leading to different policy choices [83]. A growing area of research is how climate change may affect food purchasing behaviors and whether environmental sustainability is a motivation for behavior change among food systems stakeholders, including consumers. For stakeholders involved in food production and supply chains, how might economic incentives or other measures

increase the adoption of practices that benefit human health while stewarding ecological resources. For consumers, how environments can motivate behaviors differ between various age groups, socioeconomic classes, and in different country contexts [84].

2.3 Proximal Outcomes of the Food System

2.3.1 Diet.

Shifting dietary intake at the population level is a formidable challenge, regardless of whether it is motivated by health, environmental, or other reasons. In the United States, for example, diets do not align with the Dietary Guidelines for Americans, as illustrated by the nationwide average Healthy Eating Index-2015 score of 56.6 out of 100 [85]. Human dietary behavior is complex, and the extent to which it is driven by social norms related to environmental impact compared with health or other motivations is uncertain and an important topic for further research. One environmental motivation for dietary change is related to a question of resource use: even if the food system can produce adequate calories for a growing global population, can food production systems keep up with the demand for more resource-intensive foods? Rising incomes worldwide may increase the demand for animal-source foods by 70%, which tends to have the highest environmental impact depending on where and how food is grown and raised [7]. To effectively change dietary intake, we need a comprehensive understanding of what people consume. Global dietary intake data that are nationally and sub-nationally representative remain sparse [86]. Most countries doesn't consistently and systematically collect individual dietary intake data, and the data that do exist are often based on models relying on household expenditure and consumption survey data, food balance sheet data, and/or data from subpopulation nutrition surveys [79,80].

Although these modeled estimates may give us a sense of dietary intake and patterns of consumption, they are an uncertain substitute for robust, representative individual dietary intake data reflecting recent consumption patterns at a national level. The collection of robust longitudinal dietary data will also allow researchers and policymakers to better understand how diets are changing over time and why. Since the early 1990s, researchers have been notified that diets are rapidly changing globally [81]. But surprisingly little evidence has been collected to document this change and identify the primary drivers of change. Given that dietary factors are a leading cause of the global burden of disease [87]. The time for a systematic global effort to understand how diets are changing is overdue. There is a long, tangled history of discussions, definitions, and metrics around sustainable diets [88]. It was highlighted the human footprint on the environment, and Diet for a Small Planet politicized the impact of large-scale animal production on natural resources. Joan Dye Gussow's work on "ecological nutrition" in the 1970s stressed the unsustainable nature of the United States food systems [83.]. Since that time, a growing body of literature has bridged the disciplines of public health, environmental sciences, and ecology. The terms may have changed eco-nutrition, sustainable diets, public health ecology but the topic continues to be in the spotlight owing to the growing severity of climate change in the last 20 years and increased public awareness of the contribution of food systems to environmental degradation. Notably, the UN has not reached a consensus on an agreed definition of sustainable diets, although draft definitions have been developed. The definition drafted by the FAO in 2010 did not provide substantive guidance on what specifically constitutes a sustainable diet from an environmental, biological, cultural, and health standpoint [89]. A second attempt was made in 2019 when the FAO and WHO established guiding principles for sustainable and healthy

diets [85]. These guiding principles are a set of broad qualitative recommendations but may not be useful for quantitively assessing if a diet is sustainable. At the same time, Food in the Anthropocene: The EAT-Lancet Commission on Healthy Diets from Sustainable Food Systems published in 2019 [90]. It was proposed a healthy reference diet that could meet both human and planetary health needs. Although the Commission report had serious limitations [91]. It was called for a grand food system transformation and laid out a roadmap for this transformation, starting with significant changes to what is currently consumed around the world. One of the shortcomings of the EAT-Lancet Commission report was that it provided a single healthy reference diet for the world, and did not take into account that healthy and sustainable diets may differ in their availability, accessibility, and cost at the global, regional, and individual levels [91]. Even more so, what is considered healthy is not always sustainable, and what is considered a sustainable diet is not always a healthy one [92]. Moving forward, nutrition scientists need a better understanding of how diets are changing, more scientific consensus on definitions and metrics to assess the sustainability of dietary patterns, and methods to test the effectiveness of interventions to promote diets that are both healthy and sustainable [93].

2.3.2 Food Safety in the Food System.

Human exposure to harmful chemical and biological agents occurs throughout multiple stages of food supply chains. In food production, agricultural workers may be exposed to high amounts of pesticides or other agrochemicals, which are associated with increased risk of poisoning, decreased fertility, and potential increased risk of cancer and

diabetes [89,90,91]. More research is needed on the nutrition and health effects of pesticide usage [92].

Most particularly in LMICs, where a significant proportion of the population depends on agriculture for their livelihoods. Currently, few studies have explored the relationship between pesticide exposure and adverse maternal and nutritional outcomes in LMIC settings [91,93].

Because pesticide and chemical regulation varies from country to country, it is important to have representative data regarding the health and nutritional risks associated with pesticide and chemical use and exposure within the food system [94,95]. It is also critical to assess the extent to which consumer perceptions of pesticide, chemical, and antimicrobial exposure may influence food purchasing decisions [96]. Information regarding food safety and its impacts on producer behavior, consumer awareness, and consumer behavior is limited, particularly in Sub-Saharan Africa and Asia [97]. The world's reliance on plastics for production, manufacturing, and packaging has made plastics ubiquitous in the environment and, in turn, in food systems. Plastics enter food systems directly through food packaging or indirectly through the environment. As countries develop longer supply chains, packaging becomes necessary to preserve shelf life. Plastic packaging can lead to exposure to chemicals such as Bisphenol A and phthalates, which have been linked to increased risk of obesity, cancer, and diabetes [98,99,100]. Although some governments in HICs have mandated more regulation over these chemicals, in many instances they are replaced by structurally similar chemicals that may have similar or worse health effects [101]. On the other hand, little is known about the use of these chemicals in food packaging in LMICs, and more research is needed to

assess the prevalence of exposure, and potential health outcomes, and to find solutions to reduce these exposures [102]. More distal sources of plastic enter the food supply when discarded plastic breaks down into particles known as micro-plastics and these are released into the surrounding environment. The prevalence of micro-plastics has been documented in oceans and marine life, but currently, little evidence is available on how micro-plastic consumption affects human health [103].

2.3.3 Food Loss and Waste

Food loss typically refers to losses that occur earlier in the supply chain between the farm and the retail market. Food waste typically refers to food discarded at the retail or consumption phase of the food supply chain. Food loss and waste increase the environmental footprint of food systems owing to methane emissions from the breakdown of organic materials in landfills and owing to the natural resources embedded in the production of wasted food. Food loss and waste also expose inequities in access to safe and healthy foods and represent a missed opportunity for nutrition. Food waste is nutrient waste. In the United States, nutrient-rich foods such as animal-source foods, fruits, and vegetables account for >70% of food loss and waste [104]. Food waste at the retail and consumer levels alone averages 1217 calories, 33 g protein, 6 g fiber, and 286 g Ca per person per day. What does nutrient waste look like in other countries, especially those with a higher prevalence of micronutrient deficiencies? There is a need for more accurate data on the scale of food loss and waste globally and sub-nationally, and a need for research to identify cost-effective policies and interventions to reduce food loss and waste. The FAO has established 2 new indexes to measure food loss and waste. The food loss index estimates that 14% of the

world's food produced is lost up to the retail level, with South and Central Asia experiencing the most significant losses of ≤20%. The food waste index will be published later this year [105].

2.4. Distal Outcomes of Food Systems

2.4.1 Nutrition and Health Outcomes.

The Global Syndemic Commission recently published a report in The Lancet in which they defined the "syndemic" the consequences of under-nutrition, overweight/obesity, and climate change as being related, interactive, and bound. The authors make a strong case with the support of other studies that climate change will diminish projected reductions in under-nutrition [59]. Policymakers and researchers have noted that many policies and interventions to address obesity may also have simultaneous positive effects on climate change progression, but more evidence is needed on how climate change may affect obesity prevalence and how the rising prevalence of obesity affects climate change. Furthermore, there are uncertainties about the impacts of environmental degradation and climate change on micronutrient deficiencies. Plenty of research is emerging on the micronutrient content of foods with increased temperature changes and the carbon dioxide fertilization effect earlier described, but much less so on the impacts that climate change may have on the micronutrient status of populations [60,106].

2.4.2 Environmental Outcomes.

The effects of food systems on environmental outcomes may vary by region and by method of food production. Many data gaps and methodological gaps remain in our understanding of how different foods, food groups, and dietary patterns affect a suite of environmental

outcomes, including GHG emissions blue and green water use, land-use change and deforestation, eutrophication, and acidification. These effects, of course, depend on how food is grown, where, and by whom. For example, the livestock animal systems of Brazil have very different water and land use footprints than a pastoralist system in Northern Kenya [107]. Tomatoes grown in hothouses have a different GHG profile than tomatoes grown in Southern California. Our current knowledge of the environmental footprint of food is limited by the fact that most data to date focus on a few specific foods (livestock and staple grains), on a few specific environmental stressors (namely GHG emissions), and mostly on HIC settings. There is a need for the nutrition community to work with climate and environmental scientists to go beyond global and regional averages and understand how healthy and unhealthy dietary patterns and the foods that comprise those diets affect the environment in more localized contexts. For example, a given dietary pattern may have a low average environmental impact at the global level; but what is the environmental impact of that dietary pattern in a specific region, and how might that dietary pattern align with the nutritional needs of specific subpopulations such as hospital patients or university students? A higher resolution of data is required before dietitians and other nutrition professionals are equipped to make menu planning or nutrition education decisions that appropriately reflect both health and environmental considerations [107].

2.5 Food Environment In Low and Middle-Income Countries

Food environment research is gaining prominence in low and middle-income countries (LMICs) at the start of the UN Decade of Action on Nutrition 2016–2025. Policymakers seeking to tackle global food and nutrition security and the double burden of malnutrition are

increasingly turning their attention to the role that food environments play in shaping diets, nutrition, and health in these settings. Food environments have been described as the interface where people interact with the wider food system to acquire and consume foods. Recent conceptual work has sought to define external and personal food environment domains applicable to global settings. The external domain features exogenous dimensions such as food availability, prices, vendor and product properties, and marketing and regulation, whereas the personal domain consists of individual-level dimensions, including food accessibility, affordability, convenience, and desirability. Improved knowledge and understanding of the interactions between these domains and dimensions are needed to address the double burden of malnutrition in LMICs, characterized by persistent under-nutrition amongst women and children, as well as the increasing prevalence of overweight, obesity, and nutrition-related chronic diseases (NRCDs). Food environment research has improved over recent decades within high-income countries (HICs) in response to the high prevalence of overweight, obesity, and NRCDs. Several systematic reviews have documented research methods and measures from HICs, as well as findings related to diet and nutrition outcomes [108]. However, in the absence of a systematic review of the literature from LMICs, little is known about the state of science and the emerging body of evidence from these settings. This is a significant research gap given the fundamental differences between HICs and LMICs concerning food systems, food environments, food acquisition and consumption practices, and public health nutrition challenges.

2.6 Nutritional Adequacy

Poor eating behaviors can be defined as eating behaviors that lead to increased consumption of foods high in calories, sugar, salt, and fat, which are important determinants of health among young people. Consumption of these foods is associated with the onset of several adverse health outcomes including obesity and early indicators of cardiovascular disease and type 2 diabetes. Young people who frequently eat at fast food restaurants have poorer diets than those who eat at these restaurants less frequently. Although there is a lack of analogous research on food purchases at convenience stores or coffee/donut shops, the increased consumption of sugar-sweetened beverages and snack foods .

Over the years it has been suggested that these food retailers may also influence eating behaviors. Since young people spend a large portion of their day at school, the school food environment may impact their eating behaviors and diets. Most research on the school food environment has focused directly on the school itself (e.g., cafeterias, vending machines). However, many students are permitted to leave school grounds during the school day and have access to nearby food retailers. There is sometimes a preponderance of fast food restaurants near schools, and these types of food retailers sell primarily unhealthy foods.

A few studies have considered whether the presence of food retailers near schools negatively influences young people's eating behaviors and diets. A major limitation of existing studies is that they measured the overall consumption of specific food items (e.g., fruits and vegetables), and did not consider where or when the food items were obtained. This makes it impossible to distinguish between the contribution of the school food retail environment, the home environment, and other environments to overall consumption. There

is a need for studies to examine how the presence of food retailers, both within schools and in the surrounding area, influences students' eating behaviors during the school day. It is also important to note that although young people spend a large portion of their day at school, there are other locations such as the home food environment where context-specific eating behaviours are also important. To measure the local food retail environment, previous studies have used different types of geographic boundaries, with most relying on either circular buffers or road network buffers. Circular buffers capture all land within a set distance from a location of interest "as the crow flies", while road network buffers extend outwards from a location of interest by following road networks, and therefore capture what is accessible to a person by road. Circular buffers, while easy to create, do not necessarily reflect how people travel.

Road network-based buffers address this limitation, but the creation of road network buffers requires more time and expertise in geographic information system (GIS) technologies. Furthermore, students who walk to food retailers near their school may take pathways and shortcuts which would not be captured by the road network buffers. Measures of the built environment captured using road network buffers are more strongly and consistently related to physical activity behaviors than circular buffer measures in adults [109].

2.6.1 Dietary Patterns Associated With NCDs

Hypertension is a leading modifiable risk factor for stroke and cardiovascular disease (CVD) worldwide, and recent data suggest that nearly one in every two adults lives with hypertension in sub-Saharan Africa (SSA). Several reports have itemized lifestyle factors in the epidemiology of risk of hypertension, with limited information on food and dietary intake

implications. Diet plays an essential role in health and disease outcomes. Still, information on the overall significance of diet is limited among indigenous Africans from SSA, where the burden of hypertension is high. Assessing dietary exposure is complex, but a dependable and efficient approach for evaluating dietary exposure is the dietary pattern. Several studies have evaluated the significance of dietary interventions in hypertension management, but dietary factors associated with hypertension are yet to be clearly understood, particularly among indigenous Africans. Discerning dietary factors associated with hypertension among Indigenous Africans is vital to strengthening public health efforts and interventions to prevent hypertension and its related disorders. Examining the implication of diet in the epidemiology of hypertension among indigenous Africans is critical to designing context-specific approaches, including dietary guidelines for curbing the growing burden of hypertension among indigenous Africans. Previously, dietary patterns related to stroke have been reported among indigenous West Africans from Nigeria and Ghana recruited into the Stroke Investigative Research and Educational Network (SIREN) study [100,101]. The SIREN study was designed to characterize risk factors and the burden of stroke among indigenous Africans, and evidence from that study demonstrated that hypertension is the prime risk factor for stroke among Africans. In light of these findings, interventions to mitigate hypertension risk are likely to impact the risk of stroke significantly. Identifying and modifying dietary factors related to hypertension risk is expected to be a cost-effective approach for community prevention of hypertension and stroke, particularly in SSA with a disproportionately high CVD burden. In this study, we randomly identified participants with hypertension, matched them for age, sex, and ethnicity with participants without

hypertension from the stroke-free population in the SIREN dataset, and evaluated the association between dietary patterns and hypertension [110].

2.7 Definition of Hypertension

Hypertension was defined according to the Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure. Trained personnel (being guided by standard operating procedures) measured the SBP and DBP of participants three times seated in a resting position. A 5-minute rest period was allowed between measurements. The average of the last two measurements was estimated as the participant's blood pressure (in mmHg), and hypertension was defined as one of the following conditions:

SBP at least 140 mmHg and/or DBP 90 mmHg,

a self-reported prior diagnosis of hypertension by medical personnel or current use of blood pressure-lowering medications. Participants with hypertension were matched 1: 1 by age (5 years), sex, and ethnicity with normo-tensives to minimize the confounding effect of these factors [110].

2.8 Physical Activity

Physical activity has a major impact on health. Some effects are well established; as a major component of energy expenditure, physical activity has a great influence on energy balance and body composition. It is also recognized that physical activity is a major independent modifiable risk factor that has a protective effect on cardiovascular disease

(CVD), stroke, type 2 diabetes, and colon and breast cancers, and is also associated with other important health outcomes such as mental health, injuries and falls.

Physical inactivity remains a public health problem in many areas of the world, including the UK. Activity levels are low in the UK; about two-thirds of men and three-quarters of women do not meet the national recommendations for physical activity. It is only recently that energy expenditure has not been inextricably linked to energy intake. In the past, food was less readily available and energy expenditure was needed to obtain food. But advances in technology and industrialization now mean that there is a mismatch between food availability and the energy required to obtain food and go about our daily lives. Consequently, we now have a pandemic of obesity and associated chronic diseases such as type 2 diabetes.

This challenging situation is now well-recognized by international and national health bodies. The World Health Organization has a global strategy for physical activity, and in England, the Department of Health has a 'Choosing Activity' physical activity action plan. The economic burden of physical inactivity is immense and the estimated direct cost of physical inactivity to the National Health Service in the UK is £1.06 billion [110]. The indirect costs of physical inactivity such as days lost to sickness absence and premature mortality, private healthcare costs, and home care, increase these estimates further. It has been estimated that the total (direct and indirect) cost of physical inactivity in England is £8.2 billion a year by the Department of Health.

So improving physical activity levels (PALs) is crucial. However, the best methods to achieve this are not yet known and further research is needed to ascertain the effectiveness of

initiatives already underway. A greater understanding of the psychological and environmental barriers to increasing physical activity is likely to help inform and direct campaigns to promote physical activity.

It was highlighted that the importance of physical activity for health and to provide an effective overview by assimilating the latest evidence in this area. Issues related to defining and measuring physical activity are described first, and this is followed by an explanation of the physiological impact of physical activity. It focuses on the role of physical activity in the prevention of disease but also discusses the effects of physical activity in high-risk groups (*e.g.* the obese and those with impaired glucose tolerance) in various sections. The evidence linking physical activity to disease prevention is critically assessed in sections on weight gain and obesity, CVD, cancer, diabetes, osteoporosis, mental health, and psychological well-being. The importance of physical activity across the life course is discussed and national recommendations for physical activity are presented. Finally, the challenges of public health interventions to improve PALs are considered and an assessment is made of the risks associated with physical activity. This research aspires to help those working in public health and so focuses on the health effects of physical activity in the general population, rather than the implications of physical activity in the elite athlete [111].

2.8.1 Definition and Measurement of Physical Activity

Physical activity is defined as 'bodily movement that is produced by the contraction of skeletal muscle and that substantially increases energy expenditure [112]. This term therefore includes the full range of human movement from competitive sport and exercise to hobbies or activities involved in daily living. Conversely, physical inactivity can be described as a state in which bodily movement is minimal and energy expenditure approximates the resting metabolic rate [110].

Physical activity affects total energy expenditure, which is the sum of the basal metabolic rate (the amount of energy expended while at rest in a neutrally temperate environment and a state of fasting), the thermal effect of food (otherwise known as dietary-induced thermo genesis) and the energy expended in physical activity.

A substantial amount of total energy expenditure is accounted for by BMR, which is determined principally by body mass and composition, both of which vary with age and sex. The TEF is the energy cost of digesting food and is rarely assessed separately.

Physical activity is a complex, multi-dimensional behavior. Many different modes of activity contribute to total physical activity; these include occupational, household (*e.g.* caregiving, domestic cleaning), transport (*e.g.* walking or cycling to work), and leisure-time activities (*e.g.* dancing, swimming). Exercise is a subcategory of leisure-time physical activity and is defined as 'physical activity in which planned, structured and repetitive bodily movements are performed to improve or maintain one or more components of physical fitness.

Physical activity can be further categorized in terms of the frequency, duration, and intensity of the activity. Frequency and duration refer to how often and how long an activity is performed. Intensity refers to how hard a person is working or the rate of energy expenditure that an activity demands [113].

2.8.2 Intensity of Physical Activity

Millitre of oxygen consumed per kilogram of body mass per minute (The absolute intensity of an activity is the rate of energy expenditure associated with that activity; this is usually measured in kcal/kg/min or METs (which stands for metabolic equivalents). The MET is a unit used to estimate the metabolic cost (energy expenditure or oxygen consumption) of physical activity. One MET is a person's metabolic rate when at rest; this is set as a resting metabolic rate (RMR) of 3.5 MET values are given in multiples of RMR and are assigned to activities to denote their intensity. METs are often used to define categories such as light, moderate, and heavy-intensity physical activity [114].

2.8.3 Physical Fitness

Physical activity that stimulates the body's cardio-respiratory, musculoskeletal, and metabolic systems can, over time, cause them to adapt and become more efficient. In other words, the body gets fitter. Fitness is defined as a set of attributes that people have or achieve that relates to the ability to perform physical activity [115]. While there is often a focus on cardio-respiratory fitness, this is only one element of fitness that can be enhanced through appropriate activity. Other elements include strength, flexibility, speed, and power. Optimum levels of body fat are also considered to be an element of fitness [116].

Cardio-respiratory fitness relates to the ability of the circulatory and respiratory systems to supply oxygen during sustained physical activity. It is sometimes used as a surrogate for physical activity, but because both genetic factors and responses to physical activity dictate cardio-respiratory fitness, and because fitness is also affected by age, gender, and other health habits, it is regarded by some as an inadequate measure of physical activity [117].

A person's fitness will determine the intensity felt during a specific activity. For example, it was defined moderate-intensity physical activity as that which will usually cause an increase in breathing rate, an increase in HR to the level where the pulse can be felt, and a feeling of increased warmth, possibly accompanied by sweating on hot or humid days. The amount of activity needed to experience these feelings will vary from person to person, and this depends on fitness. A fitter body will cope with a specific task more comfortably [118].

The term health-related fitness describes a dimension of fitness that goes beyond pure physical function. It encompasses sufficient functional capacity to perform activities of daily living without undue discomfort, optimal weight control, low levels of risk factors for major diseases, and optimal psychological and social well-being. The main determinants of these attributes are the physical condition of the cardio-respiratory and musculoskeletal systems, regular physical activity, a healthy diet, normal levels of body fat, blood pressure, lipids and insulin sensitivity, and good mental health [119] .

Fitness measurements usually focus on CRF (or endurance), muscular fitness, and body composition. The best way to measure cardio-respiratory fitness is by assessing maximal oxygen uptake (VO_2max). This is the maximal capacity for oxygen consumption by the body during maximal exertion; it is also known as aerobic power, maximal oxygen consumption,

and cardio-respiratory endurance capacity. Maximal oxygen uptake decreases with age so an activity of a given MET value (an absolute intensity) requires a greater percentage of their maximal oxygen uptake in older people [120].

Common features of muscular fitness are strength, endurance, and flexibility. Muscle strength and endurance are specific to the muscle group so, for completeness, several muscle groups need to be tested. Flexibility is difficult to assess reliably and is specific to the joint being tested. Balance, agility, and coordination are also regarded as skill-related aspects of fitness. These aspects of fitness are especially important among older people who are more prone to fall and suffer fractures. Balance stands are sometimes used in assessments and agility and coordination are most commonly determined by using a field test such as an agility walk or run. Hydrostatic or underwater weighing are the preferred methods for measuring body composition but these are difficult in some populations, for example, children. Other measures include bioelectrical impedance, magnetic resonance imaging, skin folds, body electrical conductivity, and dual-energy x-ray absorptiometry [121].

Physical activity is a very complex behavior that can be measured in many ways. A range of instruments are available for measuring energy expenditure and also physical activity specifically, including objective methods and those based on self-reports. These measures can be used to measure both physical activity and inactivity (sedentary behavior such as sitting or television viewing), both of which are used for surveillance and research purposes [122].

Choosing an Appropriate Measurement Instrument

Ideally, physical activity should be assessed objectively, with minimum disruption to subjects so that it is representative of daily life. To inform practical recommendations, it is also important to assess physical activity patterns (*i.e.* frequency, intensity, and duration) as well as total energy expenditure. Nevertheless, questionnaires and surveys are most commonly used in epidemiological studies because of their low cost and easy, unrestricted administration to many people [123].

Various methods of physical activity assessment have their advantages and disadvantages, and so are more or less suitable for different study objectives. Nonetheless, it is difficult to compare measures of physical activity from different assessment methods. It has been showed that motion sensors, physical activity logs, and surveys reflect physical activity, but they do not always provide similar estimates of the time spent in resting/light, moderate, or hard/very hard activities. compared three methods of physical activity measurement over 21. The major factors that require consideration when choosing a physical activity assessment method are presented below:

- scope of the study and outcome of interest, *e.g.* energy expenditure or time spent in moderate-intensity physical activity
- nature and details of the physical activity to be recorded, *e.g.* duration, frequency, and intensity.
  - The accuracy required of the outcome measurement, *e.g.* absolute measures or ranking to be used

- The summary estimate or score is to be used to rank or categorize individuals according to their physical activity levels.
- validity/reliability
- time frame and reference period
- mode of data collection, *e.g.* interview or self-administered
- number of subjects *vs.* cost
- compliance
- characteristics of the study subjects, *e.g.* age, socioeconomic status.

Some special considerations are needed for assessing physical activity in children. Children's activity is highly intermittent and transitory in nature, and so a measurement instrument needs to be sensitive enough to pick up short bursts of activity [124]. Numerous studies have examined the reliability and validity of motion sensors in children under both lab and field conditions, but the general consensus is that they provide valid measures of physical activity, but underestimates of energy expenditure associated with children's intermittent activities. There is also concern about the use of self-report measures in children. The consensus from several reviews is that previous day recall instruments offer the most promise for use with children, but they are limited by the lack of information on intra-individual variability in activity patterns. Moreover, METs (a measure of intensity) are not well established for various activities in children [125].

Similarly, measuring physical activity in older adults can present a challenge. Any activity is likely to be more challenging and therefore will be of greater intensity for an older person, than for a younger person doing the same activity.

Validation of Physical Activity Assessment Methods

The multitude of difficulties associated with measuring physical activity emphasizes the need for validation studies. Validity is defined as the extent to which a measurement instrument assesses the true exposure of interest, which is different to repeatability at the extent to which an instrument gives the same result on different occasions. Both validity and repeatability are important. The ideal validation instrument would objectively measure the true exposure without correlated error (systematic error in the same direction) with the method being validated [126]. An assessment method should be validated against another tool that measures exactly the same exposure. So if a questionnaire is designed to measure total energy expenditure then the validation tool should also measure total energy expenditure [127].

It was discovered the dose response relationship between physical activity and cardio-respiratory fitness disappeared in those classified most active by IPAQ, but put this down to over-reporting of physical activity. Studies using questionnaires which focus on vigorous physical activity may find higher correlations with VO_2max than those that attempt to measure total daily physical activity, because vigorous activities, which are related to fitness, are more reliably recalled in questionnaires. This does not imply that these questionnaires can be used to measure the totality of physical activity [128]. In addition, it is important to ensure that a validation study uses the same time frame of reference, subjects representative of the population to whom the physical activity instrument will be administered and appropriate statistical techniques. There is no ideal measurement instrument or validation study design that is suitable for all situations, but a checklist for use when choosing a validation tool is available [129].

2.8.4 Physical Activity and Fitness

Some studies have measured fitness, rather than physical activity, for investigating effects on health outcomes. It is clear that well-established methods used to measure fitness (*e.g.* VO_2max) do not have the same inherent problems as those associated with physical activity. It was attempted to determine whether physical activity or fitness is a better predictor of health [130]. They observed a stronger inverse relationship between fitness and all-cause mortality, than for physical activity and all-cause mortality. In addition, an analysis of results from the Aerobics Center Longitudinal Study showed that the highest death rates were in the unfit sedentary groups and the lowest death rates were in the highly fit, highly active group. Analyses from this study showed that fitness, rather than physical activity, was inversely associated with mortality [131].

Nonetheless, it is not possible to determine from these results whether one exposure is better than another as a predictor of health. Both physical activity and fitness relate strongly to health outcomes and act independently; both are very important independent health dimensions. It is likely that these results have been found because fitness has been measured objectively, but physical activity is usually measured by self-report. This inevitably leads to misclassification, and stronger associations for fitness than physical activity. However, a focus on physical activity, rather than fitness, is more practical for public health recommendations [132].

Key points

- Physical activity levels in the UK are low. Only 35% of men and 24% of women reach the recommended rate.

- There is a marked decline in physical activity with age in both men and women.
- Men tend to be more active than women at all ages.
- In the UK, changes in survey methods have hindered the monitoring of long-term physical activity patterns but it is clear that the percentage of adults that meet the UK physical activity recommendations has increased from 1997 to 2004 (with the exception of older women).
- There has been a decline in occupational physical activity from the 1990s onwards, but an upward trend in sports participation, *e.g.* joining fitness clubs, over the same time period. minutes of moderate-intensity physical activity per day.
- Children are more active than adults. Seventy per cent of boys and 61% of girls reach the recommended 60.
- Boys tend to be more active than girls and there is a decline in physical activity as children reach adolescence, which is more marked in girls.
- Overall, physical activity levels in children have been relatively stable in recent years. But there is some evidence to suggest a decrease in active transport to school and time spent in school physical education lessons.
- Lower-income groups have particularly low physical activity levels and there is some evidence that physical activity is lower in some ethnic minority groups [133].

2.8.5 Physiological Effects of Physical Activity

As discussed in METs. Different activities lead to a large variability in physical activity; physical activity levels ranging from 1.2 to 2.2–2.5 have been reported in healthy adults. Although an increase in total energy expenditure is expected from physical activity, it has been shown that there is an additional increase in total energy expenditure that is not directly due to the activity-induced energy expenditure from physical activity (PAEE) [134]. Physical activity is an important component of total energy expenditure. The amount of energy expended performing a particular activity depends on the muscle mass involved and the intensity at which the activity is performed; specific activities tend to range from 2 to 18.

Body Composition

Physical activity can increase lean body mass; this is done by increasing the mass of skeletal muscles used performing the physical activity. Furthermore, structural changes take place in the muscles whereby they increase in capillary density and also potential for glycogen storage [135].

Physical activity can also modify body composition favorably by reducing fat mass. Even when an exercise programme produces no loss in bodyweight, substantial reductions in abdominal subcutaneous and visceral fat can be achieved which translates to a loss of 2.1% or 1.8% body fat for men and women respectively (minutes of moderate physical activity per day is equivalent to approximately 1500 weeks of both resistance and endurance training can produce significant decreases in fat mass and percentage body fat. Nevertheless, epidemiological studies that have examined the relationship between physical activity and percentage body fat have not produced as strong an evidence base as might be expected. A

number of studies have reported unexplained gender differences in the relationship between physical activity and body fat. It was reported that total energy expenditure was related to percentage body fat in women but not men, but that physical activity energy expenditure was significantly related to percentage body fat in men but not women [136]. It was reported a stronger association in women and proposed that the steeper slope in the relationship between exercise and body fat in women is due to highly active women having greater concern about their body fat, which leads them to practise other behaviours that influence energy regulation.

Similarly, different relationships between physical activity and percentage body fat have been reported for different age groups. Using accelerometer as a measure of physical activity in young adult showed a strong graded inverse association between moderate and vigorous physical activity and fat mass. Also, in adolescents, physical activity was independently inversely associated with fat mass, percentage fat mass and body mass index (BMI) in boys but not girls. In a prospective study of middle-aged healthy whites, baseline physical activity energy expenditure predicted a change in fat mass in younger adults, who as a group gained weight in this study. Yet in the same study, baseline physical activity energy expenditure in older adults (who were on average weight stable) was associated with a gain in bodyweight, which was explained by an increase in fat mass and fat-free mass [137].

It is likely that the variation in methodology used for measurement of physical activity, energy expenditure and body composition, and in particular the major reliance on self-reported measures of physical activity, limits the research in this area and contributes to the inconsistency. In addition, body composition is also affected by energy intake, and it is

possible that interactions between physical activity and energy intake, via changes in appetite or food choice, might explain why there is some variation in the effectiveness of physical activity in changing body composition [138].

Interaction With Food Intake

Physically active individuals are able to consume a greater amount of energy to achieve energy balance, compared with those who are sedentary. Such greater energy intakes have consequences in terms of the nutrient density of the diet. In effect, increasing the amount of food needed to match energy expenditure may lessen any potential problems with micronutrient deficiencies; achievement of adequate micronutrients is more difficult in an energy-restricted diet [139].

2.8.6 Macronutrient Intake

Although difficult to assess, it has been reviewed the effects of exercise on macronutrient intake. Although several studies found a significant difference in macronutrient intake between active and inactive subjects, overall there was inconsistency in the results [158]. There were some slight trends observed: active men tended to consume more carbohydrate, and less fat and protein than inactive men, but the trend was not significant; active women tend to consume more fat than inactive women but again the trend was non-significant. Very short-term intervention trials examining the acute effects of a single bout of exercise on macronutrient intake also show mixed results. There was a conclusion that there is no evidence to suggest that long-term exercise training influences macronutrient intake. However, the highlight was that there are a few studies that show an increase in carbohydrate intake in response to exercise. These results could be explained by physiologically induced

factors as a result of glycogen depletion, or it might be because more carbohydrate-rich fluids and foods are consumed during and after exercise [140].

Cardiovascular Effects: Blood Pressure

It is well known that during exercise, blood pressure increases, particularly when the exercise activates a large muscle mass and requires a relatively great muscle strain [141]. Exercising the body's large muscles increases cardiac output several fold. Vasodilation of the arterioles in the exercising muscles causes a decrease in peripheral resistance which, in turn, attenuates the rise in blood pressure which would otherwise follow from the increase in cardiac output. When exercise ceases, cardiac output quickly falls back to pre-exercise levels, but the vasodilation and decrease in peripheral resistance persists for hours. This hypotensive post-exercise response can last for up to 12 [142]. In this way, individuals who exercise regularly spend a substantial amount of their time in a state of post-exercise hypotension.

It is therefore not surprising that, in a meta-analysis of 72 trials, The effect was more pronounced in those with greater baseline blood pressure. Mechanisms involved a reduction in vascular resistance (as described above), but in addition, it was thought that the sympathetic nervous and rennin-angiotensin systems are involved because it was observed that plasma nor adrenaline decreased by 29% (mmHg and 3.3/3.5 weeks induced significant net reductions of resting and daytime ambulatory blood pressure of 3.0/2.4) showed that endurance training for ≥4p <0.001), and plasma rennin by 20% (p <0.05) [143].

Coronary Vascular Transport and Endothelial Function

It has been described how aerobic exercise training induces an increase in the capacity to carry blood in the coronary arteries. This is the result of an increase in the size of coronary arteries and thus increases in blood flow capacity and capillary exchange capacity. Structurally, physical activity causes increases in the cross-sectional area of the proximal coronary arteries and the formation of new blood capillaries (angiogenesis), and physical activity has also been shown to alter coronary vascular control [144].

Endothelial function refers to the ability of the endothelium (thin layer of cells lining blood vessels) to interact with vascular smooth muscle and induce vasodilation or vasoconstriction. Nitric oxide is a major vasodilator that is released by endothelial cells. Thus, nitric oxide is important for increasing blood flow when required, and its release is increased during exercise. Physical activity induces improvements in endothelial function by increasing the activity of nitric oxide synthase, which produces nitric oxide, and increasing extracellular superoxide dismutase, which prevents breakdown of nitric oxide. These processes are all crucial for directing the appropriate distribution of blood in the body. Furthermore, endothelial dysfunction is thought to occur in the early stages of atherosclerosis and is a trigger for ischaemia [145].

Immune Response

Physical exertion has both positive and negative effects on the immune response, depending on the intensity and workload of the activity. Evidence from randomised controlled trials and epidemiological studies supports the view that near-daily physical activity reduces the number of days sickness, and also suggests that risk of upper respiratory

tract infection (URTI) is reduced in people who engage in regular vigorous physical activity. it was proposed that stress hormones, which can suppress immunity, and pro- and anti-inflammatory cytokines, indicative of intense metabolic activity, are not elevated during moderate physical activity. It is thought that although the immune system returns to pre-exercise levels rather quickly at the end of a session, each session is thought to boost immune surveillance, thus reducing risk of infection in the long-term. Similarly, Moderate endurance exercise causes either no change or an enhancement of a number of immunological indices such as T-cell count and serum immunoglobulin (antibody) levels [146].

However, exhaustive exercise tends to lead to adverse changes in several immunological indices, particularly if the activity is accompanied by environmental or competitive stress. This can lead to an increase in the risk of URTIs, especially in athletes who take part in competitive endurance events or who overtrain. Many components of the immune system exhibit adverse changes after prolonged heavy exertion lasting longer than 90 *i.e.* hours after exertion where viruses and bacteria may gain a foothold, increasing the risk of infection, particularly of the upper respiratory tract. skin, upper respiratory tract, lung, blood and muscle; most of these changes reflect physiologic stress and immune suppression. It is thought that an 'open window' of impaired immunity occurs between 3 and 72.

2.8.7 Physical Activity In Health And Disease

Physical Activity, Weight Gain and Obesity

In 2005, the proportion of English men and women classified as obese was 23.1% and 24.8% respectively. Obesity is a major risk factor for several chronic diseases including type 2 diabetes, CVD and some cancers. The direct cost of treating obesity in 2002 was estimated at £45.8–49.0 million, and this increased to £945–1075 million when the indirect costs of obesity were included. As an increase in physical activity increases overall energy expenditure and thus can contribute towards maintaining energy balance, it is not surprising that physical inactivity has been linked to an increased risk of weight gain and obesity. Indeed, many reports have linked the rising obesity epidemic to increasingly sedentary lifestyles. The decrease in energy intake that has taken place alongside the increase in prevalence of obesity lends further support to this concept [147].

Observational Studies of Physical Activity and Weight Change

There was association with improved weight maintenance. kJ/week (1500–2000) conducted a systematic review to investigate the effects of physical activity on weight gain. Sixteen prospective studies were identified and results were consistent. Greater physical activity was associated with less weight gain, if the level of activity was assessed at the end of the follow-up period, or as a change from baseline to follow-up. This was seen both in subjects who had and had not previously lost weight. But the association between baseline physical activity and later weight change was uncertain. The prospective observational studies suggested that an increase in PAEE of approximately 6300–8400 [148.]

2.9 Physical Activity Needed to Maintain a Healthy Weight

The World Health Organization has assessed the observational and trial evidence and concluded that there is convincing evidence that regular physical activity decreases risk, and sedentary lifestyles increase the risk of weight gain and obesity. WHO recognises that studies that measure physical activity only at baseline, and exercise intervention studies, do not provide entirely consistent results. Thus, it is thought that current patterns of physical activity, rather than past physical activity or enrolment in an exercise programme is most relevant [149].

Although there is some uncertainty around the amount of physical activity needed to prevent weight gain, it is probably significantly greater than the amount of physical activity that is needed for the prevention of chronic disease. It is likely that the amount of physical activity required to prevent weight gain varies between populations, and between life stages of individuals. However, consensus on the amount of physical activity needed to prevent unhealthy weight gain was achieved at the IASO 1st Stock conference minutes per day or a PAL of 1.7 is required to prevent the transition to overweight or obesity. For children, even more activity time is recommended. Consequently, this has been the basis for national and international recommendations since then. This group concluded that, although definitive data are lacking, it seems likely that moderate-intensity physical activity of approximately 45–60 and the minutes of moderate-intensity physical activity a day to prevent obesity. It has been now recommended 45 minutes a day in children because this is associated with lower BMI. also recommend reducing television viewing times by about 30 minutes [150].

Considering the relationship between physical activity and weight gain at the population level, kcal) per day must be expended to restore energy balance and thus eliminate weight

gain in Western populations. High levels of physical activity are needed to achieve this so the public health implications need to be considered. [150].

2.9.1 The Effects of Physical Activity on Maintenance of Weight Loss

Although evidence from exercise intervention trials suggests that physical activity is not always significantly effective as an initial means of weight loss. It have been proposed that physical activity is crucial for maintenance of weight loss. In some, but not all studies, physical activity appears to favourably alter the composition of weight loss so that a higher proportion of weight loss comes from fat mass and less from fat-free mass. Weight loss itself causes a reduction in TEE (partly because of a drop in the energy cost of weight-bearing physical activity), and so any increase in physical activity that occurs with weight loss serves to counteract this effect. Otherwise, during weight loss, food intake needs to be progressively lowered to maintain negative energy balance. Physical activity serves to counteract this effect, by increasing its direct and indirect effects (such as an increase in lean body mass) on energy expenditure. It is also thought that physical activity could be a strong predictor of success in weight loss maintenance because it is a marker for compliance. Those who maintain a high level of physical activity may also be better at maintaining their target energy intake [135].

Physical Activity and Type 2 Diabetes Risk

It is estimated that the prevalence of type 2 diabetes in England is 3.3% for men and 1.5% for women. The cost of type 2 diabetes to the National Health Service is huge, and has been estimated at £5.2 billion a year. As obesity is the major risk factor for type 2 diabetes it is clear that physical activity has a major role to play via the prevention of obesity. In addition, there is substantial evidence that physical activity has an independent protective

effect on risk of type 2 diabetes. Prospective studies indicate that physically active people have a 33–50% lower risk of developing type 2 diabetes compared with inactive people. For example, the Iowa Women's Health Study showed that women who had a high *vs.* low physical activity index had a 42% (95% CI 34–49%) reduced risk of type 2 diabetes [143].

kcal of energy expenditure in weekly leisure-time physical activity were associated with 6% decreases in the risk of type 2 diabetes. In a prospective study in men, increases of 500kcal increase in energy expenditure, the risk of type 2 diabetes was reduced by 24%. In the Alumni Health Study, incidence rates declined as energy expenditure increased. In addition to the prospective evidence, non-randomised and randomised intervention trials also show that physical activity can help to reduce the risk of developing type 2 diabetes. minutes of moderate-intensity activity per week. For example, results from the Diabetes Prevention Program study showed a 46% reduction in diabetes incidence for participants who met the physical activity goal of 150.

Physical Activity and Type 2 Diabetes

There is evidence that people at high risk of type 2 diabetes can benefit even further from physical activity. In those at high risk, physical activity can reduce risk by up to 64% . For example, exercise can improve insulin sensitivity and glucose tolerance in those with impaired glucose tolerance (state of pre-diabetes where sugar is not processed properly [125].

2.9.2 Physical Activity, Bone Health and Osteoporosis Risk

Osteoporosis is a degenerative bone disease that is characterised by low bone mass or low bone mineral density (BMD). Bones become brittle and there is a greater tendency for

fractures as a result of minor falls osteoporotic hip fractures in the UK each year, and the health and social care costs of osteoporosis in the UK amount to £1.7–1.8 billion a year [116].

Physical activity is known to affect risk of osteoporosis via its effects on bone turnover. The greatest effects on bone turnover take place during growth, because the bone matrix is in a dynamic state which allows the bone tissue to re-organise and grow to withstand new mechanical tensions and load conditions. Mechanical stimuli on the skeleton include intermittent mechanical stress caused by body movements, and vibrations exerted on the bone by muscle fibre contractions and by other vibrations such as induced by racket sports. Physical activity also exerts metabolic stimuli on the skeleton by increasing blood supply and thus nutrients, hormones and oxygen supply to bones. Furthermore, the rhythmic nature of physical activity amplifies the volume of pulsatile growth hormone delivery, which is essential for cellular proliferation in bone . Skeletal tissue is responsive to these mechanical and metabolic stimuli, which govern bone turnover. There is a continuous balance between the mechanical drive towards the formation of bone and the metabolic drive towards reabsorption of bone month periods whereby bones go through stages of resorption, formation and mineralisation and a remodelling process takes place over 3–4. Physical activity is unique in that it can activate the bone multicellular unit via both mechanical and metabolic stimuli to promote the retention of bone mass [107].

In addition to these direct effects on bone, the increase in muscle mass associated with physical activity increases the forces generated on the bones where the muscles attach, so further adding to the mechanical stimuli on the bones.

2.9.3 Physical Activity in Childhood and Young Adult

Weight-bearing physical activity has beneficial effects on bone health across the age spectrum. It is generally accepted that maximising the increase in BMD in younger life, and minimising its age and endocrine-associated decline in later years, is a suitable strategy to reduce the risk of osteoporosis and associated fractures. There is some evidence that exercise-induced increases in bone mass in children are maintained into adulthood, suggesting that physical activity habits during childhood may have long-lasting effects on bone health. Bone mass increases throughout adolescence and reaches a peak at the end of this period. The peak bone mass (PBM) also reflects skeletal size, and is achieved in early adulthood, a few years after growth in height has ceased. Maximising PBM elevates the starting point from which bone mass declines with age [118].

It is not necessary to perform a high volume of exercise to achieve the benefits from physical activity, as notable effects on bone may be achieved with just three hours of participation in sports. It has been observed that bone mass and BMD are both higher in children who are physically active compared with those who are less active. It is also clear that PBM is higher in children who participate in sports that have high impact forces such as gymnastics or football, rather than low impact activities such as walking or activities that are not weight-bearing such as swimming [121].

Puberty is an important time period during which the effects of physical activity can maximise PBM. Starting physical activity prior to the pubertal growth spurt stimulates both an increase in bone and skeletal muscle size to a greater degree than is observed with normal growth in children years in boys). In boys, BMD continues to increase through late adolescence, while in girls BMD ceases to increase earlier (see years in girls and 12–14.

who are not physically active. Again, high impact and weight-bearing sports are thought to be most effective; such sports participation during this growth period seem to increase PBM by 10–20%. Furthermore, it is clear that at least 25% of adult total bone mineral content is attained during a two year period of fast bone mineral accrual during growth (age 11–13. Based on evidence from multiple small randomised controlled trials, the American College of Sports Medicine has developed an exercise prescription that will augment bone mineral accrual in children and adolescents [150].

- mode: impact activities, such as gymnastics and jumping, and moderate-intensity resistance training, participation in sport that involves running and jumping (likely to be of benefit, but scientific evidence is lacking);
- intensity: high, in terms of bone loading forces; for safety reasons resistance training should be <60% of one repetition maximum;days per week;
- frequency: at least 3 minutes
- duration: 10–20 (two times per day or more may be more effective).

Psychological Wellbeing

There is great variation in the perception of psychological wellbeing; it is a term that is not well defined. It has been described psychological wellbeing as a phenomenon that comprises both emotional functioning and satisfaction with life. Mood, self-esteem, sleep and cognitive

performance are all often considered important aspects of psychological wellbeing. The lack of a precise definition of psychological wellbeing means that its measurement differs among researchers, and so this is a limitation to research in this area [110, 28].

In relation to mood and wellbeing, a positive association between physical activity and indices of subjective wellbeing has been reported by large-scale surveys in several countries using different methods and criteria [25,35,48]. The evidence is fairly consistent across meta-analytic or narrative reviews and these large-scale epidemiological surveys, and points to a convincing relationship between physical activity and improved positive mood .Furthermore, experimental trials support a positive effect on mood for moderate-intensity exercise; effective benefits are more likely to be experienced if participants focus on personal goals.

Additionally, physical activity can improve physical self-esteem. many researchers have established a relationship between physical activity and self-esteem, self-efficacy and psychological functioning. The positive effects are likely to be greater for those with initially low self-esteem and can be experienced by all age groups, but there is strongest evidence for change in children and middle-aged adults. The impact of exercise on self-esteem in children and young adults has been reviewed.

Sleep quality is sometimes associated with psychological wellbeing, and daylight exercise is closely related to sleep quality. A meta-analysis of 38 studies showed that exercise had no effect on the time it took to fall asleep, but it produced small increases in the amount of sleep and slow wave sleep achieved.

In terms of cognitive performance, studies that have considered reaction time and memory in older people have been reviewed. Cross-sectional data show that fitter, older adults display better cognitive functioning but experimental evidence is equivocal.. Results from intervention studies are inconclusive but findings from meta-analyses indicate a small but significant improvement in cognitive functioning of older adults who experience an increase in aerobic fitness [12,45,38,62]. Furthermore, there is some evidence from clinical trials that shows exercise can help reduce the risk of dementia and Alzheimer's disease .

2.9.4 Psychological Barriers to Physical Activity

Achieving an increase in physical activity in the population is a great challenge. There are a number of psychological barriers to increasing physical activity levels and an understanding of how these operate is crucial to developing effective ways to promote physical activity. The challenge is often to translate short-term gains into the adoption and maintenance of physically active behaviours across the lifespan.

2.9.5 Environmental Determinants of Physical Activity

Physical inactivity is a major public health problem and is linked to a huge burden of chronic disease. It is crucial to tackle this issue at the policy level and therefore consider the environmental factors contributing to low levels of physical activity.

- transport system dominated by cars
- use of lifts and escalators and inaccessible stairs
- TV, computer games, internet and other sedentary entertainment
- household appliances and labour-saving devices.

An increase in the number of physical activity facilities was associated with decreased overweight and increased relative odds of achieving ≥5 bouts per week of moderate to vigorous-intensity physical activity. These findings emphasise the connection between the built environment and physical activity.

Local authorities and town planners have an important role to play in helping people to gain the benefits of being more active, both in terms of providing appropriate sport and leisure facilities, but also by ensuring that pavements and recreational areas are of a suitable standard and that walking areas are well lit and maintained. Although there appears to be limited scope for increasing energy expenditure at work or via domestic activities, active transport initiatives offer some scope. The journey to school is a potentially important opportunity for establishing daily physical activity in childhood, and many schemes have been introduced at governmental, national and local levels to promote active transport to school. This is supported by evidence that children who walk or cycle to school are more physically active and have better CRF . The benefits of active transport are not limited to children. There is an enormous potential to increase walking and cycling over short trips, but perceived danger and inconvenience are barriers to achieving this.

Effectiveness of Interventions to Promote Physical Activity

It is of course critical to use an evidence-based approach to designing community-based interventions which aim to increase physical activity levels. The National Institute for Clinical Excellence (NICE) has issued guidance on the promotion of physical activity among adults [149].

KEY POINTS

The current recommendations for physical activity are:

- Children and young people should achieve a total of at least 60minutes of at least moderate-intensity physical activity each day. At least twice a week this should include activities to improve bone health, muscle strength and flexibility.
- All movement contributes to energy expenditure and is important for weight management. It is likely that for many people, 45–60 minutes of at least moderate-intensity physical activity a day, on five or more days a week. For general health benefit, adults should achieve a total of at least 30 minutes of moderate-intensity physical activity a day is necessary to prevent obesity. For bone health, activities that produce high physical stresses on the bones are necessary.
- A number of psychological barriers to physical activity have been identified, especially for those who are obese and need to lose weight. These include issues related to body image, poor confidence and lack of immediate rewards from physical activity.
- A number of behaviour change models have been used to identify personal factors that can help change physical activity behaviour. It is also proposed that change in physical activity behaviour is more likely to be effective when promotion strategies take into account the stage at which an individual is considering or achieving a change in lifestyle.
- There are a number of environmental factors which contribute to low levels of physical activity and these should be tackled if significant changes to population level physical activity are to be achieved. Policies which support active transport initiatives have proved to be effective in other countries and thus have greater potential in the UK.

- NICE offers a range of guidance on the effectiveness of different methods of promoting physical activity. However, current research is limited and ongoing work may provide additional guidance in the coming years.
- There are a small number of risks associated with physical activity, many of which are only linked to contact sports or physical activity at very high intensities. Many of the risks of physical activity can be avoided by building up physical activity levels gradually [150].

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Chapter Three

Methodology

3.1 Research Design

A community-based descriptive Cross-sectional was used for the interest of this study in the assessment of the food environment, dietary diversity, physical activity and nutrient adequacy and nutritional status of 18-29 year old young adults living in Ibadan North Local Government, Ibadan, Oyo State, Southwestern region, Nigeria.

3.2 Population of the study

The study population consists of 368 young adults living in Ibadan North Local Government, Ibadan. Oyo State.

3.3 Study Location

The study was carried out in Agbowo-UI, Ibadan North Local Government. Ibadan is the capital and most populous city in Oyo State, Nigeria. It is the third-largest city by population in Nigeria after Lagos and Kano. It is the largest city by geographical area in Nigeria. Ibadan is located in south-western Nigeria. Although, the major inhabitants of Ibadan are Yoruba People, other tribes also live peacefully within the city. Ibadan is a commercial center with thriving economic activities such as agriculture, trading, handicrafts, manufacturing and service industries, malls, cinemas, train stations and booming entertainment sector [1].

Eligibility of Study Population

The study participants were selected based on the following criteria

Inclusion Criteria

- Participants should be between the age of 18-29 years
- Participants who gave consent to partake in the study

- Apparently healthy participants

Exclusion Criteria

- Participants who were too ill
- Participants who were unwilling to participate

3.4 Sample and Sampling Technique

This study was carried out between the month of April to June 2024. The nutrient adequacy, food environment, nutritional status was determined. Eligible participants were selected from the designated local government on randomized sampling method.

All participants were counseled based on their nutritional status after it was obtained.

3.5 Sample Size Determination

Sample size was determined using Leslie Fischer Formular

$$n=\frac{z^2 pq}{d^2}$$

where:

n= the desired sample size of the population

z= the standard normal deviate, it was set at 1.96, which corresponds to 95% confidence level

p= prevalence of malnourished young adults. A prevalence rate of 32% . i.e 32% was used as the prevalence of the malnourished young adults derived from the recent previous studies in Nigeria[2]

q= proportion not expected to have food secured 1-p=(1-0.32=0.68)

d=degree of accuracy desire, which was set at 0.05

$$n=\frac{(1.96^2)(0.32)(0.68)}{(0.05^2)}$$

$$=334$$

34% of the value of the sample size was added to replace the loss or incomplete questionnaires. However a total of 368 questionnaires of eligible participants were realized among the young adults in the selected Local Government.

3.6 Research Instruments

- The research instrument for this study was a self-administered questionnaire. The questionnaire was adapted from previous literatures on the food environment, nutrient adequacy among young adults. The questionnaire was used to collect information on the accessibility to healthy foods, fruits and vegetables, and the consumption among young adults.
- Anthropometric measurements were taken to calculate their BMI.
- 24 Hour Dietary Recall was used to know their nutrient adequacy
- House-hold Dietary Diversity Score was used to know their Food availability in their Home Food Environment

Questionnaire for participants

The questionnaire was made up of five sections as follows:

SECTION A; Socio-Demographic and Economic Data of Participants

SECTION B; Dietary Diversity and Its Consumption

SECTION C; Home/Work Food Environment

SECTION D; Anthropometry Measurements of the Participants

SECTION E; Nutrient Adequacy (24 Hour Dietary Recall)

3.7 Data Collection

A letter of introduction was obtained from the University management and A letter of Consent was taken to the community. The researcher also explained to the authorities of the community for approval to carry out the research in the community. The procedure used was in three sections which include; questionnaire administering, anthropometric measurements and counseling sessions.

Questionnaire Administration

Participants were educated on the purpose on the study and their consent were obtained before the questionnaire was administered. The questionnaire contained socio-demographic and economic characteristics of the respondents which includes age, sex, ethnicity, marital status, student/employed and their income/allowance level to determine characteristics of study respondents, home/work food environment to determine the proximity of health foods, lifestyle habit of the respondent which include dietary consumption and pattern of the food around.

Anthropometric measurements

Anthropometric data include height in metres, weight in kilograms and body mass index(BMI). The height and weight of each respondent was measured using a validated stadiometer weighing scale.

Height

The height was measured with the respondent standing erect with back straight, heels against the scale, without shoes, caps and scarves and approximated to the nearest 0.01m.

Weight

Weight was taken with the respondent standing upright, wearing light clothing, without heavy accessories and barefooted. Zero-mark calibration of the weighing scale was ensured before measurement was taken and weight was approximated to the nearest 0.01 kilogram.

Body Mass Index

It was calculated using the formula; BMI=weight(kg)/ Height (m2). BMI findings are in categories which are; (<18.5 Low BMI, 18.5-24.9 Normal BMI, 25.0-29.9 Overweight, and >30.0 obesity).

3.8 **Data Analysis: Statistical Analysis**

Data obtained on socio-demographic and economic characteristics, home food environment, income and resource allocation towards food purchase, frequency of food purchase, anthropometric measurements (height and weight), nutrient intake,

and adequacy, were processed and summarized using measures such as frequencies and percentages, means and standard deviations.

Independent t-test was used to test for mean difference of anthropometric measurements, nutrient intake between gender, while correlation analysis was used to assess the relationship between food environment, food purchase frequency and selected variables. The level of significance was set at 5%. All statistical analyses were carried out using the IBM SPSS Statistics, Version 25.

3.9 **Ethical Approval**

The proposal was submitted to the Ethics and Research Committee of Lead City University, Ibadan and was obtained with the project number LCU-REC/148.

Chapter Four

Results

4.1 Socio-demographic Characteristics

More females (66.8%) participated in this study than males (33.2%). The respondents were aged between twenty-four and twenty-seven years (33.7%), between twenty and twenty-three years (31.3%), less than twenty years (23.6%), and more than twenty-seven years (11.4%). The mean age was 22.86±3.55years. Most of the respondents were Yoruba (76.9%), some were Igbo (13.6%), or Hausa (3.3%), while few of them (6.2%) belonged to another ethnicity. Most of them (85.1%) practiced Christianity, were mostly single (84.2%) and were students (86.1%).

Table 4.1 Socio-demographic Characteristics

Characteristics	Frequency (%)
Gender	
Male	122 (33.2)
Female	246 (66.8)
Age	
< 20 years	87 (23.6)
20 – 23 years	115 (31.3)
24 – 27 years	124 (33.7)
28 – 30 years	42 (11.4)
Mean±S.D	22.86±3.55
Ethnicity	
Yoruba	283 (76.9)
Igbo	50 (13.6)
Hausa	12 (3.3)
Others	23 (6.2)
Religion	
Islam	55 (14.9)
Christianity	313 (85.1)

Marital status	
Single	310 (84.2)
Married	58 (15.8)
Studentship status	
Yes	317 (86.1)
No	51 (13.9)

Source: Author's Findings

Table 4.2 Socio-economic Characteristics

About two-thirds of the respondents (66.3%) were not employed, and for the employed, their occupation comprised self-employment (61.3%), civil servant (31.5%), artisan (3.2%) and others (4.0%). Respondents lived with parents (27.4%), in flats (24.5%), in hostels (16.8%), in self-contained apartment (15.5%), in single room apartment (10.6%), while others squat with a friend or relative (5.2%).

Table 4.2 Socio-economic Characteristics

Characteristics	Frequency (%)
Employment status	
Yes	124 (33.7)
No	244 (66.3)
Occupation	
Self-employed	76 (61.3)
Artisan	4 (3.2)
Full housewife	1 (0.8)
Civil servant	39 (31.5)
Teacher	2 (1.6)
Private sector employee	2 (1.6)
Type of house	
Single room with shared kitchen	39 (10.6)
Self-contained with private kitchen	57 (15.5)
Flat house system	90 (24.5)

Squatting with a friend or relative	19 (5.2)
Living with parents	101 (27.4)
Hostel	62 (16.8)

Source: Author's Findings

Table 4.3 Income and Resource Allocation Towards Food Purchase

More than one-third of the respondents (38.9%) received a monthly allowance less than fifty thousand naira, some received between fifty thousand naira and one hundred thousand naira (23.4%), while others received above one hundred thousand naira (10.6%). About one-third of the respondents spent less than twenty-five thousand naira on food (37.0%), some spent between twenty-five thousand naira and fifty thousand naira (19.6%) while others spent more than fifty thousand naira on food (14.4%). The respondents earned a monthly allowance less than fifty thousand naira, between fifty thousand naira and one hundred thousand naira, and above one hundred thousand naira monthly (5.7%, 10.3% and 15.8%, respectively). They spent less than twenty-five thousand naira on food (5.4%), some spent between twenty-five thousand naira and fifty thousand naira (11.7%) while others spent more than fifty thousand naira on food (13.0%).

Table 4.3Income and Resource Allocation on Food Purchase

Characteristics	Frequency (%)
Monthly Allowance	
<₦50,000	143 (38.9)
₦50,000 – ₦100,000	86 (23.4)
>₦100,000	39 (10.6)
Undisclosed	100 (27.2)
Amount spent on food from monthly allowance	
<₦25,000	136 (37.0)
₦25,000 – ₦50,000	72 (19.6)
>₦50,000	53 (14.4)
Undisclosed	107 (29.1)
Monthly Income	
<₦50,000	21 (5.7)
₦50,000 – ₦100,000	38 (10.3)
>₦100,000	58 (15.8)
Undisclosed	251 (68.2)
Amount spent on food from monthly income	
<₦25,000	20 (5.4)

₦25,000 – ₦50,000	43 (11.7)
>₦50,000	48 (13.0)
Undisclosed	257 (69.8)

Source: Author's Findings

Fig. 4.4 Access to a Full Kitchen.

Most of the respondents (95.4%) had access to a full kitchen where respondents prepare meals most of the time, meanwhile, others did not (4.6%).

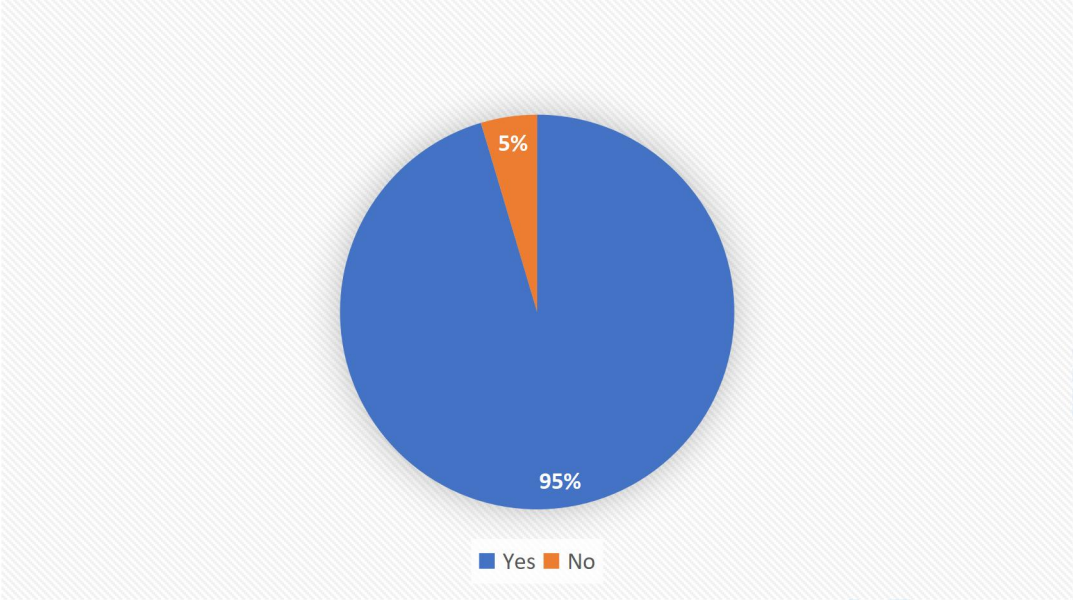

Fig. 4.4 Access to a Full Kitchen.

Table 4.5 Home Food Availability

The respondents had cereals (91.0%), white roots and tubers (52.7%), vitamin A-rich vegetables (50.0%), other vegetables (84.0%), vitamin A-rich fruits (55.2%), flesh meat (61.7%), eggs (77.7%), fish and seafoods (64.9%), legumes, nuts, and seeds (80.4%), milk, and milk products (78.3%), oils and fats (95.7%), sweets (82.1%), spices, condiments, and beverages (67.4%) at home, meanwhile, they did not have dark-green leafy vegetables (56.0%), other fruits (53.5%), and organ meats (51.6%) at home.

Table 4.5Home Food Availability

Food Group	Yes n (%)	No n (%)
Cereals	335 (91.0)	33 (9.0)
White roots and tubers	194 (52.7)	174 (47.3)
Vitamin A-rich vegetables	184 (50.0)	184 (50.0)
Dark green-leafy vegetables	162 (44.0)	206 (56.0)
Other vegetables	309 (84.0)	59 (16.0)
Vitamin A-rich fruits	203 (55.2)	165 (44.8)
Other fruits	171 (46.5)	197 (53.5)
Organ meat	178 (48.4)	190 (51.6)
Flesh meat	227 (61.7)	141 (38.3)
Eggs	286 (77.7)	82 (22.3)
Fish and seafoods	239 (64.9)	129 (35.1)
Legumes, nuts, and seeds	296 (80.4)	72 (19.6)
Milk and milk products	288 (78.3)	80 (21.7)
Oils and fats	352 (95.7)	16 (4.3)
Sweets	302 (82.1)	66 (17.9)

Spices, condiments and beverages	248 (67.4)	120 (32.6)

Source: Author's Findings

Table 4.6 Food Environment – Frequency of Purchase from Point of Sale.

There was a rare patronage of fast-food restaurants (44.6%), Supermarkets (32.9%), roadside street food vendors (37.8%), and open markets (30.2%), meanwhile, there was a frequent patronage of local canteens (24.5%), snack shops (33.4%), fruit sellers (32.1%), and street vendors (35.6%).

Table 4.6 Food Environment – Frequency of Purchase from Point of Sale

How often respondents purchase food and beverages from;	Daily n (%)	4– 6 times /week n (%)	1–3 times/ week n (%)	1 – 3 times /month n (%)	Never n (%)
Fast food restaurants (e.g., Chicken Republic, Kilimanjaro, etc.)	20 (5.4)	61 (16.6)	58 (15.8)	164 (44.6)	65 (17.7)
Local Canteens (Sell local foods)	23 (6.3)	65 (17.7)	90 (24.5)	108 (29.3)	82 (22.3)
Supermarkets (High Class that sell pastries, biscuits, and Fruit flavored drinks)	25 (6.8)	78 (21.2)	98 (26.6)	121 (32.9)	46 (12.5)
Snack shops (sells meat pie, puff-puff, doughnuts, and Fruit flavored drinks)	54 (14.7)	101 (27.4)	123 (33.4)	73 (19.8)	17 (4.6)
Roadside street food vendors (roasted corn/plantain, akara,boli, fried potatoes, etc.)	22 (6.0)	50 (13.6)	79 (21.5)	139 (37.8)	78 (21.2)
Fruits Sellers (mango, apple)	41 (11.1)	104 (28.3)	118 (32.1)	79 (21.5)	26 (7.1)

Street Vendors (pepper, groceries,etc.)	29 (7.9)	89 (24.2)	131 (35.6)	71 (19.3)	48 (13.0)
Open Markets (orita, oja-oba, Ojee.t.c)	22 (6.0)	77 (20.9)	87 (23.6)	111 (30.2)	71 (19.3)

Source: Author's Findings

Table 4.7 Food Environment – Access

There was the presence of food canteens, and snack shops within the workplace/school of most of the respondents (92.9% and 93.5%, respectively). Similarly, respondents had access to fresh drinking water (83.2%), adequate dining facility (63.0%), and fruit and vegetables (66.6%). Meanwhile, no time was set aside for eating at the respondent's workplace/school (56.8%), nor was the sale of unhealthy foods and beverages permitted (63.9%).

Table 4.7Food Environment –Access

Access to food around the workplace/school	Yes n (%)	No n (%)
Are there time(s) allocated for eating at the work/school	159 (43.2)	209 (56.8)
Is there presence of food canteens within the work/school	342 (92.9)	26 (7.1)
Is there presence of snack shops within the work/school	344 (93.5)	24 (6.5)
Is there access to fresh drinking water	306 (83.2)	62 (16.8)
Is there access to an adequate dining facility	232 (63.0)	136 (37.0)
Is there access to fruits and vegetables in school/work	245 (66.6)	123 (33.4)
Do they allow the sales of unhealthy foods and drinks	133 (36.1)	235 (63.9)

Source: Author's Findings

Fig. 4.8 Food Environment – Availability of Food Point of Sales within 1km of Respondent's Community.

In respect to the availability of the food sales points within 1km of the community, fast food restaurants (93.2%), local canteens (96.2%), supermarkets (95.9%), snack shops (98.4%), roadside street food vendors (93.5%), fruit sellers (94.3%), street vendors (90.8%), and open markets (87.0%), were available to the respondents.

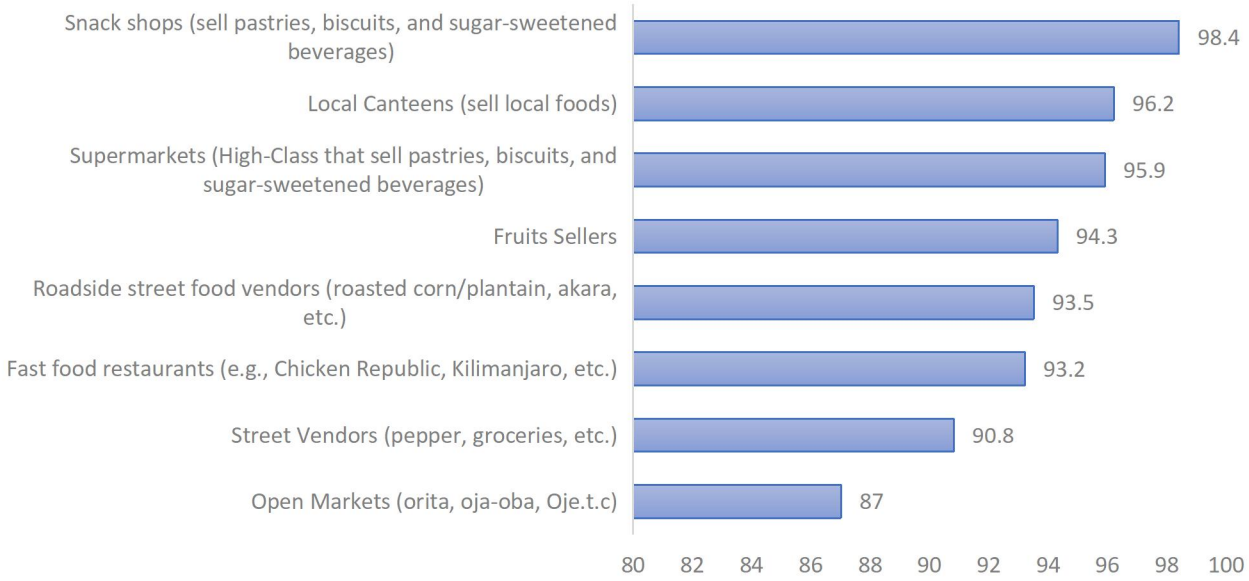

Fig. 4.8 Food Environment – Availability of Food Point of Sales within 1km of Respondent's Community

Fig. 4.9 Body Mass Index (BMI).

The prevalence of underweight, overweight and obesity among the respondents was 8.2%, 22.6% and 11.4%, respectively, meanwhile, more than half of the respondents (57.9%) had a normal Body Mass Index.

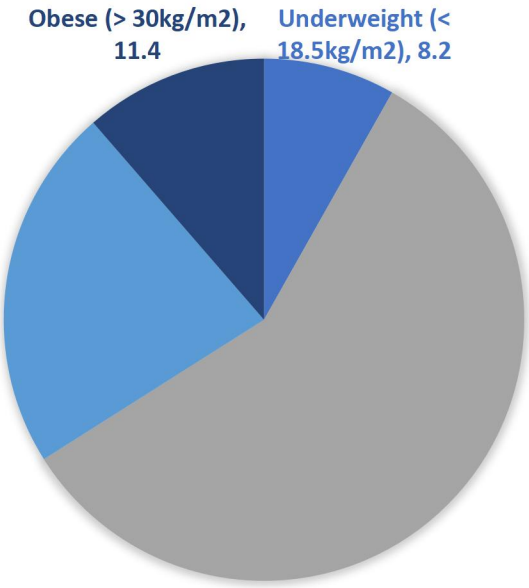

Fig. 4.9 Body Mass Index (BMI)

Table 4.10 Body Mass Index (BMI) by Gender

There were more females that were underweight (9.3%) and obese (15.0%), while there were more males with a normal Body Mass Index (61.5%) and that were overweight (28.7%). It was revealed in this study that there was a significant association between Body Mass Index and gender (p=0.004). Contrastingly, the mean BMI of female respondents (24.11±5.33kg/m^2) was not significantly higher than males' (23.53±3.81kg/m^2) (p=0.285).

Table 4.10 Body Mass Index (BMI) by Gender

Variable	Gender			
	Male	**Female**	**Both**	**p-value**
	n (%)	**n (%)**	**n (%)**	
BMI Category				
Underweight (< 18.5kg/m^2)	7 (5.7)	23 (9.3)	30 (8.2)	
Normal (18.5 – 24.9kg/m^2)	75 (61.5)	138 (56.1)	213 (57.9)	0.004*
Overweight (25 – 29.9kg/m^2)	35 (28.7)	48 (19.5)	83 (22.6)	
Obese (≥ 30kg/m^2)	5 (4.1)	37 (15.0)	42 (11.4)	
BMI Scores (Mean±S.D)	23.53±3.81	24.11±5.33	23.92±4.88	0.285

* Significant at the p<0.05 level

Source: Author's Findings

Table 4.11 Nutrient Intake; Calorie and Macronutrients.

The mean calorie intake of male respondents (1530.16±1037.49kcal) was not significantly lower that females' (1676.57±958.70kcal) (p=0.193). The mean carbohydrate intake of female respondents (316.41±106.77g) was significantly higher that males' (242.53±141.30g) (p=0.035). The mean cholesterol intake of male respondents (44.53±16.69mg) was significantly higher that females' (23.13±16.84mg) (p=0.013). The mean protein, total fibre, total fat, saturated fat, and monosaturated fat did not differ significantly between male and female genders (p>0.05).

Table 4.11 Nutrient Intake; Calorie and Macronutrients

Nutrient	Male Mean±S.D	Female Mean±S.D	Both Mean±S.D	p-value
Calories (kcal)	1530.16±1037.49	1676.57±958.70	1628.32±986.27	0.193
Macro-nutrients				
Protein (g)	45.54±32.79	50.26±36.15	48.72±35.11	0.239
Carbohydrate (g)	242.53±141.30	316.41±106.77	292.48±109.82	0.035*
Total Fibre (g)	11.16±2.74	12.21±4.05	11.87±4.05	0.515
Total Fat (g)	27.77±22.97	35.64±25.78	33.10±17.82	0.149
Saturated Fat (g)	4.04±1.56	4.82±3.39	4.57±1.46	0.553
Monosaturated Fat (g)	6.43±3.73	6.79±4.88	6.67±3.84	0.705
Cholesterol (mg)	44.53±16.69	23.13±16.84	30.07±15.48	0.013*

* Significant at the $p<0.05$ level

Source: Author's Findings

Table 4.12 Nutrient Intake; Vitamins.

The mean vitamin A intake of male respondents (3891.83±842.94mcg) was not significantly lower that females' (4267.21±887.73mcg) (p=0.577). The other B-vitamins and Folates were not significantly different between male and female genders (p>0.05).

Table 4.12 Nutrient Intake; Vitamins

Nutrient	Male Mean±S.D	Female Mean±S.D	Both Mean±S.D	p-value
Vitamins				
Vitamin A (mcg)	3891.83±842.94	4267.21±887.73	4147.09±867.68	0.577
Vitamin C(mg)	11.89±**5.27**	39.41±9.92	30.59±16.65	0.154
Thiamin B_1(mg)	1.14±1.12	122.90±37.87	83.26±17.47	0.299
Riboflavin B_2 (mg)	0.73±0.68	0.79±0.39	0.77±0.16	0.607
Niacin B_3(mg)	10.58±8.61	11.80±8.12	11.40±6.11	0.362
Vitamin B_6 (mg)	0.43±0.19	0.59±0.11	0.54±0.09	0.150
Folate (mcg)	190.24±44.04	219.64±20.54	210.18±17.52	0.176
Vitamin B_{12} (mcg)	0.28±0.17	0.33±0.19	0.32±0.16	0.779

Source: Author's Findings

Table 4.13 Nutrient Intake; Minerals

The mean calcium intake of male respondents (372.16±67.44mg) was not significantly lower that females' (390.52±47.64mg) (p=0.682). The mean phosphorus intake of male respondents (458.63±52.11mg) was not significantly higher that females' (387.15±75.80mg) (p=0.218). The mean sodium intake of male respondents (835.36±52.11mg) was not significantly lower that females' (861.92±42.98mg) (p=0.805). The mean zinc intake of female respondents (58.70±17.92mg) was not significantly higher that males' (7.14±5.48mg) (p=0.145). The mean iron intake of female respondents (39.09±14.78mg) was not significantly higher that males' (15.01±14.31mg) (p=0.149).

Table 4.13 Nutrient Intake; Minerals

Nutrient	Male Mean±S.D	Female Mean±S.D	Both Mean±S.D	p-value
Minerals				
Calcium (mg)	372.16±67.44	390.52±47.64	384.57±94.64	0.682
Phosphorus (mg)	458.63±52.11	387.15±75.80	410.28±102.07	0.218
Sodium (mg)	835.36±52.11	861.92±42.98	853.34±42.98	0.805
Potassium (mg)	706.14±187.79	636.81±325.92	658.81±345.95	0.411
Zinc (mg)	7.14±5.48	58.70±17.92	42.29±10.68	0.145
Iron (mg)	15.01±14.31	39.09±14.78	31.38±16.49	0.122
Magnesium (mg)	148.87±102.07	125.15±13.33	132.72±43.37	0.149

Source: Author's Findings

Table 4.14-16 Respondent's Nutrient Adequacy.

There was a severe inadequacy of Calories (51.1%), Protein (51.9%), Total fibre (75.0%), although, Carbohydrate was adequate in about one-quarter of the respondents (27.2%). Although, there was a severe inadequacy of Vitamin C (94.3%), Vitamin B_1 (41.8%), Vitamin B_2 (58.4%), Vitamin B_3 (51.4%), Vitamin B_6 (81.5%), Folates (69.3%) and Vitamin B_{12} (97.0%), yet, about half of the respondents consumed excess Vitamin A (47.3%). Similarly, there was a severe inadequacy of Calcium (81.3%), Phosphorus (67.9%), Potassium (94.3%), Zinc (61.1) and Magnesium (85.9%), although, Iron consumption was adequate and excess in 24.2% and 35.1%, respectively.

Table 4.14 Nutrient Adequacy; Calorie and Macronutrients

Nutrient	Severe (<60%) n (%)	Inadequate (<80%) n (%)	Adequate (80 – 120%) n (%)	Excess (>120%) n (%)
Calories (kcal)	188 (51.1)	61 (16.6)	92 (25.0)	27 (7.3)
Macro-nutrients				
Protein (g)	191 (51.9)	59 (16.0)	76 (20.7)	42 (11.4)
Carbohydrate (g)	161 (43.8)	65 (17.7)	100 (27.2)	42 (11.4)
Total Fibre (g)	276 (75.0)	49 (13.3)	23 (6.3)	20 (5.4)
Total Fat (g)	318 (86.4)	30 (8.2)	10 (2.7)	10 (2.7)
Saturated Fat (g)	353 (95.9)	4 (1.1)	9 (2.4)	2 (0.5)
Monosaturated Fat (g)	341 (92.7)	14 (3.8)	9 (2.4)	4 (1.1)
Cholesterol (mg)	339 (92.1)	21 (5.7)	4 (1.1)	4 (1.1)

Source: Author's Findings

Table 4.15 Nutrient Adequacy; Vitamins

Nutrient	Severe (<60%) n (%)	Inadequate (<80%) n (%)	Adequate (80 – 120%) n (%)	Excess (>120%) n (%)
Vitamins				
Vitamin A (mcg)	144 (39.1)	21 (5.7)	29 (7.9)	174 (47.3)
Vitamin C(mg)	347 (94.3)	6 (1.6)	6 (1.6)	9 (2.4)
Thiamin B_1(mg)	154 (41.8)	38 (10.3)	66 (17.9)	110 (29.9)
Riboflavin B_2 (mg)	215 (58.4)	53 (14.4)	43 (11.7)	57 (15.5)
Niacin B_3(mg)	189 (51.4)	34 (9.2)	66 (17.9)	79 (21.5)
Vitamin B_6 (mg)	300 (81.5)	20 (5.4)	23 (6.3)	25 (6.8)
Folate (mcg)	255 (69.3)	32 (8.7)	52 (14.1)	29 (7.9)
Vitamin B_{12} (mcg)	357 (97.0)	5 (1.4)	3 (0.8)	3 (0.8)

Source: Author's Findings

Table 4.16 Nutrient Adequacy; Minerals

Nutrient	Severe (<60%) n (%)	Inadequate (<80%) n (%)	Adequate (80 – 120%) n (%)	Excess (>120%) n (%)
Minerals				
Calcium (mg)	299 (81.3)	35 (9.5)	20 (5.4)	14 (3.8)
Phosphorus (mg)	250 (67.9)	44 (12.0)	48 (13.0)	26 (7.1)
Sodium (mg)	285 (77.4)	45 (12.2)	29 (7.9)	9 (2.4)
Potassium (mg)	347 (94.3)	10 (2.7)	7 (1.9)	4 (1.1)
Zinc (mg)	225 (61.1)	63 (17.1)	61 (16.6)	19 (5.2)
Iron (mg)	112 (30.4)	38 (10.3)	89 (24.2)	129 (35.1)
Magnesium (mg)	316 (85.9)	25 (6.8)	14 (3.8)	13 (3.5)

Source: Author's Findings

Table 4.17 **Correlation Analysis between Point of Food Purchase, Nutrient Intake and Body Mass Index (BMI).**

There was a weak negative correlation between Body Mass Index and Calorie intake (r=-0.110; p=0.040). There was a weak positive correlation between Sodium intake and patronizing local canteens (r= 0.131; p=0.014), and Body Mass Index (r= -0.118; p=0.026). There was also a weak negative correlation between Body Mass Index and patronizing street food vendors (r= -0.111; p=0.034).

Table 4.17 **Correlation Analysis between Point of Food Purchase, Nutrient Intake and Body Mass Index (BMI)**

Correlates	**Frequency of Purchasing Food from;**								
	Fast food Restaurants	**Local Canteens**	**Supermarkets**	**Snack shops**	**Road-side street food vendors**	**Fruit sellers**	**Street vendors**	**Open market**	**BMI**
Calories (kcal)	-0.087	-0.020	-0.064	-0.014	-0.02	0.023	-0.016	0.056	-0.110*
Protein (g)	0.020	0.035	-0.004	0.015	0.072	0.093	0.054	0.091	-0.083
Carbohydrates (g)	-0.062	0.021	-0.017	0.003	0.003	-0.038	-0.055	-0.020	-0.075
Total fat (g)	-0.020	0.093	0.016	-0.004	0.032	-0.056	-0.081	-0.005	-0.095
Dietary fibre (g)	-0.025	0.101	0.020	-0.015	0.053	-0.049	-0.007	0.017	-0.049
Vitamin C (mg)	-0.015	0.058	0.028	-0.033	-0.001	-0.059	-0.055	-0.021	-0.022
Sodium (mg)	-0.049	0.131*	0.022	0.056	0.039	-0.060	0.022	0.042	-0.118*

BMI Scores (kg/m^2)	0.041	0.079	0.043	0.051	-0.016	0.108*	-0.111*	-0.016	--

* Significant at the p<0.05 level (2-tailed)

Source: Author's Findings

Table 4.18 Correlation Analysis between Point of Food Environment; Access and Availability within 1km Distance, Nutrient Intake and Body Mass Index (BMI).

There was a weak positive correlation between dietary fibre intake and the availability of fast-food restaurants within 1km distance (r= 0.106; p=0.048). A weak positive correlation was found between Sodium intake and the availability of local canteens within 1km distance (r= 0.109; p=0.041). Additionally, there was a weak positive correlation between Body Mass Index and the availability of street food vendors within 1km distance (r= 0.119; p=0.022).

Table 4.18 Correlation Analysis between Point of Food Environment; Access and Availability within 1km Distance, Nutrient Intake and Body Mass Index (BMI)

Correlates	Availability of Food Vendor within 1km Distance;							
	Fast food Restaurants	Local Canteens	Supermarkets	Snack shops	Road-side street food vendors	Fruit sellers	Street vendors	Open market
Calories (kcal)	-0.053	0.045	0.015	-0.012	-0.007	0.005	0.009	0.000
Protein (g)	0.021	0.029	0.038	0.035	0.060	0.060	0.028	0.080
Carbohydrates (g)	0.041	0.046	0.021	-0.001	0.049	0.021	0.043	0.058
Total fat (g)	0.011	0.048	0.030	0.017	0.025	0.024	0.040	-0.004
Dietary fibre (g)	0.106*	0.101	0.047	0.050	0.100	0.048	0.064	0.077
Vitamin C (mg)	0.029	0.028	0.020	0.014	0.032	0.026	0.035	0.047
Sodium (mg)	0.031	0.109*	-0.009	0.067	0.083	0.036	0.039	0.070

BMI Scores (kg/m^2)	0.061	-0.011	-0.011	-0.057	0.020	-0.011	0.119*	-0.033

* Significant at the p<0.05 level (2-tailed)

Source: Author's Findings

Discussion of Findings

Malnutrition is as yet an issue that is winning worldwide with the relationship of both over-nutrition and under-nutrition in emerging nations influencing individuals of any age [1]. Young people are especially in danger of malnutrition because of quick development and advancement and works on in dietary propensities that might have impacted their supplement consumption. Being overweight and heftiness are the principal supporters of non-transmittable sicknesses [2].

Food conditions have been portrayed as the connection point where individuals collaborate with the more extensive food framework to procure and eat foods. Ongoing calculated work has tried to characterize outside and individual food climate areas relevant to worldwide settings. The outer area highlights exogenous aspects like food accessibility, costs, seller and item properties, and advertising and guideline, while the individual space comprises of individual-level aspects, including food openness, moderateness, comfort, and attractiveness. Further developed information and comprehension of the communications between these spaces and aspects are expected to address the twofold weight of malnutrition in Low-Middle Income Countries, described by tireless under-nourishment among ladies and youngsters, as well as the rising pervasiveness of overweight, stoutness, and sustenance related ongoing sicknesses. Food climate research has worked on over late a very long time inside top level salary nations because of the great pervasiveness of overweight, stoutness, and NRCDs. A few orderly surveys have recorded research strategies and measures from HICs, as well as discoveries connected with diet and nourishment results [3].

4.2.1 Socio-Demographic Characteristics of the Study Respondents

This study demographic data showed that there were more female (66.8%) respondents who participated compare with male (33.2%) respondents. This is similar to the recent study carried out among the young adults with gender50.4% and 49.6% female and male respectively [4].Another previous study demonstrated a contrary result showing 39.9% females and 60.1% males[5]. The age range of this study respondents is between 18-29 years, with a mean age of 22.86±3.55years having the 24 to 27 years most participated (33.7%), then 20 to 23 (31.3%),<20 years (23.6%), and >27 years (11.4%) as the least participated in this study. Other socio-demographic characteristics includes: ethnicity, religion and marital status. Most of the respondents were Yoruba (76.9%) and this is similar to a recent study[6].

The key findings of the study identify that there is an interplay of where young adults consume their food, their nutrient adequacy, eating pattern and nutritional status. According to World Health Organization (WHO) range for BMI were used to create the categories: underweight (< 18.5 kg/m^2), normal weight (18.5- < 25 kg/m^2), overweight (25- < 30 kg/m^2) and obesity (> 30 kg/m^2).The prevalence of the malnourished young adults living in Ibadan North Local Government was underweight (8.2%), Underweight (22.6%), Obesity (11.4%) and (57.9%) had normal BMI. as a recent study also demonstrated a contrary result [6]. Higher percentage of the respondents were single (84.2%), also reported in a study [5].This is due to the location setting of the study location. Majority of the respondents also reported to be practicing Christianity (85.1%). This aligns to the study which reported (100%) Christian participants in Calabar South Eastern region of Nigeria. The studentship status also took the higher percentage of the participants (86.1%) because of the of the study location setting.

A majority of the study participants (95.4%) had access to a full kitchen. This shows access to a place for meal preparation. This reflects in the frequency of purchase of meals and snacks from assessed point of sales by respondents. Respondents mainly purchased meals from fast food restaurants and roadside food vendors 1-3times a month (44.6% and 37.8% respectively) [7].

It was discovered that respondents had cereals, white roots and tubers, vitamin A-rich vegetables, vitamin A-rich fruits, flesh meat, eggs, fish and sea-foods, legumes, nuts, and seeds, milk, and milk products, oils and fats, sweets, spices, condiments, and beverages at home, meanwhile, they did not have dark-green leafy vegetables , other fruits, and organ meats at home. This is likely due to the perishable nature of fruits, vegetables, and organ meats which mainly require preservation due to their shelf-life. This is corroborated by the low consumption of fruits and dark-green leafy vegetables as well as organ meats. This doesn't align with the study carried out previously [8].

This study also shows the patronage of fast food restaurants (44.6 %) compared to patronizing from vendors that sells snacks (4.6%) because of individual preferences and environment it is situated. This was also shown in study carried out previously [9].

This study demonstrated high presence of snack shops (98.4%) within 1km of the study location compared to open markets (87.0%). This is logical because of the dominance of the respondents (young adults) compared to other groups in the community who do not have time to eat at their workplace/school.

4.2.2 Nutrient Intake; Calorie and macronutrients

In this study, the mean calorie intake of male respondents (1530.16±1037.49kcal) was not significantly lower than that of the females (1676.57±958.70kcal) where the (p=0.193). Contrary to the previous study which states that men tend to eat more calories than females as a result of their larger mass [10]. The mean carbohydrate intake of the female respondents (316.41±106.77g) was significantly higher than that of the male respondents (242.53±141.30g) (p=0.035) in contrast to the study [10].The mean Cholesterol intake of the male respondents (44.53±16.69mg) were significantly higher than that of the females (23.13±16.84mg), in which a study demonstrates the same result [11].

The mean vitamin A intake of male respondents (3891.83±842.94mcg) was not significantly lower that females' (4267.21±887.73mcg) where the (p=0.577). A study demonstrated contrary result which states that male consumed higher Vitamin A than female [12]. The mineral consumption of both genders were not significantly different from each other as contrarily shown in a previous study carried out among young adults which states that females tend to be more inadequate in their diet than men. [12]

4.2.3 Respondent's Nutrient Adequacy.

This study shows that there were severe nutrient inadequacy consumption among the young adults with (51.1%),(51.9%).(75.0%) Calories, protein and Total Fibre respectively as similarly demonstrated in the previous study [12]. In one quarter of the respondents, there were adequacy in carbohydrates consumption (27.2%), A previous study showed a contrary result which states there were no significant percentage of Carbohydrate consumption that is considered optimal for the respondents to prevent or treat type 2 diabetes [13].

And severe inadequate consumption of Vitamin C (94.3%). It was contrarily reported in a recent study that there is high consumption of Vitamin C [15] , Also about half of them consumed Vitamin A in excess amount (47.3%) in contrast to a recent study which shows the prevalence of VAD as a result of inadequacy of Vitamin A [16].

There were also severe inadequacy in Calcium, Phosphorus, Potassium, Zinc and Magnesium (81.3%),(67.9),(94.3),(61.1%) and (85.9%) respectively similarly to a previous study [12].

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Chapter Five

Conclusion

5.1 Summary of Findings

This study was carried out to assess the prevalence of the malnourished young adults, the proportion of their knowledge about individuals' food environment and how it has affected their nutritional status. A community-based descriptive Cross-sectional was used for the interest of this study in the assessment of the food environment, dietary diversity, physical activity and nutrient adequacy and nutritional status of 18-29 year old young adults living in Ibadan North Local Government, Ibadan, Oyo State, Southwestern region, Nigeria. A total number of 368 respondents participated using a randomized controlled sampling method but within the age range of 18-29 years.

The study showed the mean age of the participants as 22.86±3.55years, demonstrating a larger percentage of female (66.8%) than male (33.2%). Majority of the participants were Yoruba (76.9%), single (84.2%), were students (86.1%) and practicing Christianity (85.1%).

It was found that from this study that the prevalence of underweight, overweight and obesity among the participants were 8.2 %, 22.6% and 11.4% respectively while more than half (57.9%) had their weight in normal BMI range since the percentage of unhealthy foods were not permitted within their premises as (63.9%) was shown. Findings from this study also showed that there were more females who were underweight and obese (8.3%, 15.0%) respectively while there were more males with normal BMI and overweight (61.5%, 28.7%) respectively. This is associated to the relationship between BMI, carbohydrate and cholesterol as the study showed that the mean carbohydrate intake of the females respondent

(316.41±106.77g) was significantly higher than the males (242.53±141.30g) (p=0.035), while the mean cholesterol consumption of the male respondents (44.53±16.69mg) was significantly higher than that of the females participants (23.13±16.84mg) (p=0.013).

However, One-quarter of the respondents consumed carbohydrate in adequate amount (27.2%) and severe inadequacy of calories, protein and Total fibre. And about half of the respondents consumed Vitamin A in excess.

5.2 Conclusion

This study was conducted among young adults, majority of who were students. The prevalence of underweight, overweight and obesity is comparable with recent studies which have shown an increasing trend of these malnutrition domains among the young adults in developing nations of the world.

There was a somewhat sub-optimal consumption of carbohydrate, protein, dietary fibre, vitamin C, and calcium, which are essential nutrients for growth and development of the study population.

Young adults who patronized fast foods restaurants, snack shops and consume SSB have inadequate nutritional status than those who patronized the restaurant less. Meanwhile, sodium intake was slightly high among respondents who had access to and patronized local canteens. Similarly, the BMI of respondents who had access to street vendors was slightly higher than who did not.

There was a high patronage of local canteens and street food vendors due to perceived affordability by the population; thus, these food outlets could serve as a viable option for

respondents if the operators are trained and empowered to provide a diverse range of healthy food options.

5.3 Recommendations

Based on the result of this study, the prevention, management and intervention method should be introduced:

- Public Health strategies that targets this group should emphasize on hazard the junk foods can cause as well as the energy dense foods from fast-food restaurants and snack shops, while encourage the consumption of foods with low=glycaemic index such as high fiber diets, fruits and vegetables. Indiscriminate proliferation of unhealthy foods and drinks should be checked.
- All healthcare personnel should note that food environment, dietary pattern affects nutritional status and also advocate for healthy fat food sources, vitamins, proteins consumption because they help in building immune system.
- Screening for anthropometric measurements should be strengthened as early detection will help to lessen the prevalence of malnutrition.

5.4 Contribution to knowledge

1. This is one of the few community based cross-sectional surveys in the Southwestern region in Nigeria that has estimated prevalence of estimated essential nutrients amongst young adults. This could provide way of monitoring the effectiveness of public health concern related to malnutrition.
2. This research was able to determine the measure of malnourished young adults which could be a cause of inaccessibility of healthy diets within 1km in the community.

3. This study is likely to be one of the few studies in Nigeria to determine the relationship the Body Mass Index, Dietary consumption pattern and food environment on individuals between 18-29 young adults.
4. There have been studies that has determined the food environment and Dietary consumption pattern in the Africa but this study happens to be one of the very few studies that measured Food accessibility within 1km in the community and covers school/work food environment and home environment.

5.5 Suggested Area of Research

1. Further research on the major cause behind the high percentage of low Vitamin C consumption despite being in a tropical region, surrounded with fertile soil and favourable topography.
2. A general survey of Micronutrients and macronutrients prevalence among the young adults will be of great value because of their vulnerability and prone to diesases and illness.

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Appendix

LEAD CITY UNIVERSITY, IBADAN.

DEPARTMENT OF HUMAN NUTRITION AND DIETETICS

QUESTIONNAIRE ON

FOOD ENVIRONMENT, NUTRIENT ADEQUACY AND NUTRITIONAL STATUS AMONG YOUNG ADULTS AGED 18-29 IN IBADAN-NORTH LOCAL GOVERNMENT.

Dear Respondent,

I am a final semester master's student of the above-named department and university, I am currently carrying out a survey on Food Environment, Nutritional Status, Nutrient Adequacy, and Physical Activities among Young Adults Aged 18-29 in Ibadan-North Local Government, Ibadan, Oyo State. The research is for academic purposes and sincere responses to the questionnaire. Thanks.

Do you agree to participate in this research? Yes ( ) No ( )

Signature…….

QUESTIONNAIRE NO;

Instruction; Tick ( ) your appropriate response and fill in empty options as required.

Section A: SOCIO-DEMOGRAPHIC CHARACTERISTICS INFORMATION

1. Gender of respondent: (a) Male [ ] (b) Female [ ]
2. Age of respondent (years):
3. Ethnicity: (a) Yoruba [ ] (b) Igbo [ ] (c) Hausa [ ] (d) Others specify……..
4. Religion of respondent: (a) Islam[ ] (b) Christianity[ ] (c) Others specify…….
5. Marital Status of Respondent: (a) Single [ ] (b) Married [ ] (c) Divorced/Separated[ ] (d)Widowed[ ]
6. Student: (a)Yes[ ] (b) No[ ]
   If Yes,
7. Monthly Allowance:
8. How much do you spend on food from your allowance:
9. Employed; Yes[ ] No[ ]
   If Yes,

10. Occupation: (a) Self-employed [ ] (b) Artisan [ ] (c) Full-house wife[ ] (d) Civil servant [ ]
11. Average Monthly Income:
12. How much do you spend on food from your monthly income:

Section B; HOME FOOD ENVIRONMENT

1. What type of house do you live in? (a)Single room with shared kitchen [ ] (b) Self-contained with private Kitchen [ ] (c) Flat house system [ ] (d) squatting with a friend or relative [ ] (e) Living with parents [ ] (f) others specify: _____
2. Do you have access to a full kitchen where you can prepare meals most of the time? ( ) Yes ( ) No

3. Which of the following foods do you currently have in your house?

Food Group	Yes	No
All Starchy Staple foods		
Bread		
Rice		
Cereals		
Spaghetti		
Potatoes		
Beans and Peas		
Beans		
Soybean		
Nuts and Seeds		
Groundnut		
Cashew nuts		
Dairy and its product		
Evaporated Milk		
Butter		
Cheese		
Vitamin-A rich green vegetables and fruits		
Tomatoes		
Carrots		
Mango		
Watermelon		

Food Group	Yes	No
Drinks		
Soda drinks		
Alcohol Drinks		
Energy drink		
Herbal drink(Agbo)		
Sugar, Syrup and sweets		
Honey		
Sugar		
Date Syrup		
Meat, Fish and Poultry		
Crayfish		
Alaran		
Crab		
Cow meat		
Chicken		
Turkey		
Egg		
Goat meat		
Snail		
Ponmo		
Catfish		

4. How often do you consume food and beverages from the following locations?

	Daily	4– 6 times /week	1–3 times/ week	1 – 3 times /month	Never
Fast food restaurants (e.g., Chicken Republic, Kilimanjaro, etc.)					

Local Canteens (e.g Amala sky, Buka, vendors that sell local foods)					
Supermarkets (High Class that sell pastries, biscuits, and Fruit flavored drinks)					
Snack shops (sells meat pie, puff-puff, doughnuts etc)					
Roadside street food vendors (roasted corn/plantain, akara, boli, fried potatoes, etc.)					
Fruits Sellers (mango, apple)					
Street Vendors (pepper, groceries,etc.)					
Open Markets (orita, oja-oba, Oje.t.c)					

WORK/SCHOOL FOOD ENVIRONMENT

Proximity of Food within the work/school

Access to food around the work/school	**Yes**	**No**
Are there time(s) allocated for eating at the work/school		
Is there presence of food canteens within the work/school		
Is there presence of snack shops within the work/school		
Is there access to fresh drinking water		
Is there access to an adequate dining facility		
Is there access to fruits and vegetables in school/work		
Do they allow the sales of unhealthy foods and drinks		

How many of these do you find around your community?	**1km around your community**
Fast food restaurants (e.g., Chicken Republic, Kilimanjaro, etc.)	
Local Canteens ((e.g Amala sky, Buka, vendors that sell local foods)	
Supermarkets (High-Class that sell pastries, biscuits, and sugar-sweetened beverages)	
Snack shops (sell pastries, biscuits, and sugar-sweetened beverages)	
Roadside street food vendors (roasted corn/plantain, akara, fried potatoes, etc.)	
Fruits Sellers	
Street Vendors (pepper, groceries, etc.)	

Open Markets (orita, oja-oba, Oje.t.c)	

Section C: NUTRITIONAL STATUS

1. Weight(kg);
2. Height (m);

Section D: NUTRIENT ADEQUACY

TWENTY-FOUR-HOUR DIETARY RECALL

Please kindly describe all that you ate or drank whether at home or outside the home from when you first woke up yesterday morning.

Date---------- Day of the week----------

-

Questionnaire Number…… Name……

Item No.	Food/Drink	Description of Food or Drink	Time	Place	Quantity (use volume, size, or price)	Weight equivalent (gram)
1. Was food intake usual? Y/N If No, how was it unusual?				4. Probe for iron supplements, vitamins antimalaria, etc. consumed		

2. Was it a feast or a fast day? Y/N	in the last week Y/N If Yes, specify
3. Probe for sickness (Y/N) If yes, did sickness affect appetite? Y/N If Yes, how? Increase or decrease	5. Probe for fermented beverages consumed

Bio- data

A. Personal Data

1. **Full Name**: Mayowa Fortune Alade
   Email: mayowafortune@gmail.com
   Phone Number: 07062654095
2. **Date and Place of Birth**: 11th February and Osogbo, Osun State
3. **Nationality: Nigerian**
4. **Name and Address of Next of Kin**: Alade Blessing and Federal Polytechnic Ede.

B. Educational Background with Dates:

- Lead City University, Ibadan. Oyo State (MSc Human Nutrition and Dietetics) : 2022- in view
- Lead City University, Ibadan. Oyo State (BSc Human Nutrition and Dietetics 2018-2021
- Federal Polytechnic Ede. Osun State 2016-2018

C. Working Experiences with Dates:

Part- Time Lecturer at Federal Polytechnic Ede, Osun State- 2021-2023

Graduate Assistant at Lead City University, Ibadan. Oyo State 2023- till Date

D. Award and Fellowships with Dates:

- Outstanding Leadership as a Treasurer, Federal Polytechnic Ede 2018-2019
- Outstanding and Dedicated Service to the University Community, Lead City University, Ibadan 2019-2021
- Outstanding Member in Charity Community Outreach, National Youth Service Corps, Ogbomosho North 2022

E. Membership of Academics

- Nutrition Society of Nigeria
- American Society of Nigeria

F. Publications

- Aderonke O. Mosuro, Ifeoluwa O. Bodunde, Mayowa F. Alade, Adeola A. Akinyele, Abisola O. Fawole (2023). The Functional Properties and Nutritional Profile of Flour made from Two Selected

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G. Major Conferences with Dates

- Nutrition Society of Nigeria- 2022

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The University Compliance Certification

This is to certify that this thesis by Mayowa Fortune ALADE with the Matric Number: LCU/PG/005075 in the department of Human Nutrition and Dietetics, Faculty Basic Medical and Health Sciences is in full compliance with the university format and style.

…… …….....

Signature Date