

# Relationship among Food Intake, Dietary Habit and Immunity among Different Age People in West African Countries during the Covid-19 Pandemic

Oluwatoyin Oluwole<sup>1,\*</sup>, Oluwaseun Ademuyiwa<sup>1</sup>, Babatunde Kosoko<sup>1</sup>, and Gloria Elemo<sup>2</sup>

<sup>1</sup>Department of Food Technology, Federal Institute of Industrial Research Oshodi, Lagos, Nigeria

<sup>2</sup>Department of Chemical Sciences, Faculty of Natural Sciences, Ajayi Crowther University, Oyo, Oyo State, Nigeria

\*Corresponding author: Oluwatoyin Oluwole, Department of Food Technology, Federal Institute of Industrial Research Oshodi, Lagos, Nigeria, E-mail: oluwatoyinoluwole575@yahoo.com

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## Abstract

Poor dietary habits are one of the leading risk factors associated with morbidity, mortality, and disability in the world. Different regions/continents of the world have different dietary patterns which are based on environmental, cultural, technological and socio-economic factors. However, due to urbanization, there has been a steady nutrition transition in many West African countries including Nigeria, Ghana, Cote d'Ivoire and Senegal from their traditional diet made up of traditional staple foods like maize, yam, cassava, plantain, cocoyam, beans, and nuts with vegetables as soups to Westernized diet made up majorly of processed pre-packaged foods which are energy-dense foods or high-fat diet especially among urban dwellers. This transition has in turn had a negative effect on the health and well-being of the populace which can be seen in terms of susceptibility to infection and severity of infection. West Africa has also been reported to have a prevalence of people suffering from malnutrition either due to over-nutrition (over-consumption of high caloric foods with little micronutrients) or under-nutrition (inadequate consumption of both energy and micronutrients) based on nutritional status. This review attempts to show the role of good dietary habits as a means of protecting against Covid-19 infection across different age groups in four major West African countries.

**Keywords:** Covid-19; Under-nutrition; Dietary habits; Over-nutrition; Malnutrition; Immunity

## Introduction

It has been reported that poor dietary habits are the second-leading risk factors for mortality and disability-adjusted life-years (DALYs) in the world. It is responsible for about 10.3 million deaths and 229.1 million DALYs in 2016 [1]. In so many continents and regions of the world including Africa which has been influenced by Western civilization, the western dietary habit of consuming diets high in red and processed meat, diets high in sugar-sweetened beverages, and low in milk with little intake of whole grains, fruit and vegetables, and nuts and seeds are a major health concern as they lead to a predisposition to several diseased conditions which could have been avoided with healthy nutrition [1].

Ordinarily, dietary patterns are different based on cultural, environmental, technological, and economic factors. However, nutrition transition which is characterized by rapid urbanization, industrialization, trade expansions, changing diets, decreased physical activity have resulted in food patterns and dietary habits becoming similar across continents and regions [2]. Other factors associated with the similarity in dietary habits and food patterns across continents and regions are increasing standards of living and the growing globalization of the food sector [3]. Although most

West African countries are in the early stages of this transition, some West African countries, especially the rural dwellers are behaving quite traditionally in their dietary habits. However, Nigeria, Ghana, and others like Cape Verde and Senegal are at the latter stages [4]. The characteristic changes in diets from traditional foods (less saturated fats and sugars, more whole grains, fruits, and vegetables) to more 'westernized diet's (high in saturated fats, protein, refined carbohydrates, simple sugars, and salt) and frequent consumption of fast-foods has been observed especially among urban dwellers in these countries [2]. In Sub-Saharan Africa (SSA), and particularly in West African populations, aging and rapid urbanization are associated with changes in lifestyle, such as diet, which has contributed to the emergence of metabolic diseases [5].

The relationship between diet and nutrition and immunity cannot be overemphasized. A recent study showed a detailed report linking dietary and nutritional risks along with other factors such as medical, lifestyle, and environmental factors with the severity of infection or symptoms displayed in COVID-19 [1]. It is well documented that nutritional deficiencies of energy, protein, and specific micronutrients contribute to suppressed immune function, resulting in increased susceptibility to infections. It has been reported that the macro-

micronutrients, and phytonutrients in diet, such as varieties of fruits and vegetables help to improve healthy immune responses while micro-and phytonutrients provide the antioxidants and the anti-inflammatory nutrients, like beta-carotene, vitamin C, vitamin E, and polyphenolic compounds which help in modulating the immune functions [6]. With the current Covid-19 pandemic being a leading health challenge worldwide and vaccinations still inadequate and yet to be widely administered especially in West African countries, healthy nutritional status is currently seen as a very important way of maintaining strong immunity against the virus.

As of September 2021, there have been reported over 8.39 million cases on the African continent. The West African sub-region is responsible for about 580,000 (6.9%) of these cases which are 0.3% of cases worldwide and 0.2% of the death toll. However, a poor healthcare system and poor adherence to safety rules has led to about 326-451% increase in cases and death in the region from October 2020 to March 2021 [1,7].

Age is one of the major factors which affects the dietary habit and nutritional status of individuals. Other factors include sex, socio-economic status, medications, and health status. Although socio-economic status plays a major role in the dietary pattern of any group of people however food preference based on age is a very vital factor in nutrient intake and dietary pattern. For instance, infants and school-age children have their feeding habits and dietary intake influenced by the choices of their parents while adolescents who can make their own choices are said to have the poorest dietary habits as several reports showed them to have the highest consumption rate of nutrient-poor foods with snacks, carbonated drinks and confectionaries forming the major part of their diet. Optimal dietary intake of nutrients helps to impact the immune system through gene expression, cell activation, and signaling molecules activation. Some dietary components also help to modulate the gut microbiota and help influence the body's immune response [7].

The purpose of this review is therefore to highlight the immune response or susceptibility of different age groups in some West African countries to Covid-19 based on their dietary habits.

### **Food intake and dietary habits among different age groups in some West African countries**

One major influential part of culture is food/dietary habits. It is one of the oldest and most entrenched aspects of many cultures which exert a huge influence on people's behaviors. Different cultures or groups and societies possess diverse feeding habits which are passed on from one generation to another. Factors that affect the choices of food intake include socio-economic status, availability, cultural and social habits, physiological and psychological attributes, and nutritional knowledge [8]. Generally, it is usually slow and difficult to change food habits due to the satisfaction and reassurance derived from familiar foods and it is known that traditional foods of childhood do evoke a deep-sated emotional response, however over the past three generations; many countries in West Africa have experienced an extensive change in food habits and dietary patterns. Some of the major staple food materials cultivated and consumed in most parts of West Africa are maize, yams, plantains, and cassava. These are usually eaten with soups or stews or used in making porridges or consumed as gruels. However, over the years, the introduction of rice and other cereal cultivation and importation in most parts of West Africa an increased grain consumption [2]. The advent of urbanization and globalization has meant that non-traditional foods now dominate in most of the urban areas of West Africa and even in rural areas, the loss of work

force to migration to urban areas meant that the range of traditional domestic food stuffs is reduced due to increased cost of production and processing [9,10]. Typical West African meals are giving way to continental westernized/Asian cuisines due to inconvenient cooking methods. The special handling involved in preserving most of these traditional dishes when not immediately consumed has also made them an inconvenient food option for busy commuting urban dwellers. This has led to increased interest among urban dwellers for processed pre-packaged foods such as sandwiches, biscuits, cheese, and noodles. Another reason for the huge consumption of processed pre-packaged foods is that most people see them as a status symbol and thus their demand is also driven by prestige particularly among the middle and high-income populations; however, findings have shown that these unhealthy food products are less expensive per calorie compared to healthier options like lean meats, fish, fresh fruits and vegetables [2].

### **Food intake and dietary habits among different age groups in Nigeria**

Healthy eating habits have been reported to promote growth, health, and intellectual development and prevent or improve on some long term health problems such as iron deficiency anemia, cardiovascular diseases, and dental caries and cancers. It has also been reported that healthy eating habits help to boost immunity [9].

In Nigeria, different age groups have different eating habits based on taste, energy requirements, and socio-economic status. Malnutrition is a great hazard to the more vulnerable groups especially infants, school-aged children, and the old aged [10]. Nigeria, which is one of the countries grouped among the low and middle-income countries is subjected to an increasing risk of malnutrition; either under-nutrition (inadequate food intake, irregular meal consumption especially skipping breakfast) and over-nutrition (over-consumption of foods high in calories and fats but poor in nutrients). Those in the adolescent and adult groups also have their food intake and eating habits affected by the socio-economic situation of the country [11]. Among the adolescents, social pressures to achieve a certain body image is causing under-nutrition among some group while some other groups of adolescents are expose to gaining weight as their taste has moved to energy and lipid-rich diet. Urbanization and the advent of technology, use of electronic gadgets, and social media have also led to a decrease in physical activity among urban adolescents [11].

Among infants, reports have shown that only about 11% of infants received the minimum acceptable diet (a diet that met the minimum meal frequency and minimum dietary diversity parameters) in Sub-Saharan Africa while in West and Central Africa, only about 9% and in Nigeria only about 10% of infants meet the recommended minimum acceptable diet. According to National Demographic and Health Survey, only 41% of breastfed infants are fed complementary foods from at least four food groups [12]. In another report, protein-energy malnutrition has contributed to 45% of death among children of less than 5 years of age in several countries and 41% of death among children in ages 6-24 months has been associated with protein-energy malnutrition [13]. However, the socio-economic status of parents has been reported to affect the quality of the diet of the infants. Government intervention in terms of awareness and nutrition education to the caregivers have also improved the quality of diet as reports have shown that even women from the low-income demographics can still manage to give adequate diet within the minimum acceptable diet range to their infants using local and cheap food materials [12].

For school-aged children (children between the ages of 4-12 years) who have just started making their own food choices and forming

their food habits, they are influenced by the parents, friends, family, and media in their choice of food and eating habits. Also, they need nutritious and healthy foods and snacks at that age as they eat in a frequency of about 4 to 5 times a day [14]. Reports have demonstrated that children who skip breakfast have poor performance as they are likely to be inattentive, irritable, and lethargic in school [15]. Poor socio-economic status also means that children in the low-income, or poverty demographic are at higher risk of inadequate nutrient intake and malnutrition. Mental and physical development in school-age children means that they require a nutritious diet in proportion to their weight much more than adults. They require enough calories as they are active so that protein which should be used for body building will not be converted into energy. However, the calorie intake should be controlled so that it will not become excessive and thus lead to obesity. Therefore it is recommended that the diet of school-age children should consist of about 50-60% carbohydrate, 25-35% fats, and 10-15% protein [14]. In another report, gender was reported to have a significant effect on the eating habits of school-age children as boys are found to be less responsive to food than girls (that is boys are emotional eaters, they tend to stick to food based on familiarity while girls are more liable to try new food products). However, boys tend to enjoy food more than girls and thus tend to eat more. Family dynamics can also affect the eating habits of school-age children as children from dysfunctional families tend to eat poorly compared with their counterparts from stable homes [16]. Results obtained in another study conducted among school-aged children in Ibadan, showed adequate carbohydrate, fat, and protein intake with inadequate vitamins and minerals intake especially vitamins such as vitamins B6, B12, and A, and minerals such as iron, calcium, and iodine are below the recommended daily nutrient intake [17].

Adolescents who form about 22.1% of the Nigerian population have been known to have a propensity for risky health behaviors which could later lead to health problems and unhealthy eating habits have been reported to be one of the risk factors associated with morbidity and mortality among adolescents [9]. Adolescents are known to be prone to skipping meals especially breakfast and consume high-calorie snacks with low consumption of fruits and vegetables. The dietary habits of this group are also affected by socio-economic, physiological, and psychological factors. A report from South West Nigeria has demonstrated that wheat-based snacks and sweetened beverages such as carbonated drinks and fruit drinks form a major part of the diet of adolescents [18]. According to another report on adolescents in Abuja municipal area, adolescents skip meals especially breakfast due to lack of appetite, little time or religious reasons which could lead to a tendency to snack more during the day and the snacks consumed are more of junk foods and also fruits and vegetable intake is low [9]. Factors influencing the food choices include the quest for greater independence, socio-economic status, parental and peer influence, general knowledge of nutrition, and culture-specific dietary practices. Poor dietary choices are more prevalent in mid and late adolescents due to a greater quest for independence and reduced parental influence. Psychological factors such as body image and search for identity are also presumed to be responsible for these poor dietary habits [19]. However, adolescents leaving in rural areas are not as prone to skipping meals as adolescents in urban areas due to infrequent intake of snacks as a result of reduced availability [20]. Another study on adolescents in cross-river state reiterated these feeding habits as well (skipping meals, snacking, and poor fruits and vegetable intake) [21]. Among adults be it undergraduate students or working-class adults, their dietary habits are influenced by changes in the environment, availability of resources, and exposure to unhealthy foods and habits. Many

undergraduates have just gained freedom and independence from their parents and are likely to be responsible for their diet for the first time away from home [22]. In a study conducted on undergraduate students from a university in South-Western Nigeria, snacking and skipping of meals are common dietary habits amongst the majority of them and the snacks are usually high-calorie snacks. Among the female undergraduates, a certain consciousness of appearance and weight makes them more conscious of their diet. The undergraduate group has most of their meals comprised of cereals, root and tubers, fats and oils, and meat with little consumption of vegetables, fruits, and eggs [22]. This study is also corroborated by another report showing that a survey of female undergraduate students in public and private universities in Osun State whose ages range from 17-28 years tend to skip meals especially breakfast, snack a lot with little fruits and vegetable intake. However, understanding basic nutrition and socio-economic status has been reported to influence the dietary habits of some of them [23].

Amongst the working class, snacking is also prevalent, especially among those living in urban areas. In a study conducted on traders in Sokoto state, unhealthy eating habits were prevalent as a study showed that 49.9% are used to snacking and consumption of sweetened beverages such as fruit drinks and carbonated drinks. So many were also found to consume energy-dense foods with little fruits and vegetables with a percentage of about 58 of these traders confirmed to eat fruits and vegetables less than three times a week or not at all. However, the nutritionally aware ones about 42% eat fruits and vegetables at least three times a week [24]. In another report from a study conducted on bankers in Lagos state, about 57% of them do not do their shopping themselves and most of their cooking is done by house-helpers. The hectic nature of their jobs also means that many meals especially lunch are taken away from home and with very few healthy options outside of the home, they make do with fries, pies, and other baked food options. They also tend to snack often which they have attributed to time constraints. These poor dietary habits have led to about 72% males and about 85% females taking below the recommended daily calorie intake. It was also discovered that their micronutrient intake is inadequate with vitamins E, B6, and C, then potassium, calcium, magnesium, and zinc being below the recommended limit [25]. In a study conducted on women of reproductive age (18-49 years), socio-economic status is a huge factor in food intake and dietary habits. Awareness of nutrition due to regular ante-natal classes on diet even by primary health care centers means that even the poor can try to eat healthy within their means. However the current economic situation of the country and increasing food prices mean that most Nigerian households are becoming food insecure, the report also showed that women residents in the North-West are more likely to be under-nourished than women in the South due to the variation in socio-cultural factors across the geo-political zone. Educational status, employment, and marital status have also been found to affect the food intake and dietary habits of these women [26]. In another study conducted on women of reproductive age (20-50 years) in Sokoto state, carbohydrates form the majority of their diet with supplementation with micro nutrients. Snacking is not common and when extra food is needed outside the basic meals they tend to take fruits as basic knowledge of nutrition for the well-being of the unborn child is taught at ante-natal classes, however, socio-economic status has a huge effect on their dietary habits and food intake [27]. Among the elderly in low-income areas of South West Nigeria, their meal is dominated by intake of roots and tubers ("eba", yam, pounded yam, and amala), cereals (rice), legumes (beans and Moi-Moi) with low consumption of animal protein due to socio-economic status.

However, a huge part of their diet is made up of vegetables as most of the foods consumed are consumed with soups which are majorly vegetable-based while fruits are consumed in lesser amounts. There is a poor intake of micro-nutrients, protein, and fats [10]. In another report, health status and declining appetite have a negative effect on food intake and dietary habits of the aged whilst income is also a major determinant in their choice of food and dietary habit [28].

**Effect of dietary habits on immunity amidst the covid-19 pandemic among different age groups in Nigeria:** The nutritional status of individuals has been linked to several immediate and long-term health effects. It has been linked to susceptibility to infections and diseases. In Nigeria, malnutrition, poor feeding practices, and inadequate food and micro-nutrient intake have been reported to be the major direct cause of morbidity and mortality among Nigerian mothers and children [29]. According to a UNICEF article in 2019, about 49% of children in Nigeria under the age of five are not growing well due to poor nutrition which has made them susceptible to various infections and diseases [30].

In Nigeria, the food consumed by the underprivileged majority of all age groups is usually monotonous and do not provide the recommended dietary allowance for energy and essential nutrients, leading to malnutrition which has been associated with several infectious diseases such as diarrhoea, malaria, measles, and acute respiratory illnesses of which Covid-19 is one. Malnutrition leads to dysfunction in the immune system which in turn increases the vulnerability of an individual to infection. Malnutrition alters all defense mechanisms such as cell-mediated immune responses, anatomic barriers, phagocytic/microbicidal functions, and humoral responses [31]. Among the few affluent Nigerians, gluttony and consumption of processed foods are prevalent, this has led to the susceptibility of this group to co-morbidities such as obesity and cardiovascular diseases such as hypertension, diabetes mellitus, and coronary heart disease which make them susceptible to Covid-19 infection as several epidemiological and clinical data have shown the incidence and severity of infections are higher in obese individuals than in lean or normal-weight individuals [31,32]. Although according to statistics, the rate of Covid-19 infection in children is quite low and majorly asymptomatic, however, a study conducted in Bauchi state, Nigeria showed that about 18% of the infected population in the state are children below the age of 18 and the majority of the infected children are adolescents. This high rate of infection amongst children in the state has been linked to the high fertility rate in the state which means many homes are having more children below the age of 18. The high infection rate among adolescents has also been linked to decreased parental influence on the habits of these children, which means they are more likely not to adhere to protective measures. The poor dietary habits of this group of children could also make them susceptible to infection, albeit reports showed that males are more susceptible than females with more fatal outcomes [33].

The age group that is however most susceptible to Covid-19 infection according to reports in Nigeria is 21-50 years with peak infection among the 31-40 years. This contrasts with a report from China or Italy with peak infection among 50-79 years. This contrast has however been associated with the demographics of the Nigerian populace as Nigeria is a relatively young country with only about 2% of the population above 65 years [34]. The report has shown however that people with co-morbidities such as hypertension, diabetes, renal diseases which could be linked to poor dietary choices are more likely to die from Covid-19 than people without co-morbidities and more so people with 2 or more co-morbidities. However, the risk of mortality

is higher in people above 60 years of age due to immune dysfunction arising from age and for some presence of co-morbidities at that age. The risk of infection and mortality is also higher in men than women and this has been associated with behavioral, social, and biological differences as men tend to engage in poor dietary and social habits such as alcohol consumption or smoking [35].

### **Food intake and dietary habits among different age groups in Ghana**

Due to globalization, nations worldwide are experiencing a transition in their nutrition and Ghana is another West African country that has moved to the latter stages in this trend. This has led to changes in diet from traditional foods which are made up of more grains, fruits, and vegetables and less saturated fats and sugars to westernized diets which are high in refined carbohydrates, saturated fats, protein, simple sugars, and salts. Also, most of the major Ghanaian staple foods which are more of porridges and gruels are made of maize, yam, plantain, and cassava are quite difficult or inconvenient to cook and some foods such as “kenkey” and “banku” are inconvenient for busy commuting urban dwellers due to accompanying such foods with stews/soups. This has led to increased interest in processed pre-packaged foods like sandwiches, cheese, noodles, or biscuit among these commuting urban dwellers. Another factor that has led to increased consumption of these processed pre-packaged foods is the fact that they are less expensive per calorie when compared to healthier options like fish, lean meat, fresh fruits, and vegetables [2].

For infants and young children, there exists a dearth of knowledge on key infant and young child feeding practices among caregivers in the country which is coupled with a lack of skill in the preparation of nutritious food for children. Another reason for poor diversity in the diet of infants and children is the high cost of some food which should have provided needed nutrients for the infants. The belief that the only appropriate meal for infants are porridges from starches and grains due to ease of swallowing has also resulted in a low intake of iron-rich foods [36]. Adequate complementary feeding up to two years of age in infants helps to foster normal child growth and development and it allows for a good foundation for health long after childhood as inadequate complementary feeding practices may lead to illnesses and susceptibility to infection in children [37]. However, a report has shown that about 17% of children below age 5 in Ghana are stunted and only about 13% of children between 6-23 months receive the appropriate minimum diet diversity [36]. According to WHO, adequate complementary feeding for infants is based on a child receiving at least Minimum Dietary Diversity (MDD) which is provided by foods from four or more of seven food groups and also Minimum Meal Frequency (MMF) of breast-feeding and complementary foods of semi-solids and soft foods two or more times daily for ages 6-8 months, breast-feeding and complementary foods of semi-solids and soft foods three or more times daily for 9-23 months or no breast-feeding but complementary foods of semi-solids and soft foods four or more times daily for 6-23 months. Only when both the MDD and MMF criteria are met is a child considered to have received the least Minimum Acceptable Diet (MAD) for health [38]. According to a report, only an estimated 47% of infants of 6-23 months received MDD and only 50% received MMF with only 27% making the required MAD in Ghana with the northern region being the most affected due to higher than average level of poverty, lack of accessible healthcare and inadequate access to sufficient portable water and sanitation facilities [37]. The food intake and dietary habits of infants are affected by the food security of the household in which they live. A household that is constantly facing food insecurity will find it difficult to meet the MAD for their infants.

Most households do well in the MMF but fail in providing MDD. This means that the meals fed to the infants though frequent enough, are however not diverse enough to meet the MDD and inadequate diverse foods are the major cause of chronic malnutrition in children. Other factors that affect the food intake and dietary habits of infants are the level of education, socio-economic status of the mothers/caregivers, and accessibility to basic nutrition advice and education [37]. This report was corroborated by another report which also demonstrated that level of maternal education, socio-economic status, and place of residence played a huge role in the dietary habits and food consumption pattern of infants of age's 6-23months in Ghana as there was a positive relationship between maternal education/ household wealth and child's dietary diversity score. Household wealth and maternal education mean that children of such parents consume diverse meals which could include juice, fresh milk, fortified baby foods, eggs, and fruits. The study also showed that children from Greater Accra, Western, Bono-Ahafo, and central regions were likely to have a better chance of consuming adequate and diverse foods than their counterparts from Volta, Eastern, and Ashanti regions. This difference arises due to climate conditions which affect agricultural production in some regions and other problems affecting food distribution such as poor road network, lack of finance, and inadequate market which result in food insecurity in some regions [38,39].

Poor dietary habits have also been reported among school-aged children in Ghana. A report has shown a prevalence of overweight/obesity of between 7.8-25.9% among school-aged children in urban Ghana. Since the health, physical growth, and educational performance of school-aged children depend largely on good nutrition, and malnutrition or inadequate nutrition and poor dietary habits have been associated with increased risk of infection and other diseases such as anemia, dental caries, and obesity, it is therefore, a public health concern to promote healthy dietary habits among school-aged children to prevent diet-related diseases and infections [40,2]. Poor dietary habits among school-aged children have been linked to the family's socio-economic status, region of residence as a study demonstrated that children in the Eastern region and rural area of the Volta region had a 70% prevalence of malnutrition. Most of these children consume meals made majorly of grains, roots, and tubers with little meat, dairy products, eggs, and dark green leafy vegetables. The study however reported high fruit intake due to some local fruits like black velvet tamarind, and mangoes being in season [41]. Also for children from poor households, their meal choices are monotonous and limited to a few staples which are cheap and available.

Among adolescents, socio-economic status was found to be the major factor affecting dietary habits and food intake as children from the relatively wealthy background are found to typically consume a diet of a westernized nature with more sugar-sweetened snacks, energy and soft drinks, tea, coffee, milk, and milk products and fats and high fat-based foods. These children also tend to have more money to spend on snacks outside of the home and they snack more on sweets and other energy-dense foods. However, children from relatively poor backgrounds consume more of a local diet with cereal, grains, legumes, and nuts forming a huge part of their diet. However, some children from wealthy backgrounds due to nutritional awareness of their parents or guardians are more traditional in their dietary pattern with additional consumption of fish, vegetables, and sea foods but the number of adolescents in this group is very limited [42]. Some of the factors that influence the dietary habits of adolescents include family, friends, and media. A report showed that many of these adolescents do not eat with their parents but rather with their peers which have led to

poor dietary habits. They also tend to skip meals especially breakfast. Some skip breakfast so as to save time and get to school early while others do so to maintain weight. This however has led to overweight/obesity as snacks are majorly pastries, ice-creams, or carbonated drinks which are high caloric and energy-dense. Very few of them consume fruits at least once a day but 66% of them consume carbonated drinks regularly [43].

Among adults in Ghana, there has been a change in nutritional trends which is characterized by over-nutrition which leads to overweight/obesity, especially amongst adult women. Overweight and obesity are prevalent amongst women in Ghana which has increased steadily from 25% in 2003 to 40% in 2014. Men are also not left out as a report showed a 16% overweight prevalence amongst men in 2014. This poor dietary habits leading to overweight/obesity have increased the risk of susceptibility to cardiovascular diseases and type 2 diabetes. This huge problem in dietary habits and malnutrition has been associated with factors such as high socio-economic status, gender, urban residency, and few food choices [44,45]. A study conducted on the non-academic staff of a university in Ghana showed a moderate dietary diversity which could be as a result of educational and employment status which increases their knowledge about food choices. This led to a majority of them having normal weight with an overweight prevalence of 19.1% among men and 23.7% among women. This has been attributed to the nutrition transition which had led to changes of diet from a traditional diet to westernized one which is made up majorly of processed pre-packaged foods. The difference among males and female has also been linked to higher dietary diversity observed amongst men (10.5%) when compared with women (4.5%) [46]. Among young adults (university undergraduates), their dietary habits are characterized by skipping meals especially breakfast, high intake of energy-dense food, snacking on high caloric snacks, and sweetened carbonated drinks with a low intake of fruits and vegetables [47]. There is however a prevalence in the consumption of fast foods amongst males than the females. Their diet also included a high intake of energy-dense foods and soft drinks [47]. Another report also showed that adults living in urban Ghana observed a westernized diet consisting of pasta, rice, meat, and processed pre-packaged processed foods while those in rural Ghana adhere to a more traditional diet of energy dense components like yam, maize, cassava, and cocoyam taken with stew or soups which are prepared from vegetables [5].

Among women of reproductive age, it has been discovered that there exist maternal malnutrition in developing countries including Ghana due to inadequate dietary intake mainly due to inadequate quantity, quality, and diversified diet and poverty their meals is typically monotonous based majorly on plants or cereals and deficient in micronutrient dense foods such as vegetables, fruits and animal proteins [48]. A study conducted on pregnant adolescents showed that staples were the most consumed (99.3%) with dairy foods being the least consumed (17%). There was also low consumption of nutritious foods like eggs, pulses, nuts and seeds, vegetables and fruits with the diet of a majority of them being monotonous energy-dense and lacking in nutrients [49]. In another report, the majority of pregnant adolescents in Ghana consume three square meals but hardly snack between meals due to financial constraints. The report also showed that a majority do not take enough fruits and vegetables. The study also showed that first-time mothers tend to adhere better to nutrition advice and have better dietary habits than those who have been pregnant before [50].

Among the elderly, co-morbidities, physical decline, and disability were noticed. This has been attributed to consumption of unhealthy

diets, physical inactivity, and other unhealthy lifestyles like excessive alcohol intake and tobacco smoking. A study conducted of older adults in sunyani municipality of Ghana showed that the majority of them had cultivated the habit of taking three square meals and a snack. It was also discovered that the majority of them consume Ghanaian staple foods for breakfast to supper and fruits as a snack. In this study, the overall dietary habit was good containing starch, proteins, cereals, fruits, and some vegetables but did not contain legumes, dairy products, nuts, and seeds, and few consumed fiber-rich foods. Their dietary habit also contains no processed foods that are high in sugar, sodium, and fats but are Ghanaian staple foods that provide enough daily calories, some vitamins, and minerals. This moderately good adherence to the proper diet could be due to co-morbidities existing in the majority of the participants as seven out of ten of them had high blood pressure [51]. In another study conducted on older adults in Effutu Municipality in Ghana, poor nutritional status was observed which has been linked to morbidity and mortality. These nutritional deficiencies were linked with dietary habits such as skipping meals, consumption of energy-dense, and refined and processed foods [52]. Another study on the elderly in some Peri-urban communities in Ga, West municipality, Ghana showed that 90% of participants have good knowledge of nutrition, however, some physiological changes due to age have led to the loss of appetite which in turn causes skipping of meals amongst the elderly. Their diet was made up majorly of grains/cereals, vegetables, and fish which are consumed on a daily basis. However, the diet quality of more than half of them was poor due to lack of formal education, poverty, and lack of support as so many were living alone and found it difficult to prepare their meals and some especially males consume alcohol [53].

**Effect of dietary habits on immunity amidst the covid-19 pandemic among different age groups in Ghana:** As earlier stated, poor nutrition or malnutrition plays a huge role in the risk of infection as it has been reported to lead to immune system dysfunction thus making the individual susceptible to several diseases and infections.

Amidst the Covid-19 pandemic, a report in Ghana showed that the peak of infection occurred among the age group 21-40 years (33.4%) with the least infection occurring among the age group 81-119 years (0.5%). Infection is also more prevalent amongst males (51.5%) than females [54]. The male preponderance to the infection has been universally observed as several countries reported the same phenomenon. This male preponderance has been linked to the mast cells in females being able to trigger a more active immune response which helps to fight infection better than males. Estrogen in females has been reported to provide a significant level of protection against SARS-CoV [55]. Prevalence of unhealthy dietary and social habits such as alcohol consumption and smoking in males could also be a factor.

The prevalence of infection amongst the age group 10-40 years has been linked to the more active nature of this group and their involvement in outdoor engagements and many of them have been found not to adhere to safety protocols. Most of them due to lockdown and adverse effects of the pandemic on socio-economic status were not able to maintain proper dietary habits and many in this group have poor dietary habits effects before the pandemic [56]. It was however reported that the infection was more severe in older people due to compromised immune system as a result of age and also the presence of co-morbidities in some which could have resulted from poor dietary habits or aggravated by poor dietary habits. The low infection rate in older people is however because this group is less active and thus rarely go out and tend to adhere strictly to safety protocols including

nutrition advice better than the younger population [54].

### **Food intake and dietary habits among different age groups in cote d'ivoire**

Cote D'Ivoire like most countries in Sub-Saharan Africa is a low/middle-income country undergoing nutrition transition which is a change in diet from a traditional diet to a diet high in sugar, fat, and alcohol. This nutrition transition has caused these countries to experience a double burden of diseases with underweight and obesity occurring simultaneously in an increasing number of households. This has led to non-communicable diseases like diabetes mellitus, cardiovascular diseases, and cancer occurring simultaneously with infectious diseases like HIV/AIDS, tuberculosis, malaria, and some new infectious diseases like Ebola and Lassa fevers [57].

In a study conducted on infants of ages 0-36 months in urban areas of the Haut Sassandra region of Cote D'Ivoire, the dietary habits of the infants are dependent on the nutritional knowledge of their caregivers with about 56% of these caregivers believing that diversification of meal for infants should be before they reach 6 months old while 33% believe in 6 months exclusive breastfeeding as recommended by WHO. This poor knowledge was attributed to the socio-economic and marital status of the mothers as poor feeding practices was found to be prevalent in single and widowed mothers and mothers with a low level of education and poor socio-economic status while married mothers and mothers with a high level of education and stable socio-economic status have a better understanding of recommended dietary practices for infants. The meal majorly consumed by these infants is milk and dairy products (47%), others are roots and tubers (36.04%), cereals (16.95%). The complementary meal mostly consumed is porridge which is low in proteins, vitamins, and other essential nutrients with fruits and vegetables being the least consumed complementary food. This has led to a stunting rate of 33% in boys and 27% in girls with an acute malnutrition rate of 44% and chronic malnutrition rate of 29.78% [58]. Another report also showed that the feeding practices for infants in Cote D'Ivoire is poor with only about 12% of infants being exclusively breastfed until 6 months and less than 5% of infants between the ages of 6-23 months being fed according to WHO optimal feeding recommendations. It was also reported that better feeding practices are limited to the wealthier and better-educated populace. Lack of affordable complementary food for the poor populace is also a factor causing poor feeding practices in Cote D'Ivoire [59]. There is a prevalence of consumption of sugary snacks (45.4%) in children of 6-59 months in Cote D'Ivoire. The report showed that consumption of sugary snacks by infants was higher than consumption of fortified cereals or eggs and is prevalent as an alternative to complementary foods. These sugary snacks are nutrient-poor and inappropriate for infant and young child feeding. Over-consumption of these sugary snacks which are energy dense but nutrient -poor could displace consumption of other nutritious foods [60].

Amongst school-aged children, there exists an underweight prevalence of 13.6% and an overweight/obesity prevalence of 6.8%. Some of these children skip meals and consume more of processed pre-packaged snacks and sweetened beverages. Other factors that affect dietary habits of school-aged children include socio-economic status, level of education of parents as well as family size, Although children from wealthy backgrounds tend to eat a diverse diet with fruits, dairy products, and vegetables, however, this group of children also tend to consume more of sugary snacks and beverages while the ones from poor background have their meals limited to staples which are majorly roots and tubers and local cereals like maize and little vegetables and

fruits but minimal consumption of dairy products, animal proteins and eggs [61]. As this group of children is rapidly growing and constantly active, they require regular meal consumption high in energy and nutrients. This group apart from the standard 3-square meals requires in-between meal snacks or midday meals to make up their energy and nutrients requirements. A report conducted on school-aged children in Cocandy, Abidjan showed that children who take midday meals had better nutritional status when compared with children who do not take midday meals. Stunting and being underweight were also found to be prevalent in children who do not take midday meals compared with children who do. Also like reports from other countries, boys are more susceptible to malnutrition than girls as boys grow slower than girls and as a result require more nutrients and energy to help them grow [62].

Adolescence is a stage marked by numerous physical, psychological, and physiological changes and a quest for independence, and this is also reflected in the diet of adolescents. It is a known fact that dietary habits formed at this stage persist over time and can influence long-term growth and health. A study conducted on adolescents in Daloa showed that about 35% of them skipped breakfast and about 58.69% do not consume cow milk and dairy products, a very important source of essential nutrients. Consumption of fruits and vegetables is also low while the consumption of sugary snacks like doughnuts, cakes, biscuits, chocolate, and sweetened beverages is very high (70%) [63]. Another report also showed that under-nutrition is prevalent in adolescents in Cote d'Ivoire with a stunting rate of 21.6%. Consumption of fast foods rich in saturated fats and sugar has also replaced traditional diets, especially among adolescents from the higher socio-economic background. There is however limited consumption of fruits, vegetables, and dairy products which has led to a deficiency in one or more vital nutrients like iron, calcium, magnesium, vitamin A and vitamin B2 [64]. Furthermore, despite good knowledge of nutrition and health, the majority of adolescents in the low-income suburb of Abidjan still participate in unhealthy nutritional behaviors like consumption of sugar dense and fat-rich snacks which have been implicated in 17.2% prevalence of impaired fasting glycemia and 0.4% prevalence of diabetes amongst adolescents. Factors that have been implicated in the dietary habits of adolescents are socio-economic status as most healthy foods are quite expensive with the cheap options being energy-dense but nutrient poor while the quest for greater independence is the bane of some [65].

A study conducted on students of the Nangui Abrogoua University of Cote d'Ivoire showed that 88% of them skip breakfast and there exists a 17.95% prevalence of underweight amongst them. This has been linked to the socio-economic status of the students as about 33.3% of them reported having financial difficulties. The majority of them do not consume enough diverse diet and many of them take a single food group for both lunch and supper which is predominantly rice and the traditional meal "Attieke". About 66.67% of them take "attieke" for supper and 23.72% take it for lunch and it is mostly eaten with aubergine-based sauce. It was also reported that fruits are not a part of the eating habits of the majority of the students and most of the lunch menus in the university canteen have carbohydrate levels exceeding the recommended threshold [66]. Among working adults of age 25 years and above, consumption of fruits is quite high while vegetable consumption is low. Consumption of milk and dairy products, legumes, and nuts is low while consumption of processed foods and meat is quite high [67].

Amongst the elderly especially those with co-morbidities like diabetes mellitus and hypertension, the dietary diversity score is high

with only about 20-22% consuming less than five food groups daily. Many consume fruits and vegetables in good proportion. Low-fat dairy products are also part of their diet with cereals, roots, and tubers consumed with soups from vegetables forming a major part of their main meals [68]. It has however been observed that amongst adults, women are more prone to obesity than men. The valorization and admiration accorded to overweight women in Cote d'Ivoire culture has led to over-eating amongst women. The meal majorly consumed by Ivorians ("attieke") is rich in carbohydrates and it has been implicated in post-prandial hyperglycemia and has also been linked to a rapid increase in BMI and abdominal obesity. These starchy meals are usually accompanied by fried fish or fat sauce thereby increasing caloric ingestion [69].

**Effect of dietary habits on immunity amidst the covid-19 pandemic among different age groups in cote d'ivoire:** Cote d'Ivoire reported its index Covid-19 case on the 11th of March, 2020, however between March when the index case was reported and December 1st, 2020, there have been reported 21,250 cases of infection and 127 Covid-19 related deaths. The catastrophic scenarios however predicted by WHO did not occur as many African countries have learned and adopted preventive measures having seen and heard of the severity of the infection in Europe and the USA [70].

A study conducted on mine workers showed that 14-35% of them were SARS-CoV2 seropositive despite not displaying any symptoms or showing severe illnesses. Administrative staff living in Abidjan also had the same prevalence of seropositivity. These mine workers have an average age of 37 years. The low percentage of symptomatic cases and the mortality rate were linked to the younger population of the country, a favorable climate, and the possibly pre-existing immunity due to exposure to other forms of corona viruses [70].

In Cote d'Ivoire like in most countries, the infection is prevalent in males (59%) than in females (41%). Like in most African countries, the infection is prevalent among the aged 20-50 years. This has been associated with the relatively young age of the population as less than 3% of the population is above 65 years of age and the active nature of the people in this age group and the prevalence of unhealthy nutritional and social habits amongst this age group. Despite the prevalence of infection amongst the age group 20-50 years, they are majorly asymptomatic. This has been linked to the activity level of this group and the absence of co-morbidities in a majority of them. Although the rate of infection is low among the elderly, there is a higher level of mortality due to suppressed immune system as a result of age and the presence of co-morbidities like diabetes and hypertension arising from poor dietary habits [71].

### **Food intake and dietary habits among different age groups in Senegal**

Senegal is another West African country that is undergoing an epidemiologic transition which has arisen as a result of nutrition transition resulting from an increase in non-traditional lifestyles and a concomitant increase in the consumption of non-traditional diet by a majority of Senegalese. This has led to a dramatic increase in mortality from nutrition-related chronic diseases as these non-traditional foods are pre-packaged and processed and most energy-dense with little nutrients [72].

The period of 6-23 months of age is a critical stage in a child's life when nutrients and energy requirements are highest. At this stage, growth faltering or stunting reaches its peak. Due to the high nutrient and energy requirement at this stage, there is a need for a very diverse

diet and frequent meal intake for optimum and adequate diet [73]. A study conducted on infants and toddlers from 6-36 months in rural Senegal showed a stunting prevalence of 23.3% and wasting prevalence of 4.6% and as shown in numerous reports boys have a lower height to age ratio compared with girls. However, the study showed a positive dietary diversity index as most children have been introduced to complementary foods. The meal frequency was also positive as many of the children eat at least three times a day. Many also take snacks like fruits, milk, biscuits, and groundnuts in between meals [74]. Another report on children from southern Senegal however showed that the dietary diversity score is quite low in general. There however exists a disparity in dietary diversity between rural and urban regions. This once again buttresses the point that dietary habit is a function of location, socio-economic status, maternal literacy, and food supply diversity [73]. A study conducted on children below the age of two in an urban setting in Senegal showed high consumption of commercially produced snacks and sweetened beverages as three-fourth of the study population consumes commercial snacks daily. These snacks are however poor in essential nutrients but energy-dense and therefore do not provide the necessary nutrients for these children. This huge consumption of commercial snacks has been implicated in the nutrient deficiency of these infants as only one-third of them met the minimum acceptable diet as recommended by WHO [75].

Among school-aged children attending state primary schools in Dakar, Senegal, a study showed that their dietary habits have been influenced by changing food landscape and dietary patterns due to nutrition transition. Many of them consume snacks and eat less of home-cooked meals. The busy nature of life in urban cities, has also led to many school-aged children especially those aged 8-12 years to skip breakfast and thus compensate with snacks that lack essential nutrients like proteins and micro-nutrients while being energy-dense. Consumption of fruits and vegetables is also low and this has been implicated in the thinness observed in many of the children. This deficiency in essential nutrients makes the children susceptible to infections as 12% of them showed signs of inflammation indicated by elevated levels of acute-phase proteins and 8% also suffer from malaria [76]. Another report also indicated that most children from low socio-economic backgrounds in urban areas of Senegal do not observe healthy dietary habits as energy intake is insufficient and macronutrient intake is mostly inadequate. Food consumed is majorly made up of saturated fatty acids which are in excess while protein intake is insufficient. Their diets consist of starchy foods, sugary snacks, and deep-fried snacks like chips, very few fruits, vegetables, and dairy products. This has led to a deficiency of essential nutrients like iron, zinc, calcium, and folic acid. However seasonal availability of some popular fruits like mango has led to a high level of vitamin A in most children during mango season [77].

Adolescents across the world have been reported to practice poor nutritional and dietary habits which in turn have been linked to malnutrition which affects about one-third of them. They are known to consume more unhealthy foods and less fruits and vegetables. Some of the factors implicated in the dietary habits of adolescents in Dakar, Senegal are socio-economic status which can impart the quantity and types of foods which can be purchased by households and increased independence of adolescents which means they tend to often purchase their foods [78]. A study conducted on adolescent girls in Dakar, Senegal showed that the majority have poor access to food at home as about two-third of them live in food-insecure households. The low cost of fast foods compared with fruits, eggs, meat, and dairy products means that fast foods form a significant part of their diet [78]. Another

study on a cross-section of adolescents across Senegal however showed that more than half of their daily food intake is healthy food though daily consumption of unhealthy foods and saturated fats is also high. Their healthy food consumption is mostly from grains, roots and tubers, and plantain. They also consume a moderate amount of meat, poultry, or fish but consumption of milk and dairy products, fruits and vegetables is low. Despite consumption of some healthy foods, these adolescents do not meet WHO-recommended references for a healthy diet. They however observe some positive behavior like eating breakfast, drinking water, and eating three meals a day [79]. In general, the poor dietary habits observed in adolescents across West Africa has had caused a steady rise in overweight and obesity and other non-communicable diseases concomitantly with under-nutrition which also remain high. There are also concerns as more adolescents are experiencing these non-communicable diseases early in life than in previous generations [80].

Among adults, a study showed that many Senegalese adults are meeting the WHO recommendation to consume at least 5 servings of fruits and vegetables especially among the elderly however; meat consumption was below the US recommended serving size of 3-4oz o meat/serving. The majority consume Senegalese traditional diet made up of staples such as grains like fataya, millet, and couscous and local roots and tubers with vegetables mostly taken as soups to accompany their meals. Snack consumption is low however; bread and rice have formed a huge part of the diet as well due to nutrition transition and globalization [81]. However, a study conducted on adult women showed a 45% overweight/obesity prevalence and little knowledge on the effect of diet on non-communicable diseases. Intake of fruits and vegetables is low and societal belief in the desirability of overweight body sizes in women in Senegal is a major challenge [82]. Women of child-bearing age require adequate nutrients to prepare the body for pregnancy, childbirth, and lactation, and therefore poor dietary habits among these women can prove to be fatal. A study conducted on women of child-bearing age in Southern Senegal should have a dietary diversity score of 2.9 in the Kolda and Kedougou regions. The high diversity score from these regions has been linked to the locality as these regions are urban areas where there is better access to information and health care services. Sapaya department however had a diversity score of 2.4 which has equally been associated to with gold mining taking the place of agriculture, fishing, and livestock farming which has therefore affected food security in that region [83].

**Effect of dietary habits on immunity amidst the covid-19 pandemic among different age groups in Senegal:** After the identification of the imported Covid-19 case in Senegal, by June 2020, Senegal had become the fourth worst affected country in West Africa which led to several preventive and control measures being put in place by the Senegalese government as a way of containing the spread of the virus [84]. Report from Senegal also agreed with reports from most other African countries where the male population was found to be more susceptible to the infection (52%) than the female (48%). Also like other African countries earlier discussed, the highest proportion of cases was reported among those aged 20-40 years. However, most of the cases reported are asymptomatic or exhibit only mild symptoms. This high number of asymptomatic cases has been associated with the relatively young age of the majority of the cases compared with what is obtainable in Europe and America [84].

One of the suggested reasons for a high rate of infection among this age group is the active nature of this group as this group is the working class who are constantly on the move and in constant contact with other people which could expose them to infection when compared



with children and the elderly who go out less often. However, the low severity of infection in this group has been associated with their health status as this group is considered to be the least vulnerable or healthiest age group. Their immunity is well-developed and the height of its activity. They are also in control of their habits and choices. They are the age group with the earning power and have access to proper diet and better information [54].

The elderly, however, though the age group with the least infection rate, experience more severe symptoms or more critical outcomes due to the compromised immune system as a result of advanced age and the presence of co-morbidities in many arising often from poor dietary choices made in early life [54].

### Nutrition and its Effect on the Immune System as it Relates to Covid-19

The nutritional status of a person plays a very important role in the risk of infection with Covid-19, the effectiveness of treatment regimens, and the outcomes. Hence, there is a need to maintain the body's macro- and micronutrient status as it is a crucial preventive measure for COVID-19. Although the SARS-COV2 virus is attacked primarily by immune cells, the virus has however developed viral proteins over time that counteracts with the innate immune system. Some of the developed viral proteins act antagonistic to interferon (INF) and stimulate inflammatory proteins, such as IL-1 family member cytokines which in turn escalates after abnormal production of cytokines as shown in SARS in the pathogenesis of the infection [85].

A study by Abdullah & Hassan, [1] taking a sampling across all continents and regions of the world, West Africa included showed that crude mortality of Covid-19 increased significantly in those who consumed a lot of sugar-sweetened beverages and fruits while it is decreased significantly in those who consumed vegetables and legumes. This decrease in mortality has been associated with the anti-inflammatory and antioxidant components in these foods as coronavirus infections are known to cause systemic inflammation and acute respiratory infection [86].

Although fruits alongside vegetables are known to have anti-inflammatory and antioxidant components, however, a report showed that consumption of fruits increased the risk of Covid-19 infection [1]. This has been linked to the high glycaemic index of fruits as it proves a barrier in improving human response to pathogens [87], while beans and legumes are very vital in the body's response to pathogens as the plant protein obtained from these foods cannot be produced by the body and therefore the body needs them to help protect organs from coronavirus infections [88].

Age however plays a role in the suppression of the immune system which has led to the severity of infection among the aged population as reported by several countries. Aging impacts the immune system on several levels; it leads to decreased production of B and T cells in the bone marrow and thymus and also the functions of mature lymphocytes in the secondary lymphoid tissues are diminished [89].

Obesity due to over-nutrition has also been reported to impair humoral and cell-mediated immune response mechanisms as it has been demonstrated that some specific types of infections are more severe in obese individuals when compared with lean individuals. Another poor dietary habit linked with an impaired immune response is excessive lipid intake. This is as a result of the involvement of lipids in the synthesis and alteration of cell membrane which in turn affects the number and density of receptors in the cell membrane which then leads to altered production and function of cytokines [32].

### Recommendation

Globalization and urbanization have led to nutrition transition in many West African countries from a traditional diet which majorly consists of cereals or tubers made as gruels, porridge, or bolus type meals consumed with vegetable-based soups to a westernized diet which consist of processed pre-packaged foods high in calorie and low in nutrients. Due to the numerous health challenges which have been linked to the consumption of these pre-packaged foods, it is therefore recommended that a traditional diet should be adopted.

Awareness should be raised especially among adolescents and the working class on the need for healthy nutrition as these groups is the most susceptible to poor eating habits.

The Inclusion of legumes and nuts in the diet will also help to improve the body's immune response. Although fruits are generally acclaimed as a good source of essential micro-nutrients, fruits with a high glycemic index should however be consumed with caution.

### Conclusion

Just like in other parts of the world, Covid-19 has made in-roads across different age groups in West Africa especially Nigeria and Ghana. It has also been demonstrated that, unlike some countries where the peak of infection was among the elderly, the age group most affected by Covid-19 infection in the West African countries discussed is 20-50 years due to poor dietary and social habits and poor adherence to safety protocols exhibited by this group. Therefore it can be inferred that nutrition and dietary habits play a role in immune function which in turn determines susceptibility to infection or severity of infection. Diet made up of vegetables, legumes and nuts however possess beneficial effects in protecting against infection or reducing the severity of infection. Many fruits though rich in antioxidant and anti-inflammatory components however, have high glycaemic indices which make the sugar counter-productive in an immune response.

### References

1. Abdulah DM, Hassan AB (2020) Relation of Dietary Factors with Infection and Mortality Rates of COVID-19 across the World. *J Nutr Health Aging* 24: 1011-1018.
2. Alangea DO, Aryeetey RN, Gray HL, Laar AK, Adanu RMK (2018) Dietary patterns and associated risk factors among school age children in urban Ghana. *BMC Nutr* 4: 22.
3. Traill WB, Mazzocchi M, Shankar B, Hallam D (2014) Importance of government policies and other influences in transforming global diets. *Nutr Rev* 72: 591-604.
4. Bosu WK (2015) An overview of the nutrition transition in West Africa: implications for non-communicable diseases. *Proc Nutr Soc* 74: 466-477.
5. Galbete C, Nicolaou M, Meeks KA, Aikins AD, Addo J, et al. (2017) Food consumption, nutrient intake, and dietary patterns in Ghanaian migrants in Europe and their compatriots in Ghana. *Food Nutr Res* 61: 1341809.
6. Calder PC, Carr AC, Gombart AF, Eggersdorfer M (2020) Optimal Nutritional Status for a Well-Functioning Immune System Is an Important Factor to Protect against Viral Infections. *Nutrients* 12: 1181.
7. Aman F, Masood S (2020) How Nutrition can help to fight against COVID-19 Pandemic. *Pak J Med Sci* 36: 121-123.

8. Oniang'o RK, Mutuku JM, Malaba SJ (2003) Contemporary African food habits and their nutritional and health implications. *Asia Pac J Clin Nutr* 12: 331-336.
9. AT Otuneye, PA Ahmed, AA Abdulkarim, OO Aluko, DR Shatima (2017) Relationship between dietary habits and nutritional status among adolescents in Abuja municipal area council of Nigeria. *Niger J Paediatr* 44: 128.
10. Afolabi WAO, Olayiwola IO, Sanni SA, Oyawoye O (2015) Nutrient intake and nutritional status of the aged in low income areas of southwest, Nigeria. *J Aging Res Clin Pract* 4: 66-72.
11. Olatona FA, Ogide PI, Abikoye ET, Ilesanmi OT, Nnoaham KE (2020) Dietary Patterns, Nutritional Knowledge and Status of Adolescents in Lagos, Nigeria. *JAR Life*.
12. Akinrinmade R, Njogu E, Ogada (2019) Effectiveness of Nutrition Education on Nutrient intake and Nutrition Status of infants in Ondo State, Nigeria. *Am J Biomed Sci Res* 3: 98-105.
13. Sandoval-Priego AA, Reyes-Morales H, Pérez-Cuevas R, Abrego-Blas R, Orrico-Torres ES (2002) Family life strategies and their relation with malnutrition in children under 2 years old. *Salud Publica Mex* 44: 41-49.
14. Ademuyiwa IY, Faronbi J, Ejidokun A, Ojo E, Joseph AO (2019) Anthropometric evaluation and food habit of school age children in lagos, nigeria. *LAUTECH J Nurs*.
15. Akinpelu AO, Oyewole O, Odole A, Tella BA (2014) Nutritional Status of Nigerian Children from Urban Community Using Different Reference Cut-offs. *Afr J Biomed Res* 17: 61-67.
16. Obidoa JC, Onyechi KCN, Chukwuone CA, Dimelu IN, Victor-Aigbodion V (2021) Gender effect on eating habits of Nigerian school children. *Medicine* 100: 24961.
17. Tassy M, Eldridge AL, Sanusi RA, Ariyo O, Ogundero A, et al. (2021) Nutrient Intake in Children 4-13 Years Old in Ibadan, Nigeria. *Nutrients* 13: 1741.
18. Afolabi WAO, Towobola SK, Oguntona CRB, Olayiwola IO (2013). Pattern of Fast Foods Consumption and Contribution to Nutrient Intake of Nigerian University Students. *Int J Educ Res* 1: 1-5.
19. Hoffmann K, Bryl W, Marcinkowski JT, Rzesoś A, Wojtyła E, et al. (2012) Dietary behaviours of adolescents from urban and rural areas in the district of Szamotuły—a preliminary study. *Ann Agric Environ Med* 19: 103-107.
20. Olumakaiye MF, Atinmo T, Olubayo-Fatiregun MA (2010) Food consumption patterns of Nigerian adolescents and effect on body weight. *J Nutr Educ Behav* 42: 144-151.
21. Chabo JAU, Esuong, A E, Akpan-Idiok PA (2016) The influence of age on dietary habits of secondary schooladolescents, its education implication in calabar education zoneof cross river state, nigeria. *World journal of pharmaceutical and medical research* 2: 1-7.
22. Oimage K, Omuemu VO (2018) Assessment of dietary pattern and nutritional status of undergraduate students in a private university in southern Nigeria. *Food Sci Nutr* 6: 1890-1897.
23. Ikuenlola AV, Adekoya TS (2020) Nutritional status and feeding habits of females in public and private Universities in Osun state, Southwestern, Nigeria. *Heliyon* 6: 05023.
24. Awosan KJ, Ibrahim MTO, Essien E, Yusuf AA, Okolo AC (2014) Dietary pattern, lifestyle, nutrition status and prevalence of hypertension among traders in Sokoto Central market, Sokoto, Nigeria. *Int J Nutr Metab* 6: 9-17.
25. Edun BT, Odunuga BA (2015) Food Habits and Nutrient Intake of Bankers in Lagos State. *IOSR J Nurs Health Sci* 4: 1-3.
26. Morakinyo OM, Adebowale AS, Obembe TA, Oloruntoba EO (2020) Association between household environmental conditions and nutritional status of women of childbearing age in Nigeria. *PLoS One* 15: 0243356.
27. Ibrahim SG, Dandare A, Umar RA (2017). Nutritional Status of Women of Reproductive Age (20-50years old) in Wamakko Area of Sokoto State, Nigeria. *J Sci Res Rep* 16: 1-10.
28. Alao MT, Akinola OO, Ojofeitimie O (2015). Dietary Intake and Nutritional Status of the Elderly in Osun State. *IOSR J Nurs Health Sci* 4: 32-35.
29. Nwaru BI, Onyeka IN, Ndiokwelu C, Esangbedo DO, Ngwu EK, et al. (2015) Maternal and child dietary patterns and their determinants in Nigeria. *Matern Child Nutr* 11: 283-296.
30. UNICEF (2019) Poor diets damaging children's health worldwide, including in Nigeria, warns Unicef.org.
31. Enwonwu C (2017) Complex interactions between malnutrition, infection and immunity: relevance to HIV/AIDS infection. *Nigerian J Clin and Biomed Res* 6: 6-14.
32. Khan I, Ahmad S (2017) Influence of Life Style, Nutrition and Obesity on Immune Response: A GlobalIssue. *J Food Process Technol* 8: 647.
33. Adedeji IA, Abdu YM, Bashir MF, Adamu AS, Gwarzo GD, et al. (2020) Profile of children with COVID-19 infection: a cross sectional study from North-East Nigeria. *Pan Afr Med J* 35: 145.
34. Hassan Z, Hashim MJ, Khan G (2020) Population risk factors for COVID-19 deaths in Nigeria at sub-national level. *Pan Afr Med J* 35: 131.
35. Osibogun A, Balogun M, Abayomi A, Idris J, Kuyinu Y, et al. (2021) Outcomes of COVID-19 patients with comorbidities in southwest Nigeria. *PLoS One* 16: 0248281.
36. UNICEF (2019) Infant and Young Child Nutrition.
37. Agbadi P, Urke HB, Mittelmark MB (2017) Household food security and adequacy of child diet in the food insecure region north in Ghana. *PLoS One* 12: 0177377.
38. World Health Organization. Nutrition and Food. Safety Indicators for assessing infant and young child feeding practices: definitions and measurement methods. WHO.
39. Anane I, Nie F, Huang J (2021) Socioeconomic and Geographic Pattern of Food Consumption and Dietary Diversity among Children Aged 6-23 Months Old in Ghana. *Nutrients* 13: 603.
40. Ochola S, Masibo PK (2014) Dietary intake of schoolchildren and adolescents in developing countries. *Ann Nutr Metab* 64: 24-40.
41. Owusu J, Colecraft E, Aryeetey R, Vaccaro J, Huffman F (2017) Nutrition Intakes and Nutritional Status of School Age Children in Ghana. *J Food Res* 6: 11.
42. Abizari AR, Ali Z (2019) Dietary patterns and associated factors of schooling Ghanaian adolescents. *J Health Popul Nutr* 38: 5.
43. Buxton C (2014) Ghanaian Junior High School Adolescents Dietary Practices and FoodPreferences: Implications for Public Health Concern. *J Nutr Food Sci* 4: 297.
44. Steyn NP, McHiza ZJ (2014) Obesity and the nutrition transition in Sub-Saharan Africa. *Ann N Y Acad Sci* 1311: 88-101.
45. Asenso RO, Agyeman AA, Laar A, Boateng D (2016) Overweight and obesity epidemic in Ghana—a systematic review and meta-analysis. *BMC Public Health* 16: 1239.

46. Issahaku I, Alhassan M (2021) Nutrition knowledge, dietary practices and nutritional status of non-academic staff at the Tamale campus of University for Development Studies. *Heliyon* 7: 06635.
47. AgyarkwaaOti J, Eshun G (2020) Dietary Habits and Nutritional Status of Undergraduate Students of Winneba Campus of University of Education, Winneba, Ghana. *J food science nutr* 10: 109.
48. Lee SE, Talegawkar SA, Merialdi M, Caulfield LE (2013) Dietary intakes of women during pregnancy in low- and middle-income countries. *Public Health Nutr* 16: 1340-1353.
49. Gyimah LA, Annan RA, Apprey C, Edusei A, Aduku LNE, et al. (2021) Dietary diversity and its correlates among pregnant adolescent girls in Ghana. *PLoS One* 16: 0247979.
50. Appiah PK, Korklu ARN, Bonchel DA, Fenu GA, Yankey FWM (2021) Nutritional Knowledge and Dietary Intake Habits among Pregnant Adolescents Attending Antenatal Care Clinics in Urban Community in Ghana. *J Nutr Metab* 2021: 8835704.
51. Apprey C, Kalog GLS, Boakye OA, Annan RA (2019) Nutritional Status and Non-Communicable Diseases in Older Ghanaians. *J Clin Nutr Diet* 5: 1-8.
52. Abbiwa HENA, Adjetey AR, Kwakub EA, Charlesa A, Boakye A, et al. (2021) Dietary intakes, anthropometric status, and anaemia prevalence among older adults in Effutu Municipality, Ghana. *Nutr Healthy Aging* 6: 49-59.
53. Agbozo F, Mfoafo JA, Dwase H, Ellahi B (2018) Nutrition knowledge, dietary patterns and anthropometric indices of older persons in four peri-urban communities in Ga West municipality, Ghana. *Afr Health Sci* 18: 743-755.
54. Owusu M, Sylverken AA, Ankrah ST, Duah PE, Boateng NKA, et al. (2020) Epidemiological profile of SARS-CoV-2 among selected regions in Ghana: A cross-sectional retrospective study. *PLoS One* 15: 0243711.
55. Channappanavar R, Fett C, Mack M, Eyck PPT, Meyerholz DK, et al. (2017) Sex-Based Differences in Susceptibility to Severe Acute Respiratory Syndrome Coronavirus Infection. *J Immunol* 198: 4046-4053.
56. Zemrani B, Gehri M, Masserey E, Knob C, Pellaton R (2021) A hidden side of the COVID-19 pandemic in children: the double burden of undernutrition and overnutrition. *Int J Equity Health* 20: 44.
57. Abrahams Z, McHiza Z, Steyn NP (2011) Diet and mortality rates in Sub-Saharan Africa: stages in the nutrition transition. *BMC Public Health* 11: 801.
58. Gnahé DA, Obouayeba AP, Diomandé M, Niaba KPV, Beugré AGM (2021) Infant and Young Child Feeding Practices in Urban Areas in the Haut Sassandra Region (Côte d'Ivoire): Description and Nutritional Consequences. *Food and Public Health* 11: 24-34.
59. Leyvraz M, Rohner F, Konan AG, Ezzo LJCE, Woodruff BA, et al. (2016) High Awareness but Low Coverage of a Locally Produced Fortified Complementary Food in Abidjan, Côte d'Ivoire: Findings from a Cross-Sectional Survey. *PLoS One* 11: 0166295.
60. Nordhagen S, Pries AM, Dissieka R (2019) Commercial Snack Food and Beverage Consumption Prevalence among Children 6-59 Months in West Africa. *Nutrients* 11: 2715.
61. KYAS Z, Alassane M, Ouattara H, Dally T, Kouame KG, et al. (2017) Diet, Nutritional Status and School Performance of Schoolchildren in the District of Abidjan: Case of Yopougon and Bingerville. *J Nutr heal sci* 4: 102.
62. Akpole JK, Bleyere MN, Yapo PA (2018) Effect of mid-day meal on nutritional status and haematological profile in school children of Cocody, Abidjan: a case control study. *MOJ Bioequiv Availab* 5: 83-97.
63. Maxwell BGA, Valery NKP, André GD, Hortense BS, Samuel K, et al. (2019) Estimated levels of physical activity and food habits in the adolescent in the school environment of the city of daloa (Cote d'Ivoire). *Int J Dev Res* 9: 30686-30693.
64. Jesson J, Kouakou EK, Kumaran K, Adonis L, Wrottesley SV, et al. (2021) A scoping review of literature describing the nutritional status and diets of adolescents in Côte d'Ivoire. *Public Health Nutr* 24: 5261-5276.
65. Jesson J, Kouakou EK, Johnson PH, Theckly PN, Kehoe SH, et al. (2021) Adolescent nutrition and physical activity in low-income suburbs of Abidjan, Côte d'Ivoire: the gap between knowledge, aspirations and possibilities. *Public Health Nutr* 24: 5227-5237.
66. Gbogouri GA, Dakia PA, Traore S, Brou K (2018) Current dietary intake and eating habits in connection with socio-demographic characteristics of students of Nangui Abrogoua University of Côte d'Ivoire. *Ecol Food Nutr* 57: 391-404.
67. Global Nutrition Report (2015) Country Nutrition Profiles, [Globalnutritionreport.org](http://Globalnutritionreport.org).
68. Kal D, Djohan YF, Koffi KG, Manhan K, Niamké AG, et al. (2016) Individual Dietary Diversity Score for Diabetic and Hypertensive Patients in Cote d'Ivoire. *Int J Nutr* 2: 38-47.
69. Sable SP, Yan K, Yapi A, Kpebo DD, Ekou KF, et al. (2020) Epidemiologic Profile of Overweight and Obesity in Abidjan, Ivory Coast: A Cross-Sectional Study. *Ann Glob Health* 86: 46.
70. Milleliri JM, Coulibaly D, Nyobe B, Rey JL, Lamontagne F, et al. (2021) SARS-CoV-2 Infection in Ivory Coast: A Serosurveillance Survey among Gold Mine Workers. *Am J Trop Med Hyg* 104: 1709-1712.
71. Gaye B, Khoury S, Cene CW, Kingue S, Guetta RN, et al. (2020) Socio-demographic and epidemiological consideration of Africa's COVID-19 response: what is the possible pandemic course?. *Nat Med* 26: 996-999.
72. Anderson CA, Bellamy S, Figures M, Johnson CZ, Jalloh M, et al. (2010) Dietary intake of Senegalese adults. *Nutr J* 9: 7.
73. Baye K, Kennedy G (2020) Estimates of dietary quality in infants and young children (6-23 mo): Evidence from demographic and health surveys of 49 low- and middle-income countries. *Nutrition* 78: 110875.
74. Bork K, Cames C, Barigou S, Cournil A, Diallo A (2012) A summary index of feeding practices is positively associated with height-for-age, but only marginally with linear growth, in rural Senegalese infants and toddlers. *J Nutr* 142: 1116-1122.
75. Feeley AB, Coly AN, Gueye NYS, Diop EI, Pries AM, et al. (2016) Promotion and consumption of commercially produced foods among children: situation analysis in an urban setting in Senegal. *Matern Child Nutr* 12: 64-76.
76. Fiorentino M, Bastard G, Sembène M, Fortin S, Traissac P, et al. (2013) Anthropometric and micronutrient status of school-children in an urban West Africa setting: a cross-sectional study in Dakar (Senegal). *PLoS One* 8: e84328.
77. Fiorentino M, Landais E, Bastard G, Carriquiry A, Wieringa FT, et al. (2016) Nutrient Intake Is Insufficient among Senegalese Urban School Children and Adolescents: Results from Two 24 h Recalls in State Primary Schools in Dakar. *Nutrients* 8: 650.

78. Madélie GJ, Stéphanie W, Aminata NN, Isabelle G, Sonia B (2021) The Home and School Food Environments of Senegalese Adolescent Girls. *J Food Security* 9:29-35.
79. Johnson MG, Ward S, Ndiaye AN, Galibois I, Blaney S (2021) Dietary intake and food behaviours of Senegalese adolescent girls. *BMC Nutr* 7: 41.
80. Roosmarijn V, Leah S, Loty D, Ampa D, Mariama T (2020) Adolescent nutrition in West Africa: A rapid review of the research evidence. IFPRI.
81. Anderson CA, Bellamy S, Figures M, Johnson CZ, Jalloh M, et al. (2010) Dietary intake of Senegalese adults. *Nutr J* 9: 7.
82. Holdsworth M, Delpuech F, Landais E, Gartner A, Duvernay SE, et al. (2006) Knowledge of dietary and behaviour-related determinants of non-communicable disease in urban Senegalese women. *Public Health Nutr* 9: 975-981.
83. Tine JAD, Niang K, Faye A, Dia AT (2018) Assessment of Women's Dietary Diversity in Southern Senegal. *Food Nutr Sci* 9: 1192-1205.
84. Thompson HA, Mboup A, Cisse B, Nayagam S, Watson OJ, et al. (2020) The projected impact of mitigation and suppression strategies on the COVID-19 epidemic in Senegal: A modelling study. medRxiv.
85. Li G, Fan Y, Lai Y, Han T, Li Z, et al. (2020) Coronavirus infections and immune responses. *J Med Virol* 92: 424-432.
86. Conti P, Ronconi G, Caraffa A, Gallenga C, Ross R, et al. (2020) Induction of pro-inflammatory cytokines (IL-1 and IL-6) and lung inflammation by Coronavirus-19 (COVI-19 or SARS-CoV-2): anti-inflammatory strategies. *J Biol Regul Homeost Agents* 34: 327-331.
87. Hosseini B, Berthon BS, Saedisomeolia A, Starkey MR, Collison A, et al. (2018) Effects of fruit and vegetable consumption on inflammatory biomarkers and immune cell populations: a systematic literature review and meta-analysis. *Am J Clin Nutr* 108: 136-155.
88. Li P, Yin YL, Li D, Kim SW, Wu G (2007) Amino acids and immune function. *Br J Nutr* 98: 237-252.
89. Rodriguez EM, Maoz BB, Dorshkind K (2013) Causes, consequences, and reversal of immune system aging. *J Clin Invest* 123: 958-965.