Chapter One
Introduction

1.1 Background to the Study

An unhealthy diet is one of the major risk factors responsible for the increased prevalence of non-communicable diseases (NCDs), which include cardiovascular and respiratory diseases, mental disorders, diabetes, and cancer[1,2,3]. Non communicable diseases (NCDs) are the leading cause of death and disability in the world and it remains a major agony threatening public health worldwide[4,5]. Adequate nutritional intake is good for various health reasons, including optimal cardiovascular and respiratory function, muscle strength, protection from communicable and non-communicable disease, wound healing, and psychological well-being[6].

Malnutrition means either inadequate intake of nutrients due to lack of food, ignorance, socio-cultural factors, and diseases among other causes, resulting in underweight and other nutrient deficiency diseases; or intake of nutrient overs of body requirements due to poor dietary style, resulting in overweight and obesity[7,8]. Recent studies have been reported that overweight / obesity is important predictor of diabetes mellitus. Others like physical inactivity, unhealthy dietary habit, current smoking, and excessive alcohol intake were all associated with increased risk of diabetes, even after adjustment for the body mass index[9,10].

Reports from several studies also show a very strong association between diet and the development of non-communicable diseases[10,11,12]. The essence of making healthy choices in our daily meal intake is to attain a good nutritional status and prevent nutritional diseases including non-communicable diseases such as diabetes. In the past, diabetes was not known to be a disease of underdeveloped continents such as Africa and

Asia as recent studies' findings indicated that its burden and prevalence are on the high side. In line with the statement issued by Dr. Cook in early twentieth century that diabetes is being tagged as a foreign disorder in Africa[13].

The earlier estimated prevalence of diabetes in Africa was 1% in rural areas and ranges from 5% to 7% in urban sub-Saharan Africa[14]. Embracing Western lifestyles has been established consistent with some studies augmenting the increased prevalence of diabetes as a non-communicable disease in Sub-Saharan Africa. The common elements of "Westernization" include a diet higher in total calories and fat but lower in fiber and less need for energy output due to machinery development. More than 90% of the adult population in sub-Saharan Africa account for an absence of or low physical activity in leisure time[15].

Diabetes is a various group of metabolic disorders that are often linked with an increased disease burden in developing countries such as Nigeria[13]. The probability of DM is higher in overweight and obese individuals than in individuals with normal body mass index (BMI) and is even higher in participants with central obesity[16]. Dietary patterns, especially the typical western diet (low fruits and vegetables, high fat and sodium, large portion of high calories and excess sugar), have been shown to increase weight and body fat percentage. It is well known that obesity has a multi-factorial aetiology which includes genetic, environmental, and dietary factors. Of these, dietary factors are thought to play a key role in diabetes[17]. Poor diet (high consumption of sugar, salt, saturated fat, etc) and unhealthy lifestyle (smoking, alcohol consumption, and physical inactivity) have been identified as major risk factors for diabetes disease and other non-communicable diseases (NCDs)[1].

The rate at which non-communicable diseases are exploding is alarming, in which diabetes is not excluded. Studies have shown that factors like overweight and obesity have the most important predictor of the development of diabetic diseases as a result of insulin resistance and inadequate insulin secretion. Also, lack of exercise, a poor diet, current smoking, and excessive alcohol were as well associated with a significantly increased risk of diabetes[18]. The rule of halve has been suggested and confirmed in the incident rate of diabetes in Nigeria, out of millions of Nigerian livings with diabetes, a fraction of them is undetected in which is at risk of developing complication, many of those confirmed were not accessing proper care and some those that have access for proper care are not complied to the treatment creating more burden to the nation, making it becoming a thriving public health emergency[19,20].

Diabetes remains undiagnosed in many countries, especially in the African continent, study in Malawi revealed that almost half of the people with diabetes were undetected and there are many significant differences in prevalence both in the rural and urban[21]. This is also similar to a study done in Lagos on the Prevalence of undiagnosed diabetes mellitus in tuberculosis subjects in which the findings show undiagnosed cases of diabetes mellitus made up 44% of the total number of cases of diabetes mellitus detected[22]. Various epidemiological studies confirmed the true prevalence of all forms of diabetes in Asia and Sub Sahara Africa[23,24,25,26,27,28].

Previous studies have shown most common of all undiagnosed diabetes is non-insulin dependent diabetes probably due to its nature of being asymptomatic at the initial stage[29,30]. Type 2 diabetes is concentrated in older age groups, in the poor, and in the Sub Sahara Continent, yet is a larger problem in industrial and deprived areas[31,32].

Undiagnosed diabetes may impose considerable public health implications since the affected people remain untreated leading to severe complications and healthcare costs[33,34.] According to the International Diabetes Federation (IDF) universally estimated diabetes to have risen to 536.6 million people living with diabetes (diagnosed or undiagnosed) in 2021, and this number is projected to increase by 46%, reaching 783.2 million by 2045[35]. Many studies including IDF have shown an estimated approximately 50% of all people with diabetes are ignorant of their condition, globally in 2021 the prevalence of undiagnosed diabetes was 239.7 million accounting for 44.7% of total individuals with diabetes.

From a clinical perspective, earlier detection during the asymptomatic stage is key to permit earlier initiation of treatment to prevent or delay the development of micro- and macrovascular complications [33,35]. In Africa, diabetes has been ranked among the top- most modifiable cardiovascular risk factors responsible for mortality associated with NCDs[2]. Risk factors responsible for the increase rate of diabetes and other NCDs in Africa include alteration in lifestyles such as the adoption of nutritional transition, less physical activities, and changes in population demographics associated with urbanization[37].

Universally, the mortality rate of diabetes-related complications is steadily increasing, according to IDF Diabetes Atlas aiming at producing current estimates of the national, regional, and global impact of diabetes for 2015 and 2040 revealed that 5.0 million deaths related to diabetes mortality in 2017, and the total global health expenditure due to diabetes was estimated at 673 billion US dollars[38]. The aim of sustainable development goals(SDGs) is to achieve a decrease in the mortality rate from NCDs, in the year 2030,

by one-third of the level it was in 2015[32]. Achieving this goal would need the identification of those who are more at risk in the general population, discovering and monitoring the predictors, and informed adoption of effective measures to beneficially modify the prevalent of modifiable risk factors in a given setting. Some efforts have been made to assess the rate of NCDs in the market environments among the traders in the past as it's a workplace for a group of people to earn their livelihood[39,40 ,41 ,42].

The workplace is a basic aspect of the social life of adults, an environment where they spend the majority of their working hours and period of productivity in life. Market refers to the work environment in this study for the traders both men and women. The traders classify as Self-employed members of the informal labour subdivision, that are unlikely to benefit from the pre-employment and periodic medical screening usually done to those in the organized formal sector in developing countries. However, the rate of undiagnosed diabetes mellitus is higher in the developing countries compare to data available in the developed countries.

Market traders may not have health plans due to the nature of their work which involves uninterrupted long working hours with little or no time for rest and leisure. This denies them ample opportunity for regular exercise and regular medical check-up visits to ascertain their health status due to the fear of the loss of revenue prompted by their absence. These constraints are proofing the fact that market traders are the ideal target populations to assess undiagnosed diabetes in a community setting. Thus, many of the traders are likely to be unaware of their diabetes status, predisposing them to unexpected micro and macrovascular complications including death[36,42,43].

Vitamin D as micronutrient is also considered as hormone with an extensive impact on the normal physiology and pathogenesis of disease conditions[44,45]. There are documented evidences regarding its relationship to metabolic syndrome, diabetes, autoimmune diseases, arterial hypertension, and cancer[45,46,47]. Various studies in the past have been able to establish findings on the correlations between vitamin D and glucose metabolism in diabetes. Vitamin D may improve glucose metabolism systemically through its anti-inflammatory and immunomodulatory effects[48]. The main effects of vitamin D and its activated form, on the beta cell, with direct implications on the pathogenesis and prevention of type 2 diabetes, but also type 1 diabetes cannot be underestimated. The actions of vitamin D are not limited to skeletal health benefits and may extend to the promotion of insulin secretion and insulin sensitivity, but altered in type 2 diabetes mellitus subjects.

As earlier as 1980 a study observed that pancreatic insulin secretion is selectively inhibited by hypovitaminosis D[49]. Several other reports have demonstrated an active role for vitamin D and especially its bioactive form, 1,25-dihydroxyvitamin D3 (1,25(OH)2D3), in the regulation of endocrine pancreas function, especially in the beta cell[50,51]. An important role for vitamin D is suggested by the presence of the vitamin D receptor (VDR) in pancreatic beta cells, the expression of CYP27B1 hydroxylase in pancreatic beta cells, and the presence of a vitamin D response element (VDRE) in the human insulin receptor gene promoter. 1,25(OH)2D3 stimulates the expression of the insulin receptor and enhances insulin-mediated glucose transport in vitro.

More so, 1,25(OH)2D3 is known to stimulate rapid insulin secretion by the pancreatic beta cells[52,53]. Another study finding suggested that there was enhanced uptake and

clearance of vitamin D by adipose tissue in obese individuals compared with those of normal weights, leading to vitamin D deficiency mostly in obese diabetic individuals[54]. In one of the meta-analysis studies, it was found that vitamin D improved glycemic control in different populations, including Nigeria[55]. So, serum vitamin D levels are worth of been assessed in both healthy and undiagnosed diabetes individual for awareness and early management.

A recent Nigeria study among adults of north western region finding revealed a prevalence of 10.6% in Vitamin D insufficiency and 31.3% in Vitamin D deficiency[56]. This shows despite adequate sunlight exposure in such a geographical location, there is still an increased prevalence of low vitamin D status in Nigeria. In another study, associated risk factors that are linked with low vitamin D levels in Nigeria include upper socio-economic class, poor exposure to sunlight which is promoted by dysmetabolic states such as type 2 diabetes mellitus, and dyslipidemia[57].

The prevalence of vitamin D deficiency has been recorded in both developed (42% in the United States, 32% in Canada, 40% in Europe) and developing countries (60% in Iran, 85% in India, 79% in Saudi Arabia) as well on the general population, especially on diabetes[55]. Hence, many diabetic patients are vitamin D insufficient[55]. This study is aimed to assess the dietary pattern, lifestyle, vitamin D status, and undiagnosed diabetes among traders in selected markets of the Ede community in Osun State, South Western Nigeria.

1.2 Statement of the Problem

Diabetes mellitus (DM) has become a major public health issue worldwide secondary to its increased epidemic prevalence, creating more burden on individuals, families, and the community at large[58]. According to IDF 2019 world prevalence of diabetes was 51%, yet

the disorder is controllable if the diagnosis is confirmed earlier and the healthy attitude of the individual modified positively, otherwise various complications will arise such as cardiovascular diseases, neuropathy (nerves damage), nephropathy (kidney damage), retinopathy (eye damage), diabetes foot ulcer, skin disorder and sometimes hearing impairment[58,59]. The outcome of this condition is more devastating especially when an individual is unaware of his or her health status regarding diabetes. A study estimated that 60% of people with Type 2 diabetes mellitus (T2DM) were asymptomatic at the time of diagnosis[60].

Numerous studies have also revealed the burden of diabetes on the economy of the nation, so it has been confirmed to have a great danger to the public health[58,61 ,62]. Undiagnosed Diabetic individual stand more chance of getting various complications of diabetes, especially among the vulnerable group like traders who as a result of their money-making activities, hardly find time for a clinical checkup and thus prevent them from early detection of disease condition[36]. To crown it all, due to the nature of their occupation they don't have time to prepare and plan for healthy meal intake, rather they buy street junk meals that will alter good dietary patterns resulting in health implications[42]. Despite living in a climate with enough sunlight, the results of earlier tropical research showed inadequate vitamin D levels in both the healthy population and those with glucose metabolic disorders.

1.3 Justification of the Study

Numerous studies have revealed the burden of diabetes on the economy of the nation so it has been confirmed to have a great danger to public health[58,61,62]. Undiagnosed Diabetes patients stand more chance of getting various complications of diabetes especially among

the vulnerable group like traders who because of their money-making activities, hardly find time for a clinical checkup and thus prevent them from early detection of diseases condition[42,60]. Dietary factors, lifestyles, and vitamin D deficiency (VDD) are thought to play key role in the etiology of diabetes, so as obesity[1,2,45,63]. Up to 90% of Type 2 Diabetes Mellitus occurring is attributed to being overweight[64]. Previous studies have reported that body composition, especially body fat, is closely related to glucose metabolism in humans. Accumulation of subcutaneous adipose tissue and visceral adipose tissue is known to release more proinflammatory and proatherogenic factors, leading to the exacerbation of oxidative stress and insulin resistance[65].

Dietary patterns, especially imitation of western dietary patterns, have been shown to increase weight and body fat percentage. However, few reports have demonstrated the association between dietary patterns, lifestyle, body fat distribution, and diabetes diseases[66,67]. Some studies' findings have also shown that vegetables and fruits, low-fat dairy products, and regular exercise might decrease the risk of insulin resistance[68]. Conversely, the western dietary pattern, which is characterized by low dietary fiber intake and high caloric and fat intake, raised the chance of having impaired glucose tolerance[69]. The rapid social and economic growth in Africa has led to significant changes in dietary habits and lifestyle choices, which has affected the prevalence of diabetes, both diagnosed and undiagnosed.

The aim of this study is to focus on the assessment of dietary patterns, lifestyle, vitamin D status and the undiagnosed diabetes among the traders of Ede in selected major markets in Osun state. Despite many publications on diabetes globally including Nigeria, there is a paucity of this study publication, especially in the community setting focusing

on undiagnosed diabetes among the vulnerable group like market traders with associated risk factors such as dietary patterns, lifestyles, and vitamin D status as it influences glucose metabolism.

1.4 Aim and Objective(s) of the Study

This study aims to assess the dietary pattern, lifestyle, vitamin D status and undiagnosed type 2 diabetes mellitus among traders in selected markets of the Ede community in Osun State, South Western Nigeria.

The specific objectives of the study are as follows. To:

1. Determine the prevalence of undiagnosed diabetes and low vitamin D status among the traders in the Community.
2. Assess the vitamin D status of participants and its relationship with abnormal and normal glucose profile
3. Identify the dietary pattern of the traders in the community.
4. Identify the associated risk factors of undiagnosed diabetes and hypovitaminosis D among the traders in Ede, Osun State.

1.5 Research Questions

In the course of this study, the following research questions will be used to achieve its objectives.

1. What is the prevalence of undiagnosed diabetes and low vitamin D status in the Community?
2. Is there a relationship between low serum vitamin D levels of the participants with normal and abnormal glucose profile?

3. What is the dietary pattern of the study participants in market?
4. What are the associated risk factors with undiagnosed diabetes and hypovitaminosis D?

1.6 Significance of the Study

The prevalent rate of undiagnosed type 2 diabetes mellitus and low vitamin D status is alarming even among the apparently healthy individual, though unhealthy dietary habit and lifestyles practice are frequently implicated. The research work in this thesis covers novel contributions to the body of knowledge in public health nutrition and disease prevention. The magnitude of undiagnosed type 2 diabetes mellitus, prediabetes, low vitamin D status and hypertension will be estimated among the trader in three major public market of Ede. The traders are considered as vulnerable population by the nature of their work; hence they have limited access to health benefits. Evaluation of vitamin D status is also important because low vitamin D levels have been linked to an increased risk of prediabetes and undiagnosed diabetes mellitus. Understanding this will help in given support for the conceptual premise that optimal vitamin D concentration will improve glycemic control. It is our hope that the results of this study will provide baseline and reference data on the disease prevalence, pattern and associated risk factors in South Western Region of Nigeria. These results are expected to be very useful in development of appropriate preventive measures, cost effective and culturally acceptable interventions and good health policy formulation. Lastly, we hope the studies might have created certain level of public awareness on the magnitude of disorder among sub urban population of our locality.

1.7 Scope of the Study

Even though this study was aimed to assess the dietary pattern, lifestyles, low vitamin D status and undiagnosed type 2 diabetes mellitus of Nigeria market traders. The scope our of geographical coverage and the study population were maintained. The study sample population

were members of the traders within the three major selected markets in the two Ede Local Government Areas of Osun State, therefore, the scope of the study limited the research to the population of traders that fulfilled the criteria of the study participants. The study was basically limited to the traders due to their susceptibility to illnesses and lack of benefits from routine medical checkup that could prevent them from early detection of disorder.

1.8 Limitation of the Study

This study was observed to have some limitation that need to be taken into account for the interpretation of findings;

1. The study was cross-sectional with a relatively small sample size. It would have been appropriate to consider larger sample size and longitudinal cohort study in order to establish causal effect and confounding factors relationship of the variables.

2. A prospective cohort study could have been suitably designed for this study to determine the effect of vitamin D supplements on those participants with low vitamin D status among those with abnormal and normal glucose profile.

3. Due to seasonal variability that has been documented in the determination of serum vitamin D status, it was assumed that conducting it in two different seasons could have been more appropriate to test the hypothesis.

4. Another possible limitation of this study is that since it was done for a particular group of society then the findings may not apply to cultural and ethnic groups in other geographical regions of Nigeria.

5. A very low response rate among male participants could have had an effect on the results of males and the whole study population given no room for gender comparative.

6. Oral Glucose Tolerance Test (OGTT) and Glycated hemoglobin (HbA1c) for the determination of glycemic level of every participant were not use as a result of difficulty in meeting up with participant compliance and financial constraint on the part of the researcher

1.9 Operational Definition of Terms

- **Study Participants:** These are the traders in the markets that gave consent to partake in the study with condition that they meet up with study's criteria.
- **Glycemic control**: Using the WHO/ADA guidelines, values greater than 100 mg/dl (5.6mmol/L) and 140 mg/dl (7.8 mmol/L) for fasting blood glucose and random/ casual blood glucose respectively were regarded as poor glycemic control, while values less than these, were good glycemic control.
- **Undiagnosed Diabetes:** These are the participants with abnormal blood glucose profiles (dysglyceamia) values greater than 125 mg/dl or 199 mg/dl for fasting blood glucose or random (casual) blood glucose test but completely unaware until a blood glucose test is done
- **Prediabetes:** These are the participants with abnormal glucose profiles values greater than 100mg/dl or 140mg/dl for fasting blood glucose or random (casual) blood glucose but completely unaware until a blood glucose test is done.
- **Blood pressure / Hypertension:** Values greater than 140 for systolic and 90 for diastolic were regarded as abnormal, while values equal to or less were normal blood pressure.

- **Central obesity:** waist circumference ≥ 102cm(males) and ≥88cm(females)79 or Waist-Hip-Ratio (WHR): ≥ 0.9 cm (males) and ≥ 0.85 cm (females) 79
- **Diabetes Mellitus:** Fasting blood glucose ≥ 7mmol/L (126mg/dL) or Random blood glucose ≥ 11.1mmol/L (200mg/dl) at diagnosis.
- **Type 2 Diabetes:** This is a condition of hyperglycemia that its management needs dietary control of blood glucose, physical exercise, and/or oral glucose-lowering agents only or in combination with insulin for control of hyperglycemia.
- **Vitamin D deficiency:** Reference derived from the 95% confidence interval of the anti-log of transformed control group data. Values less or equal to 20ng/ml were considered deficient
- **Vitamin D insufficiency:** Reference derived from the 95% confidence interval of the anti-log of transformed control group data. Values less or equal to 30ng/ml were considered insufficiency
- **Hypovitaminosis D/ Low vitamin D Status: This is a value of vitamin D** serum concentration less than 30ng/ml, so it consists of both vitamin D deficiency and insufficiency.
- **Rule of halve:** Is a theoretical framework used to describe the burden of chronic diseases. It states that only one-half of people with a diabetes are diagnosed; one-half of those diagnosed get treatment, and one-half of treated achieve desired therapeutic goals
- **Dyslipidemia:** refers to unhealthy levels of one or more kinds of lipid (fat) in the blood.
- **Dysmetabolic syndrome:** is a condition in which a group of risk factors for cardiovascular disease and type 2 diabetes occur together.

Endnotes

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CHAPTER TWO

Literature Review

Another recent unique risk factor associated with diabetes mellitus that has received significant attention is Vitamin D deficiency. There are evidences that have suggested the anti-inflammatory action of vitamin D as well as its extra skeletal activities in infection process, autoimmune diseases, cardiovascular diseases, metabolic disorder and cancer development[1]. Low vitamin D status is typically caused by low dietary vitamin D intake and low cutaneous production of vitamin D, this condition is link with inadequate exposure to sunlight due to geographic location, genetic background affecting skin colour, age, and cultural or indoor activities (religious practices)[2].

2.1.1 Diabetes Mellitus and Its Classification

Diabetes mellitus is a serious chronic metabolic disorder of multiple aetiology characterized by hyperglycaemia with disturbances of macronutrient such as carbohydrate, fat, and protein metabolism resulting from defects of insulin production by the pancreas, insulin action on the body cell, or a combination of both. Diabetes is an essential public health issue and has been prioritized as one of four noncommunicable diseases (NCDs) targeted for action by world health leaders[3]. Both the number of cases and the prevalence of diabetes (diagnosed and undiagnosed) have been progressively increasing over the past few decades. The effect of uncontrolled increased blood glucose level in the body has been recognized as common risk that led to serious damage to the heart, blood vessels, kidneys, eyes and nerves.

The first World Health Organization (WHO) report on diabetes classification was made in 1965 by Expert Committee on Diabetes Mellitus and it received attention of international consensus. Diabetes classification was then based on age of recognized onset and need for insulin survival

including other specific types of diabetes. This classification was seemed to be the only reliable and universally acceptable[4].

Diabetes mellitus is newly classified by the American Diabetes Association on the basis of the aetiological and pathological processes leading to hyperglycaemia, its division were made into four major classes as following:

Type 1 diabetes(T1DM): This is class of diabetes mellitus that results from the pancreatic beta cells destruction, leading to absolute circulating insulin deficiency and elevated plasma glucagon in blood. As a result, exogenous insulin will then be required to reverse the catabolic state, prevent ketosis, reduce hyperglucagonemia and reduce blood glucose. Among people with Type 1 diabetes mellitus are autoimmune case which account for over 90% and idiopathic in less than 10%. This later one is those that usually show no evidence of pancreatic β cell autoimmunity. It occurs at any age but most commonly arises in children and young adults It was formerly known as insulin dependent diabetes mellitus and constitutes about 5% to 10% of all cases of DM.

Type 2 diabetes mellitus (T2DM): This is usually as result of relative rather than absolute defect in β cell insulin secretion with or without insulin resistance. Globally, it accounts for 90-95% of those living with diabetes and associated with older age, obesity, physical inactivity, family history of Type-2 diabetes in every degree of family members, or a personal history of gestational diabetes. Even though it commonly affects individual's adult older than 40 years, there are still existence in children and adolescents and this emerging situation could be as a result of the epidemic of obesity and inactivity in children these present days. It was formerly known as adult-onset diabetes mellitus or non-insulin dependent diabetes mellitus (NIDDM).

Other specific types: These are cases of diabetes mellitus that are related to genetic defects in beta cell function, genetic defects in insulin action, and diseases of the exocrine pancreas due to various causes and included in this group are chemical and drug-induced diabetes mellitus.

Gestational diabetes mellitus: Is a form of diabetes that is diagnosed only during pregnancy at second trimester to the third trimester. It occurs in African women who are obese or have a family history of type-2 diabetes. It requires treatment to bring the maternal blood glucose to normal levels and avoid complications of pregnancy wastage and other complications in the baby. About 50% of cases may eventually develop type 2 diabetes mellitus[5].

2.1.2 Associated Risk Factor of Type 2 Diabetes Mellitus

Identification of risk factors on the aetiology of type 2 diabetes mellitus is a key step in planning prevention programmes for diabetes mellitus**.** In epidemiology, risk is most often used to express the probability that a particular outcome will occur following a particular exposure[6]. There is general agreement that the term risk factor means an exposure that is statistically related in some way to an outcome. Broadly defined, a risk factor is an aspect of personal behaviour or lifestyle, an environmental exposure, or an inborn or inherited characteristic which on the basis of epidemiological evidence is known to be associated with health-related condition(s) considered important to prevent. The two main risk factors for type 2 diabetes mellitus in Sub-Saharan Africa (SSA) and other region of the world are modifiable and non-modifiable risk factors in its aetiology

Overweight and obesity

Obesity is generally described as a condition of excessive fat accumulation, with abdominal fat being the main risk factor for insulin resistance. Obesity has become a major public health problem worldwide, being the main cause to the development of diseases such as type 2 diabetes

and cardiovascular diseases (CVD). In the past, being overweight or obese was not common in Africa, possibly due to food insecurity and high-energy expenditure. However, higher incident rate of overweight and obesity has now been recorded in the Africa due to urbanisation and economic expansion. For example, High- and middle-income countries including South Africa and Seychelles, are known to have higher obesity prevalence in the past[7]. In Africa, numerous studies presenting findings on various parameters of adiposity such as obesity, overweight, abdominal obesity, Body Mass Index (BMI) and waist-to-hip ratio are marked. As it was, in Motala et al.'s study of 1025 subjects (815 women) among the rural South African population, the multivariate analysis shows that the significant independent risk factors associated with diabetes include waist circumference (odds ratio 1.1) and hip circumference (0.9) for both men and women[8]. These findings are in direct agreement with other studies in the African region.

Similarly, in Isara and Okundia's study among adult residents of rural communities in southern Nigeria, overweight/obesity (OR = 3.53) was significantly associated with diabetes[9]. Kari et al. also found that diabetes was associated with overweight/ obesity (OR = 3.02/4.43). Among a Senegalese population, Sack et al. found that abdominal obesity (OR = 1.17, p = 0.05) was strongly associated with diabetes. Similar findings have been reported in populations of South Nigeria, South Africa and Tanzania. The association between BMI and diabetes in different parts of Africa was also evident in studies conducted in Nigeria, South Nigeria, South Africa and Sudan.

Dietary Practice

Generally, quality of diet and uneven caloric consumption are major driver for the epidemics of T2DM and overweight/obesity. Unhealthy dietary pattern has been recognized as major and leading risk factor with pooled prevalence of 8.0% in the recent study of Prevalences of risk

factors for diabetes mellitus by Uloko et al.'s[10]. Evidence suggests that independent of BMI, fat quality and carbohydrates are important predictors of diabetes. Glycaemic load and trans-fat are strongly associated with increased risk of diabetes, while frequent consumption of high-fibre diet including fruits and vegetables are associated with decreased diabetes risk[11]. This is demonstrated in a meta-analysis that suggests that two servings of whole grain per day is associated with a 21% lower risk of diabetes[12]. In Africa, studies on dietary patterns conducted in urban Ghana by Frank et al. showed inadequate fruit and vegetable consumptions association with increased risk of type 2 diabetes mellitus (T2DM)[13]. These findings are concordant with Ekpenyong et al.'s study among Nigerian population and also reported in Sack et al.'s study among a Senegalese population[14,15]. In North Africa countries such as Egypt, key diets are mainly rich in high glycaemic load and high glycaemic index, including white bread and polished rice[16]. The high intake of trans fat is now evident in Africa countries. Egypt is now among the world highest consumers of these unhealthy fats.

In Africa, due to food market globalization, multinational fast-food chains have multiplied substantially, contributing to the transition from a high-fibre diet to an energy-dense westernized diet. Statistical data has shown within Sub Saharan Africa (SSA) alone that fast food outlets have increased from zero in 1980 to the current figure of more than 1000 Kentucky Fried Chicken outlets[17]. Similarly, there are about 900,000 retail Coca-Cola outlets across, with approximately 78 million servings consumed daily[17]. Independent of body mass index (BMI), consumption of sugar-sweetened beverages increases the risk of T2DM. The recent meta-analysis showed that subjects who consume one to two servings of sugar-sweetened beverages per day fall in the higher quartile and have 26% greater risk of diabetes than those in the lower quartile[17]. Further, studies suggest that a 1% rise in sugar-sweetened beverages contributes to an additional 4.8%

overweight, 2.3% obese and 0.3% diabetic adults. In many Africa countries, fruit and vegetable availability are seasonal. As such, most African's fruit and vegetable consumptions are not incorporated into normal daily food routines. While the food market globalization has the tendency to boost the availability of fruit and vegetables, easy access is strongly associated with higher socioeconomic positions in most countries and ultimately determines their intake[17].

Age and sex

Diabetes prevalence considerably increases with age. According to studies, most diagnosed cases of diabetes are between the 40 and 70 years of age of a person's life[18]. Studies revealed that working age individuals (ages 25–69 years) have more diabetes in comparison with older individuals (ages > 69 years)[19]. Also, the International Diabetes Federation (IDF) in 2010 estimated that the peak age for onset of type 2 diabetes was 40-59 years[20]. But by 2030, the highest prevalence was projected to be in the oldest age-group (60-79 years) affecting some 196 million persons. In Sub-Saharan Africa, prevalence of diabetes increases with age, with most reports indicating a peak at either 55 years or older or 30-50 years[20]. The worsening of insulin resistance with age and increasing longevity of diabetic patients due to improved care, all contribute to the rising prevalence of diabetes mellitus with age. This association suggested that in Africa, the effect of ageing of the population on diabetes prevalence is already evident. As the diabetes epidemic matures, the age at onset will shift to younger age-groups and early-onset type 2 diabetes will emerge. Furthermore, Idemyor reckoned that the Sub-Saharan Africa diabetic population is in the economically productive age group while some are usually detected lately[21]. This was blamed on the late diagnosis of diabetes in this region, coupled with inequalities in accessing care, leading to early presentations of diabetic complications. The estimates for both 2010 and 2030 showed little gender difference in the number of people with diabetes. For 2010,

the IDF estimated that about one million more women than men had diabetes (143 million women as against 142 million men). However, this difference is expected to increase to six million by 2030 (222 million women as against 216 million men). A search through local literatures indicates that the prevalence of DM was slightly higher in women than men[22].

Family history

This is an important non modifiable risk factor of the DM. Individuals who have a family history of diabetes can have two to six times the risk of type 2 diabetes compared with individuals with no family history of the disease. Ahmad et al., in Kashmir, India reported similar trend and observed that individua with family history of diabetes mellitus had 2-3 times higher risk of developing the disease[23]. It has also been noted That association of family history of diabetes mellitus and diabetes mellitus was proved highly significant[24]. Among all demographic and risk factors, the presence of three or more diabetic first-degree relatives corresponded to the highest risk for diabetes.

This association between DM and history in first degree relatives was also corroborated by Oyegbade at al., in a study at Ile-Ife, South Western Nigeria; who noted a strong positive association between fasting hyperglycaemia and parental history of type 2 diabetes[25]. Thus, on a population level, family history may help modify health promotion messages for specific population groups. It is well known that insulin resistance and β-cell failure are prerequisites for development of type 2 diabetes. The relative role of each remains controversial because adult studies of at-risk first-degree relatives of patients with type 2 DM yielded conflicting results. However, Bolandi et al., noted that family history of type 2 diabetes was associated with decreased insulin sensitivity and an impaired balance between insulin sensitivity and insulin secretion[26].

Physical inactivity

Physical activity is the major determinant of energy expenditure which play a significant role in energy balance and weight control. According to Giovannucci et. al reported WHO 2010, recommendation on moderate physical activity (approximately 150 min per week) reduces the risk of diabetes by 27%, colon cancer by 21– 25% and ischemic heart disease by 30%[27]. In Africa, studies presenting findings on physical inactivity are well documented. They include Iheanacho et al.'s study among patient of Isara and Ijebu Ode general hospital, Nigeria populations in which physical inactivity was significantly associated with higher prevalence of T2DM[28]. Various studies conducted in Sub Sahara Africa, South Africa and West Africa have all linked physical inactivity to the rising burden of diabetes. From a cultural perspective, structured or deliberate physical activity in most African countries is not usually viewed as a health-related risk factor but mainly through the lens of sports.

Additionally, in most countries particularly in North Africa, such as Egypt, exercise is avoided in public places, representing a significant factor in reduced physical activities. There is also a scarcity of exercise facilities in Africa, and those that exist are very expensive. Furthermore, while physical activity is obtained from its occupational (e.g. manual labour and farming) or incidental use (e.g. walking) in most countries, the growing use of mechanization is evident in growing urbanization. While driving in industrialised countries has largely displaced physical activity (e.g. walking and manual labour), this phenomenon is also now evident in most African countries, particularly in cities. In cities, the growing use of technologies such as mobile phones and prolonged viewing of television further contributes to the decline in physical activity. As a result, the incidental and occupational physical activities which were once used to offset the glycaemic load and trans-fat are diminishing.

Cigarette/Tobacco Use

Tobacco use (either smoked or smokeless) has a strong relationship with T2DM, either as an independent risk factor or in clusters with other risk factors such as centripetal obesity. Smokeless tobacco products are the leaves of a plant called Nicotiana tabacum, which are considerably cheaper than cigarettes and used more by people of low socioeconomic status. The product is consumed as a smoke, a chew or a snuff. A meta-analysis by Willi et al. shows that smokers have a 45% increased risk of diabetes compared with non-smokers[29]. Also, in the study of Campagna et al showed an increased risk of pre-diabetes in smokers compared to non-smokers[30]. Smoking is very common among men in both Sub Sahara Africa and North Africa including Tunisia and Libya. In Egypt, approximately,40 % of adult males are smokers[31].

In Africa, despite a paucity of data on smokeless tobacco toxicities, the available few studies show that traditionally made smokeless tobacco has higher carcinogenic tobacco-specific nitrosamines than commercially made cigarettes smoking. The use of smokeless tobacco is widespread, yet not well researched. Due to the globalisation of the tobacco industry's influence and the persistently low level of health literacy, tobacco prevalence (both smoked and smokeless) is expected to reach pandemic proportions in Africa within the next decade.

Alcohol consumption

Alcohol use is a major contributor to premature death and disability. Studies have shown alcohol abuse to be strongly linked to diabetes incidence and vastly increases adiposity and abdominal obesity among all sexes. Studies conducted in Nigeria, Kenya and other African countries found varied correlations between alcohol consumption and diabetes[32,33,34]. These findings have been reported among different population groups in Africa, including rural South Africa, Kenya and Nigeria. Alcohol use is high in Africa, except in countries where it is prohibited. In many

African countries, alcohol is central to the cultures, traditions, customs and social life, with long-standing historical significance. Western spirits, although expensive, are culturally and economically important due to their status.

Western spirits are chiefly reserved for traditional drinking events and major occasions. However, locally produced alcohol is common and cheaper and is most preferred. It is widely consumed both in rural areas and poor urban cities and includes fermented beverages like ogogoro in Nigeria, burukutu and pito or ginlike (mainly illicit) in Zambia and Ghana or gongo in Tanzania. Despite the growing interest in alcohol use in Africa, little is known about the patterns and levels of consumption among these populations. Exacerbating the effect of alcohol use is the evolution of globalisation, acculturation and urbanisation of alcohol consumption in Africa, including increased ease of access.

Hypertension

Individual with hypertension is more likely to develop diabetes compare to others. This may be because diabetes and hypertension share similar risk factors such as physical inactivity and overweight. A previous work found out that type 2 diabetes mellitus was more prevalent among people with hypertension than people with normal blood pressure (11.5% vs. 3.38%, p=0.0001); when regression analysis was done, diabetes mellitus was 2 times higher in hypertensive individuals than in normotensive respondents in that study[35]. Several previous works that showed that high blood pressure was significantly and positively associated with the risk of developing diabetes mellitus have been reported. Studies have also shown hypertension to be a definite risk factor towards the development as well as progression of cardiovascular complications in diabetics.

Inadequate blood pressure control in the majority of a group of patients with diabetes mellitus (DM) was reported in a recent study carried out in Nigeria in which only 12% of diabetic patients with hypertension had their Blood Pressure (BP) controlled below the currently recommended target level of 130/80 mmHg. However, it has been observed that antihypertensive drug compliance as well as optimal blood pressure control particularly in diabetics are often unsatisfactory in developing countries often due to financial constraints.

Low vitamin D status

This is an emerging risk factor of type 2 diabetes mellitus that has been recently documented. Various studies have unveiled the significant importance of vitamin D not only in the skeletal involvement rather in other non-skeletal conditions[36]. Hypovitaminosis D is highly prevalent in type 2 diabetes mellitus patients. Low levels of vitamin D are considered a risk factor for poor glycaemic control and microvascular complications including nephropathy[37]. Evidence indicates a high prevalence of vitamin D deficiency worldwide. Consistent with the hypothesis that vitamin D deficiency and diabetes are related, areas with high prevalence of vitamin D insufficiency and deficiency have been associated with a higher prevalence of diabetes.

The effect of vitamin D on B-cell function and insulin sensitivity has been observed in both animal and human studies. Vitamin D is required for and improves the production of insulin; and also improves insulin sensitivity. Insulin secretion was impaired in the vitamin D deficient pancreas, and was improved by dietary vitamin D supplementation. Vitamin D facilitates the biosynthetic capacity of B-cell and also accelerates the conversion of pro insulin to insulin. There was a significant correlation between the change in vitamin D levels and the first phase insulin secretion, with a decrease of 21.4% in insulin resistance after one month of vitamin D supplementation[38].

2.1.3 Prevalence and Burden of Undiagnosed Type 2 Diabetes Mellitus

The International Diabetic Federation, IDF, describes diabetes mellitus as one of the largest global health emergencies of the 21st century, largely because of its severe and deadly consequences[39]. Direct health expenditures due to diabetes are already close to one trillion USD and will exceed this figure by 2030. Diabetes is a common non-communicable disease and especially taxing because the cost of treatment and care is majorly carried by individuals who pay out of pocket[40]. The high cost of treatment is a major cause for concern from another angle. The prevalence of Diabetes Mellitus continues to increase. According to the International Diabetes Federation (IDF) statistics globally, 10.5% prevalence accounts for 537 million people living with diabetes among the age group of 20-79 years in 2021 while half of these are undetected[41]. Regionally, the prevalence of diabetes mellitus (DM) is 4.5% in Africa, 9.2% in Europe, 16.2% in the Middle East and North Africa, 14.0% in North America and the Caribbean, 9.5% in South and Central America, 8.7% in Southeast Asia, and 11.9% in Western Pacific. China, India, Pakistan, and the USA remain the top four countries with the largest number of people with Diabetes mellitus globally[3]. The current prevalence of diabetes mellitus in Nigeria is between 5-6%, accounting for 3.6 million Nigerian living with diabetes[42]. That has made Nigeria ranked second among the top 5 countries in Africa with the highest number of people living with diabetes[3].

With the above statistics according to IDF, more than half of a billion people living with diabetes in 2021. Type 2 diabetes mellitus (T2DM) is one of the prominent and most common diet-related non-communicable diseases (NCDs) globally. As one of the many chronic lifestyle diseases caused by an imbalance in diet, it has serious adverse effects on human health[43]. The recent upsurge in T2DM has necessitated the pursuit of more causal factors. In Africa, a large fraction

of all people with diabetes are undiagnosed, and more than average percentages of newly diagnosed diabetics are unaware of their condition until complications appear[35,77]. Though many confirmed diabetes passes through the stage of impaired glucose tolerance (prediabetes) for several years during which there is an opportunity to recognize it and initiate timely intervention such preventive measures[1,44]. Impaired glucose tolerance is an intermittent stage of undisguised diabetes where the blood glucose level is higher than the normal value but not high enough to meet the criteria for the diagnosis of diabetes mellitus[45,46].

The global prevalence of diabetes mellitus among adults over 18 years of age rose from 4.7% in 1980 to 8.5% in 2014, and has been rising more rapidly in middle and low-income countries[47,48]. According to a recent report of IDF in its Diabetes Atlas display cases from 2020-2045. it was reported that, in 2021, 24 million people were estimated to be living with diabetes in Africa, and this was projected to increase to 33 million by 2030, which is responsible for 416,000 deaths. Whereas, in Nigeria, the total number of people living with diabetes in Nigeria Rose from 3.05 million in 2011 to 3.6 million in 2021, and is projected to reach 4.94 million in 2030 and 7.98 million in 2045. The number of people with undiagnosed diabetes in Nigeria is expected to exceed 1.93 million by, 2021 at the rate of a 53.3 percent increase, while the number of people with impaired glucose tolerance is estimated to rise from 9.41 million in 2021 to 11.98 million in 2030 and 18.79 million in 2045[49] Diabetes mellitus can play a vital role in the cause of morbidity and mortality through continued clinical consequences and effect on cardiac functions, renal failure, visual impairment and blindness, diabetic ketoacidosis or hypoglycaemia and infection[50]. Diabetes mellitus (DM) and related complications are associated with long-term damage and failure of various organ systems. It induces changes in the microvasculature which combine with advanced glycation end products of oxidative stress, low-grade inflammation, and

neovascularization (formation of new blood vessels) of vasa vasorum to cause vascular complications, if the risk factors (hyperglycaemia, hypertension, and dyslipidaemia) are not well controlled, diabetic peripheral neuropathy, and nephropathy are common complications of diabetes[51]. The increased effect of diabetic neuropathy can be as common as a major microvascular complication[52]. An increased incidence of atherosclerosis in insulin-dependent diabetic patients has long been recognized. There is an increased risk of stroke, heart disease, retinopathy, peripheral nerve damage, and renal problems among diabetic patients compared to the general population[53]. According to the World Health Organization diabetes will be the 7th leading cause of death by 2030[54]. Attention given to diabetes in Nigeria is not corresponding with the enormous problem arising from its incident mainly because access to nutritional education, nutritional care, and medical care, as well as effective management and control that is low. The economic burden of diabetes mellitus in a developing country like Nigeria is also enormous in terms of the direct cost of intensive monitoring and control of blood glucose, managing cardiovascular, renal, and neurological consequences, as well as the cost of care. The quality of life and life expectancy of the patients are also reduced. Adequate knowledge of good dietary habits and healthy lifestyle is very essential in diabetic care. Nutrition knowledge and skills enable individuals with type 2 diabetes (T2DM) to make food choices that optimize metabolic self-management and quality of life. Increasing people's knowledge regarding the disease and its complications have significant benefits on the treatment compliance and as a result reducing complications associated with the disease[15]. However, studies in Nigeria indicate low adherence to dietary recommendations for macronutrient intakes as well as fruit and vegetable consumption in the populace especially among diabetic patients whereas an appropriate diet is necessary for glycaemic and other metabolic outcomes control. The lack of

sufficient diabetes screening programs in the nation is also a contributing factor to the increased prevalence of diabetes. Effective policy must be implemented to tackle blowup in the number of undiagnosed diabetic patients along with the lifelong complications that are imminent.

2.1.4 Pathogenesis of Type 2 Diabetes Mellitus

Insulin is the main reason for diabetes. Insulin is a peptide hormone responsible for diabetes occurrence. It is produced by some special cells of the pancreas called beta cells of islet of Langerhans, in order to regulate the increase level of glucose in the blood secondary to post meal intake. The insulin works by increase glucose uptake of peripheral tissues/cells of the body and suppresses liver pathway production of glucose (hepatic gluconeogenesis). These actions reflect the interaction between up and down of two hormones i.e. insulin and glucagon in order to maintain glucose homeostasis.

Type 1 diabetes results when the beta cells are unable to produce enough insulin, often because they have been destroyed by the body's immune system, a process called autoimmune reaction.

Type 2 diabetes on the other hand, is a progressive disease that first results due to the insensitivity of the cells of the body to the actions of insulin, which triggers increased activity of the beta cells to overcome the resistance, resulting in the exhaustion of the beta cells and their loss of function. In an individual with fasting hyperglycaemia (i.e., higher level of blood glucose after 8-10 hours fasting), insulin levels have been found to be two to four-fold greater than in non-diabetics. It is estimated that patients with Type 2 diabetes have lost about 50- 70% of the total stock of their beta cells, as at the time of the diagnosis. This loss continues with the disease,

at the rate of about 4% every year, such that most patients with Type 2 diabetes are without any functional beta cells, after about ten years with the disease.

Progressively Down drift of Beta-cell function

Using insulin for the treatment of diabetes intent to mimic how insulin is normally released by the beta cells of the pancreas. The beta cells normally release insulin in two patterns: Small amounts of insulin are continuously released by the beta cells, to maintain the blood sugar at the normal level, and to ensure that glucose is continuously pushed into the cells of the body, as at when the glucose is needed by the body cells. This continuous release is called **basal insulin production**. The beta cells release high doses of insulin, immediately after a meal, first to stop the liver from pushing out more stored glucose into the blood, and then to deal with the increased glucose level that follows the consumption of a meal. This post-meal release of insulin is called **bolus insulin production**. The amount of insulin released by the beta cells is influenced by the carbohydrate content of the meal; the higher the glycaemic index and the glycaemic load of the meal, the more the insulin that is released to deal with the calories content of the meal. **basal-bolus mode of insulin treatment** involves when an individual on oral anti-diabetes drugs who have problem of high blood sugar level in the morning (fasting hyperglycaemia) are often given a basal dose of insulin injection at night to help them deal with the problem; while those with high blood sugar levels after a meal (post-prandial hyperglycaemia) are given bolus doses of insulin injection with meals[55,56].

The Three Major Key involvements in Diabetes

(a) Insufficient production of insulin (either absolutely or relatively to the body's needs)

(b) Inability of body cells to use insulin properly and efficiently, leading to hyperglycaemia and diabetes (insulin resistance)

(c) Steady decline in number of Beta-cells, adding to the process of elevated blood sugars.

Insulin Resistance occurs as a result of the following:

Defects in muscle tissues receptor function,

Defects in insulin receptor-signal transduction pathway,

Defects in glucose transport and phosphorylation,

Glycogen synthesis, and glucose oxidation

2.1.5 Diagnoses Criteria for Type 2 Diabetes Mellitus

America Diabetes Association (ADA) and world Health Organization (WHO) are currently recommending four diagnostic tests for diabetes, choice of each test depends on whether it is for clinical or epidemiological, convenience, cost and reliability. The tests include assessment of fasting blood glucose from the collected blood sample after 8 to 10 hours of fasting; 2-hour after ingestion 75 glucose load for oral glucose tolerance test (OGTT); Glycated haemoglobin (HbA1c) from red blood cells of the collected sample thus gives the glucose status of approximately past three months; and a random blood glucose in the presence of signs and symptoms of diabetes.

Diabetes mellitus diagnoses can be achieved with fasting blood glucose values of ≥ 7.0 mmol/L (126 mg/dl), 2-hour post-load blood glucose (OGTT) ≥ 11.1 mmol/L (200 mg/dl), HbA1c ≥ 6.5% (48 mmol/mol); or a random blood glucose ≥ 11.1 mmol/L (200 mg/ dl) in the presence of signs and symptoms are considered to have diabetes. If elevated values are detected in asymptomatic people, repeat testing, preferably with the same test, is recommended as soon as practicable on a subsequent day to confirm the diagnosis[57].

Impaired Glucose Tolerance and Impaired Fasting Glucose

Impaired glucose tolerance (IGT) and impaired fasting glucose (IFG) are conditions of raised blood glucose levels above the normal range and below the recommended diabetes diagnostic

threshold. The terms 'prediabetes', 'non-diabetic hyperglycaemia', 'intermediate hyperglycaemia' are in use as alternatives. International Diabetes Federation (IDF) has attributed

	Test(s)	**Value Range**	**Comments/ Instruction**
1.	Fasting Plasma Glucose (FPG)	≥ 126 mg/dL OR (7.0 mmol/L)	Fasting is defined as no caloric intake for at least 8 hours.
2.	Oral Glucose Tolerance Test (OGTT) / 2 hours Postprandial Plasma Glucose (2-h PG)	≥ 200 mg/Dl OR (11.1 mmol/L)	Test done2 hour after ingestion 75g glucose load dissolved in water.
3.	Glycated Haemoglobin (HbA1c)	≥ 6.5% OR (48 mmol/mol).	Perform in laboratory using a method that is NGSP certified and standardized to the DCCT assay
4.	Random Plasma Glucose (RPG)	≥ 200 mg/dL OR (11.1 mmol/L)	Only for patient with classic symptoms of hyperglycaemia or hyperglycaemic crisis

three good reasons of early detection Impaired glucose tolerance (IGT) and impaired fasting glucose (IFG) which include first, they signify a risk of the future development of type 2 diabetes; second, IGT and IFG denote an already heightened risk of cardiovascular diseases (CVD); and, third, their detection opens the door to interventions that can lead to the prevention of type 2 diabetes.

The current America Diabetes Association (ADA) diagnostic criteria for diabetes and prediabetes are mentioned in tables below respectively:

Table 1.1 Criteria for the diagnosis of diabetes[19].

	Test(s)	Value Range	Comments/ Instruction
1.	Impaired Fasting Glucose ((IFG)	100 mg/dl (5.6 mmol/L) TO 125 mg/dl (6.9 mmol/L)	Fasting is defined as no caloric intake for at least 8 hours.
2.	Impaired Glucose Tolerance (IGT) / (OGTT)2 hours Postprandial Plasma Glucose (2-h PG)	140 mg/dl (7.8 mmol/L) TO 199 mg/dl (11.0 mmol/L)	Test done2 hour after ingestion 75g glucose load dissolved in water.
3.	Glycated Haemoglobin (HbA1c)	5.7% - 6.4% OR (39 - 47 mmol/mol)	Perform in laboratory using a method that is NGSP certified and standardized to the DCCT assay

Note: In the absence of unambiguous hyperglycaemia, diagnosis requires two abnormal test results from the same sample or in two separate test samples[19].

Table 2.1 Criteria defining prediabetes[19].

2.1.6 Glycaemic Control and Complication of Diabetes

Aside some uncomfortable clinical manifestation an individual living with diabetes is experience, the disorder usually results into various complications range from physical and psychological health status of an individual with diabetes and their family, this condition also affects the quality of life and reduce life expectance. Diabetes mellitus is a condition resulting from abnormal glucose metabolism via decrease insulin secretion and insulin resistance. The imbalance in blood glucose level impact negatively on all tissue cells and organs that are making use of the glucose as metabolic fuel in the body. Diabetes complications are microvascular and macro vascular in

which the system or organs that commonly involve include cardiovascular, renal, central nervous (brain and nerves), eye and skin. More devastating complications cause by long time existing undiagnosed diabetes and improper management of the disease. Some of the complications are as follow;

Diabetic cardiovascular complications

One of the most affected body systems in the complication of diabetes mellitus is cardiovascular system. Type 2 diabetes mellitus is a metabolic disorder predisposing to diabetic cardiomyopathy and atherosclerotic disease (CVD) consequently leading to heart failure via different mechanisms including insulin resistance, inflammation, endothelial dysfunction, and the toxic effects of glucose on microvasculature. In addition, elevated blood glucose levels are associated with a common set of other underlying metabolic risk factors, including hypertension, dyslipidaemia, and central obesity.

This resultant effect of persistent increase blood glucose level had been collectively comprising the largest cause of both morbidity and mortality for people with diabetes. Atherosclerotic coronary heart disease is viewed as the commonest cause of death in Diabetes Mellitus. Hyperglycaemia has been shown to be associated with about 15% of all death's due cardiovascular disease and kidney disease. Studies revealed that close link between diabetes mellitus (DM) and cardiovascular diseases (CVD) could be traced to influence of the common genetics and environmental factor existing in their association.

The most common and classic types of cardiovascular diseases (CVD) associated with diabetes are coronary heart disease, cerebrovascular disease, peripheral artery disease, and congestive heart failure, and these are manifested as specific events, hospitalizations, procedures and deaths

from acute coronary syndromes, myocardial infarction, ischaemic and haemorrhagic stroke, as well as sudden death. Prospective studies have demonstrated that diabetic patients have a two- to fourfold risk to develop coronary artery disease (CAD) and myocardial infarction (MI), confirming that type 2 diabetes mellitus is an independent risk factor for stroke and heart disease[58]. Common classical risk factors of DM which include overweight/obesity, dyslipidaemia, physical inactivity and hypertension can also trace to cardiovascular disease

Diabetic kidney disease

Globally, estimated 80% of end-stage renal disease result from complication of diabetes, hypertension, or combination of the two. Chronic kidney disease (CKD) in people with diabetes can result from diabetic nephropathy. 38.6% of people living with diabetes in Thailand have chronic kidney disease, a comparatively high prevalence of CKD, especially in older patients and those with diabetic complications-related to poor glycaemic control, was noticed[59]. Early identification may help to target optimise care and prevention programs for CKD among T2DM patients. The percentage increase risk of end stage renal disease in diabetes is up to ten times higher than those without diabetes disease. Similar study did in Kwara State, Central Northern Nigeria showed that diabetes was the most potent risk factor of chronic kidney disease with risk aOR = 6.41, 95CI= 3.50 – 11.73, p = 0.001 more than six time higher than non-diabetic individual[60]. Diabetic nephropathy prevalence increases with diabetes severity and leads to end-stage kidney disease and kidney death. The risk for nephropathy also increases with the duration of diabetes, for example, the United Kingdom Prospective Diabetes Study found a prevalence of microalbuminuria of 7.3% at the time of diabetes diagnosis, which increased to 28% at 15 years' follow-up[61]. Diabetic nephropathy causes kidney failure because of T2DM complications and leads to the need for dialysis in patients with this complication.

Nerve and/or vascular damage and diabetic foot complications

Diabetic neuropathy (DN) is poorly understood and inadequately investigated. It is increasingly evident that neuropathy plays a significant role in many other aspects of diabetes mellitus including abnormal visceral functions, hormonal secretory regulation and non-neurologic complications of diabetes mellitus. The cause of diabetic neuropathy is mostly unclear; however metabolic components and ischemia are thought to play a role. "Hyperglycaemia results in raised endothelial vascular resistance with reduced nerve blood flow. Hyperglycaemia equally brings about diminution of nerve myoinositol as it may stimulate symptom of diabetic neuropathy. Hyperglycaemia also induces oxidative stress. Protein kinase C activation has been linked to vascular damage in diabetic neuropathy (DN). Peripheral neuropathy affects the distal nerves of the limbs, principally in the feet, majorly by modification of the symmetrical sensory function causing abnormal feelings and progressive numbness. These conditions expedite the development of ulcers resulting from external trauma and/or abnormal distribution of the internal bone pressure known as 'diabetic foot'. Diabetic foot complications are severe and chronic. They consist of lesions in the deep tissues associated with neurological disorders and peripheral vascular disease (PVD) in the lower limbs[62]. The reported prevalence of diabetes-related peripheral neuropathy ranges from 16% to as much as 87% with painful diabetes-related neuropathy reported in about 26% of adults with diabetes. Lower limb amputation in people with diabetes is 10 to 15 times more common compared to those without diabetes[63]. Prevalence is higher among people with type 2 diabetes, compared with those with type 1 diabetes. The increased risk rate of diabetic foot amputation, myocardial ischaemia and stroke, with long-term disability, eventually leading to death is strongly linked with peripheral vascular disease. Chronic

ulcers and amputations result in a significant reduction in the quality of life and increase the risk of early death.

Diabetic eye disease

Diabetic eye disease (DED) is consisting predominantly of diabetic retinopathy (DR), diabetic macular oedema (DMO), cataract and glaucoma, but also double vision and inability to focus. In most countries, diabetic retinopathy DR is recognized to be one of the leading causes of blindness in the working age population with devastating personal and socioeconomic consequences, despite being potentially preventable and treatable. Cataract in diabetes is the formation a cloudiness of the lens, which can decrease visual acuity, and occurs more frequently and at a younger age in individuals affected with diabetes. Diabetic retinopathy often results from a cycle of fluctuation in the blood glucose level between extreme high and low. At hyperglycaemia increase amount glucose is transported to the eye together with excessive fluid migration leading to fluid accumulation in the eyes causing luring of vision. When the blood glucose levels reduce typically, vision will return to normal. Circle of this may continuous if the blood glucose level is not adequately control. Based on an analysis of 35 studies worldwide carried out between 1980 and 2008, the overall prevalence of any diabetic retinopathy (DR) in people with diabetes using retinal images was estimated to be 35% with vision threatening DR present in 12%. Diabetes retinopathy occurs when the accumulated damage to blood vessels in the retina of the eye and is a major cause of blindness. Increase prevalence rate of Type 2 diabetes has also implicated high proportional growing cases of diabetic retinopathy in Nigeria, this similar to the findings of a study conducted in North-Central, Nigeria investigates the prevalence and risk factors of diabetic retinopathy amongst patients with diabetes mellitus in a

hospital. The study result revealed diabetic retinopathy was present in 18.5% of the participants, while 14.3% had macular oedema[64].

Diabetes and Skin Complication

Diabetes can affect every part of the body, including the skin. Skin issues are a common complication of diabetes. More than one fourth of patients with diabetes mellitus develop one type of skin disorder or the other. Similarly, one in three people with diabetes will experience a skin problem that is either caused by or affected by diabetes. The incidence of diabetes skin complications is higher in an individual above 75 years of age[64]. Diabetes Canada reports that rough, dry and scaly skin affects at least 75% of people with diabetes in that age bracket. In fact, skin problems are sometimes the first sign that a person has diabetes[66]. One of the primary causes of diabetes-related skin conditions is high blood glucose level**,** which can lead to dehydration and results in dry skin. Also, another diabetic skin conditions as result of nerve damage, which can lead to reduced sweating and dry skin. The diabetes – related skin problems that mostly occur to people with diabetes. include diabetic dermopathy, necrobiosis lipoidica diabeticorum, diabetic blisters, and eruptive xanthomatosis.

Financial and social complication of Diabetes Mellitus

Diabetes mellitus complication burden goes beyond mortality and morbidity to financial cost globally. The high prevalence of diabetes mellitus is a global issue that affects all nations. DM and its complications have a significant economic impact on individuals, families, communities, health systems and national economy at large. Costs associated with the disease include increased use of health services, productivity loss and disability, Direct health expenditures due to diabetes are already close to one trillion USD and will exceed this figure by 2030. Diabetes is a common non-communicable disease and especially taxing because the cost of treatment and

care is majorly carried by individuals who pay out of pocket[40]. The high cost of treatment is a major cause for concern from another angle. People with Diabetes Mellitus require at least two to three times the health care resources compared to non-diabetic. National economies are suffering significant losses because of premature deaths or inability to work resulting from heart diseases and DM[67].

The burden of non-communicable diseases (NCDs) including diabetes mellitus is felt in workplaces around the world, due to elevated levels of absenteeism from illness and productivity lost from staff performing below normal standards due to poor health. A study done in Tanzania estimated that in 1989-1990 the total cost of outpatient care for all diabetic patients was US$2.7 million, of which insulin accounted for two-thirds of the expenditure, and total in-patient cost was US$1.25 million[68]. As diabetes care in Tanzania was provided free of charge to users, this total cost of US$4 million was paid from the government health budget and accounted for 8% of the government's total health expenditure 1989-1990[69]. It has been estimated that for Tanzania to provide care for diabetic patients, the government would need to spend more than half of the entire health care budget. In a systematic review of existing literature on Type 2 diabetes mellitus found that many Nigerians with Type 2 diabetes are still undiagnosed. Those already diagnosed have few known treatment options. These researchers also identified an increasing diabetes-related financial burden on individuals, the Nigerian society, as well as the Nigerian government. Therefore, the authors recommended more research on Type 2 diabetes, and the adoption of targeted response to diabetes prevention, control, and management. Other finding of study showed the high level of diabetes mellitus disease burden which African populations bear. Nigeria has the highest number of people who live below the poverty line of less than $1.25 per

day[40]. A study that was conducted among sub-Saharan Africa shows that diabetic people are at risk of selling their possessions, houses or land to raise funds to pay for medical care[70].

2.2.1 Vitamin D Overview

Vitamin D is originally recognized as a vitamin but now as a prohormone. Cutaneous synthetization of vitamin D via sunlight action on the body skin make it a unique nutrient among the vitamins group. Vitamin D, known as calciferol, consist of a group of fat-soluble seco-sterols. The two major forms are vitamin D_2 and vitamin D_3. Vitamin D_2 (ergocalciferol) is largely human-made as fortified foods or supplements, while vitamin D_3 (cholecalciferol) is produced in the human skin from 7-dehydrocholesterol and also consumed in the diet through the intake of animal-based foods[72]. Both vitamin D_3 and vitamin D_2 are synthesized commercially and found in dietary supplements or fortified foods. The D_2 and D_3 forms differ only in their side chain structure. The differences do not affect metabolism and both forms function as prohormones. Activated form of vitamin D_2 and D_3 are said to demonstration indistinguishable responses in the body, and the capacity to cure vitamin D–deficiency is the same[73]. Human experimental studies are yet to fully characterized the lesser of toxicity in both vitamins but some animal studies revealed vitamin D_2 is less toxic than vitamin D_3[74].

2.2.2 Sources and Production of Vitamin D

Sources of Vitamin D are in two major sources include endogenous and exogenous. Endogenous source are those sources that synthesis within the body via exposure of the skin to ultraviolet radiation, example include skin, liver and renal production. While exogenous sources are those that produce from diet of both animal and plant products including the fortification or supplements. Vitamin D has two main forms, (vitamin D3 and Vitamin D2) which are known

collectively as calciferol[71]. All forms of vitamin D are produced in response to ultraviolet light radiation.

- **Vitamin D3 (Cholecalciferol):** is the naturally occurring form. It is synthesized in the skin of vertebrates through the ultraviolet irradiation of 7- dehydrocholesterol from lanolin present in the epidermis. This activation is affected by the ultraviolet rays ranging in wavelength from 290 to 360A obtained from sunlight naturally.
- **Vitamin D2 (Ergocalciferol):** Vitamin D2 is the synthetic form which is produced by invertebrate fungal and plant sources in response to UV light. It is manufactured through the ultraviolet irradiation of ergosterol from mushroom yeas[73].

Production of Vitamin D can be via cutaneous, hepatic and renal production which include dietary intake.

Cutaneous Production: In the skin, 7-dehydrocholesterol, a derivative of cholesterol is photolyzed by ultraviolet light at wavelengths between 270 and 300nm, with peak synthesis occurring between 295 and 297nm. The products are Pre-vitamin D3 (preD3), lumisterol and tachysterol. At room temperature, the transformation of pre-vitamin D3 to vitamin D3 takes about 12 days to complete. Melanin in the epidermis, by absorbing UV irradiation, can reduce the effectiveness of sunlight in producing vitamin D3 in the skin. The intensity of UV irradiation is also important for effective vitamin D3 production[72]. The seasonal variation of 25OHD levels can be quite pronounced with higher levels during the summer months and lower levels during the winter. The extent of this seasonal variation depends on the latitude, and thus the intensity of sun light striking the exposed skin.

Hepatic Production: The hepatic phase is the next step in the bioactivation of vitamin D2 and D3. Whether it is made in the skin or ingested, cholecalciferol is hydroxylated in the liver at

position 25, to form 25 hydroxycholecalciferols (calcidiol or 25OHD). This reaction is catalysed by the microsomal enzyme, vitamin D 25 hydroxylase, which is produced by hepatocytes; although other tissues (skin, testes) express this enzymatic activity. 25OHD is the major circulatory form of vitamin D and provides a clinically useful marker for vitamin D status[74].

Renal Production: Renal production of dihydroxycholecalciferol (1,25OH2D) is commenced by transported to the proximal tubules of the kidneys, where it is hydroxylated at the 1 alpha position to form calcitriol (1, 25 dihydroxycholecalciferols and abbreviated to 1, 25(OH) 2D). This product is the most potent metabolite of vitamin D, and mediates most of its hormonal actions especially those involving the vitamin D receptor (VDR), a transcription factor. The conversion of calcidiol to calcitriol is catalysed by the enzyme 25- hydroxy vitamin D3 1 alpha-hydroxylase (CYP27B1). The principal regulators of vitamin D enzyme, known as Cytochrome p450 Family 27 Subfamily B Member 1 (CYP27B1) activity in the kidney are Parathyroid hormone (PTH), calcium, phosphate and 1, 25(OH) 2D. Extra renal production tends to be stimulated by cytokines such as interferon-gamma (IFN-gamma) and tumor necrosis factor alpha (TNF-alpha) more effective than PTH, and may be less inhibited by calcium, phosphate and 1, 25(OH) 2D depending on the tissue. The kidney is also the major producer of a second important metabolite of 25OHD, namely, 25(OH) 2D and the enzyme responsible is 25OHD-24 hydroxylase. The 24-hydroxylation is then followed by series of reactions and the eventual production of calcitroic acid, a metabolite with no biologic activity; thus, protecting the body against excess 1,25(OH)2D.

2.2.3 Vitamin D Physiology and Metabolism

Vitamin D has been previously known for its role in calcium and phosphorus metabolism and the prevention of rickets in children and osteomalacia in adult. The efficacy of the absorption of

renal and of intestinal calcium and phosphorus is increased in the presence of 1,25(OH)D2. It enhances calcium and phosphate absorption from the small intestine by promoting active transport. Nowadays, series of studies have been published on vitamin D's influence on key biological roles aside from skeletal functions[75]. Vitamin D is a fat-soluble vitamin; it is a prohormone with several active metabolites, it can be independently synthesised in human skin cells, in response to ultraviolet light and also produce via dietary source. Vitamin D promotes bone formation by maintaining appropriate calcium and phosphate concentrations. It increases mobilization of calcium from bone by promoting osteoclastic activity. It also inhibits parathyroid hormone secretion. It stimulates immunogenic and antitumor activity, reduce risk of autoimmune disorders[38]. It is therefore not astonishing that deficiency state leads to various clinical manifestations in the body systems, Vitamin D encompasses both vitamin D2 and vitamin D3; is obtained from dietary sources and from endogenous synthesis of a precursor substance. The major form of vitamin D in the body is vitamin D3. Dietary vitamin D is absorbed in the upper part of the small intestine.

Vitamin D is a group of fat-soluble vitamins conventionally recognized for its function in maintaining the homeostasis of calcium and phosphorous. Vitamin D commonly occurs in two forms: vitamin D_2 and vitamin D_3. Vitamin D_3, also known as cholecalciferol, is synthesized by the skin on exposure to ultraviolet-B radiation, and it is also available from animal source foods[76]. Vitamin D_2 (ergocalciferol) is obtained from plants, particularly mushrooms and yeast. Structurally, vitamin D_2 differs from vitamin D_3 in having a double bond between C_{22} and C_{23} and a methyl group at C_{24}, they are known collectively as calciferol. The major form of vitamin D in the body is vitamin D3. Dietary vitamin D is absorbed in the upper part of the small intestine. Vitamin D from the skin and diet is assimilated into chylomicrons and absorbed into

the lymphatic system. From here it enters the circulation, where it is bound to the vitamin D–binding protein (DBP) and lipoproteins. Vitamin D is not active form but need to undergo a series of metabolic transformations first in the liver and then in the kidney to form the active metabolite, known as 1,25-dihydroxyvitamin D[77].

Vitamin D transport in the system to target tissues

Vitamin D metabolites in the blood circulation bound to vitamin D–binding protein DPB and the albumin at 88% and 10% respectively. DBP concentrations are usually high above other metabolites concentration. DBP has high affinity for the vitamin D metabolites such that under normal circumstances only approximately 0.03% 25OHD and 24, 25(OH) 2D and 0.4% 1, 25(OH)2D are free. Hepatic and renal diseases (nephrotic syndrome) are conditions responsible for DBP and albumin levels reduction consequently reduce total 25OHD and 1, 25(OH) 2D levels without necessarily disturbing the free concentration[78]. However, vitamin D intoxication can increase the degree of saturation sufficiently to increase the free concentration of 1,25(OH)2D and so cause hypercalcaemia without necessarily raising the total concentration. 25(OH)D metabolites is the major circulating and storage form of vitamin D, with half-life of 2–3 weeks.

Vitamin D Regulation

The metabolic process occurs when the calcitriol required owning to inadequate calcium and phosphate level in the circulation, strongly regulated by its own concentrations, blood calcium and phosphorus levels through PTH and the FGF23, and this constitutes the basis of the vitamin D endocrine system that is central to maintaining calcium and phosphate homeostasis. During pregnancy, lactation, and the growth spurt, sex steroids, prolactin, growth hormone, and insulin-like growth factor 1 (IGF-1) play a role in enhancing the renal production of calcitriol

1,25(OH)2D to satisfy increased calcium need. Fibroblast growth factor 23, (FGF23) secreted from the bone, limits the activity of 1-alpha-hydroxylase, thereby inhibiting the renal production of 1,25(OH)2D, while simultaneously increases the production of 24-alpha-hydroxylase and 24,25(OH)2D. 1,25(OH)2D stimulates FGF23 which reduces renal phosphate reabsorption counteracting the increase in gastro- intestinal absorption induced by 1,25(OH)2D. Both the active hormone 1,25(OH)2D and its precursor 25(OH)D are, in part, degraded by 24-hydroxylase. The activity of this enzyme, in turn, is stimulated by 1,25(OH)2D and decreased by the elevation of PTH. Calcitriol has its strongest metabolic activity in inducing its own destruction by stimulating the 24-hydroxylase enzyme CYP24A1. The enzyme CYP24A1 is found in all target tissues and is induced in response to calcitriol interacting with the VDR. CYP24A1 is largely responsible for the metabolic degradation of calcitriol and its precursor, 25OHD. The active metabolites form of 1,25(OH)2D are secreted into the bile and reabsorbed via the entero-hepatic circulation. Impairment of this recirculation, seen with diseases of the terminal ileum, leads to accelerated losses of vitamin D metabolites[79].

Binding Action of Vitamin D Receptor

The vitamin D receptor otherwise called calcitriol receptor and acts as a ligand inducible transcription factor. The curiosity to comprehend the function of active form of vitamin D in the body has led to the discovery of the vitamin D receptor (VDR). Most of actions of 1,25(OH)2D are mediated by VDR acting primarily by regulating the expression of genes whose promoters contain specific deoxyribonucleic acid (DNA) sequences known as vitamin D response elements (VDREs). The binding of calcitriol to VDR allows the VDR to act as a transcription factor that modulates the gene expression of transport proteins such as transient receptor potential vanilloid (TRPV6) and calbindin which are involved in calcium absorption in the intestine.

The hormone localized almost entirely in the nucleus in a specific fashion in target tissues. This localization was also found in other tissues not previously considered. It has been identified in almost every tissue and cell in the body, including brain, heart, skin, pancreas, breast, colon, and immune cells. The discovery of the VDR in these tissues resulted in the idea that the vitamin D hormone had functions beyond calcium and phosphorus metabolism, which prompted investigations into non-skeletal actions of the vitamin D hormone, such as regulation of cell growth and maturation, stimulation of insulin secretion, inhibition of renin production, and modulation of the functions of activated T and B lymphocytes and macrophages[80].

2.2.4 Assessment of Vitamin D Status

Both calcitriol and ercalcitriol are the active metabolites form of vitamin D to exert its action in the body, yet it is not the parameter used to measure serum concentration of vitamin D status. It is usually normal or even raised up in an individual with vitamin D deficiency and half-life is short with approximation of 4 to 8 hours. Serum calcidol 25(OH)D is the chief circulating form of vitamin D that is more appropriate for the determination of one's vitamin D status because it reveals net vitamin D inputs from skin production and dietary intake. It has a half-life in the circulation of 2 weeks which associates with secondary hyperparathyroidism, rickets, and osteomalacia[80]. The optimal range is 30–100 ng/ml, however normal value ranges may vary slightly among different laboratories and body of authorities. Vitamin D deficiency is defined by most experts as a 25-hydroxyvitamin D level of less than 20 ng per milliliter (50 nmol per liter),

2.2.5 Categorization of Vitamin D Status

There is no consensus as regard the optimal level of vitamin D, however some bodies of authority categorize the vitamin D concentration as follow in the table[81]:

Table3. Criteria defining vitamin D status

	Serum Vitamin D level	Range Value
1.	Deficiency	0 – 20 ng/ml or (<50nmol/l)
2.	Insufficiency	21 – 30ng/ml or (50-75nmol/l)
3.	Optimal	> 30ng/ml or (>75nmol/l) and above

2.2.6 Prevalence of Low Vitamin D Status

Vitamin D deficiency is currently a global health problem and has been associated with non-communicable and infectious diseases. There are different consensus recommendations on the cut-off definition of vitamin D deficiency, although endocrine society criteria defined vitamin D deficiency (VDD), as 25 hydroxyvitamin D concentration (25OHD) below 50 nmol/L (20 ng/mL)[81]. The prevalence of low vitamin D still remain high with a health issue affecting around one billion people across all ethnicities, gender and age groups worldwide. The global prevalence of vitamin D deficiency was thoroughly examined in a recent systematic review and meta-analysis. The results showed that the prevalence of serum 25(OH)D <30 nmol/L (12 ng/mL) was 15.7% worldwide; for serum 25(OH)D < 50 nmol/L (20 ng/mL) and serum 25(OH)D <75 nmol/L (30 ng/mL), it was 47.9%. From 2000 to 2010, the incidence marginally fell to 2011 to

2022. Between 2000 and 2010, the prevalence of serum 25(OH)D < 30 nmol/L was 17.6%; however, between 2011 and 2022, it fell to 14.1%[82]. Similarly, high prevalence of low vitamin has also been reported in Africa. The pooled prevalence of hypovitaminosis D in a recent systematic review and meta-analysis reported. The pooled prevalence of low vitamin D status was 18·46% with a cutoff of serum 25(OH)D concentration less than 30 nmol/L; 34·22% for a cutoff of less than 50 nmol/L; and for a cutoff of less than 75 nmol/L[83]. Although in the recent review and meta-analysis of global estimation of vitamin D deficiency, African region was found to have low prevalence at 8.0 and 18.9%, respectively, for serum 25 (OH)D levels <30 and 50 nmol/L. Nevertheless, given that there were just fourteen research in Africa with 7088 people, this conclusion might not be trustworthy. Ample sunshine in Africa and a higher proportion of young persons than senior participants in the research considered are two more potential causes[84]. To put it briefly, more extensive population-based research is required to investigate that in Africa.

Prevalence of vitamin D deficiency varied by region in Africa, with the highest prevalence reported in northern African countries and South Africa. The underlying reasons are probably multi-factorial including socio-cultural practices of avoiding sun exposure, dietary restrictions, environmental pollution, increased prevalence of obesity and genetic causes. Tropical countries (such as India) with abundant sunlight are no exception, as high prevalence of vitamin D deficiency has been reported among adults as well as among children and adolescents[85]. In Nigeria, there is paucity of published work on vitamin D status of adult Nigerian. In a Nigeria study among seminomadic Fulani men and women, it was reported a high prevalence of vitamin D insufficiency 88% of the female participants had serum level of vitamin D below 30ng/mL while 45% in males. Similarly in another recent Nigeria Multiregional Survey among apparently

healthy Nigerians, more than one third (30.8%) of the study participants had high prevalence of low vitamin D status.

In addition to its classic functions of vitamin D, recent research also suggests the potential benefits of vitamin D in diabetes mellitus, metabolic syndrome, malignancy, hypertension, cardiovascular illness and neuropsychiatric disorders.

Alleviating vitamin D deficiency is, therefore, of public health significance. Increase low vitamin D status found in Africa has been associated with higher prevalence of cardiovascular disease, diabetes, and some cancers observed among African–American people. The presence of vitamin D receptors in most tissues and cells and the regulation of more than 200 human genes by vitamin D suggest that vitamin D could have diverse roles in maintaining health. So, effort most put in place to curb the higher prevalence of vitamin D deficiency in African populations via public health strategies that include prevention, detection, and treatment of vitamin D deficiency.

2.2.6 Risk Factor of Vitamin D Deficiency

Impaired cutaneous production

Due to the revolution of industrialisation, a great number people execute their daily occupational activities in indoors, and very few of them receive enough daily exposure to the sun. Fear of skin cancer is another deterrent to spending time in the sun, which has led to a rise in the usage of sunblock with a high sun protection factor (SPF), helmets, and umbrellas.

Inadequate Skin Exposure

For some people, religious and cultural beliefs require that their skin should be covered, this could predispose to reduce skin synthesis of vitamin D. Taha et al reported a high level of

vitamin D insufficiency in a cohort of women in Saudi Arabia, despite sufficient sunlight in that zone all year round. The high prevalence of vitamin D deficiencies seen was attributable to their cultural practice of wearing clothing that covers the entire body and avoidance of direct sunlight[86].

Environmental factors

The main factors influencing the earth surface magnitude of UVB are season, time of day (i.e. peak UV period 10:00-15:00 hours) and the levels of atmospheric pollution.

Geographic latitude

At latitudes above 37°N and below 37°S, sunlight is insufficient to induce cutaneous vitamin D3 synthesis especially during the winter months with fewer hours of sun exposure. A study of Asian adults in the United Kingdom showed that 82% had 25(OH)D levels less than 12 ng/mL (30 nmol/L) during the summer season, with the proportion increasing to 94% during the winter months[87].

Environmental pollution

Air pollution is one of the chief actors in determining the percentage of the ground level of UVB. The level of air pollution is inversely related to the extent of solar UVB that reaches earth surface, consequently, more pollutant areas, less UVB passage and as a result, lowers vitamin D cutaneous synthesis. A study from Iran, shows that the mean ± SD of serum 25-OH-D was significantly higher in Ghazvinian women (low polluted area) compared to that in women who live in Tehran (heavily polluted area)[85].

Old age

Aging skin requires longer exposure to sunlight to initiate vitamin D synthesis. A 70-year-old person has 25% of the capacity to produce cholecalciferol compared with a healthy young adult

Skin pigmentation

Melanin is an extremely effective UVB sunscreen. Thus, African Americans who are heavily pigmented requires at least 5 to 10 times longer exposure than Whites to produce adequate cholecalciferol in their skin.

Obesity

Vitamin D, being fat soluble, is stored in the body fat. Cholecalciferol that is produced in the skin or ingested from the diet is partially sequestered in the body fat. This store of cholecalciferol is used during the winter when the skin production is low. However, in obese children and adults, the cholecalciferol is sequestered deep in the body fat, making it more difficult for it to be available. Thus, obese individuals are only able to increase their blood levels of vitamin D by 50% compared with normal weight individuals.

Dietary insufficiency due to inadequate intake

Unfortunately, it is very difficult to get enough vitamin D from food sources alone. Many of the dietary sources are not staple food in resource poor setting.

Impaired 25-hydroxylation ln the Liver

In chronic liver disease, there may be impaired synthesis of vitamin D.

Drugs inhibit vitamin D hydroxylase

Drugs such as cimetidine, phenytoin, carbamazepine and rifampicin inhibit the action of vitamin D-hydroxylase, study has shown that prolong usage may affect synthesis of vitamin D.

Impaired 1-hydroxylation in the Kidney

Vitamin D-deficiency is common in chronic kidney disease; this is caused by dysregulation of vitamin D metabolism.

2.3 Vitamin D and Diabetes

The precise association between diabetes mellitus and vitamin D is yet to be fully recognized. However, the discovery of receptors for calcitriol ($1,25(OH)_2D_3$), as the activated form of vitamin D, in tissues with no direct role in calcium and bone metabolism such as pancreatic beta cells and cells of the immune system has widened our view on its physiological roles of vitamin D on metabolic disorder including diabetes mellitus[88]. Several researchers have demonstrated that alarming prevalence rate of type 2 diabetes has been associated with vitamin D-deficient individuals and insulin secretion and sensitivity have been shown to be altered in beta cells from vitamin D-deficient in both human and animals. Glucose tolerance is restored when vitamin D levels return to normal[89]. Several mechanisms have been suggested for vitamin D deficiency as one of the modifiable risk factors for diabetes development and poor glycaemic control. As a result, there has been proof that recognize presence of vitamin D receptors in the pancreatic beta cells and 1 alpha hydroxylase enzyme to be secreted by the β-cell in the pancreas hence the pancreatic β cell is capable of forming active form of vitamin D that can act locally on the pancreatic β cell[90].

2.3.1 Link Between Vitamin D and Type 2 Diabetes Mellitus

The main and most previously well-known purpose of vitamin D is to maintain calcium and phosphorus homeostasis for the promotion bone mineralization. However, current evidence suggests that vitamin D and calcium homeostasis may also be essential for a variety of non-skeletal outcomes including type 2 diabetes mellitus and other metabolic disorder. Based on

observational studies, vitamin D and calcium have also been alleged as modifiable risk factor for diabetes. More recently, there is accumulating evidence to suggest that altered vitamin D and calcium homeostasis may also play a role in the development of type 2 DM[91].

Vitamin D may play an important role in the regulation and of pancreatic β-cells function in T2D patients since calcitriol (1,25(OH)2D) acts as a chemical messenger by interacting with calcium flux-regulating receptors on the β-cells. Moreover, vitamin D is able to reduce hyperactivity of the renin-angiotensin system and to improve the function of β-cells. On the other hand, vitamin D could influence the insulin secretion regulated by the opening and closing of calcium channels and 1,25(OH)2D may also improve insulin sensitivity by stimulating the expression of insulin receptors and activating peroxisome proliferator-activated receptor delta (PPAR-δ). Finally, the effects of chronic inflammation may be reduced by vitamin D, because vitamin D was shown to deactivate inflammatory cytokines associated with insulin resistance and to promote calbindin expression, leading to protection from apoptosis[92].

2.3.2 Impact of Vitamin D in Type 2 DM

Vitamin D may play an important role in the development of type 2 diabetes mellitus due to presence of its receptor (VDR) in pancreatic beta cells. However, diabetes mellitus and glucose intolerance occur as result of the defect in in pancreatic beta-cell function, insulin sensitivity and systemic inflammation.

Pancreatic β- cell function (Insulin secretion)

The impact of vitamin D is mediated via its circulating active form 1,25-OHD, binding with vitamin D receptor in the pancreatic beta cells and in turn facilitates the insulin secretion from

beta cells. Vitamin D appears to play a role in regulation of insulin release in response to glucose intake[92]. On the other hand, Vitamin D may also affect insulin secretion via regulation of calcium. Insulin secretion has been shown to be calcium dependent; hence, alterations in calcium flux can have adverse effects on beta cell secretory function, which may interfere with normal insulin release especially in response to a glucose load[91,93]. Tanaka et al worked extensively on animal model and proposed that vitamin D is a basic factor, necessary for normal insulin secretion[94]. This was collaborated by Chertow et al, who found that animal model with vitamin D deficiency had lower insulin secretion[95].

Insulin Sensitivity

Vitamin D may enhance insulin responsiveness for glucose transport by directly stimulating the insulin receptor. Also, the increase in calcium content of the cells, facilitate glucose transport into the muscle, hereby enhancing the glucose uptake and increase insulin sensitivity[92]. Study by Chiu et al, disclosed that low vitamin D status increases insulin insensitivity, decreases insulin production, and was associated with the metabolic syndrome[96]. A double-blind randomized study by Pittas et al showed a beneficial effect of vitamin D and calcium supplementation on fasting blood glucose and insulin resistance in the group that had impaired fasting glucose at baseline[97].

Inflammation

Vitamin D possess anti-inflammatory effect that make its additional protective mechanism for pancreatic beta cell on the pathogenicity of diabetes. vitamin D was revealed to neutralize inflammatory cytokines associated with insulin resistance and to promote calbindin expression, leading to protection from apoptosis. In other word, Vitamin D may protect β-cell distruction by modulating the effects of inflammatory cytokines and decreasing β- cell destruction. Vitamin D may prevent generation of cytokines by interfering with the promoter gene for transcription

factors and up regulation of cytokine binding proteins[92]. These protective effect of vitamin D may explain why Hypponen et al in a birth cohort study done in Finland in 2001, demonstrated an 80% risk reduction in development of type 1 diabetes when children were placed on 2000 IU of Vitamin D at birth compared to control[98].

2.3.3 Vitamin D Status and Glycaemic Control Among Type 2 Diabetes

Optimal vitamin D level was reported to have improve glycaemic control in diabetes patient. Glycated haemoglobin (HbA1c) determination is an effective method of monitoring long-term glucose control in people with diabetes mellitus. It provides previous glucose concentration of about three months' period and not subject to the wide variations perceived with blood glucose assays. Hence, it is a valuable and widely used alternative method of blood glucose determinations for monitoring long-term glycaemic control. The impact of Vitamin D cannot be over emphasized especially on the metabolism of glucose pathway, hence understanding its involvement in the normal glycaemic control is a key. This in line with a study that determined the impact of vitamin D supplements on diabetes patient that on various treatment of diabetes compare to those that didn't take vitamin D supplement[99]. Prevalence of low vitamin D is alarming in every population both white and black, yet its more common in T2DM as it was reported in one the study done southern part of Nigeria that regression analysis showed that subjects with T2DM were 3.2 times more likely to have vitamin deficiency compared to their nondiabetic colleagues [OR = 3.24, 95% CI (1.56 – 6.73), p= 0.002)][100]. Several reports have demonstrated that it is more common in both Type 2 diabetes mellitus and Type 1 diabetes. Though the latter is less common compare to type 2 diabetes. The prevalence of vitamin D deficiency in subjects with type 2 diabetes, ranges from 63.5% to 91.1% and the deficiency remains despite most type 2 diabetes subjects taken a daily multivitamin, usually containing

vitamin D. There are also findings of lower vitamin D levels and higher HbA1C levels in Black subjects compared to their White counterparts. Results of studies looking at the effect of vitamin D replacement on glycaemic control in Type 2 diabetes mellitus subjects are few and most of these studies were retrospective. Another study had been able to observed the dissimilarity in the vitamin D status of both T2DM and non-Diabetic subject at different season of the year. Glycaemic control less improving during winter and spring among the diabetes patient, revealing the positive involvement of vitamin D in the glucose regulation. A meta-analysis study revealed that intake of Vitamin D supplements at a minimum dose of 100 mg/d (4000 IU/d), could significantly lessen level of serum FPG, HbA1c, and HOMA-IR index, and helps to control glycaemic response and improve insulin sensitivity in type 2 diabetic patients[101]. The Nurse's Health study found that women who consumed a vitamin D-and calcium-rich diet had a 33% lower risk of developing Type 2 diabetes mellitus[102]. In Caucasian patients with impaired fasting glucose, oral supplementation with vitamin D and calcium reduced the progression of insulin resistance and increased insulin sensitivity[103].

2.3.4 Similar Risk Factors existing in both low vitamin D Status and Type 2 Diabetes Mellitus Prevalence

There is increase prevalence of low vitamin D and T2DM globally and some similar risk factors are present in their epidemiological pattern. These factors are discussed below**:**

Increase skin pigmentation

Being dark skinned is a risk for hypovitaminosis D, this may be because melanin pigmentation acts as natural sunscreen; very dark-skinned people require about 1.5 hours' exposure to sunlight daily for synthesizing vitamin D, which is 6 times longer than the 15 minutes required for light-

skinned people. A study also found that the chances of developed diabetes was significantly higher for black adults than for white adults. The greatest difference was between black women and white women. This is due to poor glycaemic control and racial disparity.

Obesity

The more the body fat mass the higher the low vitamin D. Increase prevalent rate of overweight and obesity has been considered to be a key contributor to the alarming prevalence of low serum 25(OH)D in modern society. Lower concentrations of serum 25(OH)D levels in obese individual may be explained by enhanced uptake by adipose tissue, increased metabolic clearance, and it is suggested that the sedentary lifestyle of obese subjects could be associated with less outdoor activity and less exposure to sunlight. Obesity promotes the development of T2DM by promoting inflammation and beta cell stress.

Old age

The risk of developing T2DM increases with age so also is the risk of having vitamin D deficiency. With increasing age there is decreased production of vitamin D due to various factors such as: reduced sun exposure because many are house bound, in hospital or institutionalized, also there is reduced conversion of 7-dehydrocholesterol in aging skin such that a 70-year-old person skin can synthesize only 25% as much as a young person. There is also the additional burden of age-related lactose intolerance with reduce intake of fortified dairy product. With increasing age there is decreased renal conversion of 25OH vitamin D to the active form.

Low physical activity

Low physical activity predisposes to insulin resistance; low level of physical activity is one of the contributing factors to the recent pandemic of T2DM in the world. With low level of physical activity there is likely reduction in sun exposure and hence reduced synthesis of vitamin D.

Dietary pattern

It is established that diet is a risk factor associated with T2DM and previous studies have also tried to associate nutrient consumption and/or dietary patterns with the occurrence of T2DM, so as less or non-vitamin D consumption nutrient could implicate incidence of hypovitaminosis aside from photosynthesis source of vitamin D.

Conclusion

In the past, major role of Vitamin D exists within the skeletal health, however novel researches had demonstrated multiple non skeletal function of vitamin D including its role in insulin production, action and protection of beta cell from destruction. Regular risk factors for hypovitaminosis D include sex, advanced age, cultural life styles, sedentary life style and obesity. It has been reported that there is an inverse relationship between circulating levels of vitamin D and the prevalence of type 2 DM. Low levels of vitamin D are considered a risk factor for poor glycaemic control. On the other hand, the exact mechanisms are not clear which indicate the need for further investigation.

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Chapter Three

Methodology

3.1 Study Design

A community-based descriptive cross-sectional design was employed for the interest of this study in the assessment of dietary pattern, lifestyle, vitamin D status and undiagnosed type 2 diabetes among traders in selected major markets area in Ede, Osun State, Southwestern region, Nigeria.

3.2 Population of the Study

The study population consists of all traders between 20 and 80 years attending the three major markets of Ede town who gave consent and met selection criteria.

Site of the Study

This study was carried out in the sub-urban town of Ede Local Government area of Osun State in the South Western Region of Nigeria. The study took place in the three selected 5-day markets of Ede township among several markets existing in the town. Ede is located just to the south of Oshogbo, the state capital of Osun State, lying geographically between Lat 70 42’ and 70 47’ North of the Equator and Long 40 21’ and 40 27’ East of the Greenwich Meridian. The town is

situated on the banks of the Osun River, which flows in the north-south direction from Igede town in Ekiti State, going towards Ibadan, Oyo State. The three Local Governments in the town are Ede North, Ede South, and Egbedore Local Government Areas. However, parts of Ede North and Egbedore LGAs fall within the Osogbo Capital Territory planning[1,2]. Ede North Local Government has its headquarters at Oja Timi and according to the 2006 Population and Housing Census of the National Population Commission has a population of 83,831; it covers a total land area of 112.379 km². Similarly, Ede South Local Government with a population of 76,035, has its headquarters at Ede township covers a land area of about 221.619 km² while Egbedore has its headquarters at Awo and covers a land area of 270 square kilometres[1,2]. The major indigenous ethnic groups in the area are Yoruba. According to the 2016 projected population census with a 3.3% Annual Population Change the total population of Ede Planning Area, which is made up of Ede North, Ede South, and Egbedore Local Government Areas, is 321,300 (Ede North 115,400, Ede south 104,000 and Egbedore 101,900)[3]. These LGs have been experiencing rapid population growth and physical expansion of the built-up areas, due largely to their closeness to Osogbo, the state capital. Indeed, in many places, outgrowths of Osogbo have encompassed and flowed into many of the fringe communities of Ede, such as Akoda, Owode, Abere (where the Secretariat of State of Osun is located), and Ido Osun, where the old aerodrome is now being developed into an airport[1]. The three selected markets were Ede Oje Olobi Market, Ede Owode Market, and Ede Sekona market, each of these market days is in five days and no one falls in the same day as it goes in a circle. Most traders have stalls in each market. Being a scattered market that covers a little large expanse of land on the road which forms a square shape, it is not ultra-modern market square so most of it are not arranged within the market as is the case in many markets in Nigeria

though few stalls were arranged based on goods sold. The common items sold are foodstuffs, clothing, kitchen wares, household items, footwear, and the like.

Climate and Rainfall of the Study Area

Ede is located in the tropical rainforest belt of Nigeria: Like most parts of the old Western Region, the area is characterized by two distinct seasons, namely the wet and the dry seasons. The annual rainfall received in this region is very high, usually above 2,000 mm (78.7 in). Ede experiences double rainfall maxima characterized by two high rainfall peaks, with a short dry season and a longer dry season falling between and after each peak as typical with most areas in South West Nigeria. The first rainy season begins around March and lasts till the end of July with a peak in June; this rainy season is followed by a short dry break in August known as the August break which is a short dry season lasting for two to three weeks. This break is broken by the short rainy season starting around early September and lasting till mid-October with a peak period at the end of September. The end of the short rainy season in October is followed by the long Dry Season[1]. This period starts in late October and lasts till early March with peak dry conditions between early December and late February. This tropical rainforest climate has a very small temperature range and the temperature range is almost constant throughout the year. The hottest months are August and November and the lowest temperature occurs in March and September[1]. Mean daily recorded maximum temperatures at Ede varied from 15^{0} C to 16^{0} C and minimum values ranged from 70^{oc} to 90^{oc}.

Period of the Study

Due to the important effect of sunlight on vitamin D levels, the lowest levels of 25(OH)D are expected during the rainy season and the highest levels in the dry season[4]. This study was

conducted between the month end of February and March, 2023 and the fieldwork lasted for eight weeks.

Eligibility of Study Population

The study participants were selected based on the following criteria.

Inclusion Criteria

1. Participant must be a trader for at least 6 months ago and has his or her stalls in the selected major Ede markets.

2. Participants should be between 20 - 80 years.

3. Participants who gave consent to partake in the study.

4. Apparently healthy Participant

Exclusion Criteria

1. Participant with gestational diabetes.

2. Participants who were too ill to participate in the study

3. Participants who were unwilling to participate.

4. Pregnant women and lactating mothers.

5. Patients with chronic liver disease.

6. Patients on vitamin D or calcium supplements.

7. Patients on the following drugs were excluded: Phenytoin, carbamazepine, rifampicin, and cimetidine (these drugs inhibit the action of vitamin D hydroxylase).

8. Participants with known abnormal blood glucose profile (diabetes or prediabetes)

3.3 Sample and Sampling Technique

This study was conducted between the month of February and March 2023. The biochemical parameters were carried out in two different parts: an initial part was the determination of the

percentage of undiagnosed diabetes and prediabetes among the participants by two different glucose tests (random/casual and fasting plasma glucose tests), and the later was determination of serum vitamin D status of both undiagnosed diabetes, pre-diabetes and those with normal glucose profile among the participants for comparison. Eligible participants were selected from the designated markets on stratified sampling method. Each market was divided into five sub-sections according to its geographical location for the selection of eligible participants on every market day till the desired sample population was obtained.

All participants were counselled and diligently explained everything about the procedure and written informed consent obtained. The traders were approached on several visits to ensure that recruitment is extensively done by capturing sufficient required data to substantiate the validity of the study as much as possible.

After the physical and clinical assessment is done, blood sampling for relevant investigations involved random and fasting plasma glucose to assess the prevalence of undiagnosed diabetes and prediabetes among the study population. Participants were instructed to report between 8 a.m. and 10 a.m. after 8 to 12 hours of overnight fasting for sample collection on the appointment date after the random blood glucose has been done. Each participant' sample was coded and identified for further investigation on the assessment of serum vitamin D status and its relationship with the abnormal glucose profile (undiagnosed diabetes and prediabetes) and normal glucose profile (non-diabetic). At the end of the study, every participant was given opportunity to collect their results with full interpretation whereas much emphasis on clinical implications were stressed. Those with abnormal results were referred for further evaluation and proper treatment at the appropriate centre.

Sample Size Determination

The minimum sample size was estimated using Cochran's formula (Cochran, 1977) as stated and this is done due to ease of operation[10].

$$N = \frac{Z^2 \times p \times q}{e^2}$$

where: N= the desired sample size

Z = standard normal deviate usually set at 1.96,

P is the prevalence of undiagnosed diabetes. A prevalence rate (p) of 8.3% i.e., 0.083 was used as the prevalence of participants with undiagnosed diabetes derived from recent previous studies done in Southern region of Nigeria[5,6].

q = 1 − p = 0.917

e = acceptable sampling error (use 0.05)

$$N = \frac{(1.96)^2 \times (0.083) \times (0.917)}{(0.05)^2} = 117 \text{ respondents}$$

25% of the value of the sample size was added to replace the loss or incomplete questionnaires (25% of sample size = 29.25 approximately 30). The Cochran sampling formula used estimated that the study required a minimum of approximately 147 participants for validity. However, a total of 176 questionnaires of eligible participants were realized among the traders in the selected markets.

3.4 Description of the Research Instrument

A stratified sampling technique was used in carrying out this study. First, market was divided into five sub-sections according to its geographical location for the selection of the eligible study participants on every market day till the desired sample population was obtained. However, more than the required sample sizes were recruited but another screen was done to identify the most

relevant and eligible respondents which equaled to the total of 176 sampling of all eligible participants that was used. A combination of a structured interview and clinical/biochemical instruments was the interest in this data collection.

Instruments for data collection

Three types of instruments were used for the study as thus:

1. Questionnaire for Participants

2. Participants Plasma Glucose Test (Fasting and Random/casual)

3. Participants Elisa Serum Vitamin D assessment.

Questionnaire for participants: This questionnaire was made up of four sections excluding biochemical indices as follows:

Section A: Socio-demographic and economic data of participants

Section B: Medical history of Participants

Section C: Lifestyles habits of participant (dietary, physical, alcohol and cigarette intake)

Section D: Anthropometry measurement of participants

3.5 Validity of Research Instrument

A standardized structured interview conducted using a modified interviewer-administered questionnaire by WHO STEP instrument approach to surveillance of chronic non-communicable diseases risk factors, Nigeria Diet Quality Questionnaire (DQQ), UK Diabetes and Diet Questionnaire tools and food frequency questionnaire[7,8,9,10]. The contents of all these questionnaire instruments were further evaluated by the researcher's supervisor, a nutritionist and educationist to assess their applicability to the study. Some of the contents were modified and

adapted for local use since some of the foods were not typically consumed in Nigeria. As for the plasma glucose test tool all the participants firstly underwent random/casual plasma glucose test follow by confirmatory test of fasting plasma glucose on appointment of another day with proper instruction of 8 to 10 fasting overnight for the test. Enzyme-linked immunosorbent assay instrument was used to determine serum vitamin D concentration.

3.6 Reliability of the Research Instrument

The questionnaire was administered by the research assistants who were already given prior training and capable of executing the task. Also, professional registered nurses and medical laboratory technologists were involved in the biochemical and laboratory aspect of the questionnaire. The enzyme-linked immunosorbent assay for vitamin D quantitative determination was handled by biochemistry analyst. The aspects of the questionnaire examined included:

1. The participant's understanding on all the sectional aspects of the questions in the questionnaire and also their willingness to respond to the questions and participate in the study.
2. The appropriate time to administer the questionnaire, take measurements and samples and then record the outcomes usually at a less busy time of the marketers to ensure less distraction that could push to give less or untrue responses in the course of interaction, measurements and samples collection and then record the outcomes.
3. The general and specific logistic support needed for efficient instrument administration and sample collection was also evaluated.

4. The research assistants were training on how to present the questions in Yoruba translation from the original English language that will be in congruent with what was written in English language.

3.7 Data Collection

A combination of a structured interview, anthropometry measurement and laboratory/biochemical tests were the tools used for data collection.

Procedure for Data Collection

The procedure used for data collection was in three aspects which include questionnaire administering, Anthropometric measurements, and laboratory investigations.

Questionnaire Administering

Participants were educated on the aim of the study and their consent obtained before the questionnaire was administered. The questionnaire contained socio-demographic and economic characteristics of the participant (such as age, sex, marital status, religion, number of people living in the household, level of income, and educational level) to determine attributes of study participants, medical history of diabetes, hypertension and vitamin D status to know the health status of the participant and family on the related conditions, lifestyles habit of the participant which include history of alcohol consumption, cigarette smoking, physical activity, general dietary pattern includes vitamin D intake of different food sources.

Medical and Family history of diabetes

Respondents personal and family history of diabetes was confirmed, his or her family history was considered positive either in the presence of at least one diabetic parent or sibling (first degree) or if diabetes occurred in the respondent's cousin, uncle or aunt (second degree), this

was included in the questionnaire for the purpose of screen out those that fail to yield to the instruction on the inclusion criteria of the study.

Medical and Family history of hypertension

Respondents personal and family history of hypertension was confirmed, his or her family history of hypertension was considered positive either in the presence of at least one diabetic parent or sibling (first degree) or if diabetes occurred in the respondent's cousin, uncle or aunt (second degree).

History of Vitamin D deficiency diagnosis

Respondent's personal history of Vitamin D Diagnosis was confirmed and the duration of the diagnosis, this is included to screen out those that didn't meet up with the criteria of the study.

Alcohol consumption

Alcohol consumption is defined as the weekly intake of beer, wine and hard liquor (like spirits, brandy, and whisky) converted into units of alcohol. Alcohol consumption was categorized into four categories: no consumption, light (less than 10 units per week), moderate (10-20 units per week), and heavy (more than 21 units per week), consumption based on the recommendation of the Royal College of Physicians of London. The Royal College of Physicians recommended that alcohol consumption be no more than 21 units a week for men; 14 units a week for women[11].

One unit of alcohol was equivalent to a half pint [approximately 225 milliliters (mls) or 1 tumbler] of ordinary beer or lager at 5.1% volume; a single measure of spirit (25ml) at 40% volume; a small glass of table wine (100ml) at 11.5% volume. A unit of alcohol contained about 10 mls of absolute alcohol[11].

Cigarette Consumption

According to a previous report, all participants were arranged by smoking status into three groups: nonsmokers, current smokers, and past smokers. Respondents, who had smoked at least 100 cigarettes during their lifetime and, at the time of the interview, reported smoking every day or some days were classified as current smokers. Similarly, respondents were also classified as past smokers, if they were not smoking at present but had previously smoked as much as one cigarette a day for as long as a year, and never smokers are those who smoke neither at present nor in the past[12].

Dietary habits of the study participants

Information on the dietary habits of the study participants was obtained on how healthy is the dietary lifestyles of the participants, the adequacy of their vitamin D source intake, and its effects on the prevalence of undiagnosed diabetes. Dietary fiber intake was assessed by dietary history and inquiring about the participants' intake of the best sources of dietary fiber such as beans and peas, navy beans, black beans, green leafy vegetables, fruits, whole grains, and nuts. Respondents was classified into 2 categories based on the recommendations of the United States Department of Agriculture (USDA) dietary guidelines for fruit and vegetable consumption[13]. Specifically, evidence indicates that intake of at least two and a half cups of vegetables and fruits per day (or allowing half of one's plate to consist of fruits and vegetables) was associated with a reduced risk of type 2 diabetes[95].

The frequency of food consumption was Considered for an individual food groups as thus, frequent consumption was determined by consuming the food group greater or equal to five times while infrequent was determined by consuming the food group by less than five times weekly. The individual food groups were eventually regrouped into "healthy", "unhealthy" or "vitamin D-rich foods". Here, frequent consumption of healthy, unhealthy or vitamin D-rich

foods was determined by those who frequently consumed three or more of the healthy or unhealthy foods weekly while infrequent consumption was determined by not frequently consuming up to three healthy, unhealthy foods or vitamin D-rich foods weekly.

Vitamin D food source (mackerel fish, herring fish, egg yolk, and fortified milk.) intake was categorized into three according to i.u. equal or greater recommended daily allowance as thus, excellent 20% RDA, moderate 5% RDA, and mild < 5% sources[14]. The daily amount of time participants was exposed to sunlight, was measured as thus. Sunlight exposure was defined as inadequate if estimated hand and face exposure was < 30 minutes per day and adequate if it was ≥ 30 minutes per day[15].

The higher dietary glycaemic load was assessed by inquiring about the participant's patronage of fast-food centers which is associated with the consumption of energy-dense foods with a high dietary glycaemic load as well as consumption of sugar-sweetened beverages (SSBs) like soft drinks, fruit drinks, and energy drinks, and ice creams. Respondents were categorized into 2 groups based on the findings of a recent meta-analysis that showed a clear link between SSB consumption and risk of type 2 diabetes[16]. Participants who patronized these centers frequently responded 'yes' to 'intake of soft drinks and consumption of ice creams' and vice versa.

Regular Physical activity

Adequate physical activity was defined as participation in moderate or vigorous activity for 30 minutes or more per day at least 3 days a week[17]. There were six physical activity questions, a score of 1 was assigned to a response that suggests a physical activity characterized by spending thirty minutes or more doing the following: casual walk, jogging, carrying heavy or light loads, and participating in house chores, and spending less than thirty minutes sitting in a day. The total accruable score was six and participants who scored zero or two were deemed "sedentary", those

who scored between two and three "less active", a score of four and above were "Physically active". Although driving was later removed from the score because is not apply to all Participant.

This was needful because there are studies that have assessed the levels of physical activity and sedentary behaviours of individuals in which findings revealed that independent of exercise levels these sedentary behaviours especially watching television and performing desk-bound occupational tasks were associated with significantly increased risk of obesity and type 2 diabetes[18].

Clinical and Anthropometric Measurements

Anthropometric data include height in meters, weight in kilograms, body mass index (BMI), Waist circumference, Hip Circumference, and Abdominal obesity calculation while the clinical data includes blood pressure of both systolic and diastolic. The height and weight of each subject are to be measured using a validated stadiometer weighing scale and blood pressure will be measured by validated BP apparatus (sphygmomanometer).

Height

The height was measured with the respondent standing upright looking straight forward, with back straight, heels against the scale, without shoes, caps, or scarves, and approximated to the nearest 0. 01m.

Weight

Weight was taken with the participant standing erect, wearing light clothing, and barefooted. Zero-mark calibration of the weighing scale was ensured before each measurement and weight

was approximated to the nearest 0.01 kilogram. The validity of the scale was checked every day before data collection using a known weighted object (10kg).

Body Mass Index

Body Mass Index was calculated using the formula: BMI = Weight (kg)/ Height (m2). BMI findings are in four categories which include (<18.5 Low BMI, 18.5-24.9 Normal BMI, 25.0-29.9 Overweight, and ≥30.0 Obesity)

- **Nutritional Status Using BMI Grading:**

  Underweight…… < 18.5 kg/m2

  Normal Weight…… 18.5 - 24.9kg/m2

  Overweight…….. 25.0 - 29.9kg/m2

  Obesity…….. 30.0 – and above kg/m2

Waist circumference

Waist circumference was taken at the approximate midpoint between the lower margin of the last palpable rib and the top of the iliac crest on the bare skin.

Hip Circumference

The hip circumference is taken at the intertrochanteric level, at the widest portion of the buttocks. A non-stretch measuring tape is used for measurement. Abdominal obesity is defined as a waist circumference of >94cm in men and >80cm in women. Waist-hip ratio (WHR)>0.85 for females and >0.90 for males was considered abnormal

Abdominal obesity

Abdominal obesity was defined as a waist circumference of >94cm in men and >80cm in women. Waist-hip ratio (WHR)>0.85 for females and >0.90 for males was considered abnormal.

Blood Pressure

The blood pressure of the participants was measured with a mercury table blood pressure apparatus using the appropriately sized cuff. Blood pressure was measured in mmHg in the upper arm and was checked only one occasion, for at least 10 minutes apart; with the patient at rest (seated) for at least five minutes. The average of both readings was recorded and used for the study. To ensure validity, the same instrument was used throughout the study. The Instrument is rechecked on daily basis before use, by comparing its reading with another unfaulty type of manual BP apparatus used regularly. Participant readings are classified as normotensive (<140/<90mmHg), and Elevated Blood Pressure (≥140/≥90mmHg) based on the recommendations of the seventh report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure[19].

Laboratory Investigations

These include Random plasma glucose, Fasting plasma glucose, and Assay for serum vitamin D determination

Random plasma Glucose and Fasting plasma Glucose

From the feasibility survey done to each market, we find out that for the purpose of reliability and validity of the study, random plasma glucose at the first visit of giving the questionnaire then the next visit for fasting plasma glucose after necessary instructions have been given to ensure the full compliance of the respondents. Participants will be informed of the procedure, simple lancet prick on the respondents' thumb was used to obtain a fresh capillary blood sample after

cleansing with methylated spirit or a Venous blood sample be taking into Fluoride/oxalate bottle for Random plasma glucose (RBG) test, then Fasting plasma glucose for those that meet up with the criteria of overnight fast. Fasting was defined as no caloric intake for at least 8 to 10 hours overnight. A glucometer (AccuChek Active®, serial number GN, Art number) was used throughout the study to analyse the blood glucose. The validity of the glucometer reading was ensured by using the control solution provided by the manufacturers and by weekly comparison of the glucometer reading with a plasma glucose estimation from the same subject, analysed by one senior chemical pathology scientist in a standard laboratory using the glucose oxidase method. Diabetes diagnosis is based on the 2018 diagnostic criteria from the American Diabetes Association (ADA) and 2006 World Health Organization (WHO) recommendations for the diagnostic criteria for diabetes and pre-diabetes which based on fasting plasma glucose or a random plasma glucose ≥ 126 mg/dl (7.0 mmol/L) or ≥ 200 mg/dl (11.1 mmol/L) and impaired fasting glucose or impaired glucose tolerance 100 to 125 mg/dl (5.6 to 6.9 mmol/L) or 140 to 199 mg/dl (7.8 to 11.0 mmol/L). All the participants recruited were free from already known diabetes.

Assay of serum vitamin D

Participants were informed of the procedure for blood sample collection via the vein. Skin is cleaned with a spirit swab, the tourniquet was lightly applied about 2-4cm above the puncture site, sample was taken within one minute of the application of the tourniquet. 4mls of blood is collected from the antecubital veins and put in a plain bottle. After the collection, samples was allowed to clot for 30 minutes, and then centrifuged at 2000 revolutions/minute for 15 minutes for clear separation of serum from cells. Serum was extracted with the aid of a bulb pipette

which was stored at –20 °C. Total human serum levels of 25(OH)D was measured by Enzyme-Linked immunosorbent assay (ELISA) by a competent biochemistry analyst in my presence.

The Procedure for Enzyme-linked Immunosorbent Assay (ELISA) for Quantitative Determination of total 25-OH Vitamin D in Human Serum.

The used Human Serum Vitamin D Elisa Kit was Elabscience 25-Oh Vitamin D Sandwich Elisa Kit ELISA 25-OH Vitamin D Sandwich ELISA test was intended for the quantitative determination of total 25-hydroxy (25-OH) Vitamin D in human serum. For Invitro Diagnostic Use only.

Principle of the Assay

ELISA 25-OH Vitamin D Quantitative Test Kit is a sandwich-based enzyme-linked immunosorbent assay. The test employed a pair of monoclonal agglutinating sera, the first one was immobilized in the solid phase (Microwells), and another monoclonal agglutinating serum was in the liquid phase. In the assay procedure, samples along with Calibrators are added to the coated Microwells & incubated together with the first & second agglutinating sera. The wells are then washed to remove the unbound components. The resulting Vitamin D-antibody immunocomplex was detected with a third agglutinating serum conjugated with horseradish peroxidase (HRPO). After a short incubation, the wells were washed again and the bound enzyme was detected by adding substrate. The reaction is stopped after a specified time with a stop solution and absorbance was determined for each well using an ELISA reader[20].

The concentration of Vitamin D is directly proportional to the colour intensity of the test sample.

Materials and Components Assay procedure

A. Materials provided with the test kit

1. Coated Microwells: Microwells coated with monoclonal anti-25-OH Vitamin D – antibody.

2. Vitamin D Sample Diluent.

3. Vitamin D Enzyme Conjugate.

4. TMB Substrate.

5. Stop Solution.

6. Two levels of controls (Control values were provided in the kit)

7. 25-OH Vitamin D Calibrator set of 6 Calibrators labeled as A to F in liquid form. For the calibrator, concentration refers to the vial label.

8. Wash Buffer Concentrate (20x).

B. Materials required but not provided

1. Precision pipettes: 10µl, 50-200µl, 100-1000µl

2. Disposable pipette tips

3. Distilled water

4. Disposable Gloves

5. ELISA reader

6. ELISA washer

Storage and Stability of the Kit

1. ELISA 25-OH Vitamin D kit is stable at 2-8°C up to the expiry date printed on the label.

2. Coated microwells should be used within one month upon opening the pouch provided that once opened, the pouch must be resealed to protect it from moisture. If the colour of the desiccant has changed from blue to white at the time of opening the pouch, another coated microwells pouch should be used.

3. Diluted Wash Buffer is stable for up to one week when stored at 2-8°C[102].

Procedure Used for Blood Sample Collection and Precaution in the Vitamin D biochemical Analysis

1. Blood sample collected via venipuncture according to the Calibrators procedure.

2. Serum only used after separation.

3. Grossly haemolytic, lipemic, or turbid samples was avoided.

4. Participants sample were stored under frozen condition at -20°C for longer storage more than 48hours.

5. Defrosted samples mixed before commencement of testing

6. Sample heating in any form was avoided.

7. No sample contained particles used without centrifugation before use.

8. All reagents and samples were readily available within our reach at room temperature before use.

9. Unacceptable practice such pipetting any material by mouth was avoided.

10. Do not eat, drink or smoke in the area where testing is done.

11. Universal precautions were ensured such as lab kit include clothing and wearing of gloves for body fluid handling.

12. Absorbent sheet used to cover the working area.

13. Sodium hypochlorite was used to clean up any splitting sample.

14. Proper waste disposer of the reagents and materials used were carried out.

15. Acid-containing waste were neutralized before adding hypochlorite.

16. Kit expiry date were checked before used.

17. Test were done on separate kit by avoiding using components of one kit with another.

18. A new tip for each sample and reagent.

19. Liquid didn't allow from one well to mix with other wells.

20. Strips dry in between the steps was avoided.

Reagent Preparation

1. All reagents brought to room temperature (18-25°C) and mixed by gently inverting or swirling. Foaming Not induced.

2. Wash buffer diluted 20 times and mixed well before use.

The Stepwise of Test Procedure

1. The desired number of coated wells in the holder were secured placed on the absorbent. 10 µl of calibrator, serum, and controls were dispensed into the appropriate wells.

2. 200 µl of Sample Diluents were dispensed into each well. The plate was gently shaken to mix the contents. Incubated at room temperature (18-25°C), for 20 minutes.

3. The incubation mixture removed by emptying the plate content into a waste container. Rinsed and emptied the microtiter plate 5 times with washing buffer (20X). The microtiter plate was sharply struck onto absorbent paper to remove all residual water droplets.

4. 100 µl of enzyme conjugate reagent dispensed into each well. Incubated at room temperature(18-25°C) for 10 mins.

5. The incubation mixture removed by emptying the plate content into a waste container. Rinsed and emptied the microtiter plate 5 times with washing buffer (20X). The microtiter plate sharply struck onto absorbent paper to remove all residual water droplets.

6. 100 µl of TMB substrate dispensed into each well. Incubated at room temperature (18-25°C), in the dark, for 10 minutes.

7. The reaction was stopped by adding 100 µl of Stop Solution to each well. Gently mixed for 10 seconds until the blue colour completely changes to yellow.

8. The Optical density/absorbent was read at 450/630 nm with a microtiter plate reader within 15 minutes. This was done in line with the manufacturer guide line by an expert[11].

Vitamin D Status was defined according to the Endocrine Society criteria:

Vitamin D Optimal Level: -serum 25(OH)D concentration at ≥ 30 ng/mL (75 nmol/L).

Vitamin D insufficiency: - Serum 25(OH)D concentration at 20 to 29.9 ng/mL (50 to 75 nmol/L).

Vitamin D deficiency: -Serum 25(OH)D concentration at ≤ 20 ng/mL (50 nmol/L).

Vitamin toxicity: -Serum 25(OH)D concentration ≥150 ng/mL (375 nmol/L).

Other Materials Used for Clinical, Anthropometry and Plasma Glucose

1. Plain bottles for the blood sample
2. Fluoride oxalate bottles for fasting blood glucose
3. Flexible non-stretch measuring tape for the waist measurement
6. Cotton wool for blood sample collection
7. 5ml syringe and needle for blood sample collection
8. Methylated spirit for cleaning the site of sampling
9. Bulb pipette for separation of blood component
10. Interviewer administered a semi-structured questionnaire (Hard copy)
11. Lancet

12 Bucket Centrifuge

3.8 Data Analysis and Management

Data Management

Data pertinent to the study was collated utilizing study data forms. These data was repeatedly checked for errors before it was finally input into a spreadsheet for cleaning and storage. Data backed up onto an external drive, flash drive, and google drive.

Data Analysis

The questionnaire data generated was analysed using the Statistical Package for Social Sciences, SPSS version 24.0. Results presented using frequency tables and charts. Descriptive statistics such as mean and standard deviation were used to summarize quantitative variables (age, random blood glucose, fasting blood glucose serum vitamin D level, and blood pressure) while qualitative variables (occupation, marital status, dietary habit, literacy level, past medical history, family history, etc.) were summarized by frequencies and percentages. The chi-square test was also used to establish an association between 2 qualitative variables (e.g., variables between undiagnosed diabetes status and vitamin D status). Multiple regression analysis was used for assessing the association of risk factors with undiagnosed diabetes mellitus and vitamin D status. Adjusted odds ratio was calculated. 95% confidence interval used for this study and the P- value of ≤ 0.05 considered statistically significant.

3.9. Ethical Approval

The proposal was submitted to the Ethics and Research Committee of Lead City University Ibadan and the Osun State Ministry of Health for ethical approval, and same was granted by Ethics and Research Committee Lead City University Ibadan and the State Ministry of Health. Although, I was only able to obtain that of Osun State Ministry of Health review committee, with reference number (OSHREC/PRS/569T/329) and the endorsed letter of permission request by the general Baba Loja of Ede Land. Also, authorization of all leaders of every market trader's association was sought and consent obtained. Informed consent was sought and obtained from

each prospective study participant and recruitment and participation were strictly follow by ethical principles guiding research in compliance with the Helsinki Declaration of 1975 as revised in the seventh revision of the Declaration that was adopted on 19th October 2013 in Brazil[21]. The participants were informed on the nature and benefits of the survey, willingness, and right to participate or withdraw from the study, including the participant confidentiality and non-maleficence was emphasized.

Endnotes

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Chapter Four

Results and Discussion of Findings

The result of this study was presented in different parts. The first part involves the description of socio-demographic and socio-economic characteristics of participants. The medical history and occupational activities along with the level of sunlight exposure in the market place were assessed, lifestyle habit in physical activity, dietary behaviour and cigarette smoking along with alcohol consumption. Data on anthropometric, biochemical and clinical parameters including body mass index were presented. The mean difference between the serum vitamin D concentration and fasting plasma glucose level with other selected variables were documented and the level of association between the fasting plasma glucose level and serum vitamin D concentration along with other variables were analysed as last part of the result presentation.

4.1 Socio-Demographic Characteristics of Participants

Table 4.1 shows the socio-demographic characteristics of participants. Most of the participants (98.9%) were females while very few are males (1.1%). The age of participants ranged between thirty years or less (11.4%), thirty-one and forty years (19.3%), forty-one and fifty years (31.3%), fifty-one and sixty years (22.2%), sixty-one and seventy years (11.9%), and above seventy years (4.0%). The mean age was 48.30±13.16 years. Majority of the participants (79.0%) were married, some others were widowed (15.9%), single (2.8%), separated (1.1%) or divorced (1.1%). They mostly practiced Islam (83.0%), some others practiced Christianity (16.5%), and Traditional religion (0.6%). Slightly over half of the participants (54.0%) had a household size less than five, while others (45.7%) had five or more household members.

Table 4.1 Socio-demographic Characteristics

Characteristics	**Frequency (%)**
Sex	
Male	2 (1.1)
Female	174 (98.9)
Age (years)	
≤ 30	20 (11.4)
31 – 40	34 (19.3)
41 – 50	55 (31.3)
51 – 60	39 (22.2)
61 – 70	21 (11.9)
> 70	7 (4.0)
Mean ± S.D (years)	48.30±13.16
Marital Status	
Single	5 (2.8)
Married	139 (79.0)
Separated	2 (1.1)
Divorced	2 (1.1)
Widowed	28 (15.9)

Religion	
Islam	146 (83.0)
Christianity	29 (16.5)
Traditional	1 (0.6)
Household size	
< 5	95 (54.0)
≥ 5	80 (45.7)
Undisclosed	1 (0.6)

Source: Researcher's Field Work (2023)

Socio-Economic Characteristics of Participants

Table 4.2 shows the socio-economic characteristics of participants. The participants had some form of formal education; primary (31.8%), secondary (31.8%), and tertiary (8.0%), meanwhile, over one-quarter did not have formal education (28.4%). More than one-third of the participants (39.8%) were retailers, some were petty traders (30.7%), while others were wholesalers (29.5%). More than half of the participants (59.7%) had a sales assistant. The weekly monthly income of participants varied; less or equal to five thousand naira (53.4%), from more than five thousand naira to ten thousand naira (33.0%), from more than ten thousand naira to twenty thousand naira (10.2%), and more than twenty thousand naira (2.8%), meanwhile, very few (0.6%) did not disclose their average monthly income.

Table 4.2 Socio-economic Characteristics

Characteristics	**Frequency (%)**
Education level	
No formal education	50 (28.4)
Primary	56 (31.8)
Secondary	56 (31.8)
Tertiary	14 (8.0)
Type of Trading	
Wholesaler	52 (29.5)
Retailer	70 (39.8)
Petty trader	54 (30.7)
Presence of a sales assistant	
No	105 (59.7)
Yes	71 (40.3)
Average weekly income	
≤ ₦5000	94 (53.4)
₦5,001 – ₦10,000	58 (33.0)
₦10,001 – ₦20,000	18 (10.2)
> ₦20,000	5 (2.8)
Undisclosed	1 (0.6)

Source: Researcher's Field Work (2023)

4.2 Presentation of Data

Medical and Family History of Participants

Table 4.3 depicts the medical history of participants. No participants with personal history of Diabetes Mellitus (0.0%) recorded as this was among the inclusion criteria use for the study. Limited numbers of the participants had personal history of Hypertension (14.8%), or Vitamin D deficiency (6.3%). Some of them had a family history of Diabetes Mellitus (4.0%) or Hypertension (13.6%). Less than half of the r participants (42.0%) visited the health care facility for medical check-up and the frequency of such visits comprised; monthly (44.6%), every three months (35.1%), yearly (10.8%), or weekly (9.5%).

Table 4.3 Medical History, Family History and Medical Checkup Visit

History	Categories	Frequency (%)
Personal history of Diabetes Mellitus diagnosis	Yes	0 (0.0)
	No	176 (100.0)
Personal history of Hypertension	Yes	26 (14.8)
	No	150 (85.2)
Personal history of Vitamin D deficiency	Yes	11 (6.3)
	No	165 (93.8)
Family history of DM	Yes	7 (4.0)
	No	169 (96.0)
If yes, first degree relatives	Parent	4 (2.3)
	Sibling	1 (0.6)
If yes, second degree relatives	Aunt	2 (1.1)
Family history of HTN	Yes	24 (13.6)
	No	152 (86.4)

If yes, first degree relatives	Parent	16 (9.1)
	Sibling	5 (2.8)
If yes, second degree relatives	Aunt	3 (1.7)
Visit health facility for medical check-up	Yes	74 (42.0)
	No	99 (56.3)
Frequency of visit	Weekly	7 (9.5)
	Monthly	34 (44.6)
	Every three months	25 (35.1)
	Years	8 (10.8)

Market Activity and Exposure of Participant to Early Morning Sunlight

Table 4.4 describes the market activity and exposure of respondents to early morning sunlight. The average working hours of respondents were nine hours or more (53.4%) and less than nine hours (46.6%). Respondents were present at the market for less than six days (55.1%) or six or more days (44.9%). The mode of transportation to the market was mostly commercial means (49.4%), walking (37.7%) and personal vehicles (13.1%). The daily exposure to early morning sun ranged from less than thirty minutes (45.7%) to thirty minutes or more (55.1%).

Participant's Lifestyle Habit, Alcohol Consumption and Smoking

Table 4.5 depicts the respondent's lifestyle habit, alcohol consumption and smoking. In this study, most of the respondents (99.4%) had no history of alcohol consumption nor did they use cigarettes/snuff (100.0%).

Participant's Lifestyle Habit and Physical Activity

Table 4.6 depicts the respondent's lifestyle habit, physical activity. Less than half of the respondents daily spent thirty minutes or more for casual walk (47.2%), jogging (11.4%), sitting (31.3%), carrying heavy (21.1%) or light loads (23.9%), or driving (1.7%), meanwhile, more than half of the respondents daily spent thirty minutes or more doing house chores (56.3%).

Summary of the Physical Activity of participant

Fig. 4.1 summarizes the physical activity of respondents. Nearly half of respondents were light active (48.9%), some others were sedentary (40.3%) while few of them were moderately active (10.8%).

Table 4.4 Market Activity and Exposure to Sunlight

Activity	Categories	Frequency (%)
Average working hours	< 9 hours	82 (46.6)
	≥ 9 hours	94 (53.4)
Days present at the market	< 6 days	97 (55.1)
	≥ 6 days	79 (44.9)
Mode of transport to the market	Walking	66 (37.7)
	Personal vehicle	23 (13.1)
	Commercial means	87 (49.4)
Daily exposure to early morning sun	< 30 minutes per day	78 (44.3)
	≥ 30 minutes per day	97 (55.1)
	Undisclosed	1 (0.6)

Source: Researcher's Field Work (2023)

Table 4.5 Lifestyle Habit; Alcohol Consumption and Smoking

Habit	**Categories**	**Frequency (%)**
History of alcohol consumption	Never	175 (99.4)
	Yes, in the past	1 (0.6)
If yes, alcohol consumed	Wines and spirits	1 (0.6)
Consumption level	Moderate (10-20 units per week)	1 (0.6)
History of cigarette/snuff	Never	176 (100.0)

Source: Researcher's Field Work (2023)

Table 4.6 Lifestyle Habit; Physical Activity

Activity	Time spent doing the following:	Frequency (%)
Casual walk		
	< 30 minutes	93 (52.8)
	≥ 30 minutes	83 (47.2)
Sitting		
	< 30 minutes	121 (68.8)
	≥ 30 minutes	55 (31.3)
Carrying heavy loads		
	< 30 minutes	139 (79.0)
	≥ 30 minutes	37 (21.0)
Carrying light loads		
	< 30 minutes	134 (76.1)
	≥ 30 minutes	42 (23.9)
Driving		
	Nil	170 (97.7)
	< 30 minutes	2 (1.1)
	≥ 30 minutes	3 (1.7)
	Undisclosed	1 (0.6)
House chores		
	< 30 minutes	77 (43.8)
	≥ 30 minutes	99 (56.3)

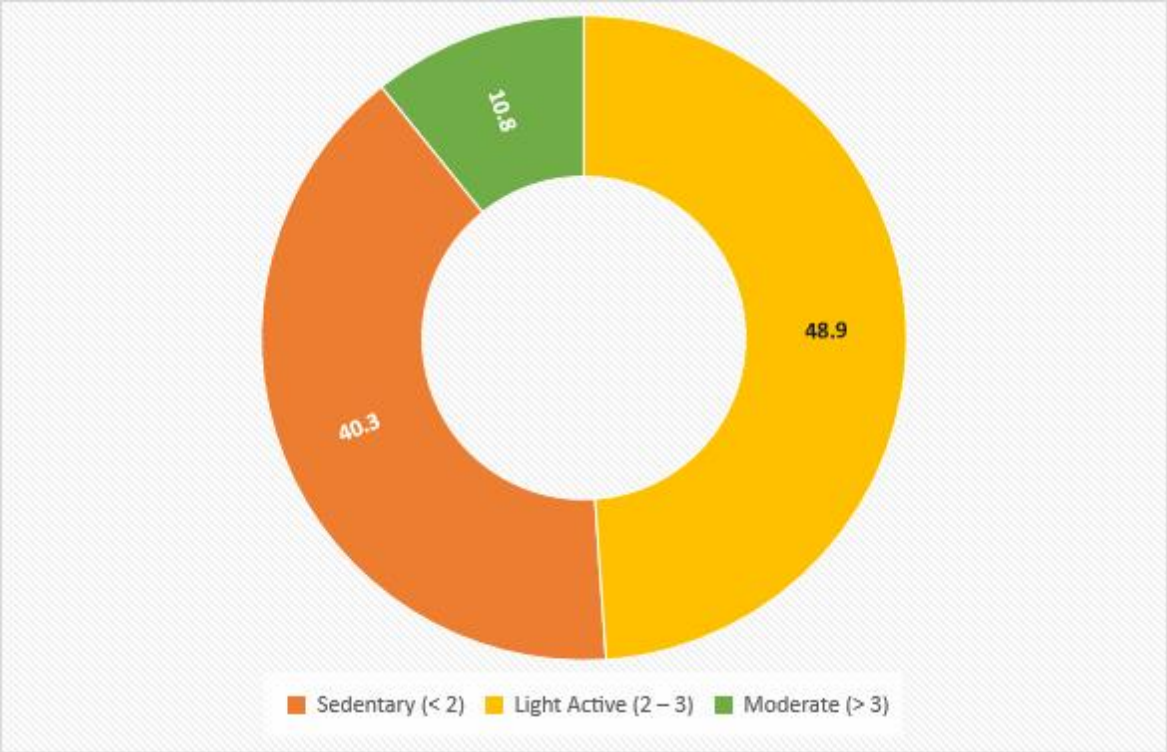

Fig. 4.1 Summary; Physical Activity

Source: Researcher's Field Work (2023)

Dietary Lifestyle of the Participants

Table 4.7 depicts the respondent's lifestyle habit, diet. Majority of the respondents ate between three and four meals per day (60.8%), some ate between one and two meals per day (28.4%) while few of them ate more than four meals per day (10.8%). Most of the respondents frequently ate breakfast (91.5%), lunch (70.5%), and dinner (89.8%). Less than half of the respondents skipped meals (42.0%), the frequently skipped meal was lunch (69.9%), and the reason(s) for meal skipping comprised; lack of appetite (32.4%), financial (31.1%) or time constraints (27.0%), or inability to cook (9.5%). The usual source of meal was mostly home (84.7%), meanwhile, those who patronized out-of-home foods bought more from roadside food vendors/hawkers (74.1%). About two-thirds of the respondents ate in-between meals/snacks (67.0%), and the snacks comprised; fruits (55.1%), biscuits/cookies (22.9%), locally made snacks (15.3%), or pastries (6.8%). Less than half of the respondents (43.3%) regularly add salt to food at the table.

Table 4.7 Lifestyle Habit; Diet

Habit	Categories	Frequency (%)
Meals per day	1 – 2 meals	50 (28.4)
	3 – 4 meals	107 (60.8)
	> 4 meals	19 (10.8)
Breakfast consumption	Always	161 (91.5)
	Often	14 (8.0)
	Rarely	1 (0.6)
Lunch consumption	Always	124 (70.5)
	Often	24 (13.6)
	Rarely	28 (15.9)
Dinner consumption	Always	158 (89.8)
	Often	10 (5.7)
	Rarely	8 (4.5)
Skipping of meals	Yes	74 (42.0)
	No	102 (58.0)
Frequently skipped meal (if yes)	Breakfast	9 (12.3)
	Lunch	51 (69.9)
	Dinner	13 (17.8)
Reason for skipping meals	Financial constraints	23 (31.1)
	Time constraints	20 (27.0)
	Inability to cook	7 (9.5)
	Lack of appetite	24 (32.4)
Usual source of meal	Homemade	149 (84.7)
	Out-of-home	4 (2.3)

	Both	23 (13.1)

Habit	Response	Frequency (%)
Out-of-home types (source)	Restaurants	1 (3.7)
	Roadside food vendors/hawkers	20 (74.1)
	Canteen	6 (22.2)
Consume snacks in-between meal	Yes	118 (67.0)
	No	59 (33.0)
Type of snacks (if yes)	Pastries	8 (6.8)
	Biscuits/cookies	27 (22.9)
	Fruits	65 (55.1)
	Locally made snacks	18 (15.3)
Regularly add salt to food at the table	Yes	76 (43.2)
	No	100 (56.8)

Source: Researcher's Field Work (2023)

Anthropometric, Biochemical, And Clinical Parameters of Participants

Table 4.8 describes the anthropometric, biochemical, and clinical parameters of respondents. The mean values of the respective assessments comprised; height (1.59±0.07m), weight (68.03±16.14kg), Body Mass Index (26.80±5.93kg/m^2), waist circumference (89.75±13.04cm), hip circumference (99.02±13.76cm), waist-hip-ratio (0.91±0.12), systolic blood pressure (118.30±16.35mmHg), diastolic blood pressure (77.09±12.63mmHg), fasting blood glucose (90.45±28.75mmHg), random blood glucose (122.40±49.41mmHg), serum vitamin D (48.63±22.20ng/ml).

Summary Body Mass Index of Participants

Fig. 4.2 shows the Body Mass Index summary of respondents. The prevalence of underweight, overweight, and obese were 5.1%, 30.1% and 27.3%, respectively. More than one-third of respondents had normal BMI, 37.5%.

Table 4.8 Anthropometric, Biochemical, and Clinical Parameters

Parameter	Mean ± S.D
Height (m)	1.59±0.07
Weight (kg)	68.03±16.14
BMI (kg/m^2)	26.80±5.93
Waist Circumference (cm)	89.75±13.04
Hip Circumference (cm)	99.02±13.76
Waist-Hip-Ratio	0.91±0.12
Systolic Blood Pressure	118.30±16.35
Diastolic Blood Pressure	77.09±12.63
Fasting Blood Glucose (mg/dl)	90.45±28.75
Random Blood Glucose (mg/dl)	122.40±49.41
Serum Vitamin D (ng/ml)	48.63±22.20

Source: Researcher's Field Work (2023)

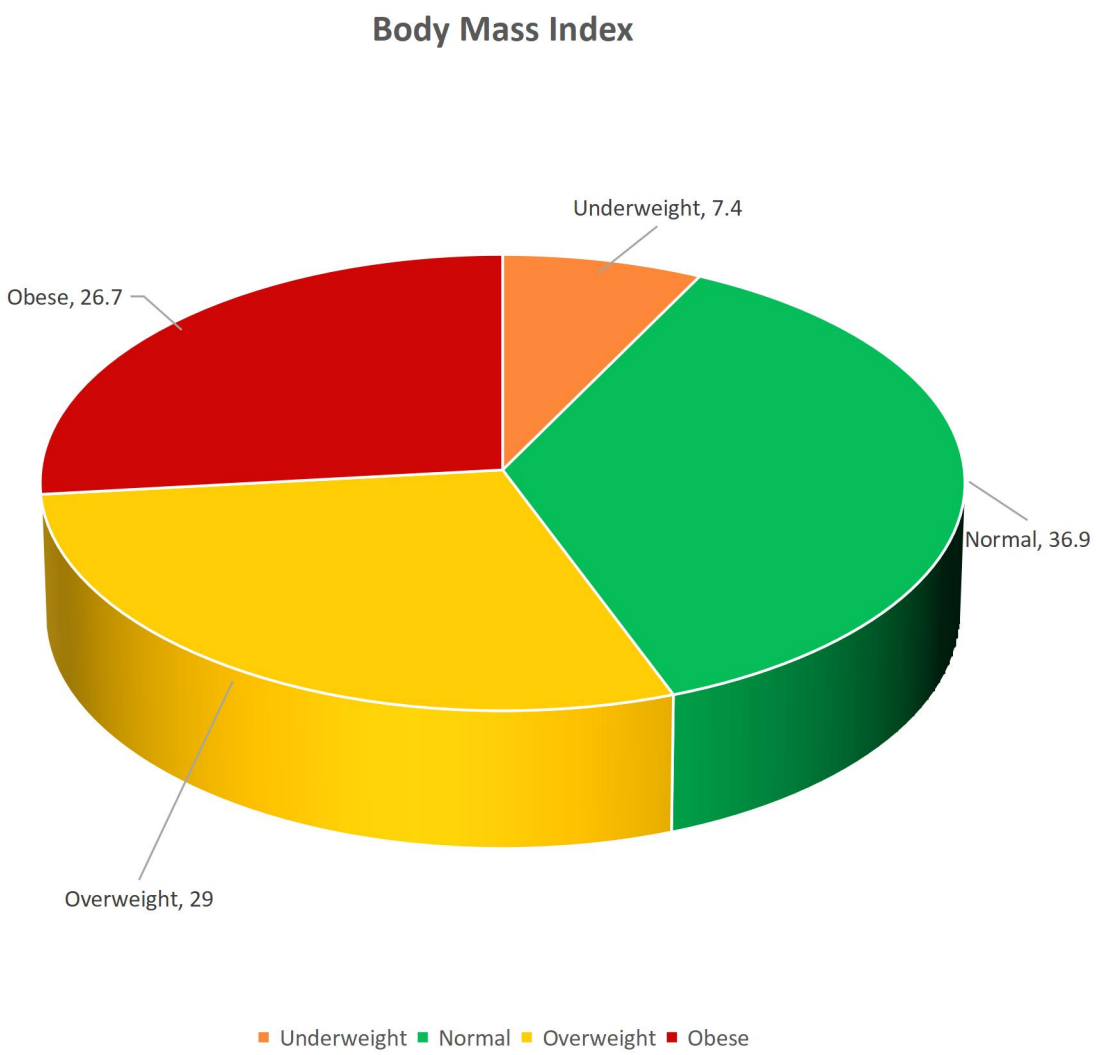

Fig. 4.2 Body Mass Index

Source: Researcher's Field Work (2023)

Prevalence of Abdominal Fat Distribution, Prediabetes and Undiagnosed Diabetes Mellitus and Hypertension of Participants

Table 4.9 shows the prevalence of abdominal fat distribution, prediabetes and undiagnosed diabetes mellitus and hypertension. In respect to the waist-hip-ratio, majority of the respondents had high health risk (67.0%), some had moderate health risk (18.7%), or low health risk (14.5%). Most of the respondents had normal fasting blood glucose levels (81.8%), while the prevalence of pre diabetes records (13.6%), and undiagnosed diabetics record (4.5%). Similarly, most of the respondents (85.8%) had normal random blood glucose levels, hence pre diabetes shows (9.7%) and undiagnosed diabetics shows (4.5%). The Serum Vitamin D Assessment showed that most of the respondents (78.4%) had optimal serum vitamin D levels, meanwhile, Low vitamin D prevalence shows (21.6%) in which vitamin D deficient prevalence records (9.1%), and vitamin D insufficient as well records (12.5%). Majority of the respondents (76.1%) were normotensive, others had elevated blood pressure with prevalence of hypertension both diagnosed and undiagnosed records (23.9%).

Table 4.9 Summary; Anthropometric, Biochemical and Clinical Parameters

Parameter	Categories	Frequency (%)
Waist Hip Ratio	Low health risk (<0.8)	25 (14.5)
	Moderate health risk (0.81-0.85)	33 (18.7)
	High health risk (≥ 0.86)	118 (67.0)
Fasting Blood Glucose	Normal (<100mg/dl)	144 (81.8)
	Pre-diabetes (100 – 125mg/dl)	24 (13.6)
	Undiagnosed Diabetes (≥ 126mg/dl)	8 (4.5)
Random Blood Glucose	Normal (<140mg/dl)	151 (85.8)
	Pre-diabetes (140 – 199mg/dl)	17 (9.7)
	Undiagnosed Diabetes (≥200mg/dl)	8 (4.5)
Serum Vitamin D Assessment	Deficiency (<20ng/ml)	16 (9.1)
	Insufficiency (20 – 29ng/ml)	22 (12.5)
	Optimal (30 – 100ng/ml)	138 (78.4)
Blood Pressure	Normotensive (<140/<90mmHg)	134 (76.1)
	Elevated Blood Pressure (≥140/≥90mmHg)	42 (23.9)

Source: Researcher's Field Work (2023)

4.2.9 Association Between Fasting Plasma Glucose and Serum Vitamin D Levels

Table 4.10 shows the association between fasting plasma glucose and serum vitamin D levels. In respect to the fasting plasma glucose of the total participants, (69.9%) with normal glucose profile had optimal serum vitamin D levels, (7.4%) had vitamin D deficiency and (4.5%) had vitamin D insufficient. This affirms the fact that in an apparently healthy populate survey low serum vitamin D concentration will still exist. However, explosive higher prevalent rate of low vitamin D (53.1%) was recorded among the participant with undiagnosed abnormal glucose profile (dysglaceamia) in this current study. There was a significant association between fasting plasma glucose and serum vitamin D levels (p=0.000). This finding was similar to the test of association between random plasma glucose and serum vitamin D levels (p=0.000).

Table 4.10 FBG and Vitamin D Assessment

Variable	Vitamin D Assessment			
	Deficiency	**Insufficiency**	**Optimal**	**p-value**
	n (%)	**n (%)**	**n (%)**	
Fasting Blood Glucose				0.000*
Normal Glucose Profile (<100mg/dl)	13 (7.4)	8 (4.5)	123 (69.9)	
Abnormal Glucose Profile (100 – 125mg/dl & ≥ 126mg/dl) (Prediabetes and UDM)	3 (1.7)	14 (8.0)	15 (8.5)	
Random Blood Glucose				0.000*
Normal Glucose Profile (<140mg/dl)	13 (7.4)	11 (6.3)	127 (72.2)	
Abnormal Glucose Profile (140 – 199mg/dl & ≥200mg/dl) (Prediabetes and UDM)	3 (1.7)	11 (6.3)	11 (6.3)	

* Significant at the p<0.05 level

Chi-square Test

UDM: Undiagnosed Diabetes Mellitus.

Source: Researcher's Field Work (2023)

Dietary Pattern of the Participants

Fig. 4.3-10 shows the frequency of food consumption. On average fruit and vegetables were more frequently consumed (55.1%) among the respondents. Separately, an infrequent consumption of fruits recorded (51.1%) while vegetables were more frequently consumed (55.1%) by the respondents. There was an infrequent consumption of pastries (50.0%), white bread (61.9%), cake/cookie/biscuits (39.2%), and fast foods (29.5%). There was an infrequent consumption of sugary drinks/carbonated beverages/sugar/honey (54.0%), and sweet/chocolate/gum/ice-cream (24.4%). Palm oil, as well as meat/poultry/fish, and rice/spaghetti/macaroni/noodles was more frequently consumed by majority of the respondents (86.9%, 72.2%, and 65.9%, respectively). There was an infrequent consumption of legumes, nuts, and seeds (55.7%) among the respondents. In respect to the consumption of vitamin D-rich foods, fish, Milo, milk, and egg yolk were more frequently consumed (31.8%, 22.2%, 19.9% and 16.5%, respectively), meanwhile others were infrequently consumed.

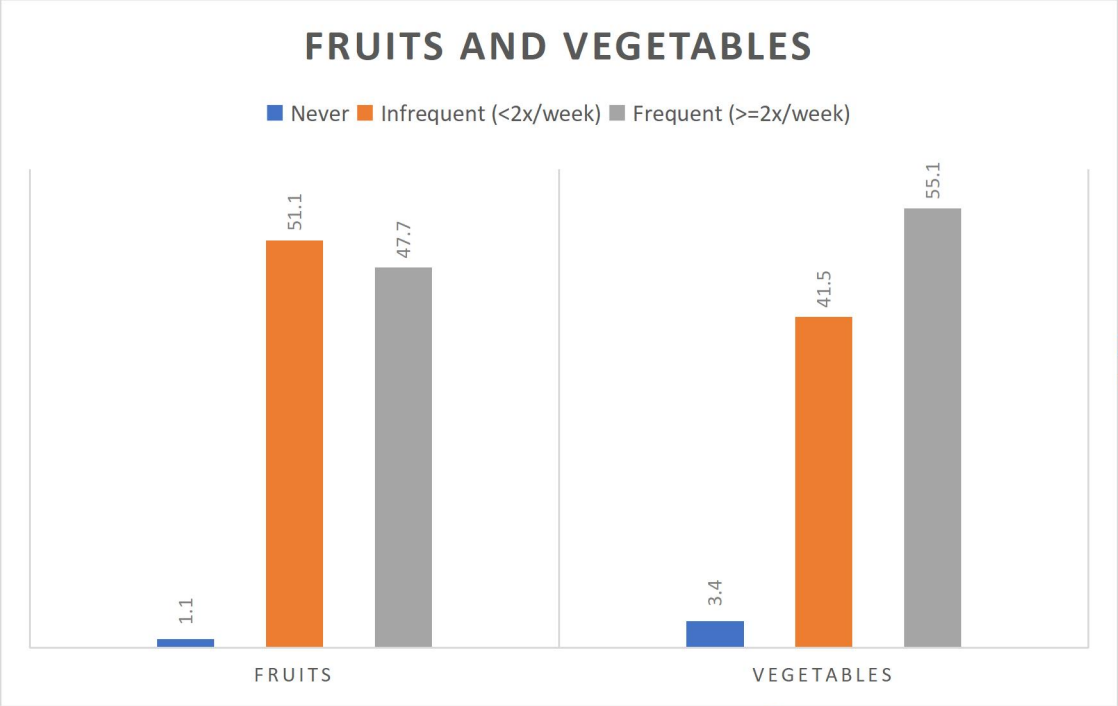

Fig 4.3 Frequency of Food Consumption; Fruits and Vegetables

Source: Researcher's Field Work (2023)

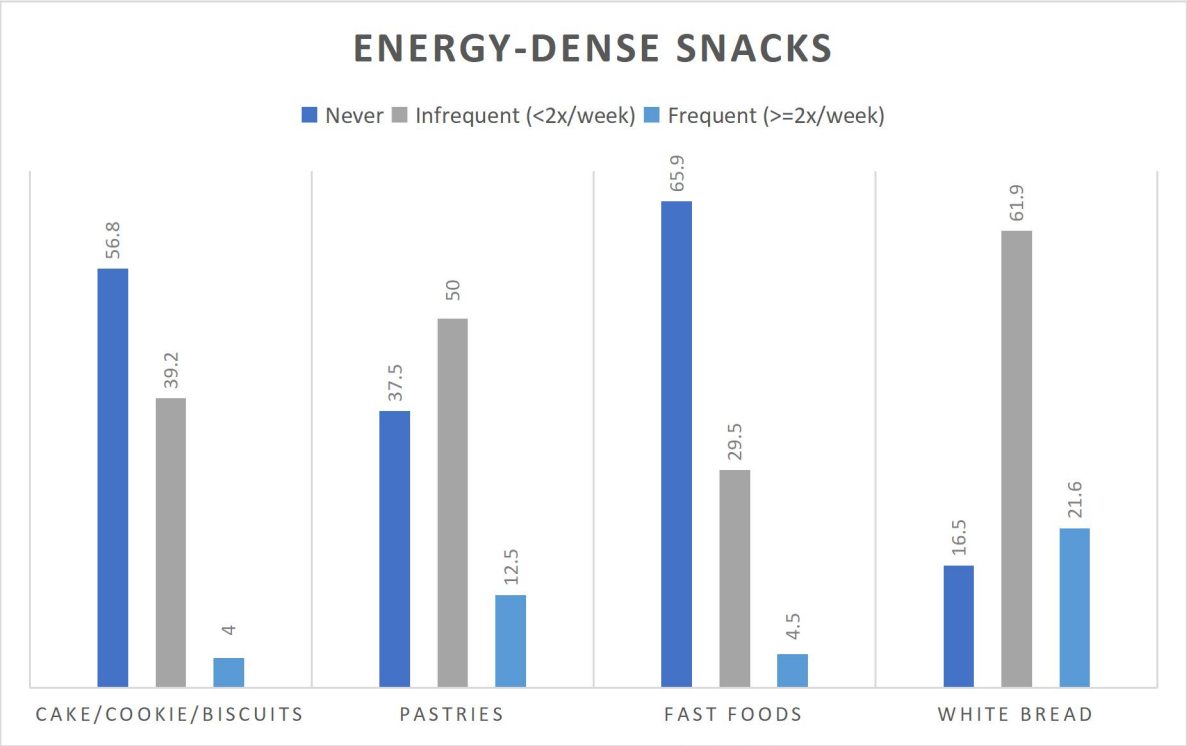

Fig 4.4 Frequency of Food Consumption; Energy-dense Snacks

Source: Researcher's Field Work (2023)

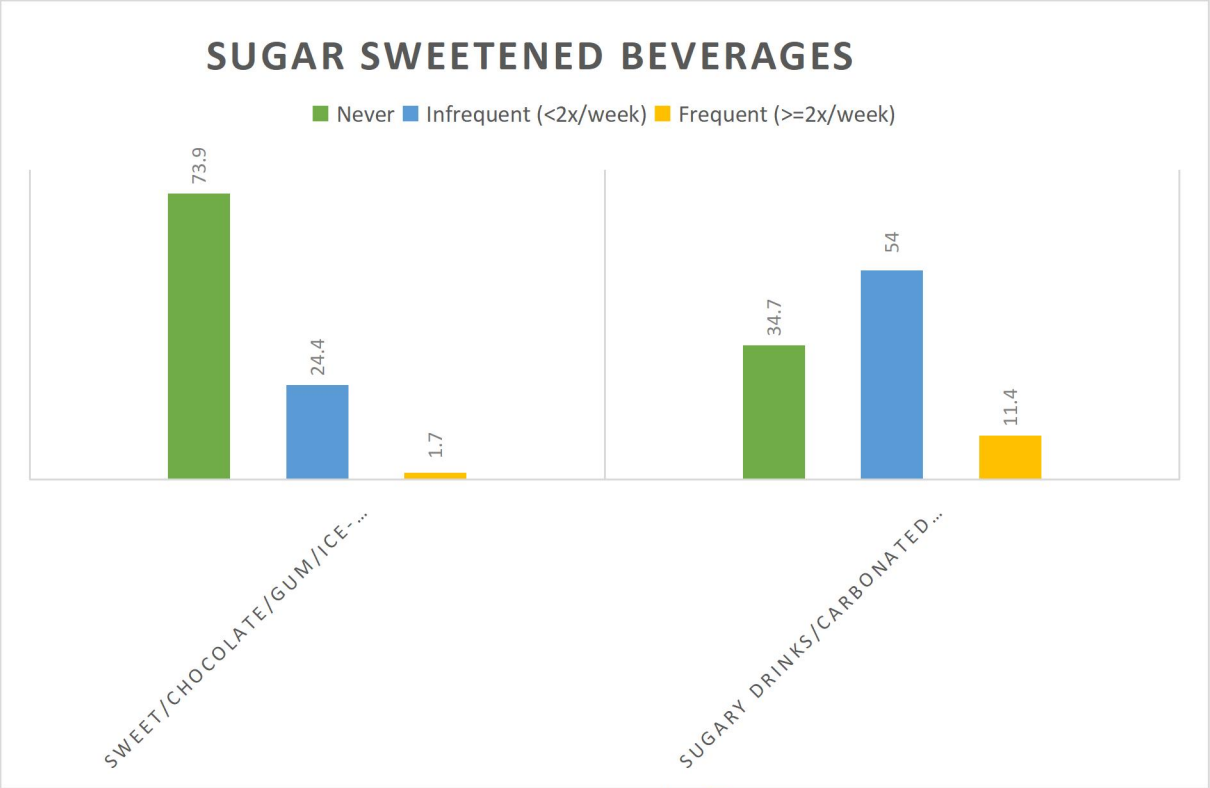

Fig 4.5 Frequency of Food Consumption; Sugar Sweetened Beverages

Source: Researcher's Field Work (2023)

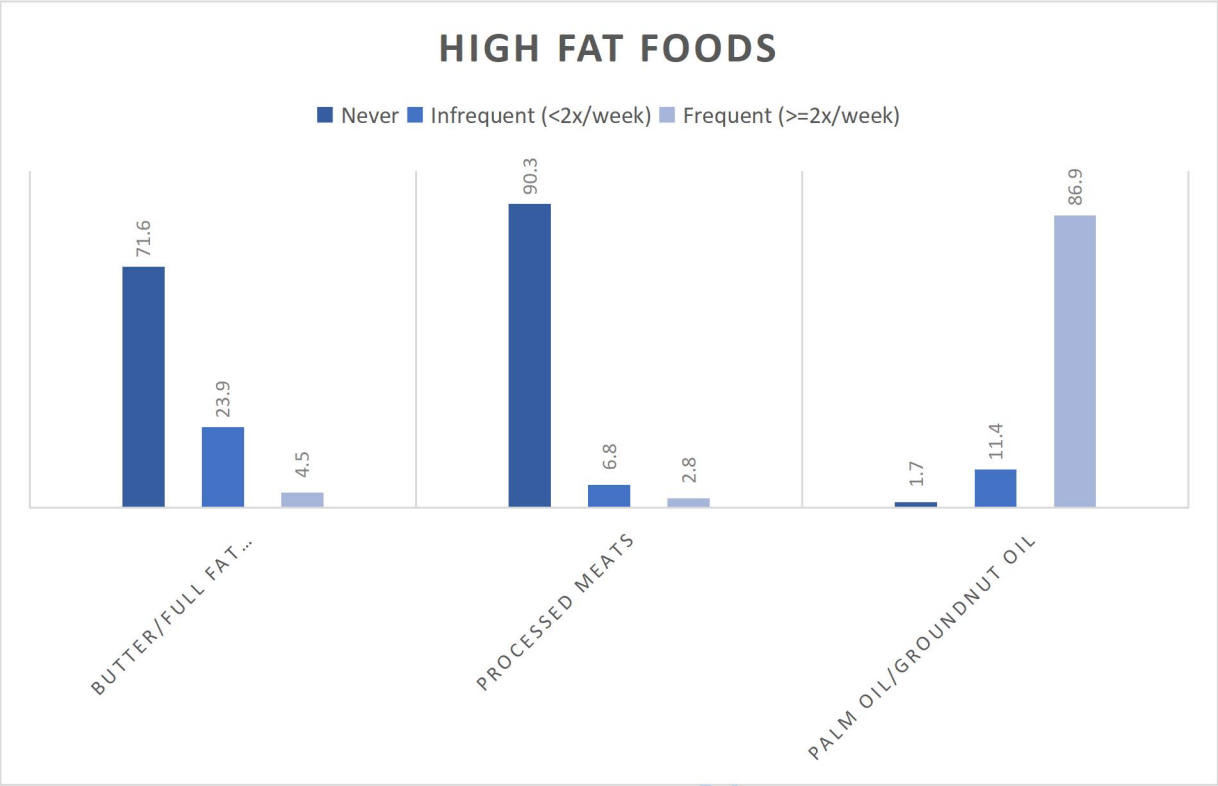

Fig 4.6 Frequency of Food Consumption; High Fat Foods

Source: Researcher's Field Work (2023)

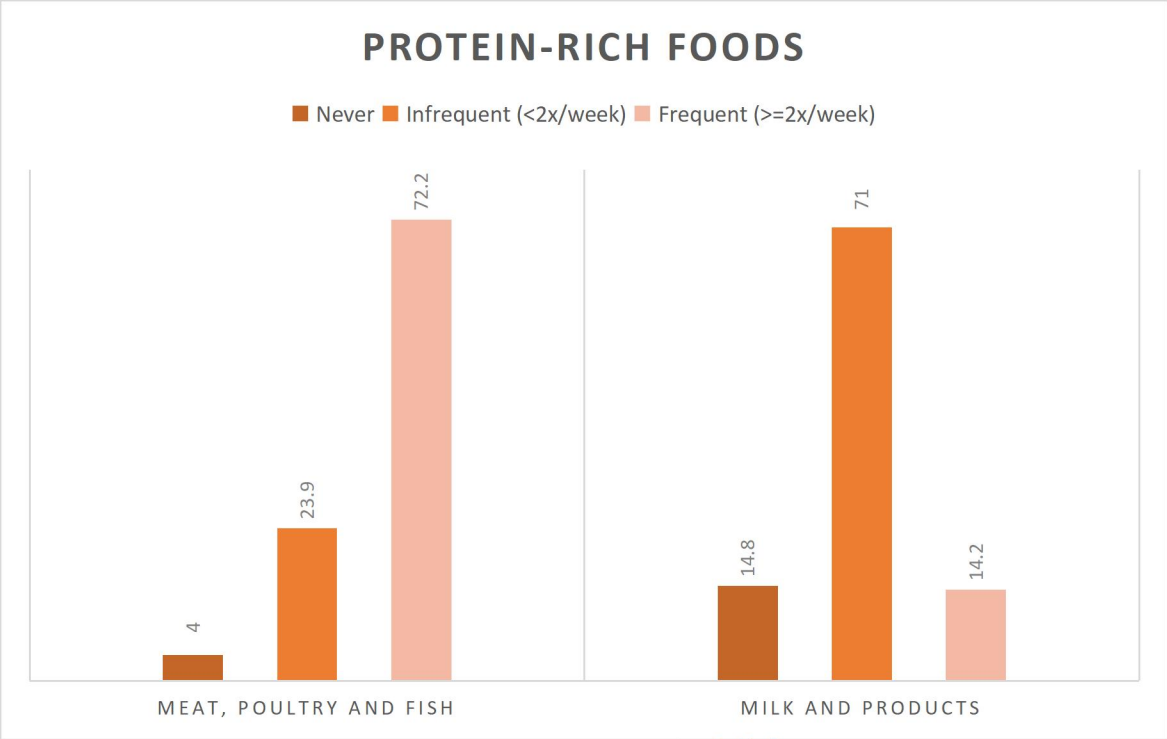

Fig 4.7 Frequency of Food Consumption; Protein-rich Foods

Source: Researcher's Field Work (2023)

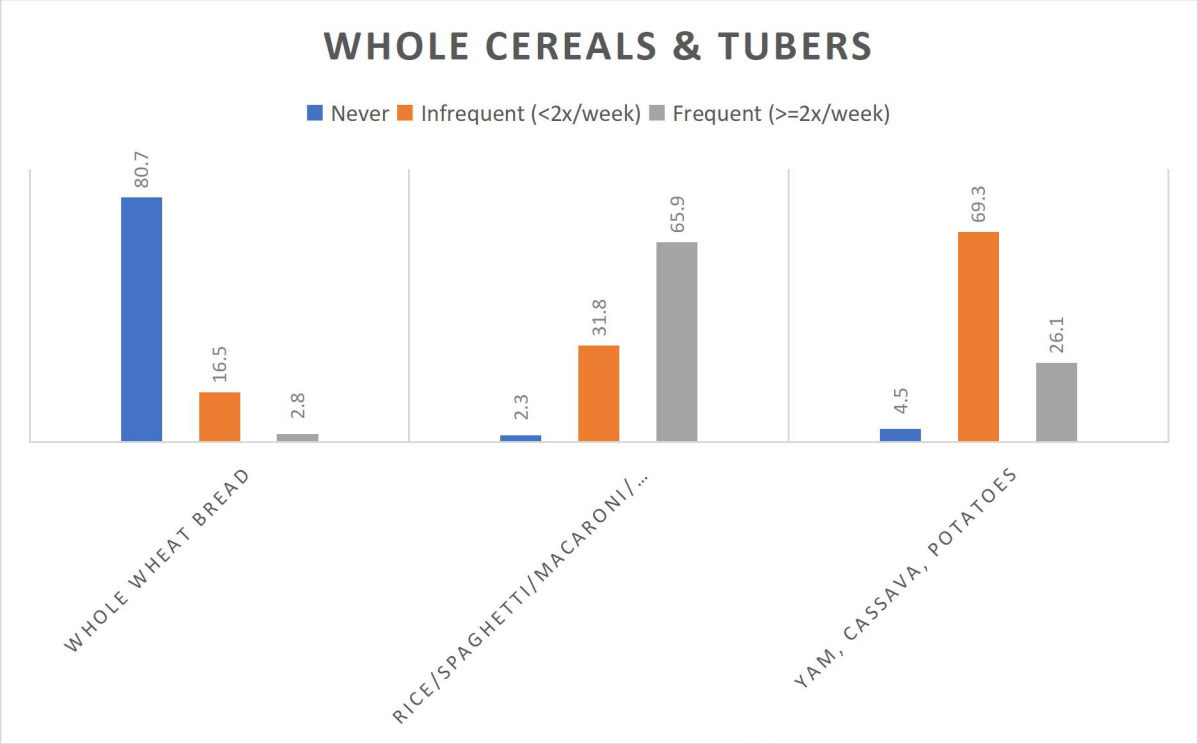

Fig 4.8 Frequency of Food Consumption; Whole Cereals and Tubers

Source: Researcher's Field Work (2023)

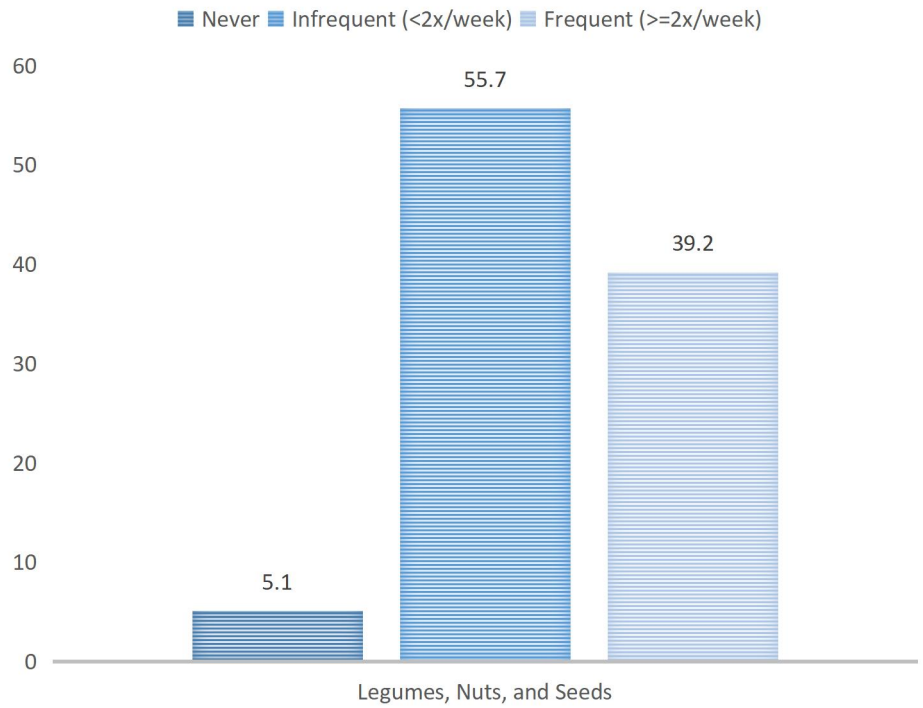

Fig 4.9 Frequency of Food Consumption; Legumes, Nuts, and Seeds

Source: Researcher's Field Work (2023)

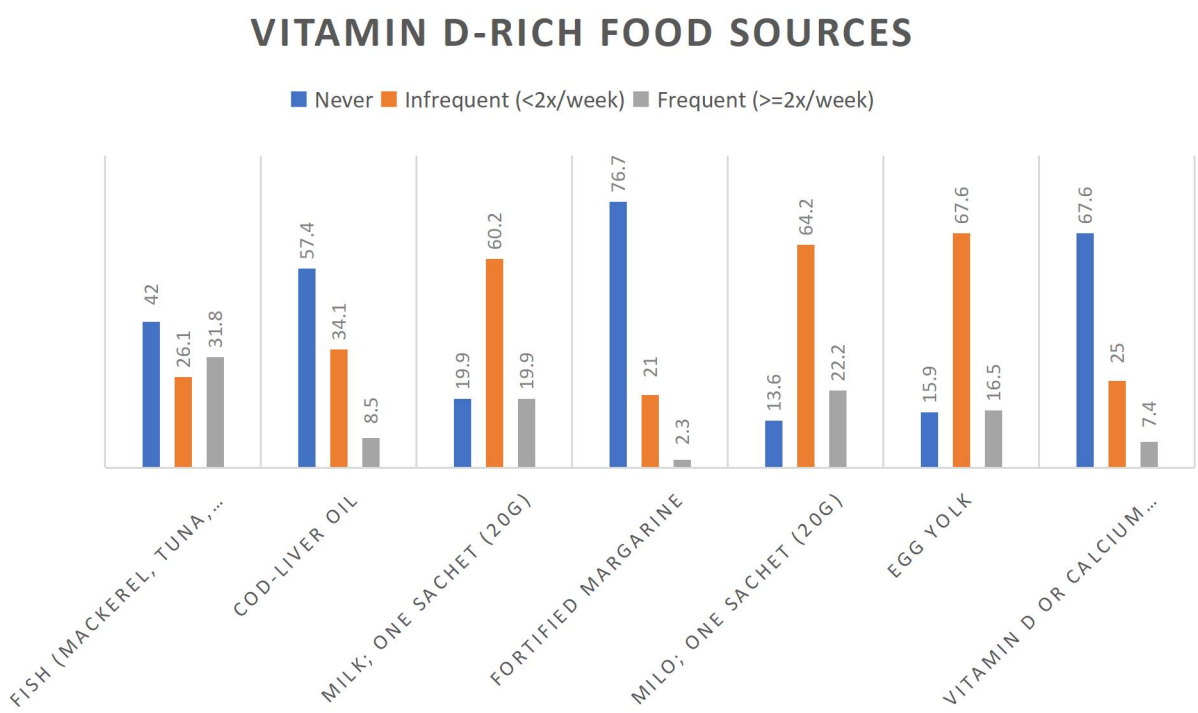

Fig 4.10 Frequency of Food Consumption; Vitamin D-rich Foods

Source: Researcher's Field Work (2023)

Summary of Frequency of Food Consumption

Table 4.11 summarizes the frequency of food consumption. The food items were recategorized into three main groups: healthy, unhealthy and vitamin D-rich foods. Majority of the participants (68.8%) consumed healthy foods more frequently, while the consumption of unhealthy foods as well as vitamin D-rich foods was more infrequent among the participants (83.5% and 84.1%, respectively).

Table 4.11 Summary; Frequency of Food Consumption

Category	Infrequent (≤2) n (%)	Frequent (>2) n (%)
Healthy Foods	55 (31.3)	121 (68.8)
Unhealthy Foods	147 (83.5)	29 (16.5)
Vitamin D-Rich Foods	148 (84.1)	28 (15.9)

Source: Researcher's Field Work (2023)

Associated Risk Factors for Low Serum Vitamin D Levels and Undiagnosed Diabetes Mellitus

Table 4.12 shows the mean difference between the serum vitamin D levels, fasting plasma glucose (FPG) and other selected variables. There was no statistically significant difference in the mean serum vitamin D levels and the fasting plasma glucose of participants forty-five years and less, and those who were older than forty-five years (p=0.724 serum vitamin D; p=0.066 FPG), less or more education (p=0.829 serum vitamin D; p=0.695 FPG), income of five thousand naira or less and more than five thousand naira (p=0.297 serum vitamin D; p=0.503 FPG), wholesalers, retailers, or petty traders (p=0.545 serum vitamin D; p=0.066 FPG), sedentary, less active, or Physically active of physical activity measurement (p=0.890 serum vitamin D; p=0.312 FPG), mode of transportation (p=0.328 serum vitamin D), exposure to early morning sun (p=0.828 serum vitamin D; p=0.817 FPG), meal skipping (p=0.484 FPG), usual food source (p=0.484 serum vitamin D; p=0.070 FPG), frequency of consuming healthy foods (p=0.674 serum vitamin D; p=0.751 FPG), frequency of consuming unhealthy foods (p=0.993 serum vitamin D; p=0.160 FPG), frequency of consuming vitamin D-rich foods (p=0.235 serum vitamin D; p=0.079 FPG), Body Mass Index (p=0.753 serum vitamin D; p=0.843 FBG), meanwhile, there was a significant difference in the mean serum vitamin D levels of those who skip or did not skip meals (p=0.007), and the mean fasting blood glucose of respondents who walked, commuted publicly or drove in their private vehicles to the market (p=0.000).

Table 4.12 Mean difference of Serum Vitamin D and Fasting Blood Glucose across variables

Variable	Serum Vitamin D			Fasting Blood Glucose		
	N	Mean ± S.D	p-value	N	Mean ± S.D	p-value
Age			0.724			0.066
≤ 45 years	75	49.87±24.19		76	85.88±16.14	
> 45 years	98	48.66±20.53		100	93.92±35.16	
Education level			0.829			0.695
Less educated	106	48.33±19.86		106	91.14±31.20	
More educated	70	49.07±25.49		70	89.40±24.77	
Income			0.297			0.503
≤ ₦5,000	93	50.75±20.82		94	89.20±22.01	
> ₦ 5,000	79	47.20±23.67		81	92.14±35.16	
Trading type			0.545			0.066
Wholesaler	52	48.29±22.46		52	97.50±41.85	
Retailer	70	46.84±21.13		70	85.26±24.93	
Petty trader	54	51.26±23.44		54	90.39±12.31	
Physical activity			0.890			0.312
Sedentary	71	49.21±22.99		71	91.87±24.49	
Less active	86	48.63±22.08		86	91.37±34.04	

Active	19	46.42±20.73		19	80.95±11.24	
Mode of transportation			0.328			0.000*
Walking	66	45.56±21.17		66	90.24±23.89	
Personal vehicle	23	52.43±24.72		23	111.04±58.45	
Commercial means	87	49.94±22.26		87	85.16±15.434	

* Significant at the $p<0.05$ level

Independent t-test (2 groups) and ANOVA (≥2 groups)

Source: Researcher's Field Work (2023)

Table 4.12 Mean difference of Serum Vitamin D and Fasting Blood Glucose (Cont'd)

Variable	Serum Vitamin D			Fasting Blood Glucose		
Exposure to early morning sun			0.828			0.817
< 30 minutes/day	78	48.99±23.19		78	91.04±19.37	
≥ 30 minutes/day	97	48.25±21.60		97	90.02±34.72	
Meal(s) skipping			0.007*			0.484
No	102	44.80±20.34		102	91.75±32.34	
Yes	74	53.89±23.68		74	88.66±23.02	
Usual food source			0.484			0.070
Homemade	149	48.60±21.39		149	88.56±23.85	
Out-of-home	4	43.25±8.62		4	86.75±11.38	
Both	23	53.96±27.77		23	103.30±50.35	
Frequency of consumption; healthy foods			0.674			0.751
Infrequent	55	49.67±21.53		55	91.47±33.30	
Frequent	121	48.15±22.58		121	89.98±26.57	
Frequency of consumption; unhealthy foods			0.933			0.160
Infrequent	147	48.85±22.43		147	91.80±30.70	
Frequent	29	49.24±22.15		29	83.59±13.91	

Frequency of consumption; Vitamin D-rich foods			0.235			0.079
Infrequent	148	44.42±27.00		148	88.79±22.13	
Frequent	28	50.03±21.15		28	99.21±46.34	
BMI			0.753			0.843
Underweight	9	48.00±15.43		9	83.78±10.59	
Normal	66	49.29±24.29		66	89.24±24.78	
Overweight	53	50.47±22.37		53	91.74±26.79	
Obese	48	43.79±20.32		48	91.94±37.43	

* Significant at the $p<0.05$ level

Independent t-test (2 groups) and ANOVA (≥2 groups)

Source: Researcher's Field Work (2023).

Table 4.13 Serum Vitamin D and Blood Glucose Levels with Odds Ratio

Variable	Fasting Blood Glucose				
	Normal	Undiagnosed Diabetes	Total	OR (95% CI)	p-value
	n (%)	n (%)	n (%)		
Serum Vitamin D Level				6.64 (2.88-15.29)	0.000*
Optimal	123 (69.9)	15 (8.5)	138 (78.4)		
Sub-optimal	21 (11.9)	17 (9.7)	38 (21.6)		

* Significant at the p<0.05 level

OR – Odds Rat

Variable	Random Blood Glucose				
	Normal	Undiagnosed Diabetes	Total	OR (95% CI)	p-value
	n (%)	n (%)	n (%)		
Serum Vitamin D Level				6.74 (2.73-16.60)	0.000*
Optimal	127 (72.2)	11 (6.3)	138 (78.4)		
Sub-optimal	24 (13.6)	14 (8.0)	38 (21.6)		

* Significant at the p<0.05 level

OR – Odds Ratio

Correlation Analysis of Selected Variables

Table 4.13 shows the correlation analysis of selected variables. There was a significant positive correlation between fasting Plasma glucose (FPG) and age (r=0.149), meanwhile, there was no significant correlation between FBG and education level (r= -0.026), waist circumference (r=0.107), BMI (r= 0.102), and physical activity (r= -0.106). There was however no significant correlation between random blood glucose (RBG) and age (r=0.110), education level (r= -0.009), waist circumference (r=0.097), BMI (r= 0.140), and physical activity (r= -0.109). Similarly, there was no significant correlation between serum vitamin D level and age (r= -0.044), education level (r= 0.058), waist circumference (r= -0.055), BMI (r= -0.041), and physical activity (r= 0.018). There was a negative weak correlation between Serum Vitamin D, FBG (r = -0.086) and RBG (r = -0.126).

Table 4.13 Correlation Analysis

Correlates		Age	Education Level	Waist Circumference	BMI	Physical Activity	Serum ELISA Vitamin D
FBG	**r**	0.149	-0.026	0.107	0.102	-0.106	-0.086
	p-value	0.049*	0.157	0.157	0.181	0.160	0.255
RBG	**r**	0.110	0.009	0.097	0.140	-0.109	-0.126
	p-value	0.148	0.909	0.199	0.067	0.149	0.095
Serum ELISA	**r**	-0.044	0.058	-0.055	-0.041	0.018	--
Vitamin D	**p-value**	0.563	0.445	0.471	0.596	0.810	--

* Significant at the $p<0.05$ level

r – Correlation coefficient

BMI – Body Mass Index

FBG – Fasting Blood Glucose

RBG – Random Blood Glucose

Source: Researcher's Field Work (2023).

Research Questions

The associated research questions posed to be answered are as follow:

1. What is the prevalence of undiagnosed diabetes and low vitamin D status among the traders in the Community?
2. What is the dietary pattern of the study participants in market?
3. Is there a relationship between low serum vitamin D levels of the participants with normal and abnormal glucose profile?
4. What are the associated risk factors with undiagnosed diabetes mellitus and hypovitaminosis D?

4.3 Discussion of Findings

Background

Type 2 diabetes poses burden of the morbidity and mortality to an individual general health and quality of life and is more severe when the condition is undetected or unaware. Diabetes mellitus has been associated with many risk factors including advanced age, dietary pattern, over weight and obesity with low vitamin D status. Vitamin D has been popularly recognized in the past with its skeletal function but recently, global interest has been observed on the influx studies on the vitamin D due to its non-skeletal role on the pancreatic beta cell insulin secretion and insulin sensitivity. However, the role of vitamin D can be suggested in the management and pathogenesis of non-communicable diseases such as diabetes mellitus. Low vitamin D status has been linked with abnormal glucose profile in diabetic and prediabetic individual. Novel researches are coming up globally to give more explanation on the associated risk factor of low serum vitamin D in diabetes mellitus. Yet there is paucity of studies in our locality or Nigeria on assessment of undiagnosed diabetes and low vitamin D status with associated risk factors. Henceforth, this study finding is aim to answer related research questions posed to be tackled.

Socio-Demographics Characteristic of The Study Participants.

This study demographic data showed very few males (1.1%) in compare with female (98.9%) that took larger number of participants in this study. This is similar to two southern Nigeria studies on the traders in the market place with sex range (31.4%) vs (68.6%) and (25.7%) vs (74.3%) for both male and female respectively[1,2]. On the contrary, another Nigeria study on the factors influencing health seeking behaviour among civil servants in Ibadan showed (55.5%) of respondents being male while (44.5%) being female[3]. The preponderance of the adult women in any of the health outreach, survey and their increase patronage in the health facilities has been

observed[4,5]. Explanation for the larger percentage of female and very low male percentage in this study could be due to cultural practice in the southern Nigeria among the traders and positive increase health awareness in adult female of the community. This study findings from the gender data view are in line with the usual practice known to occur in the southern part of Nigeria that women constitute greater percentage of workers in the open market as traders and could improve the knowledge and strategies use in the design and organization of health promotion outreach in order to achieve anticipated outcome. The age range of this study participants is between 20 years and 80 years, with a mean age of 48.30±13.16 years having middle age as mostly participated (53.5%), follow by young adults (30.7%), and the old adults (15.9%) as the least in this study. This is in consistent Oparah, et al study, on undiagnosed hypertension and diabetes among traders in a Nigerian market[1]. Findings from this study however differs from trends seen in the developed world where the mean age of 75.19 years. The lower mean age in Nigeria compared with those in the developed world may be a reflection of the poor healthcare system and the lower life expectancy of Nigerians[6].

Other socio-demographic characteristics include, marital status, religion and household size. Majority of the participant were married at the time of data collection (79.0%) and this similar to a previous study (80.5%)[7]. Considering the significant of marriage in making provision for the children and other members of the family, it will not surprise to have higher data of the married respondent.

Majority of the participants were practicing Islamic Religion (83.0%), follow by the Christianity (16.5%), and tradition (0.6%). This is logical because the study setting population were predominantly practicing Islam. However, it is contrary to the report of Okon et.al who (100%) Christian participants in Calabar South Eastern part of Nigeria[7].

Most participants with household size less than five were (54.0%) and those greater or equal to five were (45.7%). This indicate lesser family size were common in this study, similarly to the report of a study which showed lesser household size of (62.9%) and larger household size (37.1.0%) at same study setting with similar target population[8].

Socio-economic Characteristics

Other socio-economic variables include education level, type of trading, presence of a sales assistant and average weekly income. Approximate two third of study participant had formal education between primary and secondary school, whereas only (8%) had tertiary education and (28,4%) had no formal education. This may be due to the nature of the study group in which the skill involvement in their occupation setting is informal and the little level of educational attainment among them could be because of south western environment in which education is valuable more than the northern part of the country. This is similar to the previous studies did on the same target population at the same setting in different part of the southern Nigeria[1,2]. However, much higher level of illiteracy observed in a study of similar type did in Maiduguri, Northern part of Nigeria[9]. Majority of the participants (59,7%) had no sales assistant whereas more than forty percent of the traders still have sales assistant that could prone them to sedentary practice despite outdoor nature physical activities associated with their work. Over half of the participants (53.4%) among the traders earned less or equal to ₦5000 (about $5.00) per week, (33.0%) earned above ₦5000 to ₦10,000 (> $5.00 – $10.00) per week, one tenth earned greater than ₦10,000 – ₦20,000 (> $10.00 – $20.00) per week while (2.8%) earned the highest income of more than ₦20,000 (> $20.00) per week. The average income data is in contrast with the study did among the traders at Marian market Calabar in which the highest income earners were much in numbers (30%) compare to (2.8%) of this study whereas, the least income earners of the study

took the highest percentage of (53.4%) as against (12.4%)[9]. The difference observed in the both studies may be due to Calabar study was done in the city market of an urban environment vs the market of sub urban town. The socio-economic demographical data revealed that more than half of the traders participated in the study were living below poverty level i.e. (<1.25dollar/day equivalent to 8.7 dollar/week)[10].

Prevalence of Undiagnosed Diabetes and Low Vitamin D Status.

Prevalence of Undiagnosed Diabetes and Prediabetes.

The prevalence of undiagnosed diabetes mellitus in the current study was high and even more bothersome was the magnitude of hyperglycaemia detected in those without a previous diagnosis, that was high as (4.5%) and (13.6%) for pre diabetes in this current survey. It should be worthy of been noted that Findings from various studies and IDF have estimated that, half of all case of diabetes mellitus were undiagnosed and that the highest proportions of undiagnosed diabetes mellitus case (53.6%) are from Africa continent[11,12]. The burden prevalence of undiagnosed diabetes mellitus in this study (4.5%) was higher than the Nigeria national survey on prevalence of diabetes mellitus 2.2% (previous diagnosed and undiagnosed)[13]. The prevalence of undiagnosed DM observed in the study was comparable to Sabir et al. who reported; 4.6% of undiagnosed DM among the urban Fulani in Sokoto state Nigeria and other reports elsewhere[2,14,15]. Similar records of 4.5% and 5% undiagnosed diabetes mellitus were reported in Debre Tabor town north central and Bishoftu Town East Shoa, Ethiopia[16,17]. Other, comparable findings outside Nigeria studies[18,19,2021]. In contrast some other studies documented lower burden of undiagnosed diabetes mellitus to this present study including 2.76% among women group at Naze South East, 2.38% in Ile Ife South West, 3.0% in a screening for diabetes mellitus and hypertension South West, 1.9% in Abua district of Niger Delta region, 0.8% Uyo metropolis

South-South, Nigeria[22,23,24,25,26]. Other outside studies documented lower prevalence than this study[27,28,29]. However, the prevalent of the present study noted a relatively low level of undiagnosed DM to some studies such as 18.9% undiagnosed diabetes mellitus among the oil company staffs and non-oil company staffs in Port Harcourt, South-South Nigeria[30]. The high prevalent rate seeing in Port Harcourt study in Nigeria, could be traced to high socio-economic status of the workers as result of unhealthy eating and lifestyle habit. Other Nigeria studies documented higher prevalence are, 6.7% reported among the trader at Marian market in Calabar and also 7% among the adult residents of two Calabar city local Government, South East, 8.3% in Wari, South-South, 8% undiagnosed diabetes mellitus was also recorded in Lagos report in comorbidity with Tuberculosis[1,31,32,33]. Other higher prevalent findings recorded outside Nigeria include 6.6% in Addis Ababa Ethiopia, 10.2% Bahir Dar city, northwest Ethiopia, 14% in Kiambu, Kenya, 7.2% in the result of India screening twin epidemics study, 8.9% in Malaysian nationwide study, 11% in Texas USA and 8.2% in Augsburg, Germany[34,35,36,37,38,39,40]. The disparity that was observed in various aforementioned reports on prevalence of Undiagnosed Diabetes mellitus could be as result of different factors ranging from variation in lifestyles, genetical makeup, study population, sample size, and socio-economical and socio demographic characteristics of study respondents. Age of the respondents as criteria could also responsible for the variation in the findings, as it is noteworthy that advanced age is a key predictor for undiagnosed diabetes mellitus. Higher rate prevalences observed in high income countries such as USA and others could be the diagnostic methods use in determine the undiagnosed diabetes mellitus that will not underestimating its burden.

Prevalence of Pre diabetes

Pre diabetes is a predictor to diabetes mellitus and its complications especially when an individual is unaware. Prediabetes without a preventive measure such as physical activity and healthy lifestyles practice could easily predispose to development of diabetes mellitus concurrently with its complications. However, the current study revealed the magnitude prevalence of prediabetes at 13.6%. The finding was in line with study conducted in Warri South South Nigeria (11%), North west Nigerian among urban Fulani (16.9%), Debre Tabor town, northcentral Ethiopia (14.5%) Dessie, northeast Ethiopia (15.7%) and Bahir Dar, northwest Ethiopia (12.9%), Jimma, southwest Ethiopia (12.9%), Augsburg, Germany (16.4%), Qatar (12.5%), and Pakistan (14.4%)[32,14.30,41,35,42,40,20,43,]. Meanwhile, this present finding of prediabetes was seemed to be lower than other studies conducted in UCH Ibadan Nigeria (22.3%), ABUTH, Zaria Nigeria (19%), Bayelsa, Nigeria (43%), South east Nigeria (27.2%), Ningbo, China (28.5%), Texas, USA (32%)[44,45,46,47,48,39]. Moreover, the result of the burden prevalence of prediabetes in this study was higher than some other studies conducted in Ilaro, Nigeria (3%), Anambra South east Nigeria (7.2%), rural Community of Abuja Nigeria (4.2%), South Africa (4.8%), and Punjab, India (6.3%)[49,50,51,52,53]. The differences and the discrepancies observed from one and other studies could be as result of variances in the ages of study participants, lifestyle, genetics, sample size, socioeconomic, and sociodemographic factors. Other responsible factor including type of diagnostic methodology and research setting.

Prevalence of Low Vitamin D Status

The result from this study to a great extent validated the earlier studies on the general increase of low Serum vitamin D prevalence globally which doesn't exclude both healthy population and unhealthy population of different pathologies such as undiagnosed diabetes mellitus[54]. The prevalence of low serum vitamin D (insufficiency and deficiency) observed among study participants for this study was 21.6%. (Deficiency (<20ng/ml) was 9.1% and Insufficiency (20 – 29ng/ml) was 12.5%). This low serum vitamin D result was in agreement with 27% of Grootheest et al in a Netherlands study among the healthy adults[55]. Also, the Deficiency result was in line with 8% of Mogire et, al in Kenya[56]. The insufficiency as well in agreement with 12.6% of Adekunle et.al in a cross-sectional report of prospective data among study population of up to 18years of age sickle cell anemia in Lagos south west Nigeria and 10.6% of Muhammad et.al kano Northestern Nigeria in a community based descriptive study among 500 adult study participants[57,58] (3,4,5). Nevertheless, these values were lower than what was reported in another place in Nigeria. Higher values were reported with low serum vitamin D (30.8%) by Abubakar et al in a Multiregional Survey among healthy adults in Nigeria, vitamin D deficiency of 29.7% by Adejumo et al among non-diabetic control participants in Warri South South Nigeria and vitamin D insufficiency of (21.2%) by Abbiyesuku et al among healthy adult control group in Saagmu Ogun State Nigeria[59,60,61]. The lower rates of serum vitamin D seen in Ede among the market

traders could be attributed to the seasonal variation in serum vitamin D level which was major consideration of this stud that led to data survey been executed in the spring season of the year whereas this may not be a criterion for other studies that seem to have recorded higher value of hypovitaminosis. This gave a hope that participants considering their occupation will have exposure to ultra violet rays via the sunshine in order to achieve serum vitamin D optimal level or correcting deficiency. This has been supported by Liu et al in a cross-sectional study from Toronto which revealed that the prevalence of hypovitaminosis D increased from 38% in the fall sample to 60% in the spring sample[62]. More reason to this, people living in rural area tend to have more outdoor activity and sunlight exposure than the city people. Ede town, being a sub-urban and the major markets within the two Local Government Area of the town have the traders that are probably more utilitarian by involving in outdoor physical activities than most people in the city that engage in indoor office activities that prevent exposure to sunlight. This and many could contribute to the lower prevalence of vitamin D deficiency observed in this study compare to others. Higer prevalence of hypovitaminosis D were reported from the Middle East and other part of the world. The factor that could be responsible have been reported in these studies[63,64,65]. However, in this study despite less low serum vitamin D prevalence, it was observed that the value in this was still higher than some other studies finding[61,66,67]. A probable explanation for the variation in the low rate hypovitaminosis prevalence observed from other view studies might be explained by differences in latitude, geography, skin pigmentation, clothing coverage, religious and cultural practices across Africa. The year-round abundance of sunshine in sub-Saharan Africa may also explain higher vitamin D status although vitamin D supplementation and food fortification is less common[68].

Assessment and Relationship Between Serum Vitamin D Status and Normal and Abnormal Glucose Profiles.

Previous epidemiological studies have linked hypovitaminosis D to the pathogenesis of hyperglycaemia (pre diabetes and type 2 diabetes mellitus)[69,70]. Though probable mechanism behind it is not fully understood but some attributed reasons could be in the role of optimal vitamin D on insulin sensitivity, insulin secretion and increase autoimmune and protection of pancreatic beta cell from cell apoptosis[71]. The current study findings showed an inverse association between vitamin D and abnormal glucose profile with six times increase chances of having undiagnosed type 2 diabetes mellitus. This is consistence with several other studies[72,73,74]. Higher percentage (51.1%) level of low vitamin D was observed among participant with abnormal glucose profile (Pre-Diabetes and Undiagnosed Type 2 diabetic participants) than those with normal glucose profile (non-type 2 diabetic participants) 53.1% vs 14.6%. There is statistically significant relationship between vitamin D status and undiagnosed type 2 diabetes with p-value ($p < 0.001$). Participants with low vitamin D status were at larger risk of undiagnosed Type 2 Diabetes Mellitus compared with those that have sufficient vitamin D (OR = 6.64; 95% CI = 2.88 – 15.29; p = 0.000). From the above result, it implies that the adequate vitamin D is required to maintain heathy status and alleviate the risk of diseases progression. This is in agreement with a cohort study which showed participants with optimal health and vitamin D status have a slightly stronger association and 54% risk reduction of diabetes compare with lowest status of serum vitamin D[72].

Assessment of dietary pattern of the participants

A Nigeria meta-analysis study has connected unhealthy dietary pattern among the risk factor for undiagnosed type 2 diabetes mellitus, in the study unhealthy dietary pattern took the most prevalent of all risk factors[75]. This could be as a result of different fast-food outlets explosion in many cities within the nation though its effect could be lesser in the rural or sub urban setting. This study findings of dietary habit revealed 60.8% of the participants eat between three to four meals per day, more than average 58% didn't skip meal and the majority 84.7% source of participants meal is homemade while 67% consume snacks in between the meal.

Fruit and vegetables, palm oil, as well as protein rich food, and whole cereals and tuber food were more frequently consumed by majority of the participants (51.4%, 86.9%, 72.2%, and 65.9%, respectively). However, more than one third of the participant were frequently consume legumes, nuts, and seeds (39.2%). In summary, it was observed that high prevalence of frequently consume healthy food were recorded in the majority of the participants (68.8%) of this study. This result was not in agreement with the study did among the trader in an urban setting of the north west Nigeria[76,77]. Also, not in consistent with the findings of nutritional status in which the possible reasons could be different setting and frequently intake of meal per day and in between the meal snacks that took preponderance among the participants. It is noteworthy of been recognized that the setting of this study is not an urban environment with different fast-food outlets like city.

Factors Associated with Undiagnosed Diabetes and Low Vitamin D Status

Associated Risk Factors for Undiagnosed Type 2 Diabetes Mellitus

Advanced Age

This study observed more than average participants 56.8% with the age greater than 45years that were recruited, also a rising trend in the prevalence of undiagnosed Diabetes Mellitus as the age advancing was noted in the previous epidemiological studies. This study showed significant mean differences in the fasting plasma glucose level of age more than 45 years compared with the respondents that has the lesser age. This alludes to the findings that observed more prevalent type 2 diabetes mellitus in the older than in the younger individual. Although the index study however found no statistically significant association between age and undiagnosed diabetes mellitus ($\chi 2$= 6.914, p= 0.066). This may be due to the fact that a small sample size was used for this study. The increase in diabetes prevalence with increasing age observed in this study has been reported in most studies comparing DM and age[78,79,80]. In line with the trend of increase prevalent of diabetes in Nigeria, A Nigeria study finding documented that the risk of diabetes increases 3-4-folds after the age of 44 years[81]. Probable reason to this could be due to decrease physical activity in elderly subject and insulin resistance or reduce insulin production.

Education level

Low socioeconomic status especially less education should be part of risk factors to consider for undiagnosed diabetes mellitus among the populace. Lesser educational level include factor that are associated with health vulnerabilities and related to an increased risk of diabetes mellitus[82]. This current study observed increase mean fasting plasma glucose level in those that have less education as compared to those with higher education. This is line with previous studies finding that showed result of statistically significant association between lesser education and diabetes mellitus[83,84]. In the result of another study, lower education has a relationship with an increase prevalence of diabetes mellitus and had a statistically significant difference with a greater odds

ratios ($p < 0.05$) compared to more educational status[85]. The reason that could support is less education give less exposure to know about the health risk and an individual will have more chances of susceptibility.

Economic status

Increase prevalence of undiagnosed type 2 diabetes mellitus has been observed in class of people with higher socio-economic status[86]. This is in line with the result of this current study on the categorization of the participants as regard the level of their income on weekly basis. The mean plasma glucose level of those who are earning more was far higher than those who earn lesser. This can further validate the significant difference observed among the mean plasma glucose level of the wholesaler and petty trader (97.50±41.85 Vs 90.39±12.31). As a result of this it can be deduced or stated in line with some other studies that individual with high economic status could have more risk of type 2 diabetes mellitus as compare to those with low-income status and this is supported by the findings from Korea National Health and Nutrition Examination Survey (KNHANES) 2010–2012[87].

Physical activity

In this study, the physical activity was graded into three as active, less active and sedentary, though majority of the respondents (89.2%) were noted to practice sedentary and less active form of physical activity as against (10.7%) physically active participants. An inverse association was observed between undiagnosed diabetes mellitus and level of physical activities of the participants in the study. The mean fasting plasma glucose level of the physical active participants were lower as compare to the less active and sedentary category of the participants.

Low prevalent rate of undiagnosed diabetes mellitus was recorded among the physical active subject and that even employed as preventive measure in the management of pre diabetes. Moreso, the above can still be justify with the finding recorded in the mode of transportation of the participants to the market. A statistically significant ($p<0.05$) relationship was established among the mean fasting plasma glucose level of those walking to and fro the market and those using their personal vehicles. This inverse association even not statistically significant ($\chi 2= 0.054$, $p= 0.312$), was in agreement with previous studies[88,89]. Reason behind this could be the positive effect of physical activity on the insulin sensitivity

Nutritional Status/ Obesity and Overweight

Participants' nutritional status was assessed by the scale of BMI body mass index along with their waist hip ratio. Few of the participants (5.1%) were underweight, (37.5%) with normal weight whereas (57.4%) were overweight and obese. Major and independent predictor of undiagnosed diabetes mellitus in the previous studies were overweight and obesity. This can be validated with the findings from this study in regard to the mean value of fasting plasma glucose level in the category of obesity and overweight was recorded high as compare to underweight and normal weight category of the participants. Weak positive association between body mass index of the participants and fasting plasma glucose level was noted, although not statistically significant while same correlation observed in the waist circumference.

Hypovitaminosis D.

The role of vitamin D in the metabolic pathway of body system has been identified by various studies. Adequate vitamin D in the body could prevent or delay the development of diabetes

mellitus. In this study, finding revealed low vitamin D status gives more than six times chances of an individual develop undiagnosed diabetes mellitus. An inverse weak correlation was established between vitamin D and fasting plasma glucose though not statistically significant.

Factors Associated with low vitamin D status

Age

Greater amount of Low vitamin D deficiency have been reportedly found among the people with advanced age group and the difference was statistically significant. The finding in this study was in agreement with previous studies. A negative relationship was noted among the serum vitamin D and age though is weak and p value not significant as the case may be for this study. However, the mean serum of higher age group was recorded low compare to lesser age group. The probable explanation for low vitamin D prevalent among elderly are as result of factors which including, loss of skin ability to synthesis adequate vitamin D via the sunlight, decreased renal conversion of 25OH vitamin D to the active form vitamin D in advanced age, and reduced intake of diet diversity especially the vitamin D rich source of food.

Adiposity

An inverse weak correlation was noted in the study between serum vitamin D body mass index as well as waist circumference of the participants. No statistically significant differences observed among the BMI parameters and serum vitamin D but low mean serum vitamin D was documented for obesity both in the lower and upper range. This was in agreement with what was seen in some earlier studies which also showed an inverse relationship between vitamin D levels and obesity[90,91]. Lower level of serum vitamin D in obese individual may be explained by

enhanced uptake by adipose tissue, increased metabolic clearance, and the sedentary lifestyle of obese subjects could be associated with less outdoor activity and less exposure to sunlight. This in agreement with a study finding[92].

Dietary Factors

Higher prevalent rate of vitamin D deficiency was observed in tropical countries despite adequate amount of sunlight availability. Hence, other possible factor could be inadequate intake of vitamin D rich food or fortification. In this study it was observed that majority were not frequently consuming vitamin D rich food but the reverse was seen with intake of fish. Surprisingly, statistically significant differences were recorded in the inferential statistic of serum vitamin D among those who skipped meal and those that did not. Mean serum vitamin D concentration of those who skipped meal was higher than those that did not skipped meal. Explanation for it could be that the meal skippers were usually consumed the vitamin D rich food or indulge in the intake of vitamin D supplement.

Exposure to Early Morning Sun

All the study participants were categorized into less than 30minutes exposure and greater or equal to 30minutes exposure but the finding of the study reported nil obvious mean difference in their serum vitamin D concentration. The availability of vitamin D for an individual is greatly influenced by the exposure to sunlight, as vitamin D is mostly produced in the skin. As in the case of this, various other factor that could influence production of vitamin D could be a reason. However inadequate exposure to sunlight and use of sunscreen have been identified as risk factor for hypovitaminosis D in the previous studies[93,94].

CONCLUSION

High prevalent rate of hypovitaminosis D seen in individuals with undiagnosed diabetes mellitus establish an inverse relationship between UDM and vitamin D. The common share risk factors identified between Low vitamin D and undiagnosed type 2 diabetes mellitus in this study are age, dietary habit, obesity and Physical activity. This study also showed that vitamin D deficiency is associated with increase glycaemic level in the blood.

Endnote

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Chapter Five

Conclusion

5.1 Summary of Findings

This study was carried out to assess the dietary pattern, lifestyles, vitamin D status and undiagnosed diabetes mellitus among the market traders. Therefore, a descriptive cross-sectional design was employed for the interest of this study among the traders in selected markets area in Ede Osun state in Southwest Nigeria. A total of 176 study participants were recruited using stratified sampling method by dividing each market to five sub-sections according to its geographical region for data collection.

The study found the mean age of the participants to be 48.30±13.16 years, with larger percentage of female. Majority of the respondents were married and practicing Islamic religion. Slightly over half of the respondents had a household size less than five while few possess tertiary level of qualification. More than one quarter of the were categorized as wholesaler and above average numbers of respondent had a sales assistant. Over half of the participants among the traders earned less or equal to ₦5000 (about $5.00) per week which indicated the larger numbers of people living below the poverty level less than 1.25 dollars per day.

Findings from this study revealed the high magnitude of undiagnosed diabetes mellitus, prediabetes and hypertension at prevalence of (4.5%), (13.6%) and (23.9%) respectively. This is bothersome and unexpected in the can of study setting being a sub urban area. The prevalence of low serum vitamin D (insufficiency and deficiency) observed among study participants for this study was 21.6%. (Deficiency (<20ng/ml) was 9.1% and Insufficiency (20 – 29ng/ml) was

12.5%). Results showed a significant increase prevalence rate even in low vitamin D status among the apparently healthy individual despite tropical nature of the environment.

The current study findings showed an inverse association between low vitamin D and abnormal glucose profile with six times increase risk of having undiagnosed type 2 diabetes mellitus. Higher percentage (51.1%) level of low vitamin D was observed among participant with abnormal glucose profile (Pre-Diabetes and Undiagnosed Type 2 diabetic participants) than those with normal glucose profile (non-type 2 diabetic participants). There is statistically significant relationship between vitamin D status and undiagnosed type 2 diabetes.

This study findings on the dietary patterns revealed majority 60.8% of the participants eat between three to four meals per day, more than average 58% didn't skip meal and the majority 84.7% source of participants meal is homemade while two third 67% consume snacks in between the meal.

However, higher percentage of participant observe to be more frequent consume the follow group of healthy the food, fruit and vegetables, palm oil, protein rich food, and whole cereals and tuber food. Whereas, more than one third of the participant were frequently consume legumes, nuts, and seeds as well. In summary, it was observed that high prevalence of frequently consume healthy food were recorded in the majority of the participants (68.8%) of this study

The study findings revealed some variables as identified associated risk factors for undiagnosed diabetes such as advanced age, education level, socio-economic status, physical activity, nutritional status, and low vitamin D status. In this study all the variables mention above showed higher mean fasting plasma glucose among it individual groups. For instance, an inverse

correlation was established between vitamin D concentration and Dysglyceamia. Increase mean fasting plasma glucose observed in participant with low vitamin D status than those with optimal vitamin D status.

Also, in this study some other variables identify to have associated with increased risk of higher prevalence of low vitamin D status among the participant are age, adiposity, dietary factors and exposure to sunlight. Nevertheless, study observed and identified in some common share risk factors as age, dietary habit, obesity and physical activity in between the low vitamin D status and undiagnosed diabetes mellitus.

5.2 Conclusion

Diabetes is a complex, costly, and debilitating condition that can pose a significant threat to both health and quality of life. Despite the global epidemic of noncommunicable diseases (NCDs) that was recognized by the United Nations and was addressed by the Sustainable Development Goals (SDGs) aiming by 2030 to reduce the burden of non-communicable diseases by one third via prevention, treatment and promotion of health and well-being. High prevalence of undiagnosed diabetes, prediabetes, hypertension and low vitamin D status found in the current study it is an alarming sign towards an increase in the number of other non-communicable diseases in near future. This suggests that vulnerable group of population should also be given special attention in terms, of creating public health awareness, knowledge, screening, and other strategies need to be developed to sustain the interest of the masses on of non-communicable disease prevention and treatment.

This study has also shown that serum vitamin D level is lower in persons with abnormal glucose profile, the prevalence of vitamin D deficiency is higher in undiagnosed diabetes individual compared to non-diabetic and serum vitamin D levels inversely correlated with fasting plasma glucose in undiagnosed type 2 diabetes.

Also notable in this study are the associated risk factors for both low vitamin D status and undiagnosed diabetes mellitus. It is anticipated that; the high burden of undiagnosed diabetes includes low vitamin D status and the existences of modifiable diabetes risk factors associated in the study provides an indication that the disease can be controlled and prevented when appropriate measures are taken. The measures that can potentially reduce the disorder can be channeled via opportunistic screening and early intervention. Knowledge of the factors associated with undiagnosed diabetes and prediabetes can help target the appropriate population and assist with tailoring their intervention.

5.3 Recommendation

Based on the findings of this study the following is therefore recommended for the improvement, prevention and control of undiagnosed diabetes and low vitamin D in the South west region Nigeria.

1. All healthcare stake holders should be aware that hypovitaminosis D is common in Undiagnosed diabetes mellitus and therefore advocate for vitamin food sources intake because optimal vitamin D concentration prevent and alleviate diseases progression. All

members of the community are advice on healthy lifestyle and dietary intake to optimize serum vitamin D level.

2. Screening for diabetes and associated risk factors should be strengthened, as early detection will contribute in lessening the menace of undiagnosed diabetes and its associated complications.
3. Public health strategies that target the populace, emphasizing the dangers of consumption of junk foods as well as energy-dense foods from fast food outlets; while accentuating the benefits of consumption of food with low glycaemic index such as high fiber diets, fruits and vegetables. Indiscriminate proliferation of fast-food outlet within our environment should be checked
4 It is recommended that assessment of vitamin D status should be considered in the management of diabetes mellitus, if found low it should be corrected considering the important role of vitamin D in the metabolic path way.
5. Advocacy on vitamin D fortification of consumers products such as fruit juices, cooking oil, milk etc should be made to manufacturers, policy makers, Governmental and Non–Governmental agencies in order to alleviate the deficiency of vitamin D in our community.
6. Longitudinal studies are highly recommended to assess the contribution of other risk factors toward development of the diabetes mellitus and low vitamin D status in communities especially previously known impoverished communities.
7. Nutritional education should formally be incorporated into the curricula of primary, secondary and tertiary educational institutions, in Nigeria.

8. The Ministry of Health and Social Welfare should encourage and collaborate with health-related academic institutions and research centres to perform research on diabetes and novel associated risk factors in order to strengthen availability of local information on diabetes and other related condition vitamin D deficiency.
9. National and Local Health Systems should plan to prepare the guidelines for community sensitization and mobilization on the risk factors; symptoms, complications and preventives measures of both diabetes mellitus and vitamin D deficiency such as mass or mainstream media.

5.4 Contribution to Knowledge

1. This is one of very few if any, of epidemiological cross-sectional surveys in Nigeria that has estimated prevalence of undiagnosed diabetes mellitus, as it has been reported in 2021 IDF global estimation on undiagnosed diabetes that only six studies from five African countries (Seychelles(1), Comoros(1); Kenya(2); South Africa(1) and Mozambique(1)) that has in country data on undiagnosed diabetes mellitus in which Nigeria not included. Added value of this study data is that it provides a way to monitor the effectiveness of public health efforts related to diabetes screening and diagnosis.
2. This study was the first community base descriptive cross-sectional study in Nigeria (probably in Africa) to examine in association between Undiagnosed diabetes and vitamin D status among the vulnerable group of community like traders. The few study that might at have done something related is hospital base study among the patient not apparently healthy individual of the community.

3. There are few studies that have measured the prevalence of low vitamin D status in Nigeria but no study to the best of our knowledge has measured that along with unrecognized diabetes mellitus.
4. Among many studies in Nigeria that measured the prevalence of diabetes or undiagnosed diabetes used only one diagnosis criteria test but this is among few that used two diagnoses tests for confirmation.
5. There is paucity of data Nigeria that was able to identify low vitamin D status as an independent risk factor for undiagnosed diabetes like this current study.

5.5 Suggested Areas for Further Research

1. Further study on the actual cause behind the high rate of low vitamin D status in Nigeria despite being in a tropic region with regular availability of sunlight.

2. Large scale survey on the prevalence of undiagnosed diabetes mellitus in Nigeria will be of great value

3. Since even local studies report have been linked low vitamin D status with Diabetes then large longitudinal random control trial study in our locality will be of great help in the medical practice.

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Appendix

Appendix I

Informed Consent

Title of Study

Assessment Of Dietary Pattern, Lifestyles, Vitamin D Status and Prevalence of Undiagnosed Diabetes Mellitus Among Traders in Selected Markets Area Ede, Osun State

Principal Investigator; Selim Abuzayd ABDULKAREEM

DESCRIPTION OF THE RESEARCH

Name and affiliation of researcher: This study is being conducted by Abdulkareem Selim Abuzayd of Human Nutrition and Dietetic Unit, Department of Biological Science, Lead City University Ibadan, Oyo State.

Sponsor of research: This study is being sponsored by Abdulkareem Selim Abuzayd

Purpose of research: The purpose of this research is primarily to find out the prevalence of undiagnosed diabetes mellitus and Low vitamin D status among the traders. Also, to assess the dietary pattern and lifestyles traders with undiagnosed diabetes mellitus.

Procedure of the research: A well-structured questionnaire will be tailored towards traders from the three selected market. Information relating to dietary habit, lifestyles, history of Vitamin D source intake and medical history on diabetes mellitus including general well-being. The expected sample size for this study is 150 participants from the three selected major markets in Ede, Osun State.

Expected duration of research and of participant(s)' involvement: I expect data collection of this research to last for about 8 weeks. Participants would be interviewed and examined once.

Risk(s): This study is unlikely to cause any physical harm to investigator and participants.

Costs to the participants, if any, of joining the research: Participants are not going to be charged in this research.

Benefit(s): The goal of this research is to identify Undiagnosed Diabetes Mellitus respondents with their vitamin D status in comparison of those that free from diabetes at the moment among the target population. This will create awareness among the traders for those that will be

confirmed of the diabetes mellitus and those that did not have, in order to know their status at that particular period.

Confidentiality: All information in this study will be treated with confidence, name or any identifier will not be used in any publication or reports from this study.

Voluntariness/withdrawal: Participation in this research is entirely voluntary. Participants can choose to withdraw from the research at any time without any penalty.

Alternatives to participation: If any participants choose not to participate, this will not affect any form of benefits you believe you could gain from us.

Due inducement: Participants will not be paid any fees for participating in this research.

Modality of providing treatments and action(s) to be taken in case of injury or adverse

event(s): If you suffer any injury as a result of your participation in this research, which is very rear, participants will be taking care of that and the researcher will bear the cost of this treatment.

What happens to the research participants when the research is over: During the course of this research, participants will be informed about any information that may affect their continued participation or their health.

INFORMED CONSENT BY THE PARTICIPANT

I……. do hereby consent to participate in this study titled ***assessment of dietary pattern, lifestyles, vitamin D status and prevalence of undiagnosed diabetes mellitus among traders in selected markets of Ede, Osun State.*** I acknowledge that I have been properly counseled on the implications of my involvement. I understand that the investigations that would be carried out in the course of this study are solely for the purpose of medical research and I express my willingness to participate on the understanding that I shall be entitled to withdraw this consent at any time I choose to do so.

Date……. Signed ……

STATEMENT OF PERSON OBTAINING INFORMED CONSENT:

I confirm that I have explained to the respondent the purpose and nature of this study and his/her refusal to participate will not in any way affect the normal care by me or any member of the research team. I know the consequences of any false declaration on this or any other form.

Date……. Signed…….

This research is expected to undergo the review of approval by the, Osun State Ministry of Health, Research Ethics Committee before it is been executed. If you have any question about your involvement in this research, you can contact me: Abdulkareem Selim Abuzayd 08057523645 or abdulkareem.selim@lcu.edu.ng

Appendix II

Questionnaire

Assessment Of Dietary Pattern, Lifestyles, Vitamin D Status and Undiagnosed Diabetes Mellitus Among Traders in Selected Markets Area in Ede, Osun State

This study aims to access the dietary pattern, lifestyle, vitamin D status, and undiagnosed diabetes mellitus among traders in selected major markets area Ede, Osun State.

In order to achieve this goal, your participation and co-operation is highly needed.

Responses to this questionnaire will be treated with absolute confidentiality.

Official use

Data Collector Sign…….

Name of Data Collector……

Participant's Name (Initials)……

Coded No……

Market Name……

Phone No: ……

Home Address:

Next of Kin Phone Contact

Contact No…….

Date of Data Collection……

Instructions: Please tick your choice as appropriate and fill in the answer where necessary. Your responses will be treated confidentiality.

Section A: Socio-demographic and economic information

1. Age (years) ……

2. Gender: (a) Male [ ] (b) Female [ ]

3. Marital status: (a) Single [ ] (b) Married [ ] (c) Separated [ ] (d) Divorced [ ] (e) Widowed [ ]

4. Religion: (a) Islam [ ] (b) Christianity [ ] (c) Traditional [ ]

5. Educational level: (a) No Formal Education [ ] (b) Primary [ ] (c) Secondary [ ] (d) Tertiary [ ]

6. Household size: (a) 1 – 5 [ ] (b) 6 – 10 [ ] (c) ≥ 11 [ ]

7. Type of trading: (a) Wholesaler [ ] (b) Retailer [ ] (c) Petty trader [ ]

8. Presence of sales assistant: (a) Yes [ ] (b) No [ ]

9. Average weekly income: (a) ≤ #2000 (b) #2001 – #5000 (c) #5001 – #10,000 (d) >#10,000

10. Average working hours: (a) ≤ 8 hours (b) ≥ 9 hours

11. Number of working days: (a) ≤ 5 days (b) ≥ 6 days

Section B: Medical History

12. Personal history of Diabetes mellitus Diagnosis: Yes/ No

- If yes, duration of Diabetes mellitus……. (months/years)

13. Personal history of Hypertension: Yes / No

- If yes, duration of Hypertension……. (months/years)

14. Personal history of Vitamin D deficiency diagnosis: Yes / No

- If yes, duration of Diagnosis……. (months/years)

15. Family history of diabetes: Yes / No

- If yes, First degree relatives at least (a) one diabetic parent (b) or sibling (c) Both
- If yes, second degree relatives (a) cousin (b) uncle (c) aunt (d) grandparent
- Not sure.

16. Family history of Hypertension: Yes / No

- If yes, First degree relatives at least (a) one hypertensive parent (b) or sibling (c) Both
- If yes, second degree relatives (a) cousin (b) uncle (c) aunt (d) grandparent
- Not sure

Section C: Lifestyles Habits

17. Do you visit health facility for medical checkup: Yes / No

- If yes, when last? ……..
- How frequent? ……

18. Do you consume alcohol? (a) Yes [ ] (b) No [ ]

If yes,

18(b) how often? (a) Daily [ ] (b) 4 – 6 times/per week [ ] (c) 1 – 3 times/week [ ]

18(c) how many bottles? (a) < 3 bottles [ ] (b) 3 – 5 bottles [ ] (c) > 5 bottles [ ]

18(d) type of alcohol consumed? (a) Beer [ ] (b) Wines and Spirits [ ] (c) Local [ ]

19a. Do you currently smoke tobacco? (a) Yes [ ] (b) No [ ]

If yes,

19(b) how often? (a) Daily [ ] (b) 4 – 6 times/per week [ ] (c) 1 – 3 times/week [ ]

19(c) how many sticks per smoking episode? (a) ≤ 2 [ ] (b) ≥ 3 [ ]

20. How do you get to your market place? (a) Walking [ ] (b) Personal Car/motocycle [ ] (c) Commercial Means [ ]

21. How long do you spent in performing any of the following activities per day?

i. Brisk Walk (a) Nil [ ] (b) 0 – 30 minutes [ ] (c) 31 – 60 minutes (d) > 60 minutes

ii. Casual walk (a) Nil [ ] (b) 0 – 30 minutes [ ] (c) 31 – 60 minutes (d) > 60 minutes

iii. Running/Jogging (a) Nil [ ] (b) 0 – 30 minutes [ ] (c) 31 – 60 minutes (d) > 60 minutes

iv. Sitting (a) Nil [ ] (b) 0 – 30 minutes [ ] (c) 31 – 60 minutes (d) > 60 minutes

v. Carrying heavy loads (a) Nil [ ] (b) 0 – 30 minutes [ ] (c) 31 – 60 minutes (d) > 60 minutes

vi. Carrying light loads (a) Nil [ ] (b) 0 – 30 minutes [ ] (c) 31 – 60 minutes (d) > 60 minutes

vii. Driving (a) Nil [ ] (b) 0 – 30 minutes [ ] (c) 31 – 60 minutes (d) > 60 minutes

viii. House chores (a) Nil [ ] (b) 0 – 30 minutes [ ] (c) 31 – 60 minutes (d) > 60 minutes

Section D: Dietary Pattern

22. How many meals do you take in a day? (a) 1-2 meals (b) 3 - 4 meals (c) > 4 meals

23. How often do you eat breakfast? (a) Always (b) Often (c) Rarely (d) Never

24. How often do you eat lunch? (a) Always (b) Often (c) Rarely (d) Never

25. How often do you eat dinner? (a) Always (b) Often (c) Rarely (d) Never

26. Do you skip meals? Yes ( ) No ( )

27. If yes, which meal do you often skip? (a) Breakfast (b) Lunch (c) Dinner

28. Why do you skip this particular meal? (a) Lack of money (b) Lack of time (c) Inability to cook (d) Loss of appetite

29. What is the usual source of your meal? (a) Homemade (b) Purchased (c) Both

30. Where do you purchase your meals from? (a) Restaurant (b) Roadside food vendors/Hawkers (c) Canteens

31. Do you eat snacks in-between meals? Yes ( ) No ( )

32. What type of snacks? (a) Pastries (b) Biscuits/Cookies (c) Fruits (d) Locally-made snacks

33. Do you regularly add salt to food during cooking or at the table? Yes / No

34. On average, how much early morning sun exposure (before 10am) have you had in the past week? (a) < 5 minutes/day, (b) 5–15 minutes/day, (c) 15–30 minutes/day (d) > 30 minutes/day.

Food Frequency Questionnaire

Food Group	Daily	Frequently (5-6 times/ wk)	(2-4 times/ wk)	Once/Wk	Never
Fruits					
Vegetables					
Cake/Cookies/Biscuits					
Sweet/Chocolate/gum/ ice cream					
Sugary drinks/Carbonated beverages/ sugar, honey					
Butter/Palm oil/Full fat margarine/ mayonnaise					
Oily fish e.g., mackerel, herring, canned fish					
Processed meats e.g. bacon, sausages, etc.					
Pastries e.g., pies, samosas, sausage rolls, buns, puff-puff, egg buns, shawama, etc.					
Fast foods e.g., pizza, fried chicken, ham burger, fried rice,					
White Bread					
Whole wheat bread					
Rice/spaghetti/Macaroni/Noodles					
Yam, Cassava, Potatoes etc.					
Legumes, nuts and seeds e.g., beans, groundnuts, melon, etc.					
Milk and products					
Meat, poultry and fish					
Food Sources of Vitamin D					
Fish (Mackerel, tuna, sardine)					
Cod liver oil					
One (1) sachet (20g) of whole milk					
Fortified margarine (e.g. blue band)					
One (1) sachet (20g) of milo					
One Egg yolk					
Vitamin D supplements or calcium (with vitamin D)					

supplements					

Section E: ATHROPOMETRY MEASURMENT

34. (a) Height (m): …… (b) Weight (kg): …… (c) BMI (kg/m2: ……

(d). Waist Circumference (cm): …… (e) Hip Circumference (cm): ……

35. Blood Pressure Measurement (Mm/Hg) (After A Seated 5-Minutes Rest) (a) BP1……... (b) BP2 (At Least 10 Minute after BP1) …… (c) Final BP: (BP1 + BP2)/2……

Section F: Laboratory Data / Biochemical Indices

i. Fasting Blood Glucose (mg/dl) ……

ii. Random Blood Glucose (mg/dl) ……...

iii. Serum ELISA vitamin D (ng/ml) ……

Appendix III

s

MINISTRY OF HEALTH

HEALTH PLANNING, RESEARCH AND STATISTICS DEPARTMENT

PRIVATE MAIL BAG NO. 4421 OSOGBO, OSUNSTATE OF NIGERIA

Your Ref. No: _____

All communications should be addressed to the Permanent Secretary quoting

Our Ref. No OSHREC/PRS/569T/329 23rd Feb, 2023

ABDULKAREEM SELIM ABUZAYD,
Department of Nutrition and Dietetics,
Faculty of Basic Medical Sciences
Lead City University, Ibadan.

ASSESSMENT OF DIETARY PATTERNS, LIFESTYLES, VITAMIN D STATUS AND UNDIAGNOSED DIABETES AMONG TRADERS IN SELECTED MARKETS IN EDE, OSUN STATE

I wish to inform you that the Osun State Health Research Ethical Committee (OSHREC) has granted you an approval to proceed on the above exercise.

The approval lasts one year spanning 23rd Feb., 2023 and 23rd Feb., 2024. You are to inform the Committee the starting date of the exercise and if there is any delay in starting, kindly inform the Committee to enable it adjust the date accordingly which will allow for monitoring by designated representative of the Committee. A copy of the outcome of the research must be made available to the Committee.

Regard this letter as Certificate of OSHREC approval.

Thank you.

Dr. I. A. Adekunle
Chairman
(OSHREC)

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Appendix IV

Department of Nutrition and dietetic.
Faculty of Basic Medical Sciences
Lead City University, Ibadan.
13th February, 2023.

The Baba Loja of Ede Land.
Ede North Local Government.
Ede, Osun State.

Dear Sir.

REQUEST FOR THE PERMISSION TO DO HEALTH OUT REACH FOR THE TRADERS AND COLLECTION OF DATAS FOR MEDICAL RESEARCH.

I, Abdulkareem Selim Abuzayd, of Olukolo Asinjapa Ede, a post graduate student of the department of Human Nutrition and dietetics, Lead City University Oyo State in collaboration with Al Ameen Hospital and Maternity Home Ede, hereby request for your permission and the consent of the traders attending the three major markets to do health outreach and conduct a medical research work title ***"Assessment of Dietary Patterns, Lifestyles, Vitamin D Status, And Undiagnosed Diabetes Among Traders in Selected Markets In Ede, Osun State."***

I will strictly adhere to the law guiding ethics of research while going about research work and no risk whatsoever will be incurred by the participants.

Thank you for your favorably response.

Attached here is the copy of ethical approval given from state ministry of health, Abere, Osun State.

Yours Respectfully,

14/02/23

Abdulkareem S.A

08057523645

(Email: [redacted] **)**

Cc:

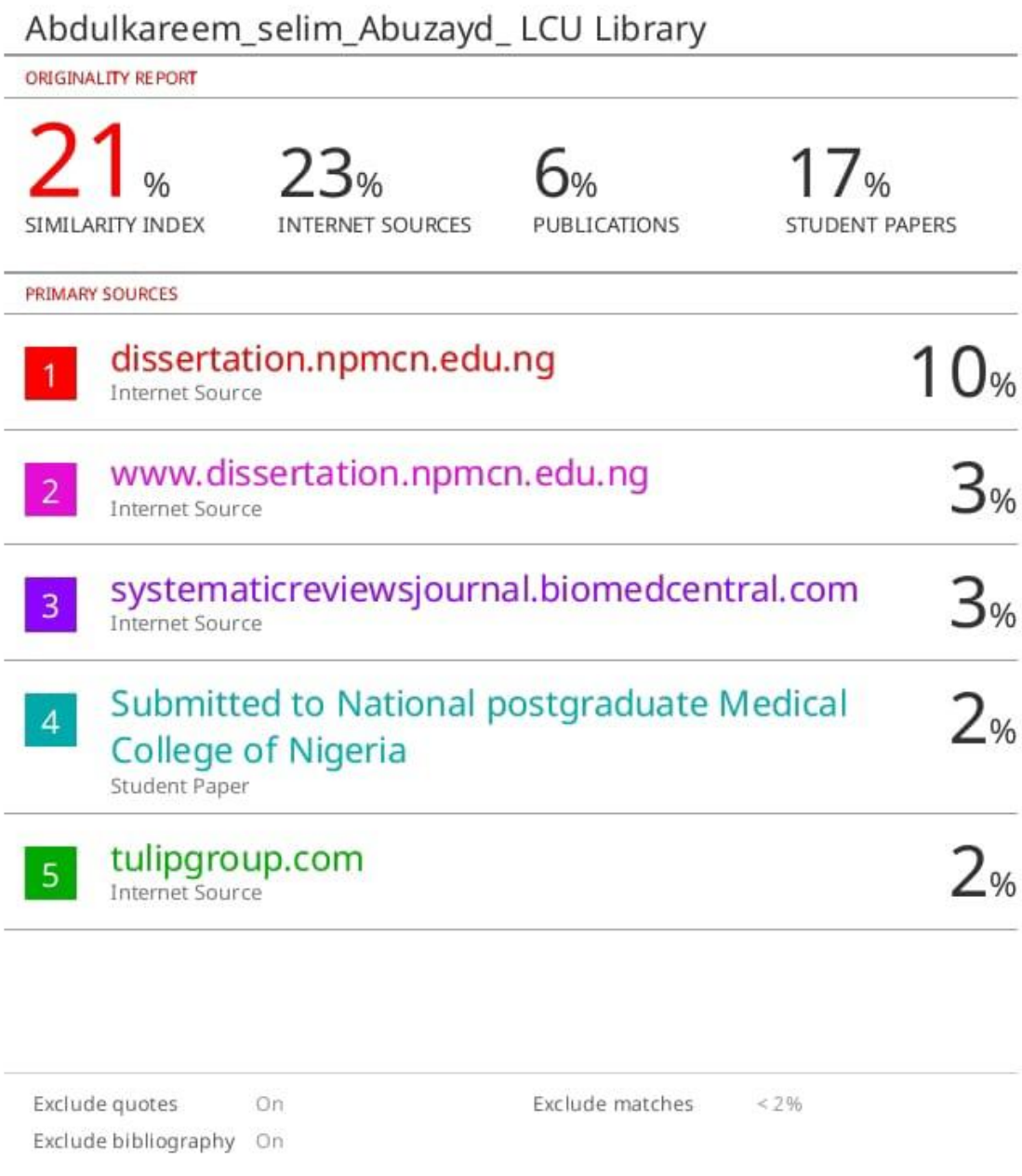
Iya Loja of Ede Land

Iya Loja and Baba Loja of Every selected Market

(Oje Olobi, Owode and Sekona Market)

The secretary of every market trader's association

Appendix V



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Bio-data

Abdulkareem Selim Abuzayd

Nursing Unit, Medical Centre, Federal Polytechnic Ede Osun State, Nigeria.

+234-805-7523-645

abdulkareem.selim@lcu.edu.ng

Professional Summary

- A conscientious registered nurse with 16 years of strong experience in delivering quality care to patients in general nursing, various emergency care and child welfare services.
- Strong knowledge of medicine, nutrition and dietetic, pharmacology, mental health, and standard of care to patients.
- Caring and reliable person with a reputation for building a great rapport between medical providers and patients.
- Committed to making patients more informed and comfortable during their care.

Core Skills

- Dedicated patient advocate
- Ability to deal with emotionally charged situations
- Ability to follow instructions and procedure
- Expert multitasker and highly organized
- Excellent sense of integrity and honesty
- Strong oral and written communication
- Strong observational skills
- Medical Procedures
- Excellent team working skills
- Flexibility and adaptability
- Ward Management
- Health promotion

Career Summary

- **Assistant Chief Nursing Officer**

May 2013 – Present **Federal Polytechnic, Medical Center Ede, Osun-State.**

- **Registered Nurse**

January 2013-April 2013. **General Hospital Ringim, Jigawa State North Western Region.**

- **Senior Registered Nurse**

Febuary2009 - March 2013. **Maradun General Hospital and Moriki General Hospital Under Zamfara State Hospital Service Management Board Gusau.**

- **Registered Nurse**

March 2008–January 2009. **Kura General Hospital Under Kano State Hospital Management Board, Kano.**

Education

Master Of Science in Human Nutrition and Dietetics **In view**
Lead City University, Ibadan, Oyo State, Nigeria

Bachelor of Science in Nursing **2019**
Ladoke Akintola University of Technology, Ogbomoso, Oyo State, Nigeria

Registered Nurse **2007**
Kwara State college of Nursing, Formal UITH, Ilorin, Kwara State, Nigeria

Hobbies

Reading, Meditating, Caring And Relaxation.

Number of Peer-Reviewed Publications:

Two

The University Compliance Certification

This is to certify that the thesis of Abdulkareem Selim Abuzayd with Matric No. LCU/PG/001927, Human Nutrition and Dietetic unit, the Department of Biological Sciences, Faculty of Basic Medical and Applied Sciences, Lead City Univrity, Ibada, Nigra is in full compliance with the approved university format.

_____ _____

Date Signature