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# Improving the prevention and treatment of Lean Type 2 Diabetes in Sub-Saharan Africa: A review

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**ABSTRACT**

With its normal or low body mass index, lean Type 2 Diabetes Mellitus (T2DM) poses particular issues in Sub-Saharan Africa, where the disease is becoming more common in the middle of complicated socioeconomic and healthcare environments. In contrast to usual T2DM presentations, this study examines the unique risk factors, clinical characteristics, and genetic predispositions linked to lean type 2 diabetes (LT2D) in sub-Saharan Africa. We critically evaluate the efficacy of the current treatment and preventative plans, emphasizing the shortcomings in lifestyle modifications, early diagnosis, and access to culturally appropriate health education. We also assess the effectiveness of current pharmaceutical treatments, highlighting the necessity for tailored strategies that consider the distinct genetic and metabolic characteristics of LT2DM patients in Sub-Saharan Africa. This review further addresses the socioeconomic limitations, lack of qualified healthcare providers, and restricted access to healthcare facilities as obstacles to providing good care. Our findings indicate a notable lack of awareness regarding Lean Type 2 Diabetes (LT2D) in Sub-Saharan Africa, revealing a considerable gap in understanding its unique characteristics compared to traditional Type 2 Diabetes. Essential recommendations involve launching focused educational initiatives to enhance awareness among healthcare professionals and the general population, incorporating LT2D screening into standard health evaluations, and creating culturally appropriate strategies to enhance diagnosis and management. These steps are essential for tackling the specific challenges of LT2D in this area.

**Keywords:** Lean Type 2 Diabetes, Sub-Saharan Africa, prevention, treatment, healthcare access, personalized medicine

## INTRODUCTION

### Overview of Lean Type 2 Diabetes (LT2D)

Type 2 diabetes (LT2D) is a distinct type of T2DM, defined as diabetes occurring in non-obese adults with a body mass index (BMI) of less than 25 kg/m$^2$. Compared to the traditional form of type 2 diabetes, which is associated with obesity and insulin resistance, LT2D presents unique challenges with regard to diagnosis, management, and understanding of its underlying pathophysiology. The development of LT2D casts doubt on the widely held belief that being overweight is the primary cause of T2DM and emphasizes the disease's diversity (Salvatore et al., 2022). Individuals with LT2D also exhibit many of the clinical traits linked to conventional T2DM, including insulin resistance, hyperglycemia, and an increased risk of cardiovascular complications. It is the relatively low BMI, however, that distinguishes this category and gives rise to serious questions about the disease's underlying causes. One major distinction between obese T2DM and LT2D patients appears to be the maintenance of β-cell function. Although it normally occurs to a lesser degree, insulin resistance can still exist in LT2D. Insulin secretion or β-cell dysfunction may be more closely linked to the primary problem in LT2D. Weaker or delayed insulin sensitivity to glucose can lead to hyperglycemia (Chantrapanichkul et al., 2020).

The particular cause of LT2D is unknown, however, it is most likely complicated and arises from a mix of genetic

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predisposition, environmental factors, and maybe unique metabolic anomalies. Genetic studies have revealed a higher frequency of certain SNPs associated with insulin sensitivity and secretion in thin individuals with type 2 diabetes. Numerous hereditary factors may increase a person's susceptibility to diabetes regardless of body weight. Additionally, there may be differences in the distribution of fat. For instance, some LT2D patients may have normal BMIs but higher levels of ectopic or visceral fat, which could contribute to metabolic dysregulation (Sheikhpour et al., 2020). Additionally, some studies indicate that LT2D may be more prevalent in some ethnic groups, suggesting a potential genetic or environmental foundation for this phenotype. For example, lipid abnormalities that raise the risk of cardiovascular disease, such as increased triglycerides and low high-density lipoprotein (HDL) cholesterol, may be more common in LT2D patients. These patients may have dyslipidemia and hypertension, two characteristics of the metabolic syndrome, in addition to their normal weight. These risk variables highlight the need for LT2D patients to receive comprehensive cardiovascular risk management, akin to the strategy employed for obese T2DM patients (Yang & Civelek, 2020). Since the typical therapeutic approach to type 2 diabetes (T2DM), which generally entails weight loss and lifestyle adjustment, may not be as relevant or effective for lean patients, managing LT2D presents distinct issues. For such individuals, the emphasis might need to change to pharmaceutical therapies that improve insulin sensitivity or secretion in order to maximize glycemic control. It may be more appropriate to use drugs like metformin, which increases insulin sensitivity, or sulfonylureas and incretin-based treatments, which increase insulin secretion. Furthermore, lifestyle treatments should be customized to the requirements of patients who are thin, with an emphasis on dietary modifications and physical exercise that promote metabolic health generally rather than solely on weight loss (Bellary et al., 2021).

The prognosis for lean people with diabetes (LT2D) may be different from that of obesity-related type 2 diabetes (T2DM). According to certain research, lean people with diabetes may be more likely to die, especially from cardiovascular causes. This could be a result of lean people with T2DM being diagnosed later in life when problems have already arisen, or having a more serious underlying disease process. In light of this, cardiovascular risk factors must be aggressively managed and detected early in this population. As a result, Lean Type 2 Diabetes, which is defined by the presence of diabetes in people with a normal or low BMI, is a distinct and significant subset of T2DM. Its distinctive characteristics include distinct metabolic problems and a distinct pathophysiological background, maybe emphasizing β-cell dysfunction more (Blasco-Blasco et al., 2020).

## Epidemiology and Global Prevalence, with a Focus on Sub-Saharan Africa

Although the global burden of diabetes is extensively reported overall, the epidemiology of type 2 diabetes in particular is still poorly understood, especially in places like Sub-Saharan Africa (**Figure 1**) where distinct patterns of disease prevalence and risk factors appear (Skinner et al., 2023). The prevalence of LT2D varies throughout the world and is higher in some groups than others, especially in Asia and Africa. Research indicates that a sizable fraction of T2DM patients live lean lifestyles in various Asian nations, such Japan and India. This phenomenon may be related to dietary practices, lifestyle variations, and genetic factors. Similarly, LT2D seems to be more common in Sub-Saharan Africa than it is in Western nations, where the bulk of T2DM diagnoses are linked to obesity and overweight. Numerous factors, including a complex interaction between hereditary susceptibility, early-life nutritional inadequacies, and potentially the effect of infectious infections that might affect metabolic health, contribute to the increased prevalence of LT2D in these areas (Skinner et al., 2023).

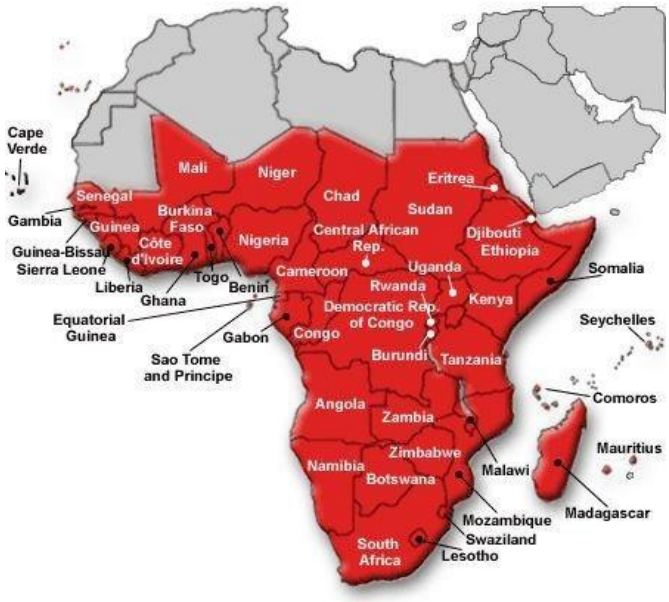
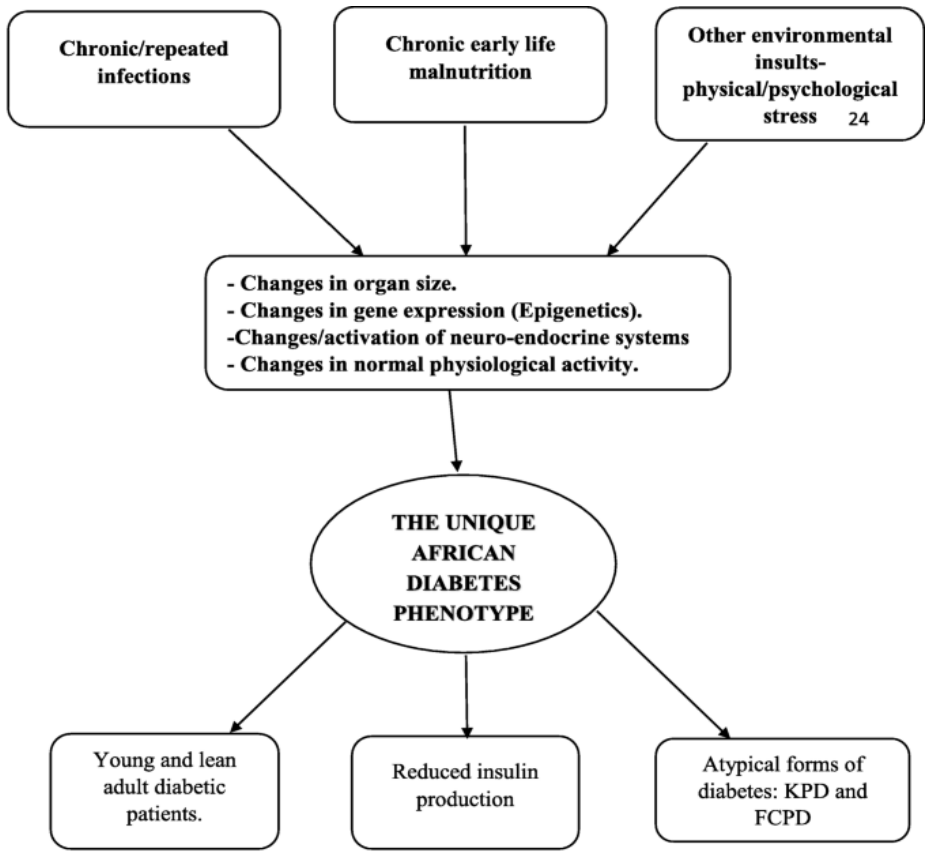



**Figure 1.** Map of Sub-Saharan African countries (David et al., 2020)

The epidemiology of LT2D is especially interesting in Sub-Saharan Africa since this region has a particular additional burden of disease: non-communicable diseases like diabetes are becoming more common while infectious diseases are still prevalent. Because of inadequate diagnostic resources, a lack of infrastructure for healthcare, and a lack of awareness of the condition among healthcare professionals, the prevalence of LT2D may be underreported or overestimated in many African nations. However, the data that are now available show that LT2D is a serious concern, particularly in rural areas where diabetes prevalence is rising despite obesity being less common. Despite their thin phenotype, individuals may be predisposed to metabolic problems later in life due to a combination of environmental exposures, including starvation in early life, and genetic factors (**Figure 2**) (Kibirige et al., 2019). Additionally connected to Sub-Saharan Africa's fast urbanization and lifestyle changes is the region's rising diabetes prevalence, including LT2D. Dietary patterns alter as populations move from traditional rural lives to urban settings. This might result in a paradoxical situation where people may still be slim yet have higher rates of metabolic risk factors like insulin resistance, dyslipidemia, and hypertension. A crucial component of the epidemiology of LT2D in the area




KPD: Ketosis Prone Diabetes, FCPD: Fibrocalculous pancreatic diabetes.

**Figure 2.** Pharmacological Treatments for LT2D: Efficacy and Availability in Sub-Saharan Africa (Kibirige et al., 2019)

is the urban-rural divide, which emphasizes the need for more complex public health initiatives that address undernutrition as well as the new problems associated with non-communicable diseases (Adjanor et al., 2020).

There is still a substantial epidemiological data gap in Sub-Saharan Africa, despite the disease's increasing recognition. Few research has distinguished between various diabetes phenotypes; the majority of studies have concentrated on the prevalence of diabetes generally. The inability to obtain precise data on LT2D makes it more difficult to create focused treatments and public health regulations. More focused research is required since the epidemiology of LT2D may fluctuate greatly within the region due to genetic variability among African groups and varied environmental exposures. The prevalence of LT2D worldwide and its particular effects in Sub-Saharan Africa highlight how crucial it is to comprehend the various ways that diabetes manifests itself in various communities. Comprehensive research on the epidemiology of LT2D is crucial as the epidemiological change continues in many African countries with rising rates of non-communicable diseases alongside persistent infectious disorders (Kibirige et al., 2019). Finding the genetic, environmental, and socioeconomic factors that contribute to the illness is the main goal of this research since it may help build preventative and treatment plans that are suitable for the local and cultural contexts.

## Significance of the Review

This review has significance as it examines Lean Type 2 Diabetes (LT2D) specifically in the context of Sub-Saharan Africa, a location where socioeconomic, cultural, and environmental factors have a particular impact on the condition's epidemiology and effects. Given the rising incidence of diabetes and the heavy toll it takes on both patients and healthcare systems, addressing LT2D in this area is critical. Because LT2D does not meet the traditional profile of Type 2 diabetes, which is typically associated with obesity, it is frequently underdiagnosed and undertreated. This gap exacerbates the health consequences of those afflicted by it by delaying diagnosis and providing incorrect therapy in Sub-Saharan Africa, where the prevalence of lean individuals is high (Firima et al., 2022). This review emphasizes how important it is to treat LT2D in Sub-Saharan Africa as a separate clinical category. Patients with LT2D, who frequently have distinct metabolic traits and risk factors, may not benefit from traditional diabetes care strategies that are based on the typical presentation of Type 2 diabetes. This emphasizes how important it is to provide focused interventions that are specially designed to meet the particular requirements of LT2D patients in this area. Healthcare systems can enhance early diagnosis, optimize treatment, and ultimately lessen the burden of diabetes-related complications—which are presently on the rise in Sub-Saharan Africa—by treating LT2D with tailored initiatives (Gatete J de et al., 2023).

The urgent need for new reliable diagnostic methods and standards that are suitable for the local and cultural contexts for LT2D in Sub-Saharan Africa is also highlighted by this research. Relying too heavily on diagnostic criteria created for groups where obesity is more common can result in under- or misdiagnosis of LT2D in lean people, which can

hurt management outcomes. Diagnostic instruments must be modified or created with the distinct metabolic profiles of LT2D patients in this area in mind. Further investigation is also required into the possible contribution of infectious diseases, including HIV, to the development of LT2D, as well as the interplay between diabetes, poverty, and malnutrition (Martins et al., 2020).

The significance of creating focused interventions to close these knowledge gaps is emphasized by this review as well. Through region-specific research, the creation of diagnostic criteria that are appropriate for the local culture, and the execution of public health efforts that address the socioeconomic determinants of health, such interventions should concentrate on improving the detection and management of LT2D. Community-based education initiatives that emphasize the unique characteristics of LT2D, the value of early diagnosis, and the necessity of following treatment plans may be one way to achieve this. Furthermore, healthcare workers in the region must receive training on how to identify and successfully manage LT2D while taking into account the available resources and the local context (Gatete J de et al., 2023).

## EPIDEMIOLOGY OF LT2D IN SUB-SAHARAN AFRICA

### Prevalence and Demographics

Lean Type 2 Diabetes (LT2D) is a highly variable disease that is influenced by a complex interplay of genetic, environmental, and socioeconomic factors. While LT2D is more commonly associated with obesity than with other forms of the disease, its prevalence varies greatly across Sub-Saharan Africa, and this heterogeneity is due to a variety of factors, including differences in diet, physical activity, access to healthcare, and the burden of infectious diseases. In many parts of this region, LT2D is becoming a serious public health concern, despite being frequently ignored. For example, LT2D may be more common in rural areas than in urban areas due to the prominence of physical labor and traditional diets, as well as the latter's tendency toward increased intake of processed foods and sedentary activity (Chilunga et al., 2019). To properly comprehend these variances and create focused public health interventions, more research that are particular to certain regions are necessary as the data on LT2D prevalence are currently few. In Sub-Saharan Africa, demographic variables like age, gender, and socioeconomic level are also very important in determining the frequency and symptoms of LT2D. One important factor is age, with middle-aged and older persons more likely to be diagnosed with LT2D. Nevertheless, there is increasing proof that LT2D may also underdiagnosed in younger individuals, especially in areas with high incidences of infectious diseases and malnutrition. This could confuse the clinical presentation and cause a delay in diagnosis. This emphasizes the requirement for age-specific screening and management plans that consider the population's overall health context (Chilunga et al., 2019).

Notable variations exist across genders in terms of LT2D prevalence and results. Women may be more susceptible to LT2D in many Sub-Saharan African nations because of an integration of biological, cultural, and socioeconomic factors. For instance, women frequently take on the majority of domestic duties, such as caring for others and preparing meals, which may restrict their access to healthcare and opportunities for physical activity. Furthermore, eating habits and health-seeking behaviors may be influenced by gender roles and cultural norms, which could result in disparities in how men and women present and treat diseases. To create equitable and successful interventions that guarantee women have access to the tools and assistance they require to manage LT2D, these gender dynamics must be understood (Keith et al., 2023). Another important factor affecting the management and prevalence of LT2D in Sub-Saharan Africa is socioeconomic level. Due to limited access to healthcare, lower levels of education, and increased exposure to unfavorable environmental circumstances like poor nutrition and infectious infections, those with lower socioeconomic status are frequently more susceptible to LT2D. The difficulties of controlling LT2D, such as being able to buy prescription drugs, maintain a healthy diet, and get frequent medical attention, are made more difficult by poverty. Furthermore, the stigma attached to diabetes in some societies may deter people from getting a diagnosis and treatment in a timely manner, exacerbating the health disparities that people from lower socioeconomic backgrounds already face (Obasohan et al., 2023).

The complexity of treating LT2D in Sub-Saharan Africa is highlighted by the combination of these demographic variables with local differences. Public health solutions need to be customized to meet the unique requirements of various populations while accounting for the wide range of social, economic, and cultural situations in which LT2D is found. This necessitates a sophisticated comprehension of how regional characteristics, age, gender, and socioeconomic status interact to affect the frequency and consequences of LT2D. For example, focused interventions that address gender-specific barriers to healthcare access and health education may be more successful in areas where women are disproportionately affected by LT2D. Similarly, in areas with high levels of poverty, community-based programs that provide affordable healthcare services and nutritional support could help mitigate the impact of socioeconomic disparities on LT2D outcomes (Gouda et al., 2019).

### Contributing Factors

In Sub-Saharan Africa, a complex combination of genetic, dietary, infectious, socioeconomic, and environmental factors influences the prevalence of lean Type 2 Diabetes (LT2D). These variables interact in complex methods to influence the development and progression of LT2D in this area rather than acting alone. In groups where a high frequency of specific genetic features predisposes individuals to LT2D, genetics plays a major influence in the illness. Genetic predisposition to LT2D is frequently associated with particular genes that affect glucose metabolism overall, β-cell function, and insulin sensitivity (Kibirige et al., 2019). Genetic investigations have found distinct variations that, even in the absence of obesity,

are linked to an elevated risk of LT2D among populations of Sub-Saharan African descent. The medical situation may be further complicated by the interaction of these hereditary variables with other metabolic diseases that are common in the area, such as dyslipidemia and hypertension. Nevertheless, further investigation is required to pinpoint the precise genetic variations that contribute to LT2D in various African communities, as the condition's genetic base remains incompletely understood. Comprehending these genetic foundations may facilitate the creation of more efficient, customized interventions and therapies for LT2D (Ogunjobi et al., 2024).

Another important component in the development of LT2D in Sub-Saharan Africa is nutrition. Although Type 2 diabetes has historically been linked to obesity and overnutrition, undernutrition or a history of malnutrition is a common cause of LT2D. The main characteristics of LT2D, insulin resistance and poor glucose tolerance, can be more likely to develop as a result of a variety of metabolic changes brought on by chronic undernutrition. Furthermore, metabolic dysfunction may be made worse by the high frequency of micronutrient deficiencies, such as those affecting vitamins D and B12. An additional factor contributing to the rising incidence of LT2D in urban areas is the shift from traditional diets to more Westernized eating patterns, which are marked by greater consumption of processed foods and refined sugars. This nutritional transition, coupled with the persistence of undernutrition in rural regions, creates a dual burden of malnutrition that complicates the management of LT2D (Adjanor et al., 2020).

Infectious disorders are also essential to the development and treatment of LT2D, especially those that are endemic to Sub-Saharan Africa. Chronic infections, including HIV and TB, have been shown to affect glucose metabolism and may put people at risk for LT2D. For example, antiviral medication use in HIV-positive people has been linked to a higher risk of diabetes, particularly LT2D. Insulin resistance may also be exacerbated by diseases like malaria, which have the potential to significantly increase inflammation and immunological activity. Given that the prevalence of infectious diseases is still high in many regions of Sub-Saharan Africa, the relationship between chronic infections and LT2D is a developing issue. Addressing this interaction requires a comprehensive approach that integrates diabetes care with infectious disease management, ensuring that individuals receive appropriate treatment for both conditions (Gouda et al., 2019).

The environment and socioeconomic factors play equal roles in determining the LT2D landscape in Sub-Saharan Africa. The development and inadequate management of long-term diabetes (LT2D) are largely caused by socioeconomic factors such as poverty, low levels of education, and restricted access to healthcare. Lower socioeconomic group members frequently have less access to dietary supplements, medical care, and prescription drugs—all of which are critical for the management and prevention of LT2D. Further complicating the management of LT2D are cultural attitudes and practices that may have an impact on food choices and health-seeking behaviors. Urbanization and modifications in patterns of physical activity are examples of environmental factors that have a big impact. The shift from rural to urban living has been associated with increased exposure to risk factors for LT2D, such as sedentary lifestyles, poor diet, and pollution. These environmental changes are particularly pronounced in rapidly growing cities, where the infrastructure for healthy living is often inadequate (Koçak et al., 2021).

The complex nature of LT2D in Sub-Saharan Africa is highlighted by the interaction of various key elements. In this situation, treating LT2D necessitates a comprehensive strategy that takes into account the disease's dietary, genetic, viral, socioeconomic, and environmental causes. Public health interventions need to be customized to meet the specific requirements of various populations while accounting for the wide range of variables that affect the onset and course of long-term diabetes. This could involve addressing socioeconomic barriers to healthcare access, managing chronic infections, and enhancing nutritional status (Goedecke & Olsson, 2020). To help design more focused and efficient therapies, further study is required to identify the precise genetic and environmental variables that contribute to LT2D in various African populations (Boukhalfa et al., 2023).

## CHALLENGES IN THE DIAGNOSIS OF LT2D

### Clinical Presentation

In the African context, lean type 2 diabetes (LT2D) frequently manifests with atypical symptoms, deviating from the conventional presentation of the illness observed in other groups. Individuals with LT2D often present with a variety of distinct features that make diagnosis and treatment more challenging in several African nations, such as South Africa, Ethiopia, and Nigeria. In contrast to conventional Type 2 diabetes, which is closely linked to obesity and metabolic syndrome, low- or generally normal-body mass index (BMI) people can develop LT2D. It is extremely difficult to identify and diagnose the illness early because of this lean phenotype, insulin resistance, and other metabolic dysfunctions (Ekoru et al., 2019). Among the most prominent abnormal characteristics of LT2D in the African setting is the high incidence of complications connected to diabetes at the time of diagnosis. Patients who do not have the usual risk factors, such as obesity or a family history of diabetes, frequently come with advanced sequelae, such as nephropathy, retinopathy, or neuropathy, in nations like Kenya and Ghana. This implies that the illness could develop slowly or go undiagnosed for a while, showing symptoms only when problems materialize. Further complicating the clinical picture and potentially misdiagnosing LT2D as Type 1 diabetes or malnutrition-related diabetes are the indications of malnutrition that persons with LT2D may display in many African settings, such as muscle wasting and low subcutaneous fat.

Because LT2D shares clinical characteristics with other diabetes subtypes, it might be difficult to differentiate between it and other kinds of diabetes in the African context. For instance, type 1 diabetes is defined by a complete lack of insulin and usually manifests in younger people as weight loss, polyuria, and polydipsia that occur quickly. Nonetheless, some people with LT2D may also exhibit these symptoms in African nations like Tanzania and Uganda, which could result in a mistaken diagnosis of Type 1 diabetes (Balogun et al., 2020).

**Table 1.** Diagnostic tool limitations impacting LT2D management in Sub-Saharan Africa

| Diagnostic Tool/Criteria | Description | Limitations in Sub-Saharan Africa |
|---|---|---|
| Fasting Plasma Glucose (FPG) | Measures blood glucose levels after an overnight fast. Diagnosis of diabetes if FPG ⩾ 126 mg/dL. | Limited access to reliable laboratory facilities, variability in fasting practices due to cultural and religious factors. |
| Oral Glucose Tolerance Test (OGTT) | Measures blood glucose levels before and 2 hours after consuming a glucose-rich drink. | Expensive and time-consuming, low patient compliance, and lack of standardized testing protocols in rural areas. |
| Glycated Hemoglobin (HbA1c) | Reflects average blood glucose levels over the past 2-3 months. Diagnosis of diabetes if HbA1c ⩾ 6.5%. | Inconsistent availability of HbA1c testing equipment, inaccurate results in populations with high prevalence of anemia. |
| Random Plasma Glucose (RPG) | Measures blood glucose levels at any time, without fasting. Diagnosis if RPG ⩾ 200 mg/dL with symptoms. | Lack of trained personnel to interpret results, variability due to non-standardized testing conditions. |
| Body Mass Index (BMI) | Calculation of BMI based on height and weight; used to assess obesity and overweight as diabetes risk. | Not an accurate indicator for LT2D, as LT2D patients typically have normal or low BMI, leading to underdiagnosis. |
| C-Peptide and Insulin Levels | Measures endogenous insulin production to distinguish between Type 1 and Type 2 diabetes. | High cost, limited availability, and lack of specialized laboratory facilities for accurate measurement. |
| Urinalysis (Glucosuria and Ketone Testing) | Checks for the presence of glucose and ketones in the urine. | Often used in resource-limited settings, but provides less accurate and less specific information compared to blood tests. |
| Clinical Assessment (Symptom-based Diagnosis) | Diagnosis based on common diabetes symptoms such as polyuria, polydipsia, and unexplained weight loss. | Symptoms can overlap with other conditions prevalent in Sub-Saharan Africa (e.g., tuberculosis), leading to misdiagnosis. |
| Point-of-Care Testing Devices (e.g., glucometers) | Portable devices for measuring blood glucose levels, used in rural and remote areas. | Limited access to high-quality devices, lack of standardization, and variability in results due to environmental conditions. |

Additionally, especially in thin people, LT2D can show similarly to Latent Autoimmune Diabetes in Adults (LADA), a type of diabetes that shares characteristics with both Type 1 and Type 2 diabetes. Making the difference is essential for the proper course of treatment since LT2D demands a different treatment strategy than Type 1 diabetes or LADA. Differentiating between LT2D and other types of diabetes, like malnutrition-related diabetes or ketosis-prone diabetes (KPD), becomes more difficult in the African setting. Similar to LT2D, malnutrition-related diabetes, which has been documented in nations like Malawi and Sudan, is linked to persistent undernutrition and can manifest as insulin resistance despite a lean body habitus (Balogun et al., 2020). On the other hand, KPD is defined by episodic ketoacidosis in people without the traditional signs and symptoms of Type 1 diabetes, and after an acute episode, insulin secretion usually returns. Without appropriate metabolic assessment and follow-up, KPD and LT2D share key clinical and biochemical markers, making distinction challenging. KPD has been documented in several West African nations, including Nigeria and Ghana.

In the African environment, diagnostic problems are further aggravated by the restricted availability of modern diagnostic technologies and resources in many healthcare settings. The variability of diabetes presentations in African cultures may not be adequately captured by the use of clinical criteria, which are mostly based on research done in Western populations. For example, hemoglobinopathies, which are common in areas like West and Central Africa, may have an impact on the use of HbA1c as a diagnostic criterion for diabetes. These circumstances may have an impact on the precision of HbA1c tests, which could result in an under- or incorrect diagnosis of LT2D (Wade et al., 2021). A thorough approach to the differential diagnosis of LT2D in the African environment is important in light of these difficulties. A thorough clinical history that covers the patient's dietary state, illness history, and family history of diabetes should be part of this strategy. The patient's metabolic profile should also be carefully taken into account. It could be required to do further diagnostic procedures to distinguish LT2D from other types of diabetes, such as autoantibody screening for Type 1 diabetes and C-peptide levels to measure residual insulin secretion. Moreover, studies on the distinctive characteristics of diabetes in African populations must be used to inform the establishment of region-specific diagnostic criteria and guidelines in order to increase the precision of diagnosis and the efficacy of treatment approaches (Boukhalfa et al., 2023).

## Diagnostic Tools and Techniques

### *Limitations of current diagnostic criteria in Sub-Saharan Africa*

Due to the specific socioeconomic and health circumstances of Sub-Saharan Africa, as well as the limits of current diagnostic criteria, the identification of diabetes, including Lean Type 2 Diabetes (LT2D), presents considerable hurdles (**Table 1**). With their varied environments and few resources, the conventional diagnostic methods and instruments, which were mainly created in affluent nations, might not be entirely appropriate or efficient in Sub-Saharan Africa. These constraints are made worse by the high prevalence of infectious diseases in the area, differing degrees of healthcare infrastructure, and unequal access to medical professionals and diagnostic centers (Bavuma et al., 2019). The basic approaches for diagnosing diabetes in Sub-Saharan Africa are glycated hemoglobin (HbA1c), oral glucose tolerance tests (OGTT), and fasting plasma glucose (FPG)

values. This represents one of the core shortcomings of the current diagnostic criteria. Numerous conditions common in the area, including starvation, anemia, and infectious illnesses like HIV and malaria, frequently have an impact on these tests. One example is the artificial lowering of HbA1c levels, a crucial criterion for long-term diabetes control, in people with hemoglobinopathies or anemia, which are prevalent in Tanzania, Ghana, Nigeria, and other nations. This may cause diabetes, especially LT2D, to be misdiagnosed or under classified in cases where individuals do not exhibit the typical signs and symptoms of hyperglycemia (Hodel et al., 2020).

The fundamental methods for diagnosing diabetes in Sub-Saharan Africa are glycated hemoglobin (HbA1c), oral glucose tolerance tests (OGTT), and fasting plasma glucose (FPG) values. This represents one of the core shortcomings of the current diagnostic criteria. Numerous conditions common in the area, including starvation, anemia, and infectious illnesses like HIV and malaria, frequently have an impact on these tests. One example is the artificial lowering of HbA1c levels, a crucial criterion for long-term diabetes control, in people with hemoglobinopathies or anemia, which are prevalent in Tanzania, Ghana, Nigeria, and other nations. This may cause diabetes, especially LT2D, to be misdiagnosed or underclassified in cases where individuals do not exhibit the typical signs and symptoms of hyperglycemia (Hodel et al., 2020). Research conducted in South Africa and Ethiopia, for instance, has revealed that the normal HbA1c threshold of 6.5% may understate the prevalence of diabetes because African people may have distinct glucose homeostasis or glycation rates. This raises concerns about whether a one-size-fits-all method of diagnosing diabetes in a region with such diversity is suitable (Kibirige et al., 2019). The lack of diagnostic infrastructure in many Sub-Saharan African countries exacerbates the shortcomings of the current diagnostic standards. In rural regions of nations such as Mozambique, Malawi, and Uganda, access to lab facilities that can conduct OGTTs or HbA1c tests is frequently restricted or nonexistent. Due to this, medical professionals are forced to use less precise techniques, including haphazard blood glucose testing, which might result in inaccurate diagnoses. Furthermore, the high expense of these tests and the low socioeconomic level of many patients further limit their application, which makes the implementation of early diagnosis and screening programs difficult. This is especially troublesome when it comes to LT2D patients, who might not show obvious symptoms and might not get recognized until problems start to show (Moetlhoa et al., 2023).

Another challenge is the co-occurrence of diabetes and other diseases that are common in Sub-Saharan Africa, like tuberculosis and HIV/AIDS. These infections can affect glucose metabolism through immune activation and persistent inflammation, which can result in hyperglycemia or insulin resistance that resembles diabetes. Without sophisticated diagnostic techniques like C-peptide measures or islet autoantibody testing, it can be challenging to distinguish between diabetes brought on by antiretroviral medication (ART) and long-term diabetes (LT2D) in nations with high HIV prevalence, such as Kenya, Zambia, and Zimbabwe. Sadly, outside of large cities, these sophisticated diagnostics are rarely accessible, which results in many LT2D patients being misdiagnosed or going untreated (Jeremiah et al., 2020). Moreover, the limitations of the diagnostic criteria that are now in use are influenced by cultural and socioeconomic issues. Diabetes, especially type 2 diabetes (LT2D), is not well understood by the general public or healthcare professionals in many Sub-Saharan African nations. Diabetes symptoms may not be regarded as a medical problem in nations like Mali, Burkina Faso, and Niger, where traditional beliefs and practices are deeply rooted, but rather as supernatural causes. Delaying getting medical attention can lower the chance of receiving a correct diagnosis. Moreover, the stigma attached to chronic illnesses, such as diabetes, may deter people from getting tested for these conditions, making it more difficult to diagnose and treat LT2D (Jeremiah et al., 2020).

Another barrier to the diagnosis of diabetes in Sub-Saharan Africa is the region's dependence on foreign diagnostic instruments and reagents. Numerous nations, like Sierra Leone, Liberia, and Sudan, rely on imported diagnostic kits that might not be appropriate for the local populace or environmental circumstances. For instance, the high temperatures and humidity typical in many regions of Sub-Saharan Africa can affect the stability of reagents used in HbA1c testing, resulting in unreliable findings. Furthermore, there are frequent shortages and disruptions in the provision of testing due to the unreliability of the diagnostic instrument supply chain (Kibirige et al., 2019).

### *Need for culturally and regionally appropriate diagnostic tools*

The heterogeneous population genetics in Sub-Saharan Africa necessitates culturally and regionally customized diagnostic methods. Genetic factors significantly contribute to the etiology of diabetes, and the genetic diversity within African people is among the largest globally. The variety can influence the manifestation and advancement of diabetes, necessitating the establishment of diagnostic criteria that align with the genetic composition of the local populace. Contemporary diagnostic instruments frequently neglect this variability, potentially resulting in mistakes in identifying LT2D, which may exhibit distinct pathophysiological characteristics (**Figure 3**) compared to other diabetes types commonly observed in Western cultures (Skinner et al., 2023).

Cultural traditions and dietary habits substantially affect the manifestation and management of diabetes in Sub-Saharan Africa. Traditional diets, often high in carbohydrates and low in fat and protein, can influence glucose metabolism and insulin sensitivity in distinct ways compared to Western diets. Moreover, the cultural attitudes towards body weight and health differ significantly throughout the region. In numerous African societies, increased body weight is frequently linked to health and affluence, in contrast to the slender phenotype observed in LT2D. The cultural context must be taken into account when formulating diagnostic methods and criteria, as the conventional indicators of obesity and insulin resistance employed in Western nations may lack relevance or accuracy for diagnosing LT2D in African people (Kiguli et al., 2019). A vital consideration is the accessibility and usability of diagnostic instruments in the area. Many locations in Sub-Saharan Africa confront considerable resource constraints, including inadequate access to

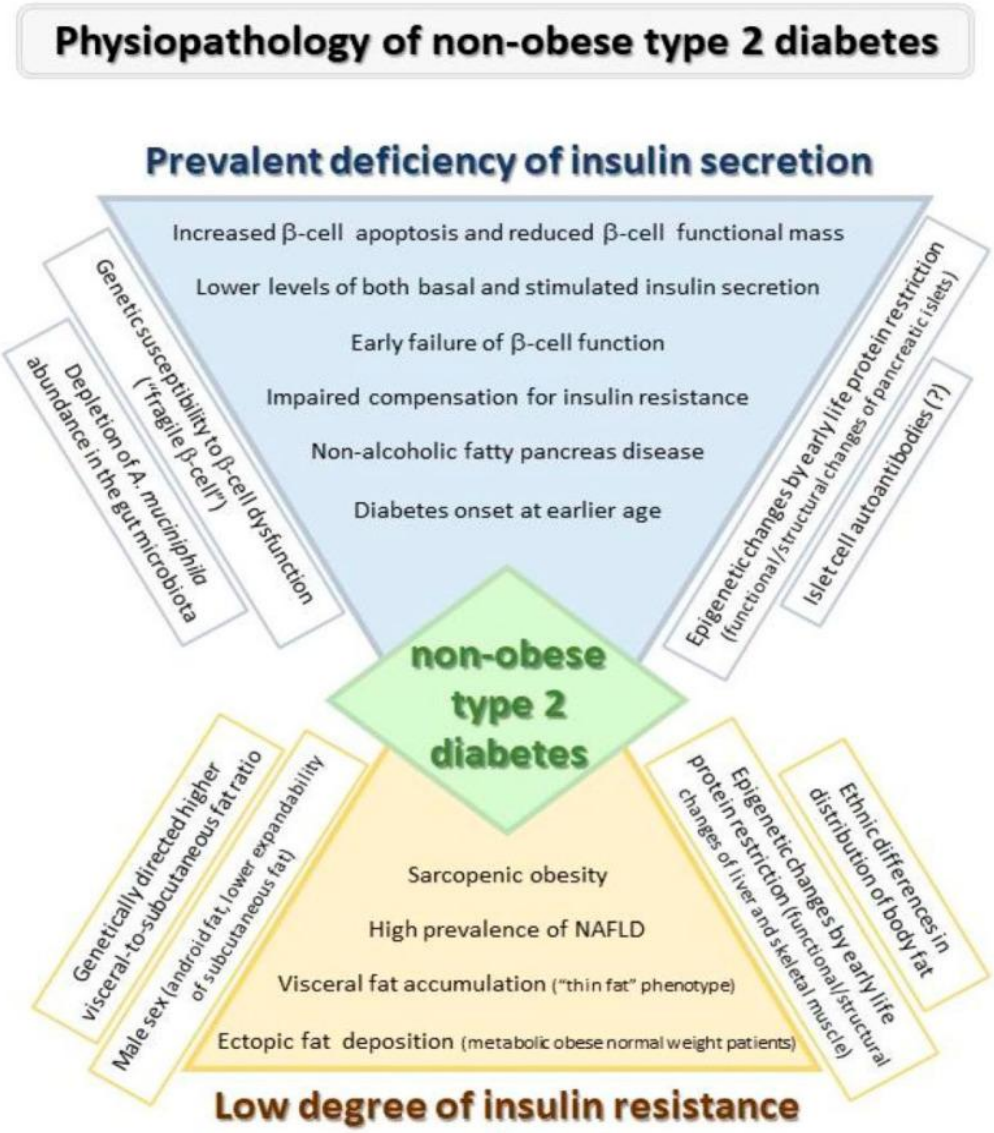



**Figure 3.** Pathophysiological characteristics of lean Diabetes (Salvatore et al., 2022)

healthcare facilities, laboratories, and qualified healthcare workers. Diagnostic methods that need complex equipment, several visits, or substantial laboratory work are generally impracticable in these circumstances. There is a pressing need for diagnostic instruments that are not only accurate but also easy to use, cost-effective, and adaptable to the local healthcare infrastructure. Point-of-care testing approaches, for example, could be more relevant for rural and resource-limited settings, allowing for speedier and more accessible diabetes screening and diagnosis (Osei et al., 2021).

The high frequency of infectious diseases such as HIV, TB, and malaria in Sub-Saharan Africa further complicates the diagnostic landscape. These disorders and their therapies can interfere with traditional diabetes diagnostic markers including HbA1c and fasting glucose readings. For example, antiretroviral medication (ART) used in HIV treatment can develop insulin resistance and hyperglycemia, which might be mistaken for or coexist with diabetes. Diagnostic tools are required to discriminate between diabetes caused by or aggravated by infectious illnesses and LT2D. This demands a comprehensive approach that examines the complicated interplay between chronic infections and diabetes, which is not often addressed in standard diagnostic criteria (Eze et al., 2022).

Culturally and regionally acceptable diagnostic techniques must also include the stigma associated with diabetes and other chronic diseases in particular societies. In many parts of Sub-Saharan Africa, chronic diseases like diabetes are commonly stigmatized, leading to delays in seeking diagnosis and treatment. Diagnostic methods and approaches need to be devised in a way that is sensitive to these cultural beliefs, encouraging early screening and eliminating the stigma associated with a diabetes diagnosis. This could incorporate community-based screening initiatives, the inclusion of traditional healers, or the use of culturally relevant communication tactics to enhance awareness and acceptability of diabetes screening (Sinclair, 2019). Furthermore, the creation of regionally suitable diagnostic tools involves collaboration between local researchers, healthcare professionals, and international experts. It is crucial to involve local stakeholders in the creation and execution of these tools to ensure they are culturally appropriate and realistically viable. This collaborative approach can also help to establish local capacity for diabetes

diagnosis and management, ensuring that the tools are sustainable and can be integrated into existing healthcare systems (Granda Morales et al., 2022).

## PREVENTION STRATEGIES

### Public Health Initiatives

#### *Community-based education and awareness programs*

One of the key goals of community-based education programs is to raise public understanding of LT2D, including its risk factors, symptoms, and long-term implications. In many Sub-Saharan African communities, awareness of diabetes is generally low. There is even less awareness of Lean Type 2 Diabetes (LT2D), which differs from traditional Type 2 Diabetes. LT2D does not present with the common indication of obesity that is frequently associated with Type 2 Diabetes. Education programs that are adapted to the local environment might assist bridge this knowledge gap by delivering culturally relevant information that resonates with the community. These programs generally incorporate local languages, and culturally relevant analogies, and involve community leaders or health workers who are trusted within the community. By using existing social institutions, these programs can more effectively communicate the need of recognizing early symptoms and obtaining urgent medical advice (Owoyemi et al., 2021). Community-based initiatives also emphasize the relevance of lifestyle adjustments in preventing LT2D. This is particularly relevant in Sub-Saharan Africa, where changes in nutrition and physical activity habits are contributing to an increase in non-communicable diseases like diabetes. Educational activities that focus on promoting healthy eating habits, boosting physical exercise, and controlling stress are vital. These programs sometimes involve practical demonstrations, such as cooking workshops that teach how to prepare nutritious meals using locally available foods, or organized group workouts that encourage regular physical activity. By making these activities accessible and relevant to the local people, these programs can create sustainable lifestyle modifications that lessen the chance of developing LT2D (Aremu et al., 2022).

In addition to lifestyle education, community-based awareness programs play a key role in eliminating the stigma associated with diabetes, including LT2D. In some parts of Sub-Saharan Africa, diabetes is widely misunderstood and stigmatized, leading to delays in diagnosis and treatment. Community education campaigns can assist to debunk myths and preconceptions regarding the disease, encouraging patients to seek medical help without fear of criticism. These programs can also give assistance for those already diagnosed with diabetes, including knowledge on how to manage the condition efficiently and live a healthy life. By building a more knowledgeable and supportive community context, these interventions can enhance both prevention and management outcomes for LT2D (Firima et al., 2022).

The success of community-based education and awareness programs also rests on their ability to be flexible and sensitive to the changing requirements of the community. Continuous evaluation and feedback systems are important to guarantee that these programs stay relevant and effective. This can involve regular community surveys, focus group discussions, or cooperation with local health authorities to assess the impact of the programs and make any adjustments. By being flexible and responsive, these programs can preserve long-term involvement and success in reducing LT2D (Wade et al., 2021). Finally, community-based education and awareness campaigns should be supported by broader public health policies and infrastructure. Government and non-governmental organizations must collaborate to ensure that these programs are well-funded, sufficiently staffed, and incorporated into the wider healthcare system. This entails educating community health workers, providing culturally relevant instructional materials, and ensuring that there is consistent message throughout all levels of the healthcare system. By connecting community-based programs with national public health objectives, it is possible to build a coordinated and comprehensive strategy to LT2D prevention in Sub-Saharan Africa (Aremu et al., 2022).

#### *Integration of LT2D prevention into existing public health frameworks*

Integrating the prevention of Lean Type 2 Diabetes (LT2D) into existing public health frameworks in Sub-Saharan Africa is crucial to successfully address the increased prevalence of this condition. The complexity of LT2D, especially its peculiar presentation and the unique challenges it offers in resource-limited settings, needs a systematic strategy that uses existing public health infrastructures. By embedding LT2D prevention within broader health programs, governments in Sub-Saharan Africa can optimize resources, expand the reach of prevention efforts, and ensure that LT2D is handled within the broader context of non-communicable diseases (NCDs). One of the primary benefits of integrating LT2D prevention into existing public health frameworks is the potential for synergy with ongoing NCD preventive efforts (Harrison & Jordan, 2022). Many Sub-Saharan African countries have created projects addressing cardiovascular illnesses, hypertension, and obesity—conditions that share common risk factors with LT2D. By linking LT2D prevention with these activities, public health agencies can establish holistic strategies that address several illnesses simultaneously. For example, community health programs that encourage physical exercise and good diets can be expanded to incorporate particular messaging and interventions for LT2D, ensuring that at-risk groups receive focused information and support (Alkhatib et al., 2021).

The integration of LT2D prevention into mother and child health initiatives is another crucial route. Given that early life variables, including maternal nutrition and birth weight, are key drivers of LT2D risk, including diabetes prevention in antenatal care and early childhood therapies can have long-term effects. Public health frameworks that already target maternal and child health can be extended to incorporate screening for gestational diabetes, education on good baby feeding habits, and tracking of childhood growth patterns. By intervening early in the life span, these programs can minimize the occurrence of LT2D and other metabolic disorders in later life (Juan & Yang, 2020). Also, integrating LT2D prevention into existing infectious disease control initiatives, particularly those targeting HIV and tuberculosis,

can boost the effectiveness of public health efforts. In Sub-Saharan Africa, the high burden of infectious diseases often coexists with rising rates of NCDs, generating a dual burden of disease. Patients with HIV or tuberculosis are at higher risk of developing diabetes, including LT2D, due to variables such as antiviral medication, chronic inflammation, and immunological dysregulation. Public health programs that focus on HIV and tuberculosis can incorporate diabetes screening and prevention techniques as part of comprehensive treatment. For instance, frequent screening for hyperglycemia in HIV clinics, together with counseling on lifestyle adjustments, can help diagnose and control LT2D early in individuals already involved in the healthcare system (Oga-Omenka et al., 2020).

Another important aspect of integrating LT2D prevention into public health frameworks is the utilization of current surveillance systems for NCDs. Robust data collection and monitoring systems are crucial for understanding the epidemiology of LT2D and identifying trends over time. Public health programs that already gather data on NCDs, such as hypertension and obesity, can be expanded to include LT2D-specific indicators. This integration can increase the accuracy of prevalence estimations, enable the tracking of risk variables, and facilitate the evaluation of prevention initiatives. Additionally, utilizing existing health information systems can strengthen the capacity of health authorities to respond to developing concerns associated with LT2D (Kabir et al., 2022). Capacity building within the public health workforce is also necessary for successfully integrating LT2D prevention into current frameworks. Health professionals, including doctors, nurses, and community health workers, must be provided with the information and abilities to recognize, diagnose, and manage LT2D. Training programs that are part of broader public health campaigns might include lessons on LT2D, ensuring that healthcare personnel know the condition's particular characteristics and can offer appropriate care. Furthermore, public health campaigns might be designed to promote awareness among health workers about the need of LT2D prevention, particularly in groups that may not exhibit usual risk factors for Type 2 Diabetes (David et al., 2020).

In addition to healthcare provider training, community engagement is crucial for the successful integration of LT2D prevention into public health frameworks. Community health workers, who frequently act as the primary link between the healthcare system and the community, play a critical role in delivering health education and preventative services. By adding LT2D prevention into their outreach operations, community health workers can assist raise awareness, encourage healthy habits, and allow early diagnosis of the condition. Public health frameworks that promote community-based interventions can ensure that LT2D prevention is effectively integrated into grassroots-level activities, making prevention efforts more accessible and culturally relevant (Wolfenden et al., 2019). Finally, policy-level integration is important to guarantee that LT2D prevention is emphasized within national health agendas. Governments and health ministries need to acknowledge LT2D as an important public health issue and devote resources accordingly. Integrating LT2D prevention into national NCD programs, health budgets, and development plans helps assure ongoing focus and financing for preventative activities. Moreover, policy integration can allow the coordination of multisectoral interventions that address the social determinants of health, such as poverty, education, and access to healthcare, which are crucial for successful LT2D prevention (Pati et al., 2020).

## Nutritional Interventions

Nutritional therapies are critical in addressing Lean Type 2 Diabetes (LT2D) in Sub-Saharan Africa, where malnutrition plays a substantial influence in its development. Unlike the classic type of Type 2 Diabetes, which is frequently connected with obesity, LT2D often appears in persons with a normal or low body mass index (BMI), showing the intricate interplay between diet and metabolic health. In many places of Sub-Saharan Africa, malnutrition, particularly during important periods such as childhood and pregnancy, contributes to long-term metabolic alterations that enhance the susceptibility to LT2D. Early-life undernutrition can impair pancreatic function, lower insulin sensitivity, and alter fat distribution, setting the scene for the development of diabetes in adulthood (Duhuze Karera et al., 2023). Addressing malnutrition through focused nutritional treatments is therefore critical for both the prevention and management of LT2D. Effective dietary treatments must include the individual nutritional demands and cultural circumstances of the groups at risk. In regions where food insecurity is prevalent, ensuring appropriate intake of vital nutrients is a priority. This includes treating shortages in micronutrients such as iron, zinc, and vitamins, which are critical for maintaining good metabolic function. Programs that give fortified foods or supplements can be beneficial in correcting these deficits. Additionally, improving the intake of traditional foods rich in whole grains, legumes, fruits, and vegetables, which are naturally low in processed sugars and harmful fats, can help minimize the incidence of LT2D (Duhuze Karera et al., 2023) (**Table 2**). These meals provide a balanced supply of nutrients and have a lower glycemic index, minimizing the chance of insulin resistance and glucose spikes that contribute to diabetes.

Public health policies play a vital role in promoting these dietary treatments. Policies that provide food security, improve access to healthy foods, and encourage nutritional education are crucial in the fight against LT2D. Governments and health organizations must prioritize the integration of nutritional education into existing health programs, particularly in places where malnutrition and LT2D are widespread. Educating the public about the importance of balanced diets and the hazards associated with processed foods might empower individuals to adopt healthier dietary choices (Petroni et al., 2021). In addition, regulations that limit the marketing and availability of unhealthy foods, particularly in metropolitan areas where the dietary transition is most prominent, are important to curb the rising incidence of LT2D. Implementing community-based programs that focus on diet and lifestyle modifications can also be useful. These programs can provide education, tools, and support to help people and families adopt healthier eating habits. For instance, community gardens and local food cooperatives can enhance access to fresh vegetables in places where food deserts are frequent. In addition, school-based nutrition

**Table 2.** Comparing traditional diets and recommended dietary interventions for LT2D prevention

| Aspect | Traditional Diets | Recommended Dietary Interventions |
|---|---|---|
| Carbohydrate Sources | High in starchy staples (e.g., maize, cassava, yams) | Emphasize low-glycemic index (GI) foods (e.g., whole grains, legumes) |
| Protein Intake | Plant-based (e.g., beans, lentils); occasional meat | Increase lean protein (e.g., fish, poultry, legumes); reduce red/processed meat |
| Fat Consumption | High in saturated fats (e.g., palm oil, animal fats) | Replace with unsaturated fats (e.g., olive oil, nuts, seeds) |
| Vegetable and Fruit Intake | Limited, often seasonal | Increase intake of a variety of non-starchy vegetables and fruits |
| Sugar and Sweeteners | Minimal use of refined sugar; natural sweeteners used | Limit added sugars; focus on natural sweeteners in moderation |

programs that serve healthy meals and teach children about correct nutrition can have a long-term influence on the prevention of LT2D (Hansen et al., 2022).

Moreover, public health programs should address the broader social determinants of health that lead to malnutrition and LT2D. Poverty, lack of knowledge, and restricted access to healthcare all exacerbate the risk of malnutrition and diabetes. Policies that aim to eliminate poverty, increase educational opportunities, and broaden access to healthcare services are crucial to tackling the basic causes of LT2D. For example, social protection programs that provide food assistance or income support can help reduce the immediate impacts of poverty and food insecurity, while long-term investments in education and healthcare can build resilience against the factors that lead to LT2D (Frier et al., 2020; McCrory-Churchill & Hill, 2022).

## CURRENT TREATMENT APPROACHES

### Pharmacological Interventions

Pharmacological therapies are a cornerstone in the therapy of Lean Type 2 Diabetes (LT2D), particularly in regions such as Sub-Saharan Africa, where the burden of the illness is rising. The use of insulin sensitizers, along with other antidiabetic drugs, plays a significant role in improving glycemic control and minimizing the long-term problems associated with LT2D. However, the success of these treatments is typically challenged by circumstances unique to the region, including restricted availability of pharmaceuticals, fluctuating adherence rates, and the existence of co-morbidities that complicate treatment procedures. Insulin sensitizers, such as metformin and thiazolidinediones, are among the most extensively utilized pharmacological medications in the therapy of LT2D (Duhuze Karera et al., 2023). Metformin, in particular, is generally recognized for its potential to improve insulin sensitivity, lower hepatic glucose synthesis, and enhance peripheral glucose uptake. Its benefits extend beyond glucose control, as it also contributes to weight stabilization and has a favorable safety profile, making it a favored first-line treatment for LT2D patients. Thiazolidinediones, another type of insulin sensitizers, work by activating peroxisome proliferator-activated receptors (PPARs), resulting to enhanced insulin sensitivity in adipose tissue, muscle, and the liver. These medications have been proven to be beneficial in decreasing fasting blood glucose levels and HbA1c, particularly in patients with substantial insulin resistance (Susilawati et al., 2023).

Despite the established efficacy of insulin sensitizers, the availability of these drugs in Sub-Saharan Africa is typically limited, providing a substantial hurdle to the proper management of LT2D. The healthcare infrastructure in many sections of the region is poor, resulting in frequent stockouts of important drugs, including metformin and thiazolidinediones. Additionally, the cost of these treatments, even when available, might be prohibitive for many patients, especially those living in rural areas or low-income settings. The reliance on out-of-pocket expenditures for drugs further exacerbates the issue, as patients may be compelled to choose between purchasing their medication and meeting other necessities (Inusah et al., 2024). In addition to insulin sensitizers, other pharmacological medications, including as sulfonylureas, dipeptidyl peptidase-4 (DPP-4) inhibitors, and sodium-glucose co-transporter-2 (SGLT-2) inhibitors, are also utilized in the treatment of LT2D (**Table 3**). Sulfonylureas, which enhance insulin release from pancreatic beta cells, are sometimes used in combination with metformin to promote improved glycemic control. DPP-4 inhibitors and SGLT-2 inhibitors, which function by regulating incretin hormones and boosting renal glucose excretion, respectively, offer additional options for patients who require more extensive therapy. However, the use of these newer agents is limited in Sub-Saharan Africa due to their higher cost and limited availability (Inusah et al., 2024).

Adherence to drug programs is another key difficulty in the therapy of LT2D in Sub-Saharan Africa. Even when medications are available, issues such as limited health literacy, lack of access to regular healthcare services, and cultural attitudes can hinder patients' ability to stick to prescribed treatment plans. In other situations, patients may not completely appreciate the need to take their medicine consistently, resulting in poor glycemic control and an increased risk of complications (Gatete J de et al., 2023). Additionally, adverse effects associated with some drugs, such as gastrointestinal pain with metformin or weight gain with thiazolidinediones, may further affect adherence, particularly in populations where access to healthcare practitioners for management of side effects is restricted. The existence of concurrent illnesses, such as hypertension, dyslipidemia, and infectious disorders like HIV/AIDS, also complicates the pharmaceutical therapy of LT2D in Sub-Saharan Africa. These co-existing illnesses sometimes require additional drugs, increasing the complexity of treatment regimens and the possibility of drug interactions. The strain of maintaining several drugs can be daunting for patients, particularly in resource-limited settings, where routine monitoring and follow-up care are typically unavailable. This can lead to

**Table 3.** Table on top of a page

| Pharmacological Treatment | Efficacy | Availability in Sub-Saharan Africa |
|---|---|---|
| Metformin | High efficacy in lowering blood glucose and improving insulin sensitivity | Widely available, but supply may be inconsistent in rural areas |
| Sulfonylureas | Moderate efficacy; effective in increasing insulin production | Available in many regions, but access may be limited in lower-income areas |
| DPP-4 Inhibitors | Moderate efficacy; lowers glucose without causing weight gain | Limited availability; often expensive and not widely stocked |
| GLP-1 Receptor Agonists | High efficacy; improves insulin secretion and promotes weight loss | Rarely available due to high cost and limited distribution networks |
| SGLT-2 Inhibitors | High efficacy in lowering blood glucose and reducing cardiovascular risk | Very limited availability; high cost restricts access in many areas |
| Insulin Therapy | Essential for managing LT2D in advanced cases | Availability varies widely; often scarce in rural and resource-poor settings |

inferior treatment outcomes and an increased likelihood of medication cessation (Aloke et al., 2023).

To address these difficulties, there is a need for creative techniques that enhance access to important pharmaceuticals and support adherence to treatment regimens in Sub-Saharan Africa. Strengthening the healthcare infrastructure to provide a regular supply of inexpensive pharmaceuticals is vital, as is the establishment of community-based initiatives that educate patients about the necessity of adherence and give help for managing side effects. Additionally, studying the use of fixed-dose combination treatments, which simplify treatment regimes by mixing many medications into a single pill, should increase adherence and lessen the burden of managing LT2D in patients with co-morbidities (Buh et al., 2022).

## Non-Pharmacological Interventions

Non-pharmacological therapies play a vital role in the management of Lean Type 2 Diabetes (LT2D), particularly in situations where access to medicine may be limited or where cultural and socioeconomic factors strongly impact health habits. Lifestyle modifications, including changes in diet and physical activity, are foundational components of diabetes management and are especially pertinent for individuals with LT2D, who often present with unique metabolic profiles that differ from those typically associated with obesity-related Type 2 Diabetes. The purpose of these therapies is to not only enhance glycemic control but also to address the broader aspects of health and well-being that contribute to the progression of LT2D (Sarker et al., 2022). Dietary adjustments are a cornerstone of LT2D care, aiming to improve nutritional intake, maintain stable blood glucose levels, and support overall metabolic health. However, the effectiveness of nutritional treatments is strongly contingent on their cultural relevance and acceptability. In Sub-Saharan Africa, where traditional diets vary greatly between regions, it is vital to design dietary guidelines that resonate with local eating practices and tastes. Traditional African diets, frequently rich in whole grains, legumes, vegetables, and less processed foods, have the potential to enhance glycemic control if carefully tailored to meet the needs of patients with LT2D. Emphasizing the consumption of low glycemic index foods, appropriate macronutrient distribution, and portion control will help maintain blood glucose levels efficiently (Duhuze Karera et al., 2023).

Dietary modifications are a cornerstone of LT2D care, aiming to improve nutritional intake, maintain stable blood glucose levels, and support overall metabolic health. However, the effectiveness of nutritional treatments is strongly contingent on their cultural relevance and acceptability. In Sub-Saharan Africa, where traditional diets vary greatly between regions, it is vital to design dietary guidelines that resonate with local eating practices and tastes. Traditional African diets, frequently rich in whole grains, legumes, vegetables, and less processed foods, have the potential to enhance glycemic control if carefully tailored to meet the needs of patients with LT2D. Emphasizing the consumption of low glycemic index foods, appropriate macronutrient distribution, and portion control will help maintain blood glucose levels efficiently (Duhuze Karera et al., 2023). Additionally, implementing community-based initiatives that promote group activities, such as walking clubs or dance groups, can generate social support and boost the likelihood of prolonged engagement in physical exercise. The importance of culturally relevant lifestyle adjustments cannot be emphasized in the context of LT2D management. Many individuals in Sub-Saharan Africa may be influenced by cultural beliefs and practices that affect their approach to diet and physical exercise. For example, certain tribes may have traditional beliefs on body weight and health that differ from Western medical perspectives, thus influencing the adoption of food restrictions or physical activity guidelines (Razak et al., 2023). Therefore, it is essential to collaborate with community leaders, healthcare practitioners, and patients to produce guidelines that respect and embrace these cultural values while promoting healthier behaviors. Tailoring interventions to the cultural environment not only increase their acceptability but also enhances their effectiveness by aligning them with the values and behaviors of the population.

Moreover, modifications to lifestyle offer a cost-effective approach to LT2D management, particularly in resource-limited situations where healthcare resources are few. While pharmacological therapies are important for many patients, lifestyle changes can serve as a complementary strategy that lessens the dependency on pharmaceuticals and minimizes healthcare expenses. By focusing on prevention and early intervention through diet and physical activity, it is possible to delay the onset of problems and enhance the quality of life for patients with LT2D (Adjanor et al., 2020). In addition to individual-level interventions, broader public health measures are needed to facilitate lifestyle adjustments across

communities. This includes the formulation of policies that promote access to nutritious foods, foster safe venues for physical activity, and give education on diabetes prevention and management. Schools, companies, and community organizations can play a significant role in distributing knowledge and building settings that support healthy habits. Collaborative efforts between governments, non-governmental organizations, and local communities are vital to create durable reforms that benefit individuals with LT2D (Bekele et al., 2020).

## BARRIERS TO EFFECTIVE LT2D MANAGEMENT

### Healthcare Infrastructure

The management of Lean Type 2 Diabetes (LT2D) in Sub-Saharan Africa is greatly affected by many hurdles associated to healthcare infrastructure, specifically the restrictions in healthcare access and resources and the availability of skilled healthcare personnel. These limitations create a complex environment where adequate diabetes management is often unattainable for many individuals, aggravating the burden of the condition and contributing to poor health outcomes. One of the most significant hurdles to effective LT2D management is the pervasive limitation in healthcare access across Sub-Saharan Africa (Firima et al., 2022). In many rural and underserved metropolitan regions, healthcare facilities are scant, and patients often have to travel significant distances to get basic medical care. This geographical barrier is reinforced by the absence of reliable transportation and the financial burden involved with seeking medical treatment, which might dissuade individuals from receiving critical services. For patients with LT2D, regular monitoring, access to medications, and conversations with healthcare specialists are critical components of disease management. However, the shortage of healthcare facilities and the related expenditures make consistent and effective management problematic, resulting to delays in diagnosis, inefficient treatment, and an increased risk of consequences (Gizamba et al., 2022).

The limits in healthcare resources further compound the difficulty of managing LT2D. Healthcare facilities in many parts of Sub-Saharan Africa are generally underfunded and poorly prepared, lacking the required tools and supplies to diagnose and treat diabetes efficiently. This includes a shortage of diagnostic equipment, like as glucometers and HbA1c testing devices, which are crucial for monitoring blood glucose levels and determining long-term glycemic control. Additionally, the availability of pharmaceuticals, particularly insulin and other antidiabetic therapies, is variable, with many hospitals facing regular stockouts or depending on obsolete or less effective treatments. This constraint of resources causes healthcare practitioners to make tough decisions, sometimes resulting to inferior care and a dependence on less effective management measures (McCrory-Churchill & Hill, 2022). Another important barrier is the availability of qualified healthcare providers. The shortage of healthcare staff, especially doctors, nurses, and diabetes specialists, is a prevalent concern in Sub-Saharan Africa. This deficit is particularly acute in rural locations, where healthcare providers are typically overwhelmed and lack the specialized expertise needed to manage complex illnesses like LT2D successfully. The restricted number of diabetes experts implies that most patients with LT2D are managed by general practitioners or nurses who may not have the skills to give optimal care. This gap in knowledge and skills can lead to misdiagnosis, improper treatment, and inadequate patient education, further complicating the management of LT2D (Gumede et al., 2023).

In addition to the limited availability of healthcare workers, the existing workforce typically faces issues due to inadequate training and continuous education. Many healthcare personnel in Sub-Saharan Africa receive limited training in diabetes treatment during their medical education, with little emphasis on the special characteristics and issues related to LT2D. Furthermore, possibilities for continuous professional development are restricted, particularly in rural locations where access to training programs and resources is scarce. This lack of continued education implies that healthcare personnel may not be up to date with the current standards and best practices for managing LT2D, resulting in obsolete and less effective treatment approaches. The limitations in healthcare infrastructure and the availability of educated healthcare workers also have broader consequences for public health activities targeted at preventing and controlling LT2D (Van der Merwe et al., 2023). The effectiveness of public health campaigns, community-based education initiatives, and other interventions is sometimes hindered by the lack of resources and skilled individuals to implement and sustain these activities. Without proper support from the healthcare system, these programs may fail to reach the people most in need or may not be given with the necessary quality and consistency to impact significant change (Herlitz et al., 2020).

Moreover, the lack of integrated healthcare systems in many parts of Sub-Saharan Africa further complicates the management of LT2D. In many circumstances, healthcare services are fragmented, with inadequate coordination between primary care, specialist services, and public health programs. This lack of integration can result in gaps in care, when individuals with LT2D may not receive the comprehensive and ongoing care needed to manage their condition effectively. For instance, individuals who are diagnosed with LT2D in a primary care setting may not have access to specialized care or may not receive appropriate referrals for additional assessment and therapy. This dispersion of resources can lead to delays in diagnosis, inappropriate treatment, and poor health outcomes (McCombe et al., 2022). Addressing these impediments needs a multidimensional approach that involves investment in healthcare infrastructure, increased access to resources, and the training and retention of healthcare personnel. Strengthening the healthcare system to support the effective management of LT2D will involve increasing the availability of diagnostic tools and medications, expanding access to healthcare services, particularly in rural and underserved areas, and enhancing the training and capacity of healthcare workers. Additionally, efforts to integrate healthcare services and enhance coordination between multiple levels of care are

critical to ensure that patients with LT2D receive the comprehensive and ongoing treatment they need (Jaca et al., 2022).

### Economic and Social Barriers

The management of Lean Type 2 Diabetes (LT2D) in Sub-Saharan Africa is closely linked to the region's economic and social difficulties, especially the widespread effects of poverty, education, and cultural beliefs. These characteristics establish significant obstacles to efficient disease management, constraining access to care, diminishing medication adherence, and intensifying the total burden of diabetes in the region. Comprehending and tackling these obstacles is essential for formulating targeted solutions that can enhance health outcomes and diminish the prevalence of LT2D. Poverty is a major economic obstacle that profoundly impacts the management of LT2D in Sub-Saharan Africa (Suglo & Evans, 2020). A significant component of the population resides beneath the poverty threshold, with insufficient financial means to obtain healthcare services, drugs, and nutritious food essential for diabetes control. The expense of healthcare, encompassing consultations, diagnostic assessments, and pharmaceuticals, frequently imposes a significant financial strain on individuals and families. Consequently, numerous individuals with LT2D may postpone obtaining medical attention, forgo essential therapies, or depend on inferior, cost-effective substitutes. This financial burden can result in inadequately managed diabetes, heightening the risk of complications and perpetuating the cycle of poverty and ill health. The absence of health insurance coverage in numerous areas of the region intensifies this problem, forcing individuals to assume the entire expense of their care (Haque et al., 2021).

Educational challenges also play a key role in the management of LT2D. Insufficient health literacy and restricted educational access in numerous regions of Sub-Saharan Africa result in pervasive ignorance regarding diabetes, its risk factors, and the need for early detection and care. Many individuals may not identify the signs of LT2D or grasp the long-term ramifications of the disease, leading to delays in diagnosis and treatment (Adugna et al., 2020). Furthermore, patients diagnosed with LT2D may fail to adhere to suggested treatment regimens, including medication, food, and lifestyle modifications, due to a lack of awareness of the condition and its management. The absence of concentrated health education initiatives that address these gaps in understanding exacerbates the situation, leaving many people ill-equipped to manage their disease effectively. Cultural attitudes and behaviors also represent important societal hurdles to the management of LT2D in Sub-Saharan Africa. Traditional ideas about health and illness often influence perceptions of diabetes and its management (Olaoye & Onyenankeya, 2023). In some groups, diabetes may be seen as a result of spiritual factors or as an illness that may be addressed with traditional medicine rather than modern interventions. This can lead to hesitation to seek conventional medical therapy, dependence on traditional healers, or the employment of alternative therapies that may not be beneficial in managing the disease (Bonin et al., 2022).

Addressing these economic and social limitations needs a holistic approach that includes initiatives to alleviate poverty, enhance education, and interact with cultural ideas in a way that supports better health outcomes. One essential method is to enhance access to affordable healthcare through the extension of health insurance coverage, subsidies for diabetic drugs, and the provision of free or low-cost healthcare services in underprivileged areas. This would ease the financial strain on individuals and families, enabling them to get the care they need to manage LT2D effectively. Education plays a significant role in addressing barriers connected to health literacy. Implementing tailored health education initiatives that are culturally relevant and accessible to varied populations can help promote knowledge about LT2D, its symptoms, risk factors, and the need of early detection and care (Chopra et al., 2022). These programs should be given through multiple channels, including schools, community centers, and mass media, to reach a wide audience. Additionally, training healthcare practitioners to communicate effectively with patients from varied educational levels can assist guarantee that individuals with LT2D receive clear, intelligible information about their disease and treatment options.

Engaging with cultural beliefs and practices respectfully and inclusively is also vital for overcoming social hurdles to LT2D management. Public health initiatives should cooperate with traditional healers and community leaders to encourage the merging of biological and traditional methods to diabetes management. By identifying and incorporating cultural ideas into health education and intervention programs, it is feasible to establish trust within communities and encourage higher acceptance of standard medical care. Furthermore, tackling the social stigma associated with diabetes through public awareness initiatives can help minimize discrimination and isolation, encouraging individuals to seek treatment and support from their communities (Wadi et al., 2021).

In addition to these techniques, initiatives to address the broader socioeconomic determinants of health, such as expanding access to education, reducing poverty, and promoting gender equality, are crucial for creating an environment where effective LT2D management is achievable. By addressing the core causes of health disparities, it is possible to build a more equitable healthcare system that supports individuals with LT2D in managing their illness and obtaining better health outcomes. However, by applying focused initiatives to increase access to healthcare, expand health education, and engage with cultural attitudes, it is possible to overcome these hurdles and improve the lives of persons living with LT2D. Addressing these issues will require concerted efforts from governments, healthcare providers, community leaders, and international organizations to create sustainable and culturally appropriate interventions that support individuals in managing their condition and preventing the onset of complications (Shewamene et al., 2021).

## RESEARCH GAPS AND FUTURE DIRECTIONS

There are considerable gaps in research that need to be addressed to enhance outcomes for communities afflicted by Lean Type 2 Diabetes (LT2D) in Sub-Saharan Africa. A

fundamental difficulty is the requirement for thorough epidemiological data specific to this region. Although global research has produced useful insights into the prevalence and risk factors linked to Type 2 Diabetes, they often fail to represent the particular characteristics and difficulties associated with LT2D in Sub-Saharan Africa (Wong et al., 2023). The region presents a wide diversity of genetic origins, environmental conditions, and lifestyle factors that may have a role in the genesis and advancement of LT2D in distinct ways compared to other forms of diabetes. There is an urgent need for extensive, geographically focused epidemiological investigations that can precisely evaluate the occurrence of LT2D, identify crucial risk factors, and clarify the complex relationship between genetic, dietary, and infectious illness variables that are peculiar to this community. These statistics are vital for providing information to public health initiatives and adapting interventions to the specific requirements of the place (Sirdah & Reading, 2020).

Aside from epidemiological research, there is an urgent need for clinical research that especially focuses the invention of diagnostic and therapeutic procedures adapted for the Sub-Saharan African context. The current diagnostic criteria for diabetes may not fully capture the specific aspects of LT2D, especially in individuals who do not fit to the conventional profile of obesity-related Type 2 Diabetes. It is necessary to design diagnostic tools that are more precise and accurate, taking into consideration the lean phenotype and other regional peculiarities. Furthermore, therapeutic strategies that are useful in other groups may not be as successful in Sub-Saharan Africa due to differences in genetics, lifestyle, and healthcare infrastructure (McCombe et al., 2022). It is essential to perform clinical trials in this region that explicitly target LT2D to analyze the effectiveness and safety of current drugs and research novel therapy techniques. These trials should also evaluate the impact of comorbid disorders, such as infectious diseases, that are prominent in the region and may complicate diabetes management.

From a policy standpoint, there is a need for research that investigates health policy initiatives aimed at improving LT2D outcomes in Sub-Saharan Africa. Effective management of LT2D needs not only clinical interventions but also the integration of these efforts into broader health systems. Policymakers must study methods for introducing LT2D screening, prevention, and treatment into existing primary healthcare systems. This may involve training healthcare professionals to recognize and manage LT2D, securing the availability of suitable medications and diagnostic equipment, and adopting community-based programs that raise awareness and early identification (Mthiyane et al., 2023). Additionally, research should explore how to overcome the socio-economic barriers that restrict access to healthcare for LT2D patients, such as poverty, education, and cultural views. By incorporating LT2D management into primary healthcare systems, the region can improve early detection, promote treatment adherence, and ultimately lower the burden of the disease (Chopra et al., 2022).

## CONCLUSION

This study highlights the unique difficulties and potential in the prevention and treatment of Lean Type 2 Diabetes (LT2D) in Sub-Saharan Africa. Among the important findings is the strong impact of socioeconomic and environmental factors, such as poverty, education, and cultural attitudes, on the management of LT2D. These issues contribute to delayed diagnosis, poor adherence to therapy, and overall unsatisfactory illness management, worsening the health burden in the region (Firima et al., 2022). Additionally, the limited healthcare infrastructure, availability of skilled healthcare workers, and culturally unsuitable diagnostic instruments further restrict successful management and demand tailored interventions. The implications for practice underline the significance of establishing context-specific solutions to improve LT2D management. Healthcare providers are recommended to promote culturally relevant patient education, enhance the accessibility of healthcare services, and engage with traditional community traditions respectfully to foster trust and adherence to biomedical treatments (Tremblay et al., 2020). Policymakers should focus on incorporating LT2D prevention and management into current public health frameworks, ensuring that efforts are customized to the special needs of the Sub-Saharan population. This involves expanding health insurance coverage, subsidizing needed pharmaceuticals, and investing in healthcare infrastructure to promote better illness management. This review recommends for urgent action to combat LT2D in Sub-Saharan Africa through further research and policy development. There is a pressing need for greater study on the epidemiology of LT2D, the effectiveness of various therapies, and the development of diagnostic methods that are culturally and regionally relevant. Policymakers must emphasize LT2D within public health agendas, creating policies that address the social and environmental determinants of health that contribute to the condition. Collaborative efforts between governments, healthcare providers, researchers, and communities are crucial to lessen the burden of LT2D and improve the health outcomes of persons affected by this complicated disorder (Duhuze Karera et al., 2023).

Addressing Lean Type 2 Diabetes (LT2D) in Sub-Saharan Africa requires targeted policy changes and focused research initiatives. Specifically, policies should prioritize the inclusion of LT2D in national health education campaigns, ensuring that both healthcare providers and the general public are aware of its distinct features. Research efforts should be directed towards understanding the genetic and environmental factors contributing to LT2D in the region, while also developing culturally appropriate screening and diagnostic tools. By aligning policy with research, we can create a comprehensive approach to improving LT2D management, ultimately leading to better health outcomes across Sub-Saharan Africa.

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