Chapter

# The African Face of Childhood Diabetes

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## Abstract

This chapter will talk about diabetes in African children living in Africa. It will cover diabetes, the classification in general, and the gray areas of diabetes in Africa. It will also cover part of the genetics of diabetes around Africa and its shortfall. The chapter will also look at the management of diabetes in an African setting, where insulin is stored in pots, and the challenges that a child with diabetes goes through in Africa. This chapter will be useful for pediatric endocrinologists, pediatricians, adult diabetologists, doctors, nurses, and everyone in the health sector dealing with children with diabetes.

**Keywords:** diabetes mellitus, sub-Saharan Africa, malnutrition, health care systems, type 1 diabetes mellitus

## 1. Introduction

Diabetes mellitus is a biochemical disorder caused by the defect in insulin secretion, action, or both, resulting in hyperglycemia [1]. Reduced insulin leads to abnormal metabolism of carbohydrates, fats, and proteins. There are different types of diabetes known globally, namely, type 1 diabetes mellitus (T1DM), type 2 diabetes mellitus (T2DM), gestation diabetes mellitus, and other forms of specific diabetes (e.g., maturity-onset diabetes of the young (MODY), neonatal diabetes, etc.) [2]. However, this classification may be difficult to locate in Africa due to challenges of diagnosis as well as other forms of diabetes that do not follow the global trend like malnutrition-related diabetes, [3] ketosis prone diabetes [4], and fibrocalculus pancreatic diabetes [5]. T1DM is an immune-mediated condition; however, in African people living in Africa, the picture might look different. Apart from the immune-mediated T1DM, which is attributed to most of the patients with type 1 diabetes in sub-Saharan Africa, other patients have diverse forms of type 1 diabetes, which are non-immune-mediated. Few studies done on autoimmunity in T1DM in sub-Saharan Africa showed less than 50% immunogenicity ranging from 30 to 40%. Most of them have a single autoantibody, mainly GAD65. Other forms also fall in the category of T1DM but are not immune mediated.

## 1.1 Sub-Saharan Africa and diabetes

Sub-Saharan is the term used to describe the area in the continent of Africa that is below the southern border of the Sahara Desert. It is a savanna grassland with some trees. Sub-Saharan Africa has about 42 countries and 5 islands, which are different geographically and culturally. It has a landmass of 23,890,896.1 sqm as o 2020 with 1.17 billion people. The annual population growth is 2.6%, and the GDP per capita is 1.92 (World Bank 2020). The number of prevalent (existing) cases of type 1 diabetes is 1,211,900. The number of incident (new) cases of type 1 diabetes per year is 149,500.

Diabetes mellitus used to be a disease of the developed countries, more so in children. However, the recent global data shows that about 536.6 million adult people with diabetes live in Africa, with the projection of 783.2 million people in 2045. In children up to 19 years, the number is at 1.2 million, with 184,100 new diagnoses each year (IDF Atlas). Among these, 1,211,900 are children aged 0–19 years with type 1 diabetes and 149,500 are those diagnosed yearly with type 1 diabetes. All of these are affected by missed diagnosis, which reaches to about 53.6% of the population in Africa, which is 72 million people (IDF). Few studies have been done on the prevalence and incidences of diabetes in children in Africa, and most of the prevalence studies are hospital based. The few incidence studies that have been carried out range from 1.9 to 11.2/100,000 population (**Table 1**) [6, 7].

There is variation in the incidence of diabetes in children in sub-Saharan Africa by region, with the population in the horn of Africa (e.g., Eritrea 11.2/100,000 population and Sudan 10.3/100,000) [6, 8] more affected compared to western regions (e.g., Nigeria 3.1% and Cote devoir 0.4%) [10, 11]. Probably, these are the regions that have more of missed diagnosis and early deaths, or it is true that there is less incidence of diabetes in those areas.

## 1.2 The healthcare systems in sub-Saharan Africa

Most of the sub-Saharan African health systems are designed in such a way that they are able to tackle the infectious diseases and their acute patterns. HIV has been a challenging situation, because of its chronicity nature, hence forcing the system to deal with chronic diseases and meeting the global sustainable development goals. The system has not been planned to tackle the NCD (diabetes in sub-Saharan Africa, from clinical care to policy). There is a move by the UN to reduce premature deaths from NCDs by 2030, in which case it requires a lot of co-ordinations that are difficult to achieve right now. As it has been studied, to

| Country | Incidence /100,000 population |
|---|---|
| Sudan | 10.3 |
| Eritrea | 11.2 |
| Rwanda | 2.7 |
| Tanzania | 1.8–1.9 |

**Table 1.**
*Incidence studies of diabetes in children in sub-Saharan Africa [6–9].*

manage diabetes, a broad-based health system is needed, which more often than not is not present there. Because of the way sub-Saharan Africa health systems are, most patients with diabetes will likely drop off the system, because the system cannot cater to their needs, including facilities to manage micro- and macrovascular complications; adding it to the present infectious disease program like HIV has not been successful yet.

## 1.3 Care of children and adults with diabetes

Diabetes care in Africa has been a subject of many challenges especially after being hit by triple burden of HIV, diabetes, and tuberculosis, among other infectious diseases [12]. To add to the fire, the COVID-19 pandemic brought in more challenges to the governments and the healthcare system that was already fragile. The system has been used to cater to acute and infectious conditions rather than chronic infections, which has a different model and high costs.

### *1.3.1 Types of diabetes in Africa*

For the most part, the types of diabetes in sub-Sahara Africa are no more different from the global types. However, very few studies have investigated in detail on diabetes occurring in Africa. Apart from the classical global forms of diabetes, that is, type 1 diabetes, type 2 diabetes, gestational diabetes, and specific genetic types, there have been studies indicating other forms of diabetes that occur in Africa, such as atypical African diabetes, ketosis prone atypical diabetes mellitus, and malnutrition-related diabetes of tropical diabetes [13, 14]. This is a significant challenge in which intervention needs to be set and prevalence of complications observed.

### *1.3.2 Type 1 diabetes mellitus*

T1DM is characterized by deficiency in insulin secretion. Its cause is unknown; however, genetic susceptibility, environmental factors, immune system, and β-cells are implicated. The interaction of these causes immune-mediated beta cell destruction and hence partial/absolute insulin deficiency. There are four stages toward the development of T1DM symptoms: 1. multiple islet antibodies and normal glucose; 2. multiple islet antibodies, raised blood glucose, but no symptoms; 3. islet autoimmunity, raised blood glucose, and symptoms (when the islet cells have diminished to about 90% lost); and 4. long-standing T1DM. However, in sub-Saharan Africa, some patients do not have auto-antibodies, and so it can be confused with other types of diabetes. Management of T1DM can be challenging in Africa because of lack of laboratory support and access to insulin.

### *1.3.3 Genetics of T1DM*

Despite the great leap in technologies and advances in genetic studies in T1DM, numerous gaps in knowledge remain, especially in sub-Saharan Africa. More data and genetic studies from non-European ancestry population are needed to identify novel risk genes and novel variants in known genes. It has to be noted that environmental factors play a major role as the triggering stimulus to develop diabetes even in people with low genetic risk to develop T1DM.

### 1.3.4 Evidence of the role of genetics in diabetes

The overall risk of T1DM in the general population is 0.4%, but it is higher in relatives of patients. For example, siblings of patients have on average a 6–7% lifetime risk; the risk of T1DM is 1.3–4% in children of a female patient and 6–9% in children of a male patient. While the risk in identical twins with one positive autoantibody reaches up to 60% in some populations and is prone to development of diabetes within three years from detection, accumulated data showed that those with more than two positive autoantibodies will eventually develop diabetes. T1DM in non-identical twins is similar to that in siblings, which is about 6%.

Over the past 40 years, histocompatibility leukocyte antigen (HLA) regions, on chromosome 6p21, have been the first and largest loci that are linked to T1DM susceptibility, namely, class II HLA DR (especially DR3 and DR4) and DQ (mainly DQ2 and DQ8). These genes are felt to alter type 1 diabetes risk by affecting the ability of these class II molecules to bind to and present β-cell protein peptide fragments to T-cells and therefore to activate an autoimmune reaction. Up to 90% of individuals with type 1 diabetes carry either the DR3/DQ2 halotype, which is associated with glutamic acid decarboxylase autoantibody (GADA), or the DR4/DQ8 haplotype, which is associated with insulin autoantibodies (IAA) (both DQ2 and DQ8 are non-Asp alleles). In contrast, while 20% of the population carries the DQ6.2 alleles (with aspartate at position 57), this allele is rare in individuals with type 1 diabetes, marking this as a dominantly protective allele.

### 1.3.5 Genetics of T1 diabetes mellitus from sub-Saharan Africa

Data from certain areas in the world are very limited including sub-Saharan Africa. A recent study from Sudan by Tamador et al. has concluded that young Sudanese individuals with T1DM generally have similar characteristics as reported from European-origin T1DM populations. However, they have higher rates of DKA and slightly lower autoantibody rates than those reported from European-origin populations and a particularly strong association with *HLA-DRB1*03:01*. Another study from Ethiopia by Shitaye et al., which has studied specifically the Amhara genomes, has concluded that Amhara genomes were distinct from modern European and other African genomes. *HLA-DRB1*03:01 ($p = 0.0014$) and HLA-DRB1*04 ($p = 0.0001$)* were positively associated with this form of diabetes, while HLA-DRB1*15 was protective ($p < 0.0001$). This means type 1 diabetes genetic risk score (derived from European data) was higher in patients than in control participants ($p = 1.60 \times 10–7$). Interestingly, despite the modest sample size, autoantibody-positive patients revealed evidence of association with SNPs in the well-characterized MHC region, already known to explain half of type 1 diabetes heritability in Europeans.

### 1.3.6 Pathogenesis of type 1 diabetes

Type 1 diabetes is an insulin-dependent type of diabetes with an onset in childhood extending to early adulthood (≤ 30 years old); however, any age group can be affected.

Its pathogenesis involves three interlinked mechanisms:

Genetic susceptibility, immune system regulation abnormalities, and environmental factors; however, for type 1 b, the pathogenesis is idiopathic. The HLA locus on chromosome P21 contributes about 50% of susceptible genes. The HLA molecules

are located close to peptide-binding pockets that are related to disease code alleles (HLA-DR3 or HLA-DR4) with features of antigen display. Then, there are environmental factors that have been associated with triggering the islet cell destructions; this includes some viral infections, for example, cytomegalovirus, which will either induce the destruction of islet cells releasing β-cells antigen that will cause activation of T-cell-mediated reactivation of antibodies, or virus release proteins that resemble β-cell antigen and the immune system cross-reacts with the self-tissue.

Therefore, the autoantibody produced against the islet cell antigens as a result of environmental exposure cause injury to the pancreases of people with genetic susceptibility.

### *1.3.7 Non-Type 1 diabetes mellitus*

Because of lack of fancy laboratory support in sub-Saharan Africa like islet cell autoantibodies and molecular testing, it is sensible to know when to suspect a monogenic form of diabetes or non-type 1 diabetes. Symptoms of diabetes in the first six months of life are defined as neonatal diabetes, which is a rare type of monogenic diabetes due to single gene mutation. Symptoms are usually vague but physicians should be aware of the problem with high suspicion rate. A neonate with unexplained growth failure, dehydration, and irritability with frequent nappy changes (polyuria) although good appetite and frequent breast feeding should be subjected to a simple blood sugar measurement and urine ketones. Blood sugars levels more than 35 mmol/L are not usually a presentation of stress hyperglycemia. Communities with high consanguinity rate are prone to have this kind of gene mutations since most of

**Figure 1.**
*Neonatal diabetes in sub-Saharan Africa.*

the cases are recessive. For example, in Sudan, a country with 45% consanguinity rate, 56% of neonatal diabetes were found to be caused by EIF2AK3 recessive variants causing the Wolcott–Rallison syndrome, which usually presents with skeletal abnormalities and liver dysfunction, while only 8.1% and 5.4% were caused by mutations in KCNJ11 and ABCC8 genes, respectively (*local unpublished data*). This is completely different from what has been reported from Western and Asian populations, where ABCC8 was the commonest cause of neonatal diabetes (**Figure 1**).

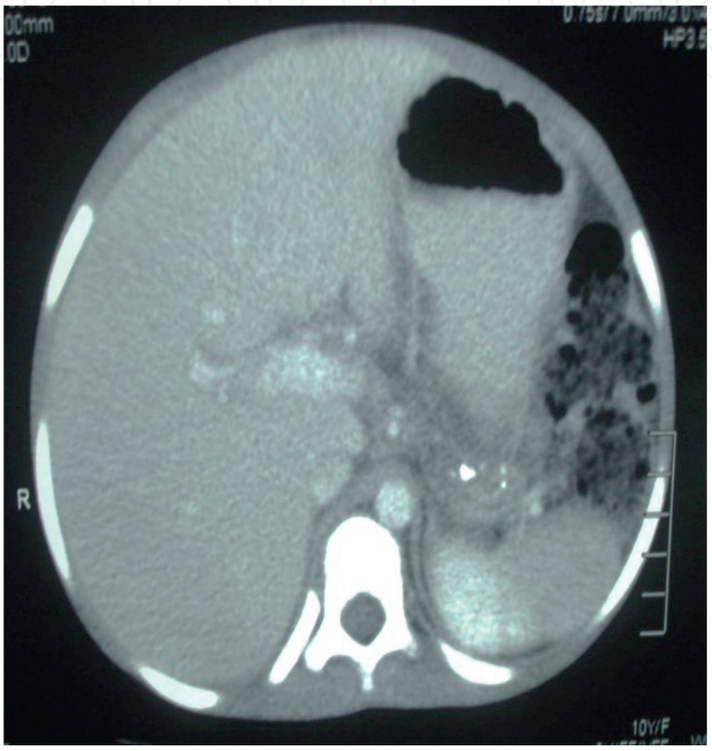


**Figure 2.**
*Fibrocalcular pancreatitis causing diabetes and malnutrition.*

**Figure 3.**
*Diabetes and malnutrition.*

Other monogenic diabetes forms like MODY should be suspected clinically even when there is lack of laboratory facilities. A family history of diabetes in three subsequent generations, minimum or no requirements to insulin to maintain euglycemia, and bouts of unexplained hypoglycemia outside the honeymoon period should raise the suspicion of monogenic diabetes. Other clinical supportive findings of monogenic diabetes are presence of megaloblastic anemia that is responsive to thiamin (TRMA), deafness with diabetes insipidus and optic atrophy (DIDMOAD), deafness with renal anomalies in Roger's syndrome, and liver dysfunction and skeletal malformation (WRS). Early detection and correct diagnosis are crucial for a better outcome. Molecular testing is very helpful in such cases whenever feasible.

In a recent study from South Africa, 1643 diabetic adults who were diagnosed to have either type 1 or type 2 diabetes were subjected to molecular testing. A total of 6.6% were found to have monogenic diabetes caused by two genes mutations: HNF41A and GCK polymorphism [15]. This indicates that monogenic diabetes is underdiagnosed in our community, which might result in inappropriate treatment and exacerbation of related illnesses. Awareness should be increased among healthcare professional about when to suspect a non-type 1 diabetes mellitus.

*1.3.8 Ketosis prone diabetes*

Ketosis prone diabetes is a form of diabetes that is characterized by severe beta cell dysfunction presenting with DKA or unjustified diabetes.

It is a syndrome classified by four systems that are based on: immunological criteria; immunological criteria and insulin requirements; BMI and immunological criteria, or beta cell function. They are all non-autoimmune diabetes with severe insulin deficiency [4]. The classes are non-autoimmune diabetes with DKA, [16] the ketosis-prone insulin-dependent (clinical features of type 1 diabetes) and ketosis-prone non-insulin-dependent clinical characteristics of type 2 diabetes, [17] lean ketosis-prone features of Type 1. and obese Ketosis-prone features with features of type 2 diabetes [18, 19].

However, in Africa, these conditions were present in the past 4–5 decades [20–22]; with the usual characteristics of absence of autoimmunity and beta-cell function reduction in this category, there are those who may need insulin for a short time and those that may need insulin permanently. These patients present with DKA (**Figures 2** and **3**).

## 2. Presentation and diagnosis

Suspicion of the diagnosis of diabetes mellitus begins with the presence of clinical features, then doing random capillary blood glucose to confirm the diagnosis. Glycated hemoglobin supports the diagnosis. Urine glucose is important for diagnosis, especially in settings where laboratory support and glucometers are a challenge. However, the criteria involve having the symptoms of hyperglycemia and high levels of blood glucose.

The commonest symptoms are tiredness, polyuria, polydipsia, and weight loss despite polyphagia; however, there are other subtle symptoms that may indicate diabetes mellitus, including skin infections such as boils and recurrent fungal infections. Most of the occasions for diagnosis within the context of an acute illness.

It is common to measure random blood glucose either by using capillary blood (using glucometers) or venous blood where laboratory facilities are available. In settings where there are in the diagnosis, the most common form is the severe form of diabetes, where a patient presents with diabetes ketoacidosis (hyperglycemia, acidosis, and ketonemia/ketonuria). At this point, the diagnosis will involve random blood glucose for hyperglycemia greater than 11.1 mmol/L and urine dipstick to look for ketonuria of 2+ or more, weakness, unclear poor growth for children, neglects, and anger of youth.

The finger prick at any time should be the same or exceed 11.1 mmol/L along with clinical symptoms of short duration of loss of weight, polyuria, and polydipsia. This can be done in sick patients or outpatients. Thus, the diagnosis of diabetes is confirmed when:

1. Classical symptoms and signs of diabetes or hyperglycemia crisis and a plasma glucose of ≥11.1 mmol/L or

2. Fasting plasma glucose of ≥7 mmol/L on more than one occasion or

3. Two hours post-glucose load/standard ≥11.1 mmol/L (OGTT)

4. HbA1c > 6.5% two hours post-glucose load ≥11.1 mmol/L (OGTT)

Note: If there are no symptoms, there should be two blood glucose readings tested at different times.

At initial diagnosis, glycated hemoglobin (HbA1c) is an important parameter, but a normal value does not rule out the diagnosis of diabetes. HbA1c is used for monitoring hyperglycemia in 3 monthly checks because of its variation in availability.

Since type 1 diabetes is an autoimmune condition, the likelihood of other autoimmune conditions is high; hence, screening for other autoimmune conditions is important. These include: thyroid profile (TSH, FT4, and FT3) ± coeliac disease. Most of the times, patients in sub-Saharan Africa delay the diagnosis, resulting in a lot of loss in follow-up; therefore, there is need for screening for complications of diabetes, that is, urine examination for micro-albumin, lipid profile—triglycerides and lipoproteins, and renal function tests (serum creatinine, blood urea nitrogen) as well as the assessment for neuropathy using filament touch for sensation.

## 3. Management

Management of diabetes involves diagnosis of diabetes, which consists of taking history, conducting a physical examination and testing blood to confirm the high level of blood glucose.

Clinical features suggestive of diabetes with random blood glucose (RBG) of 11.1 mmol/L or more confirm diabetes. If there are suggestive clinical features but RBG is less than 11.1 mmol/L, fasting blood glucose test or oral glucose tolerance test (OGTT) and HbA1C are done. Fasting blood glucose of 7 mmol/L or more confirms diabetes. OGTT of 11.1 mmol/L or more after 2 hours confirms diabetes. It is important to do urine routine examination to look for ketone because in Africa many children with diabetes may present for the first time to hospital in diabetic ketoacidosis.

For first-time diagnosis, admit the patient to the ward and stabilize blood glucose with 0.1 units/kg of short-acting insulin until blood glucose level falls to 10 mmol/L or less. Then, put the patient on a multiple dose injection regimen; the total dose is divided over long-acting and short-acting insulin in a ratio of 1:1, that is, 50% each. The short-acting portion is divided into three portions and given at breakfast, lunch, and supper, 30 minutes before meals. The long-acting portion is usually given once a day usually at bedtime. Where an intermediate-acting insulin is given as long acting, the dose is divided into two, and each portion is given in the morning and evening. If there is no food, the patient should skip the short-acting insulin at that specific time. Patients and families are usually taught how to draw the dose, give injection, and adjust the insulin dosage. They are also taught about injection sites and how to rotate the injection sites to prevent ulcers and lipodystrophy.

## 3.1 Different regimens that are feasible in sub-Saharan Africa

### *3.1.1 Insulin access and storage*

Due to the cost and availability of food, the insulin injection most of the times is not constant; there are different regimen being used, the commonest being multiple dosing regimen and twice daily dose regimen (**Figure 4**). With all these, the storage of insulin is a challenge with many families who store in a pot (**Figure 5**).

### *3.1.2 Multiple dosing regimen (MDI)*

The multiple dose injection regimen is more physiological and usually gives better glycemic control. It involves giving 1–2 injections of basal insulin (long acting) and three or more times of prandial blood glucose. The total dose is divided over long acting and short acting in a ratio of 1:1. It is the recommended dose globally and gives better control; however, in sub-Saharan Africa, it has


**Figure 4.**
*Improvised container for transportation (courtesy of EADSG-guidelines).*


**Figure 5.**
*Local pot for insulin storage.*

different challenges from no food to the time of getting food, the insulin access itself, etc.

### *3.1.3 Twice dosing regimen*

This uses pre-mixed insulin, which is a combination of short-acting and NPH insulin insulin in a fixed proportion or a free mixture of regular insulin and intermediate-acting insulin. It is given two times a day. Two-thirds (2/3) of the total dose is given in the morning and 1/3 is given in the evening.

Patients should be educated on insulin use, storage dosage, and Side effects in simple terms and in a dialect they understand; this includes knowledge about insulin injections, injection sites and how to rotate, doses and dose adjustment, how to take care of injection sites, signs of hypoglycemia and its management, and short-term and long-term complications. And in both the regimen, the gadget for delivering insulin is mostly syringes; a few times there are pens, and rarely do they use pumps.

In Africa, a very sensible regimen of insulin use is the premixed Twice-daily dose. It is Cost-effective and available, and patients and their families love it because of the infrequent injections. With the progress of diabetes services in the continent, healthcare professionals (HCPs) started to modify this regimen by adding a fixed pre-lunch dose of short-acting insulin (since it is the biggest meal in most countries). In addition to that, the concept of the basal bolus regimen started to emerge especially among patients coming from the developed side of the world. Endocrinologists in the recent years have seen the benefits of the basal bolus regimen of delivering insulin in the form of a better glycemic control and fewer hypoglycemic bouts. What is currently observed from the developed world is the impact of continuous glucose monitoring on the time one spends in target blood glucose when using pumps and flash glucose monitoring [23–25].

As sweet as it sounds, continuous glucose monitoring goes hand in hand with carb counting, which has many challenges in Africa. Carb counting is a bit difficult in Africa since families eat in one plate, and it is difficult to know the exact amount of food the child is going to eat. To overcome that, a scale system is used based on the blood glucose readings (pre/post meals over a week or so). The daily pattern of the patient is figured out, and a fixed short- or rapid-acting insulin is given before each meal. The second challenge of using a basal bolus regimen is the resistance to regularly and frequently check blood glucose at home even if strips are given for free.

Regarding the insulin pumps, the number of patients who use them started to escalate, specifically among prosperous and highly educated people. The decision to shift a patient to use an insulin pump is not easy. It is highly recommended in

Africa that one should have experienced the use of insulin syringes and a basal bolus or premixed regimen prior to using a pump so as to adapt to the whole concept and learn how to use a syringe in case of any pump breakdown. The cost is still high, although it is subsidized and supported by the Governments of some sub-Saharan countries like Sudan. In spite of that, it still needs a high-class category of people who are dedicated and educated and can afford the pump expenses.

In a mini-survey done at the last African Society of Pediatric and Adolescent Endocrinology's (ASPAE) virtual conference in February 2022, 74% of the endocrinologists from sub-Saharan Africa have never used a pump for their patients. More than 50% of the endocrinologists have never educated their patients about carb-counting because they either do not know how to do it, or they think patients would not understand it, or because of the lack of local food exchange tables. From that survey, 44% of the patients could check their blood glucose twice daily, while about 20% would do it about 4–5 times a day, and these are the patients on the basal-bolus regime. In that survey, it was clear that training should be intensified among doctors about the benefits of basal bolus regimen and insulin pumps whenever feasible. Even for basal bolus regimen, NPH insulin can be used with short-acting insulin since these are much cheaper than insulin analogues.

Premixed insulin regimen, which has been widely used in sub-Saharan Africa, is associated with early diabetes complications like nephropathy and neuropathy in addition to Mauriac syndrome, which is rarely seen nowadays in Western countries. In a recent study from Sudan by Hana Ahmed et al., frequency of nephropathy and retinopathy has been found in 36% and 33% of the patients in the age category 10–18 years, respectively [26]. In another study from Sudan, 88% of the studied population had evidence of peripheral neuropathy [27]. All patients from the two studies were on premixed or modified premixed insulin regimen. Although the sample size was small in the two studies, it still rings a bell that early complications are common among premixed insulin users.

**Figure 6.**
*Readily available foods (Mostly starch).*

### 3.1.4 Diet

Diabetes diet is a balanced diet. It involves a dietician. Highly concentrated sugar drinks such as fizzy soft drinks should be avoided except in periods of hypoglycemia. In the hospital setting, food rich in starch are staple food and readily available; thus, education on portions and limiting consumption of these food types is insisted. Various food types are recommended in all Type 1 diabetes clinics in this setting; this includes proteins such as diaries along with vegetables and fruits.

Difficulties in carb counting are faced because in most of the foods, the carbohydrate content is not estimated (**Figure 6**).

### 3.1.5 Exercise

Exercise is important for all children with diabetes. Exercise improves insulin sensitivity, cardiac strength, and glucose absorption. Children may not comply with exercise. Involve the whole family because it is good for everyone, and it gives motivation to the patient.

### 3.1.6 Monitoring and appointments

Diabetic children are asked to monitor and document their blood glucose levels, two to three times a day, at home. Blood glucose logbook is reviewed each visit to the clinic. Based on blood glucose values, the insulin dose can be adjusted to make sure they attain the blood glucose target values.

HbA1C is checked every three months. The HbA1C is used to monitor blood glucose control in patients with diabetes. With good glycemic control, most blood glucose values will be within target ranges and HbA1C will come down to the normal range or closer. For children and adolescents, the desired value is less than 7.5%. In order to achieve better control, target values should be in place. Before meals: 4–7 mmol/L, after meals: 5–10 mmol/L, bed time: 5–10 mmol/L, 3 am: 5–8 mmol/L. The insulin dose is adjusted until most of the blood glucose levels are within the target range.

### 3.1.7 Screening for complications

It has been shown by different studies that complications start either after a duration of 5 years if a child is pre-pubertal or after 2 years if the patient is diagnosed within/after puberty. This is different from studies done in Africa, where achieving a good control is challenging, screening must be done much earlier after the initial diagnosis and then 1-2 yearly. Hence, every year, the following screening tests should be done:

1. Microalbuminuria. This screens for early kidney damage

2. Eye examination. Fundoscopy should be done by an ophthalmologist to rule out eye diseases

3. Lipid profile

4. Microfilament examination of the limbs to rule out neuropathy

5. ECG, Echoccardiography, etc

In the current century, a very rare diabetes complication is still seen in sub-Saharan Africa, which is Mauriac syndrome. It is a constellation of hepatomegaly, delayed growth, and puberty with cushingoid features in a poorly controlled diabetic. In addition to that, contracted small joints creating what is known as "a prayer sign" is a common clinical sign that junior staff are trained to look for when taking care of patients in the outpatient setting. No recent publication from the region has estimated its prevalence.

Other complications that are seen in the transitional clinics are problems related to final adult height, puberty delay, and infertility. At the same time, adolescents, commonly females, refuse to take frequent insulin injections so as not to gain weight. Learning difficulties like dyslexia and memory disturbances as well as psychological instabilities of poorly controlled diabetic children and adolescents are other serious complications that are not always discovered.

To prevent such complications in the coming future, more epidemiological studies are needed from the region to identify the burden of the disease. Continuous training to the HCP and Enhancing the awareness among the community about diabetes could play a role in improving the delivery and efficiency of diabetes services through better glycemic control, early complications detection, and timely intervention whenever needed. Intensive insulin therapy should always be the practice, targeting better glycemic control and less complications.

## 4. Challenges: in management of diabetes in Sub-Saharan Africa

Despite the improvement that is taking place, Africa still has a long way to go before realizing the standard of care. There are different challenges affecting the management of diabetes in Africa, including the following:

### 4.1 Education/awareness

Diabetes mellitus has been termed as a disease of the affluent, so there is a gap of knowledge on diabetes in the society as well as with the healthcare providers. Food security is poor, since majority of the rural clients are dependent and either work in

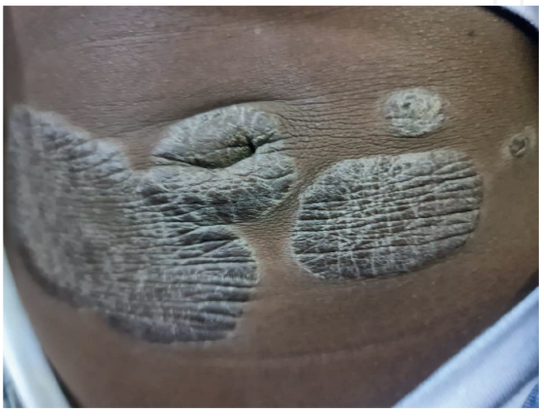

**Figure 7.**
*Local Acanthosis Nigricans at insulin injection site.*

seasons in a year as well as are from same families who earn annually. Thus, the food stored is limited and with inadequate distribution interfamily and within the family. At lease every client is able to feed unrefined food but is limited in terms of other sources of food like proteins, minerals, and vitamins.

The independents are either spending time outside to hang with friends with unstandardized meal or skip both meals and take insulin on trial to adjust his or her day.

Fuels may be a problem in early morning; thus, leftovers may be used if well kept. And majority do not have cooling methods to keep big share of raw foods, and the distance to the market or butchers is long (**Figure 7**).

### 4.2 Healthcare providers

There is inadequate number of healthcare providers for comprehensive management of type 1 diabetes patients in Africa. It is known that in Africa the doctor–patient ratio is low as compared to the Western countries, and the ratio is unacceptably low for the number of pediatric endocrinologists in Africa. So, the available healthcare providers are overwhelmed with work. The few available healthcare providers lack/have less knowledge about the management of diabetes, specifically type 1 diabetes.

An infectious disease burden is still on the rise; hence, there is the double burden of communicable and non-communicable diseases. Unworthy to some workers as a rare disease or unclear management brings a message of difficulty to learn and retain the knowledge. This is comparable to the emergency and outpatient conditions.

### 4.3 Guidelines

The continent lacks adequate guidelines with local evidence to run diabetes care. Hence, most of the guidelines used are European oriented and hence difficult to adopt and apply to the African environment. The continent still uses the acute care model; however, the chronic care model is still difficult in a setting where most of the conditions are infectious. The existing models are childhood oriented but not for adolescents, and they focus on children's pictures. The young medics prefer electronic ones, which are difficult to use when there is no electricity, and limited digital office infrastructure deploys the use.


**Figure 8.**
*Challenges in reaching out diabetic children in remote areas.*

**Figure 9.**
*Clay pot Olympics in Sudan 2016.*

### 4.4 Diagnostic tools and medication

There is lack of diagnostic tools to diagnose, manage, and follow up patients with diabetes, as well as tools to screen for complications; hence, patients are managed poorly. There is generally poor laboratory support especially at the secondary and primary care levels coupled with high cost of supplies such as glucometers, strips, lancets, and insulin.

Despite all these challenges, there are efforts being taken in different countries to manage T1DM, including establishment of clinics specific for T1DM, training of healthcare providers in management of T1DM even if they are not diabetologists, improvement of public–private partnership in order to get support from different organizations, and public awareness campaigns.

Glycated hemoglobin test performed when the supporting programmes deliver of supplies and medicines and few clients are health insured to have this done.

### 4.5 Distance to healthcare facility

Most African villages are very far from the services, so it takes a long time for a client to reach hospital; they may take two or three days to reach a clinic. Some of the countries have managed to assist with mobile clinic, but most of the countries cannot afford this (**Figure 8**).

### 4.6 Storage challenges

Lack of fridges and electricity have forced people to use local pots, which is a challenge in temperature control (**Figure 9**).

## 5. Poor glycemic control

Despite the provision of insulin for those who are being supported by different organizations, their HbA1C is still very high (**Figure 10a** and **10b**).

(a) (b)

**Figure 10.**
*(a) Mauriac syndrome and coeliac disease, (b) Mucormycosis of the eyes in a poorly controlled diabetic.*

## 6. Conclusion

Diagnosis and management of type 1 diabetes has improved over the past decade, but there are still challenges. More than a hundred pediatric endocrinologist have been trained from Nairobi, Lagos and Khartoum for the African sub-region, but the continent needs more pediatric endocrinologists for comprehensive care of type 1 diabetes mellitus. More education about type 1 diabetes is needed to improve awareness so that early diagnosis and management can be made.

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