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Challenges and Opportunities in Managing Type 2 Diabetes Mellitus in Sub-Saharan Africa: The Cases of Nigeria and South Africa.

By

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ABSTRACT

Background: Diabetes mellitus is a chronic, non-communicable, and metabolic disease characterized by elevated levels of blood glucose due to insulin deficiency/defective action, leading to severe damage of the heart, eyes, blood vessels, kidneys, and nerves, and conditions that make walking painful. While diabetes was considered the disease of the affluent, populations from low socio-economic communities are also affected. So, while diabetes is rising worldwide, its prevalence has risen faster in Sub-Saharan Africa and other low-and middle-income countries than in high-income countries. Diabetes prevalence in Africa underlines the need to understand its causes, magnitude, and management challenges.

Aim: This study's specific objectives were to analyze the challenges in the detection and diagnosis of diabetes in Nigeria and South Africa and to offer recommendations to overcome some of the management challenges.

Methods: This search entailed an exploration of the PubMed, EMBASE, Scopus, Medline, and Lancet Diabetes & Endocrinology databases. Additionally, desk research was conducted in African Journals Online, the International Diabetes Federation and the World Health Organization open access sources. Google and countrywide health surveys, including reports from health regulatory bodies such as the Society for Endocrinology, Metabolism and Diabetes of South Africa, the Endocrine and Metabolism Society of Nigeria, and the Diabetes Association of Nigeria were undertaken.

Results: The analysis indicates that high dependence on complementary and alternative medicine, treatment, and cost of T2DM, the low capability of healthcare systems to tackle diabetes, and poor adherence to diabetes guidelines correlate highly with diabetes prevalence in Nigeria and South Africa.

Conclusions: The study underscores the need: (1) to increase the budgetary allocation for health, and integrate generic medicines into diabetes care (2) to inform health care practitioners about the simultaneous use of herbal and conventional medicine, and understand the biological effects of herbal medicines (3) for a concerted effort to be put in place to ensure that optimal care for diabetes patients is attainable, and (4) for more extensive implementation of diabetes guidelines and collaboration between policymakers, healthcare providers, the pharmaceutical industries, herbalists, and users of anti-diabetic medication to ensure adequate regulation of the importation of diabetes medicines.

Key Words: Diabetes Mellitus Type 2, Challenges, Management, Nigeria, and South Africa

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LIST OF ABBREVIATIONS

CHW	Community Health Worker
DAN	Diabetes Association of Nigeria
DM	Diabetes Mellitus
DSME	Diabetes Self-Management Education
EMSON	Endocrine and Metabolism Society of Nigeria
GAD	Glutamic Acid Decarboxylase
HDI	Herb-Drug Interaction
IDF	International Diabetes Federation
NCD	Non-Communicable Disease
SEMDSA	Society for Endocrinology, Metabolism and Diabetes of South Africa
T1D	Type 1 Diabetes
T2D	Type 2 Diabetes
THM	Traditional Herbal Medicine
WHO	World Health Organization

CHAPTER 1: INTRODUCTION

1.1 Background

Over the last few years, globally, sub-Saharan Africa has projected the highest prevalence rates of diabetes mellitus (commonly called diabetes) (Agyemang et al., 2016). The effect of this increase in diabetes prevalence is adverse. It spans from health to socio-economic domains of individuals and even nations. The UN Member States have pledged to the goal of ensuring healthy lives and promoting well-being for all, which includes increasing life expectancy and ending diabetes, among other non-communicable diseases (NCDs). To implement this goal, many governments, including Nigerian and South African governments, have adopted an operational policy/strategy/action plan for diabetes, as the following chapters indicate.

1.2 Diabetes Mellitus

Diabetes or diabetes mellitus is one of four NCDs targeted by world leaders in, among others, the 2011 Political Declaration on the Prevention and Control of NCDs (UNGA, 2011, p. para. 39), the 2013 Comprehensive Global Monitoring Framework including indicators and a set of voluntary global targets for the prevention and control of NCDs by 2025 (WHO 2012, 2012), and the WHO Global Action plan for the prevention and control of NCDs between 2013-2020 (WHO, World Health Organization, 2013). These commitments aim to strengthen national efforts to address the burden of NCDs in the world. They were deepened in 2015 by adopting the 2030 Agenda for Sustainable Development—a shared blueprint for peace and prosperity for people and the planet, right now and into the future. In this context, governments agreed to take action to achieve ambitious targets by 2030, to reduce by one-third premature mortality from NCDs through prevention and treatment, and promote mental health and well-being (United Nations, 2015, p. 18). This section reviews the etiology of diabetes (phenotype, prevalence, and burdens) globally.

The International Diabetes Federation (IDF) Diabetes Atlas (IDF Diabetes Atlas) is an authoritative source of evidence on the prevalence of diabetes. This document defines diabetes as a chronic disease that occurs under one of two conditions (i) when the pancreas is unable to make insulin or (ii) when the body cannot make good use of the insulin it produces. Accordingly, insulin is a pancreatic hormone essential for the metabolism of carbohydrates, protein, and fat (IDF Diabetes Atlas, 2019, p. 12). Insulin acts like a key to allow glucose from the food we eat pass from the bloodstream into the cells in the body to produce energy—it helps glucose get into the cells.

Therefore, the inability to make insulin or use it effectively can result in raising glucose levels in the blood, a condition known as hyperglycemia (International Diabetes Federation, 2020). Without insulin, sugar (glucose) builds up in the blood rather than being used for energy (Diabetes Canada, 2020). Hence, diabetes is a chronic, metabolic disease characterized by elevated levels of blood glucose (or blood sugar), which leads over time to severe damage to the heart, blood vessels, eyes, kidneys, and nerves (WHO, Diabetes, 2020). It develops when insulin-producing cells are unable to compensate for insulin resistance.

Following recent calls to update the classification system for diabetes, as many people with diabetes do not fit into any single category, the World Health Organization (WHO) expert group came up with the WHO classification of diabetes 2019. The system prioritizes clinical care and helps health professionals to choose suitable treatments, and to decide whether or not to start treatment with insulin, particularly at the time of diagnosis (WHO, 2019, p. 11). Table 1 highlights several diabetes subtypes—Type 1 diabetes, Type 2 diabetes, hybrid forms of diabetes, other specific types, unclassified diabetes, and hyperglycemia first detected during pregnancy. They are caused by a relative or absolute insulin deficiency/defective action resulting in the disorder of carbohydrates, fat, and protein metabolism (Diabetes Association of Nigeria, 2013, p. 3) and (SEMDSA, 2017, p. 11).

1.2.1 Type 1 Diabetes mellitus

Type 1 Diabetes mellitus (T1DM) is a disease in which the pancreas fails to produce insulin (Diabetes Canada, 2020). Based on the most recent specifications of the IDF Diabetes Atlas, T1DM results when the body's immune system attacks insulin-producing cells in the pancreas, which results in profound insulin deficiency. These specifications also include excessive thirst, lack of energy, fatigue, constant hunger, sudden weight loss, blurred vision, and bedwetting as the typical symptoms of T1DM (IDF Diabetes Atlas, 2019, p. 13). In the absence of insulin, sugar will build up in the body rather than being used for energy. So, people living with T1DM need daily administration of insulin to regulate the quantity of glucose in their blood in order to survive. This suggests that T1DM is treated with insulin injected into the body, besides a healthy lifestyle (Diabetes Canada, 2020) and (WHO, Global Report on Diabetes, 2016, p. 11).

1.2.2 Type 2 diabetes

Type 2 diabetes mellitus (T2DM), also known as non-insulin-dependent or adult-onset diabetes is common in adults. However, an increasing number of children and adolescents are also affected (WHO, 2019, p. 14). Epidemiological data illustrate that genetic syndromes—autoantibodies to insulin, primary target cell defects, and increased insulin degradation—can cause insulin resistance (Epidemiology of Diabetes, 2019, p. 91). T2DM makes up about 90% of all cases of diabetes. It occurs when the body's cells are unable to respond adequately to insulin, leading to an elevation in insulin production (IDF Diabetes Atlas, 2019, p. 13).

As blood glucose levels keep rising (because insulin cannot work adequately), hyperglycemia is the outcome, with symptoms including excessive thirst and dry mouth, frequent urination, lack of energy, tiredness, slow healing wounds, recurrent infections in the skin, blurred vision, and tingling or numbness in hands and feet (International Diabetes Federation, 2020). The further observational analysis illustrates that the risk factors of T2DM include a family history of diabetes, overweight, unhealthy diet, physical

inactivity, increasing age, high blood pressure, ethnicity, impaired glucose tolerance (IGT), history of gestational diabetes, poor nutrition during pregnancy (International Diabetes Federation, 2020).

1.2.3 Hybrid forms of diabetes

Efforts to differentiate T1DM from T2DM among adults have led to new disease categories and nomenclatures— (1) slowly evolving immune-mediated diabetes and (2) ketosis-prone T2DM. A slowly evolving immune-mediated diabetes has been defined, most often, in adults who present clinically with what is primarily assumed to be T2DM, but who have indications of pancreatic autoantibodies that can react with non-specific cytoplasmic antigens in islet cells, glutamic acid decarboxylase (GAD), protein tyrosine phosphatase IA-2, insulin, or ZnT8 (WHO, Classification of Diabetes Mellitus 2019, 2019). On the other hand, ketosis-prone T2DM can be differentiated from T1DM and T2DM by certain clinical, epidemiologic, metabolic features of diabetes onset, as well and by the natural history of impairment in insulin secretion and action. Glucose toxicity may influence the acute and phasic β-cell failure in ketosis-prone T2DM (WHO, Classification of Diabetes Mellitus 2019, 2019, p. 16).

1.2.4 Other specific types of diabetes

Other specific types of diabetes, according to the World Health Organization, include monogenic diabetes, which comprises (i) monogenic defects of β-cell function; (ii) monogenic defects in insulin action; (iii) disease of the exocrine pancreas (defects in the pancreas can result in hyperglycemia—trauma, tumour, inflammation, etc.; (iv) endocrine disorders (it occurs in diseases with excess secretion of hormones that are insulin antagonists); (v) drug or chemical-induced diabetes; (vi) infection-related diabetes; (vii) uncommon forms of immune-mediated diabetes; and (viii) other clinically defined subgroups (WHO, Classification of Diabetes Mellitus 2019, 2019, p. 18).

1.2.5 Unclassified diabetes

A category of "unclassified diabetes" has been introduced by the World Health Organization, and it could be used temporarily when there is not a clear diagnostic category, especially close to the time of diagnosis

of diabetes. Instances where the "unclassified diabetes" category should be used include in cases such as: the global upsurge in the prevalence of obesity has led to T2DM being diagnosed in children and young adults. Also noteworthy is that at the same time, children and young adults with T1DM are more commonly overweight or obese than in the past. Besides, ketosis or frank ketoacidosis is not confined to T1DM. These complications make the classification of diabetes difficult, particularly at diagnosis (WHO, Classification of Diabetes Mellitus 2019, 2019, p. 23).

1.2.6 Hyperglycemia first detected during pregnancy

This classification—Hyperglycemia first detected in pregnancy—includes two categories of hyperglycemia: (1) diabetes mellitus, defined by the same criteria as in non-pregnant persons; and (2) gestational diabetes, defined by newly recommended glucose cut-off points that are lower than those for diabetes (WHO, Diagnostic criteria and classification of hyperglycaemia first detected in pregnancy: a World Health Organization Guideline, 2014). High blood glucose levels characterise gestational diabetes during pregnancy, which may occur at any time during gestation (even though most likely after week 24). Usually, it vanishes after pregnancy (IDF, 2020).

1.3 Global prevalence of diabetes

The global prevalence of diabetes has practically doubled since 1980. WHO estimates suggest that 422 million adults were living with diabetes in 2014, compared to 108 million in 1980, climbing from 4.7% to 8.5% in the adult population (WHO, Global Report on Diabetes, 2016, p. 6). Estimates from 2020 by the International Diabetes Foundation (IDF) illustrate that in 2000, the global estimate of adults living with diabetes was 151 million: by 2009 it had grown by 88% to 285 million. A shocking 463 million people are living with diabetes today. The IDF predicts that there will be 578 million adults with diabetes by 2030 and 700 million by 2045 (IDF, 2020).

Table 1: Types of diabetes

Diabetes Types	Brief description
Type 1 diabetes Mellitus	β-cell destruction and absolute insulin deficiency; onset most common in childhood and early adulthood
Type 2 Diabetes Mellitus	Most common type, various degrees of β-cell dysfunction and insulin resistance; commonly associated with overweight and obesity
Hybrid forms of diabetes 1. Slowly evolving, immunemediated diabetes of adults	Similar to slowly evolving type 1 in adults but more often has features of the metabolic syndrome, a single GAD autoantibody and retains greater β-cell function
2. Ketosis-prone type 2 diabetes	Presents with ketosis and insulin deficiency but later does not require insulin; common episodes of ketosis, not immune-mediated
Other specific types	
Monogenic defects of β-cell function	Caused by gene mutations; has several clinical manifestations requiring treatment,
Monogenic defects in insulin action	Caused by gene mutations, with features of severe insulin resistance without obesity
Diseases of the exocrine pancreas	Caused by conditions that affect the pancreas
Endocrine disorders	Occurs in diseases with excess secretion of hormones that are insulin antagonists
Drug- or chemical-induced	Caused by some medicines/chemicals impair insulin secretion or destroy β-cells
Infection-related diabetes	Some viruses have been associated with direct β-cell destruction
Specific forms of immune-mediated diabetes	Associated with rare immunemediated diseases
Other genetic syndromes associated with diabetes	Many genetic disorders and chromosomal abnormalities increase the risk of diabetes
Unclassified diabetes	Used to describe diabetes that does not clearly fit into other categories. This category should be used temporarily when there is not a clear diagnostic category especially close to the time of diagnosis
Hyperglycaemia first detected during pregnancy	
• Diabetes mellitus in pregnancy	Type 1 or type 2 diabetes first diagnosed during pregnancy
• Gestational diabetes mellitus	Hyperglycaemia below diagnostic thresholds for diabetes in pregnancy thresholds for diabetes in pregnancy

Source: Adapted from WHO Classification of diabetes mellitus 2019

Although considered the disease of the affluent, however, a paradoxical shift in rural-urban lifestyles means that populations from low socioeconomic communities are also affected (Adeniyi et al, 2016). Next, it was considered a current epidemic in both developed and developing countries, accounting for 90% of global cases of diabetes. However, it is currently of higher incidence in non-European countries, including those in Africa, Asia, and other developing countries (WHO, Global Report on Diabetes, 2016, p. 6) (Misra et al, 2019); (C Sarpong, 2017). Current diabetes statistics demonstrate that 77% of global diabetes patients live in developing countries: on the island of Nauru in the Pacific, closely 40% of adults

have diabetes, while the disease was almost nonexistent in this location five decades ago (Epidemiology of Diabetes, 2019, p. 91). So, while diabetes is rising worldwide, its prevalence has risen faster in low- and middle-income countries than in high-income countries.

Compared with other regions, the increase in the number of people with diabetes from 2019 to 2045 is the highest in Africa. In 2019, 19 million people had diabetes, with projections that this number will soar to 29 million in 2030 and 47 million in 2045—signifying a 143% increase (IDF, 2019, p. 43). Regional prevalence of nearly 6% increase by 162.5% by 2045 will result in 40.7 million T2D patients and costs escalating to USD 6 billion (International Diabetes Federation, 2017). The increase in diabetes prevalence in Sub-Saharan Africa is expected to outpace all other global regions (Agyemang C et al., 2016).

1.4 Prevalence of diabetes in South Africa and Nigeria

South Africa is a sub-Saharan African country with an upper-middle-income economy with one the largest economies in Africa, with at least a quarter of the population unemployed and living on USD 1.25 per day (SEMDSA, 2017, p. 9). Based on the Worldometer elaboration of the latest United Nations data, South Africa has a total land area estimated at 1,213,090 Km^2, ranks 25^{th} by population, and comprises 0.76% of the world's total, with over 59,113,944 South Africans as of March 29, 2020 (Worldometer, 2020). South Africa has the highest prevalence of diabetes and age-adjusted comparative prevalence of diabetes in adults aged 20–79 years (12.7%) in the African Region (4.6 million) (IDF, 2019, p. 65). Over 1,826, 000 cases of diabetes were reported in South Africa in 2017, with a 5.4% prevalence in adults (International Diabetes Federation, 2020), lower than what was predicted in the previous year. In 2016, the prevalence of diabetes in South Africa was about 9.8% (WHO, South Africa, 2016) (Coetzee et al., 2019) and 7.0% in 2015 (SEMDSA, 2017, p. 9).

The latest United Nations data shows that Nigeria is another sub-Saharan African country. It has a total land area of 910,770 Km^2 (351,650 sq. miles), ranks 7^{th} by population, with about 204,772,072 Nigerians as of Sunday, March 29, 2020, comprising 2.64% of the total world's population (Worldometer, Nigeria Population , 2020). Trailing behind South Africa, Nigeria has the second-highest number of people with diabetes (2.7 million) in the African region (IDF, 2019, p. 65), up from 1,702,900 cases of diabetes in 2015 with a 2.0% prevalence of diabetes in adults (International Diabetes Federation, 2020). This figure is entirely dissimilar to the pooled diabetes prevalence of 5.77% in a 2018 meta-analysis indicating an escalation in the prevalence of diabetes in Nigeria (Uloko A. E. et al., 2018, p. 1311). Other assessments in rural districts in Nigeria concluded the prevalence to be 8.0% (Arugu & Maduka, 2017) and 4.3% (Sabir et al., 2017) as well as 0.65% in rural areas in the North, 6.8% in the Niger Delta to 11.0% in urban areas in Lagos (Diabetes Association of Nigeria, 2013).

The prevalence of T2DM in Nigeria and South Africa underlines the significance of understanding its causes and magnitude. The WHO data on the prevalence of diabetes in South Africa identified related risk factors such as overweight, obesity, and physical inactivity estimated respectively at 51.9%, 25.6%, and 47.1% (WHO, South Africa, 2016). Data on the prevalence of diabetes and related risk factors in Nigeria has shown that there is an association between physical inactivity 9.8%, overweight 30.1% and obesity 9.7% and diabetes prevalence in Nigeria (WHO, Nigeria, 2016). Comparatively, the 2016 prevalence of diabetes and related risk factors in South Africa are higher than those in Nigeria. It was reported in 2018 that there had been no countrywide health (diabetes) survey in Nigeria since 1992, when diabetes mellitus prevalence was 2.2% (Uloko AE et al., 2018).

In addition to the above risk factors, other assessments in Nigeria and South Africa have identified alcohol intake, urban-dwelling, unhealthy dietary habits (including the consumption of sugar-sweetened beverages), cigarette smoking, older age, diastolic blood pressure, and family history of diabetes as causative risk factors of diabetes (Arugu & Maduka, 2017), (Coetzee et al., 2019), (Sabir et al., 2017),

(Uloko AE et al., 2018) and (Adeleke & Ayenigbara, Preventing Diabetes Mellitus in Nigeria: Effect of Physical Exercise, Appropriate Diet, and Lifestyle Modification, 2019).

The magnitude of the diabetes burden in Nigeria and South Africa is further reflected in the mortality statistics. Diabetes is the second leading cause of morbidity and mortality in South Africa (Mutyambizi et al., 2019) and (V. Pillay-van Wyk, 2017). Diabetes has moved from being the fifth cause of death in 2013 to, respectively, the third and second underlying cause of death in 2014 and 2015 (IDF Atlas, 2015). By the end of 2015, complications from T2DM were the leading natural cause of death in women in South Africa and the second-largest cause for the total population (SA, 2017, p. 35). In 2016, the number of diabetes deaths (ages 30–69) in South Africa was 19,400 (WHO, South Africa, 2016) and about 18,000 in Nigeria (WHO, Nigeria, 2016).

T2DM is the most familiar form of diabetes and constitutes over 95% of the diabetic population in Nigeria (Diabetes Association of Nigeria, 2013, p. 10). In 2017, the prevalence, hospitalisation and mortality from T2DM in Nigeria was 30.2%/100 000 population, with a case fatality rate of 22.0% (Davies Adeloye et al., 2017). The WHO, in 2016, estimated the number of diabetes death at 8770 (males) and 9380 (females) ages 30-69 (WHO, Nigeria, 2016). Based on these statistics, T2DM is a threat to the health of people in Nigeria and South Africa.

1.5 Global burden of diabetes

Associated risk factors of T2DM have resulted in complications in many parts of the body. Diabetes can increase the risk of mobility disability (E Wong, 2013) and can result in hypoglycemia, peripheral circulatory complications, renal complications and ketoacidosis—the result of very high levels of glucose in the blood (C Sarpong K. N.-D., 2017). Complications of diabetes are both microvascular (as a result of damage to small blood vessels) and macrovascular (as a result of damage to larger blood vessels); (SEMDSA, 2017) and (World Health Organization, Diabetes Programme, 2020).

Complications include damage to small and large blood vessels in the eyes, kidneys, heart, brain, and legs and all over the body**,** which can lead to vision impairment or blindness, kidney failure, delayed wounds heal, heart failure, strokes, and painful conditions that make moving painful (American Diabetes Association, 2018). Specifically, eye disease (diabetic retinopathy) is a major cause of visual disability and blindness with symptoms such as blurred vision; diabetic kidney disease (nephropathy) is a leading cause of kidney failure; nerve disease (neuropathy) can result in impotence in diabetic men and damage to limbs and cardiovascular disease which can lead to chest pain to confusion and paralysis (World Health Organization, Diabetes Programme, 2020).

The 2016 Global Report on Diabetes indicates that lower limb amputation rates are 10 to 20 times higher among diabetes patients (WHO, Global Report on Diabetes, 2016, p. 30). In sum, diabetes patients generally present the following symptoms: polyuria, polydipsia, polyphagia, weight loss, recurrent infections, eye symptoms, erectile dysfunction, poor obstetric history, foot sepsis, foot gangrene, and loss of consciousness (Diabetes Association of Nigeria, 2013, p. 5).

Regarding diabetes-related mortality, the number of deaths resulting from diabetes and its complications in 2019 was about 4.2 million, equivalent to one death every eight seconds, with almost half (46.2%) of theses deaths being in people under the age of 60 years – the working-age group (IDF Diabetes Atlas, 2019, p. 54). The Global Status Report on NCDs suggests that NCDs caused more deaths than all other causes combined. With nearly three-quarters of these NCDs deaths (28 million) appearing in developing countries, NCDs deaths are projected to soar from 38 million in 2012 to 52 million by 2030. The report also shows that the chief causes of NCDs deaths in 2012 were, among others, cardiovascular diseases (17.5 million deaths, or 46.2% of NCD deaths) and diabetes (1.5 million, or 4% of NCD deaths) (World Health Organization, 2014).

Escalation of diabetes in Africa is a concern given its substantial impact on morbidity, mortality and costs. In 2019, diabetes was expected to cause 366,200 deaths in Africa (International Diabetes

Federation, 2019, p. 65). In 2015, the estimated health expenditure on diabetes in Africa was USD 3.4 billion, which accounted for 0.5% of the global expenditure, and which is equivalent to 7.0% of Africa's total health budget and USD 24.3 - 419 person annually (SEMDSA, 2017, p. 9). Therefore, as the rates of T2DM grow in Africa, so too do worries about the abilities of their healthcare systems to deliver excellent healthcare. This increase is problematic in many ways, primarily because of management challenges. Africa is a region facing poor care, a delay in seeking treatment, "fatalistic attitudes," high cost and non-availability of drugs and insulins (Misra et al, 2019).

Diabetes is one of the biggest causes of death worldwide: it was the seventh leading cause of death in 2016, with an estimated 1.6 million deaths directly caused by diabetes in 2016, and 2.2 million deaths were attributable to high blood glucose in 2012. Statistics also show that 50% of all high blood glucose-related deaths occurred before the age of 70 years (WHO, Diabetes, 2020). The percentage of deaths attributable to high blood glucose or diabetes before age 70 is higher in low- and middle-income countries than in high-income countries (WHO, Global Report on Diabetes, 2016, p. 6).

Besides resulting in mortality and complications in many parts of the body, diabetes brings about considerable economic loss to diabetes patients and their families, to national economies and health systems owing to loss of wages and direct medical costs. The rising cost of diabetes has been considerable, growing from USD 232 billion spent worldwide in 2007, to USD 727 billion in 2017 for adults aged 20–79 years, and was estimated that total diabetes-related health expenditure would reach USD 760 billion in 2019, representing a 4.5% increase on the 2017 estimate (IDF Diabetes Atlas, 2019, p. 56). While the major cost drivers are hospital and outpatient care, a causative factor is a rising cost of analogue insulins, which are gradually more prescribed despite little evidence that they provide substantial advantages over less pricy human insulins (WHO, Global Report on Diabetes, 2016, p. 6).

1.6 Theory

This study employs a social-ecological perspective as the theoretical model to analyze, explain or otherwise predict the relationship between factors that influence the prevalence of T2DM in Nigeria and South Africa. Ecological studies are useful for understanding the assortment of factors that influence health and wellbeing and framed as "...the interaction between, and interdependence of, factors within and across all levels of a health problem. It highlights people's interactions with their physical and socio-cultural environments" (Rural Health Information Hub, 2020).

But a Social-ecological framework views the ethical practice as the outcome of interaction among a range of factors at eight levels: individual factors (patients and families); individual factors (nurses); relationships between healthcare professionals; relationships between patients and nurses; organisational healthcare context; professional and education regulation and standards; community; and social, political and economic (Davidson P et al., 2018). It is a theory-based framework for understanding the multifaceted and interactive effects of personal and environmental factors. It is useful in examining a full breadth of elements that influence and contribute to prevalence, prevention tactics, and evaluation of programming and policy to examine safety in the agricultural environment (Kilanowski JF, 2017).

1.7 Research aims, hypotheses and question

1.7.1 Research aim

The overarching aim of this study is to provide a better approach and understanding of how to address the prevention and care of diabetes and improve the quality of care given to diabetes patients in South Africa and Nigeria. The specific objectives of this study include:

- To analyze the challenges in the management of diabetes in Nigeria and South Africa by reviewing such challenges under the heading—detection and diagnosis challenges in these countries.

- To explore the opportunities in overcoming detection and diagnosis challenges in these countries.

1.7.2 Research Hypothesis

This study lays forward the hypothesis that the factors associated with the escalating diabetes epidemic in Nigeria and South Africa have to do with the underlying challenges of the continuous use of complementary and alternative medicine, the high costs of diabetes, the low capability of healthcare systems to tackle diabetes, and poor adherence to diabetes guidelines.

1.7.3 Research questions

- What are the problems in the management of T2DM in Nigeria and South Africa?
- Which lessons can South Africa or Nigeria learn from each other to improve the quality of care of patients with T2DM?

CHAPTER 2: METHODS

2.1 Study design

Throughout this chapter, an appropriately detailed description of the study will be offered to facilitate duplication by others. It was a systematic review of literature, collected from a variety of primary and secondary sources, which evaluated the challenges and problems of managing T2DM in Nigeria and South Africa.

2.2 Study period

This research was carried out in two quarters. The first quarter was an extensive literature review and developing a study procedure from the University of Applied Sciences, Hamburg (between December 2019 and March 2020). The second quarter was the write-up.

2.3 Study Population and eligibility criteria

The study population comprised of two Member States of WHO (Nigeria and South Africa), classified as middle-income countries with a gross domestic income per capita of between $1,026 and $12,475. Nigeria, South Africa, and many other developing countries have displayed substantial economic growth during the past decades, resulting in significant mechanization, urbanization, and opening of multinational food companies that produce processed energy-dense fast foods (Motta LA. et al., 2016) and (Misra A et al., 2019). This economic growth has led to important nutrition and lifestyle transitions, such as changes from traditional eating patterns/cuisines and physical activity.

Research has been consistent in showing that these changes are sharply linked to the rapid escalation of T2DM in these countries (Gulati & Misra, 2017); (Atun et al., 2017); (Fasanmade & Dagogo-Jack, 2015), with the consequence that life expectancy in theses countries is further reduced. So, given their population and diabetes prevalence, studies targeting Nigeria and South Africa were considered eligible.

There was no sample size calculation because it was a qualitative analysis, and qualitative analysis does not require any calculation of sample size. Systematic theoretical sampling was employed in this investigation. Systematic theoretical sampling is about selecting samples according to their bearing on the research question. The sample size was 120, as it was deemed enough to determine enough information to develop theories regarding challenges to T2DM in Nigeria and South Africa.

2.4 Inclusion and exclusion criteria

2.4.1 Inclusion criteria:

- This project included quantitative and qualitative studies, indexed and non-indexed, in national, regional and international databases.
- Articles included were based on availability, relevance, quality, reliability, and comparability of the resulting estimates.
- Publications in English
- All eligible (primary and secondary) data searches were conducted from December to March 2020.

2.4.2 Exclusion criteria:

- Publications that were older than 2015
- Studies not published in English
- Studies that investigated T1DM
- Studies that investigated diabetes in children
- Studies that were not conducted in Nigeria or South Africa.

2.5 Information sources

This search entailed an exploration of the PubMed, EMBASE, Scopus, Medline, and Lancet Diabetes & Endocrinology databases. Additionally, desk research was conducted in African Journals Online, the

International Diabetes Federation (IDF) and the World Health Organization (WHO) open access sources. Google and countrywide health surveys, including reports from health regulatory bodies such as the Society for Endocrinology, Metabolism and Diabetes of South Africa (SEMDSA), the Endocrine and Metabolism Society of Nigeria (EMSON), and the Diabetes Association of Nigeria (DAN) were undertaken. The objective of using non-journal sources was to identify publications that were not indexed in international databases.

2.6 Ethical considerations

While research projects should undergo a comprehensive review process with the University of Applied Sciences research ethics board, I did not acquire approval signatures from my supervisors because my research neither involved human participants nor human remains or biological fluids.

2.7 Search strategy

The search was conducted using key concepts (and their synonyms) derived from the hypothesis/research question through a trial search on different search engines. Medical Subject headings (MeSH) were used, and were then combined using the Boolean Operator—AND. PubMed, containing publications from the biomedicine and health fields, among other related disciplines, with Medline being the most abundant component, for example, gave the following results: “diabetes South Africa”; “diabetes Nigeria”; “diabetes AND prevalence AND Nigeria”; “diabetes AND prevalence AND South Africa”; “diabetes AND risk factors AND Nigeria”; “diabetes AND risk factors AND South Africa”.

2.8 Data screening, extraction, and management

So, the search resulted in over 1068 documents. Of these, 901 were removed because they were either duplicates or were older than 2015. Duplicates were removed using the automatic tool on some of the databases, and for those missing this tool, the duplicates were eliminated manually after screening the abstracts and titles, leaving the most relevant documents for full-text review. Therefore, the article search

was followed by the removal of duplicates. So, the first level of screening involved screening of abstracts. Articles were then downloaded for a full-text review. Reference lists of all eligible articles were also screened for additional relevant information. Furthermore, after screening the full-text review, and based on the research question, 119 appropriate studies were then classified as shown below.

2.9 Data items

The extracted data comprised information on the study (name of the authors, year of publication, journal reference, place and year and study design/setting), characteristics of study (study population and sample size) and main findings. This information was crucial in testing the hypothesis—the factors associated with the escalating diabetes epidemic in Nigeria and South Africa have to do with the underlying challenges of the continuous use of complementary and alternative medicine, the high costs of diabetes, the low capability of healthcare systems to tackle diabetes, and poor adherence to diabetes guidelines.

2.10 Quality assessment and appraisal of individual studies

Risk-of-bias assessment, sometimes called "quality assessment" or "critical appraisal," is a central component of systematic reviews (Meera Viswanathan et al., 2018). While several tools are available for quality assessment, the quality of the studies in this review was assessed using the Revised Cochrane risk of a randomized trial bias assessment tool. It is the standard approach to evaluate the risk of bias in randomized clinical trial. It is used in Cochrane and non-Cochrane reviews (Lars Jørgensen et al., 2016). It is structured into a set of bias domains and focusing on different aspects of the trial design, conduct and reporting. Each domain has a few questions designed to elicit information about characteristics of the trial that are crucial to the risk of bias. After using the proposed judgment about the bias risk arising from the domains, each study was rated as either "high" of "low" risk. The Critical Appraisal Skills Program, comprising ten questions distributed as follows: *study design*, *sources and quality of data*, *data analysis*, and *interpretation of results* was used to evaluate the quality and risk of bias. The questions have "No", "Yes", and "Not Clear" (Galdas et al., 2015).

CHAPTER 3: RESULTS

Figure 1: Prisma Flow Diagram

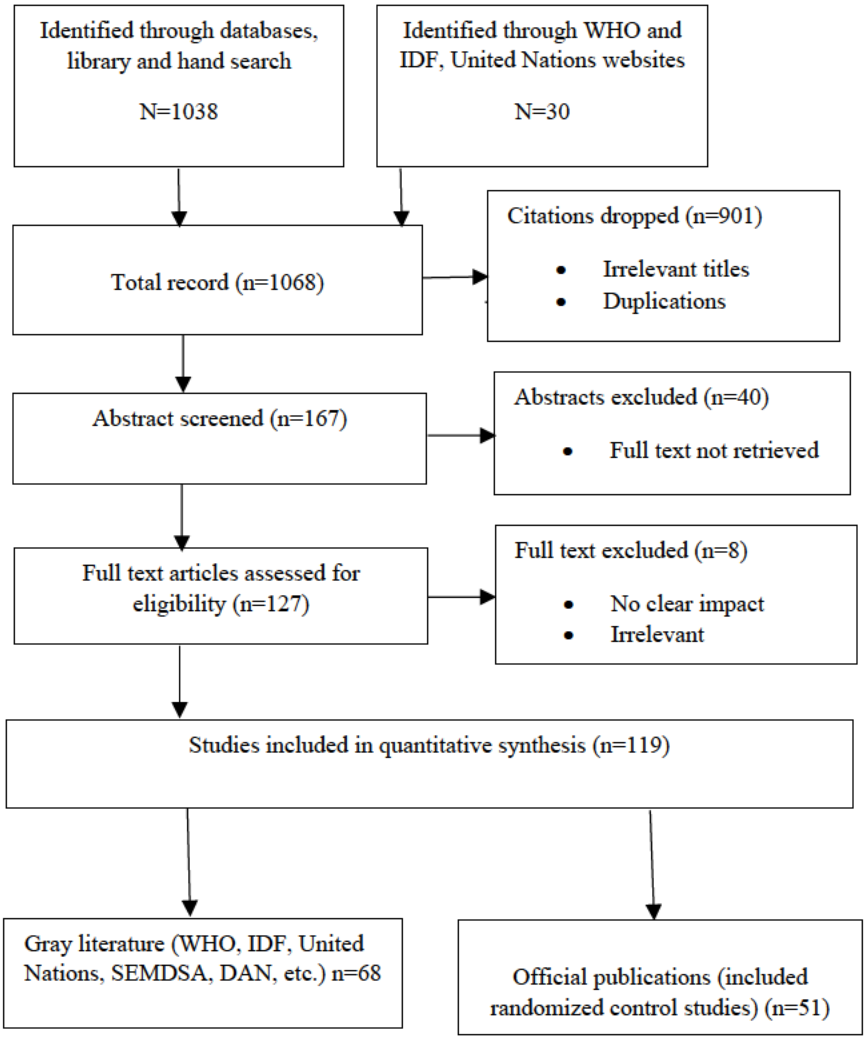

Table 2: Characteristics and Results of Included Randomized Control Studies

Reference (Author, Date, Country)	Purpose	Participants	Study design	outcome	Recommendation
Aboyade et al 2016, South Africa	To understand the health-seeking behaviour, healthcare practices and prevalence of THM use among older women with NCDs	n = 250 Age range: (women) 50 or older years Mean age:	A homogenous purposive sampling, descriptive statistics, and logistic regression were used	Medical pluralism was rampant among users of traditional herbal medicine.	Future studies are needed to investigate further the health-seeking behaviours among older black South African women.
Adeleke & Ayenigbara 2019, Nigeria	To explore the effects of diet, lifestyle, and physical activity on the prevention of diabetes in Nigeria		A systematic review of studies in reputable journals.	Obesity is a significant causative risk factor of diabetes mellitus	Physical activity and rich local nutrients are viable prevention options of diabetes
Adeloye & Aderemi, 2017, Nigeria	To estimate country-wide and zonal prevalence, hospitalization and mortality rates of T2DM in Nigeria.	n= Age range: 20–79 years Mean age:	Experimental hospital-based within subject random assignment	The rising burden of diabetes significantly increased diabetes treatment cost.	Improved research on T2DM in Nigeria is crucial.
Adeniyi et al., 2015, South Africa	To explore patients' perspectives on the challenges of glycaemic control.	n=17 Age range: 45–72 years Mean age:	A qualitative study using semi-structured open-ended interviews with prompts.	Poverty and lack of diabetes knowledge and doctors affect the management of diabetes	Recruitment and retention of doctors is recommended
Adeniyi et al, 2015, South Africa	To examine the determinants of uncontrolled T2DM in individuals attending primary healthcare in OR Tambo district, South Africa	N=360 Age range: ≥30 years	A cross-sectional analytical study	A significantly high prevalence (83.8%) of uncontrolled T2DM among the patients was found.	Addressing these determinants will require re-engineering of primary healthcare in the district
Adeloye et al, 2016, Nigeria	To estimate prevalence, hospitalisation and mortality rates of T2DM in Nigeria	N=91 320 Age range: 20–79 years	Conducted a random-effects meta-and meta-regression epidemiological model	Findings suggested an increasing burden of T2DM in Nigeria with many persons currently undiagnosed/on treatment.	More evidence-based epidemiological studies on T2DM is recommended
Alaofè et al, 2017, South Africa, Asia, and America	To critically appraise data on the effectiveness of CHW interventions for prevention and management of T2DM in LMICs	n=160 Age range:25-92 years Mean age:	Randomized controlled, cross-sectoral, cohort, case-control, and before-and-after studies	CHW interventions include patient education, provision of social support through home visits, and identification and referral of high-risk individuals to physicians.	Further research is needed to determine the facilitators of and barriers to the successful implementation of CHW interventions
Amaeze et al, 2018, Nigeria	To determine the prevalence and predictors of herbal medicine use among T2D patients in Lagos, Nigeria	n=453 Age range: Mean age:	A structured and standardized interviewer-administered questionnaire	Beliefs and perceptions about and the use of herbal medicine among 2TDM patients in Lagos, Nigeria is high	There is a dire need for health care practitioners to be aware of patients' health behaviour and choices, to managing the T2DM better.
Anioke et al, 2019, Nigeria	To investigate the predictors of poor glycemic control in T2DM	n=140 Age range: ≥ 65years	A cross-sectional survey using standard tools	Age, waist-hip ratio, fasting plasma glucose and systolic blood pressure were highly	The complex interactions between potential predictors of poor glycemic control

		Mean age:		link to differences in glycemic control.	among the elderly require further investigation on a broader scale
Arugu & Maduka, 2017, Nigeria	To identify risk factors for diabetes mellitus among adult residents of a rural District in Southern Nigeria	N=462 Age range: 18-82 years Mean age: 40.4614.36	A descriptive cross-sectional community-based survey	Alcohol intake, physical activity, diastolic blood pressure, age and family history of DM are associated with diabetes mellitus.	Study findings underscore the need for diabetes prevention and control activities that address the four major risk factors identified by WHO.
Attaei et al, 2017	To assess the availability and affordability of blood pressure-lowering medicines in countries at varying levels of economic development	N=626 Age range: years Mean age:		The availability of two or more classes of blood pressure-lowering drugs was lower in low-income and middle-income countries than in high-countries	Ensuring access to affordable blood pressure-lowering medicines is essential for control of hypertension in LMICs recommended
Awodele & Osuolale, 2015, Nigeria	To evaluate the impact of medication adherence on the clinical outcomes of T2DM patients	N=152 Age range: 61 years and above Mean age:	A descriptive (retrospective) and prospective study	A significant relationship existed between patient age, gender and adherence to medication but no association between educational level and adherence	Non-adherence should be minimized in order to minimize morbidity and mortality in diabetic patients.
Balogun et al, 2016, South Africa	To update the various scientific evidence on certain plants used in the management of diabetes in Sotho	N=23 plants	Desk research of the individual botanical names of plants on Google Scholar	Plants with antidiabetic activity are needed given the undesirable side effects of the oral hypoglycemic agents	Studies to adequately explore the folkloric use of most of the medicinal plants are crucial
Bosun-Arije et al, 2019, Nigeria	To investigate the factors that influence T2DM management in Nigerian public hospitals	N=20 studies	Synthesis of quantitative studies	Non-adherence, self-care related, psychological-related, social-related, cost-related and drug-related can influence T2DM management	Strategic plans for T2DM management in Nigerian public hospitals should consider the potential impact of social class, social capital, etc.
Chen et al, 2016, US	To analyze relationships between adherence to guidelines for diabetes care and complications and mortality.	N= 1,142 Age range: 65+ years Mean age:	Survey	Adherence to screening, physical activity and medication guidelines were associated with lower risks of diabetes complications and death	Adherence to screening tests and a self-care measured in terms of physical activity and medication should be improved
Chrvala et al, 2016	To assess the effect of diabetes self-management education and support methods, providers, duration, and contact time on glycemic control in adults with T2DM	N=118	A desk search	Engagement in diabetes self-management education results in a statistically significant decrease in A1C levels	
Coetzee et al, 2019, South Africa	To assess the contribution of traditional and modifiable risk factors to the overall risk and prevalence of T2DM amongst health workers in the public sector.	n=260 Age range: ≥ 55 years Mean age:	A retrospective analysis	Based on risk stratification, 29 of the 260 participants will develop incident T2DM in the next 10 years.	Policies and guidelines focused on limiting unhealthy/obesogenic work environments are urgently needed.
Davids et al, 2016, South Africa	To document medicinal plants used to manage High Blood Pressure	N=112 Age range:	Semi-structured surveys and in-depth interviews	Medicinal plants are widely used by High Blood Pressure and T2DM sufferers	

	and T2DM in Bitterfontein				
Davidson et al, 2018, South Africa	To develop a framework to address ethical issues in nursing practice		Comprehensive literature review to develop a conceptual framework	A social-ecological framework views the ethical practice as the result of different interactions at different levels.	Considering the challenges that nurses face in a social-ecological framework is recommended because it can assist in developing strategies and resolutions
Egbujie et al, 2018	to examine how CHWs have been utilized to support T2DM self-management globally, their preparation for and supervision to perform their functions	N=54	Scoping reviews	CHWs were mostly deployed to provide education, support, and advocacy	
Erzse et al, 2019, South Africa	Too estimate the direct medical costs associated with T2DM in the South African public health sector	N=240.000	A 'bottom-up' approach and a standard cost of illness approach	In 2018, public sector costs of diagnosed T2DM patients were about ZAR 2.7 bn and ZAR 21.8 bn	Increased financial resources are crucial to deliver effective services to T2DM patients in South Africa.
Ezuruike & Prieto, 2016, Nigeria	To assess the potential for pharmacokinetic herb-drug interactions (HDIs) amongst Nigerian adult diabetic patients	N=112 Age range: 30+ years	A literature analysis	over 50% of diabetic patients use herbal medicines alongside their conventional drugs	Additional studies to accurately identify potential HDIs amongst diabetic patients in Nigeria is needed.
Fadare et al, 2015, Nigeria	to assess the level of adherence to antidiabetic drugs among outpatients in a teaching hospital in southwestern Nigeria.	N=129	A cross-sectional study using the eight-item Morisky Medication Adherence Scale	The adherence of diabetes patients to their medications was satisfactory.	The integration of generic medicines into routine care is vital
Fasanmade, 2015, Nigeria	To describe the elements of diabetes management in Nigeria, areas for improvement, and proposed strategies to optimize care	N=	A systematic literature search	Diabetes-related morbidity and mortality continue to increase due to population expansion, urban migration, declining physical activity, and dietary factors	The way forward is to improve maternal and child care, promote screening of at-risk populations and develop strategies for primary prevention and early intervention to optimize glycemic control
Govender &, 2017, South Africa	To evaluate the management of T2DM in an under-resourced hospital in rural South Africa.	N=360	A retrospective chart review	Glycaemia was poorly managed at this hospital, which may be explained by clinical inertia	The results of this study need to be interpreted with caution and cannot be axiomatically generalised.
Herrmann et al, 2018, Australia	To explore the decision-making process of women who are at an increased risk of developing ovarian cancer and had to decide for or against the removal of their ovaries	n=18 Age range: 22-81 years Mean age: 57	A qualitative study of 18 semi-structured interviews	Age, menopausal status and family commitments can influence but not determine women's decisions on oophorectomy	The need for tailored decision support, which could help improve doctor-patient-communication and patient-centred care, is highlighted.
Ipingbemi & Erhun, 2015, Nigeria	To evaluate the economic cost of T2DM in Ibadan, Nigeria.	N=52	A pre-designed data form and an Open-ended, Affirmation, Reflective listening and Summaries	The annual cost of diabetes mellitus was $20,827.37 for the 52 patients	There is a need for the policymakers of the health sector to plan towards reducing the financial burden of diabetes on society.

Jackson et al, 2015, Nigeria	to assess medication adherence among T2DM patients and factors associated with nonadherence	N=303	A descriptive, cross-sectional research design	Medication adherence was generally poor among the cohorts studied. depression	Likely predictors of medication nonadherence should be assessed and addressed appropriately
Kasole et al, 2019,	to determine patients' and herbalists' practices/perspectives regarding the use/role of traditional medicines in diabetes management	N=140	A structured questionnaire and in-depth interviews	Patients and herbalists provided a range of perspectives regarding the use of traditional medicines to treat diabetes.	Further research is needed to identify bioactive compounds present in commonly used traditional medicines and their efficacy.
Kibiti et al, 2015, Africa	To review and classify herbal medicine's mode of action in therapy for diabetes disease	n=65 plants	An online database search	The use of herbal therapy will promote good health and improve the status of diabetic patients	More investigations should be encouraged in order to validate the anti-diabetic activity of the identified plants.
Masupe et al, 2018, South Africa	To understand contextual and environmental issues pertinent to the patient that could influence T2DM care and self-management	n= Age range: 35–72 years Mean age:	A qualitative study using in-depth interviews, focus group discussions (FGDs) using structured interviews and FGD topic guides	T2DM carries a different meaning for the patient compared to the health care professionals, and that meaning places significance on the physical, social and psycho-logical changes that results from the diagnosis	The current status quo needs to be challenged when promoting healthy eating and physical activity for the prevention and self-management ofT2DM.
Mendenhall & Norris, 2015, South Africa	To investigate women's experiences with diabetes care in Soweto	N=27 Age range: 43-79 years Mean age: 59 years	In-depth interviews	They identified structural barriers as overcrowded clinics and poor access to medicines as impeding adherence to treatment	Systemic issues should be reshaped to ensure patients have access to essential medicines and services.
Misra et al, 2019 developing countries	To analyse various aspects of diabetes in developing countries in Africa, South and East Asia, Middle East and North Africa and South and Central America	n=61 Age range: 19 and older years Mean age:	A narrative review of literature from different databases	Significant challenges to managing T2DM include ignorance, undiagnosed cases, the coexistence of T2DM with tuberculosis, the scarcity of trained health workers and the high cost of insulin, diagnostic tests and drugs	Increasing awareness, the use of allied health professionals for prevention and education, improving the standard of care; regulation to promote healthy food are some of the efforts to contain T2DM
Motta et al., 2016, South Africa	To evaluate the effectiveness of Point-of-care testing (POCT) in diabetes management	N=332 Age range: 27-85	Onsite recording of HbA1c and urine POCT	POCT promoted accessibility to HbA1c testing	Continuity of the supply of HbA1c and urine ACR testing cartridges should be enhanced
Mutyambizi et l, 2018, Africa	to capture the evidence on the cost of diabetes in Africa	N=26 articles	A desk search	Diabetes elevates costs of treatment, which furthers the presence of complications.	More systematic assessment of diabetes costs in Africa needs to be conducted
Odeyemi & Bradley, 2018, South Africa	To compare the families of previously reported anti-diabetic plants	N=45	A comprehensive literature search	The investigated plants have more than one mechanism of action	Further studies to identify the active ingredients of potent plants still need to be carried out
Ojewale, et al, 2019, Nigeria	To determine the association between patients' characteristics,	N= 197 Age range: 18	A cross-sectional multi-centre survey	DSM was positively influenced by previous diabetes education,	Providing well-structured diabetes education to family

	perception of family support and diabetes self-management (DSM) behaviours among T2DM patients	years and older		duration of diabetes, and family support	members of DM patients should be enhanced
Okoronkwo, et al, 2015, Nigeria.	To assess the magnitude of the economic burden borne by people living with diabetes mellitus (PLWD) in Nigeria	N=139 Age range: 31-65 years	Cross-sectional descriptive survey design	All socioeconomic status (SES) groups suffered catastrophic expenditure but the poorest quartile had the highest incidence.	PLWD needs financial protection, especially for the poorest since they buy from the same market and incur the same costs.
Olamoyegun et al, 2018, Nigeria	To assess insulin adherence, mode of insulin delivery and the burden of insulin usage among people with diabetes.	N= 213 Age range: 60 and older	A cross-sectional, prospective questionnaire	The insulin adherence among diabetics in this study was high.	Adopting other ways to deliver insulin (insulin pens, finer gauge needles is crucial
Onakpoya et al, 2015, Nigeria	To assess compliance with diabetic retinopathy screening in a tertiary hospital	N=179 Mean age: 61+12 years	A cross-sectional analytical prospective study	More than half (56%) of patients defaulted from retinopathy screening in this study	Screening need to be carried out after diagnosis,
Onwuchuluba et al, 2019, Nigeria	To assess adherence to antidiabetic medications and the influence of pill burden on adherence	N=418 Age range: 18 years and older	A cross-sectional, self-administered questionnaire survey	Nearly 27.5% of the participants were adjudged nonadherent to antidiabetic medications	Interventions to increase adherence to medication such as DSME is crucial
Pascal & Nkwa, 2016, Nigeria	To determine the role of diabetes treatment satisfaction in medication adherence and glycemic control among ambulatory T2DM Nigerians	N=120 Age range: ≥18 years	A clinic-based descriptive study	Diabetic treatment satisfaction, medication adherence, and glycemic control rates were 85.8%, 72.5%, and 61.7%, respectively.	Diabetic treatment satisfaction should be integrated into a standard care package for diabetic patients in primary care settings
Pinchevsky et al, 2017, South Africa	To determine if patients with T2DM attending a community health centre were having their ABCs measured, were treated with appropriate cardioprotective agents and were achieving guideline-based targets	N=159 Age range: >18 years of age	A cross-sectional record review	There were a significant number of patients who were not tested nor received adequate pharmacotherapy or achieved their ABC targets.	Wider implementation of evidence-based guidelines must be instituted in order to ensure better patient outcomes.
Pastakia et al, 2017, Nigeria	To review the care protocols, policy landscape, epidemiology, medication availability, and healthcare systems in sub-Saharan Africa (SSA)		A non-systematic review	There has only been a limited effort in building the structures necessary to promote safe and effective self-management strategies in SSA	Effort to pursue SSA-specific diabetes research is needed.
Powers et al, 2015,	To improve the patient experience of care and education, to improve the health of individuals and populations, and to reduce diabetes-associated per capita health care costs		Diabetes education algorithm	The numbers of patients who are referred to and receive DSME/S are disappointingly small	The health care community must mobilize efforts to address the barriers for DSME/S
Rampersad et al, 2018, South Africa	To assess compliance with local diabetic guidelines at a district	N=500 Age range: 42–91 years	Systematic random sampling	Evaluation of selected records demonstrated compliance with the SEMDSA guidelines in only 4.2% of patients.	There is an urgent need to review barriers to the implementation of

	hospital in KwaZulu-Natal,	Mean age: 61 years			guidelines in South Africa.
Sabir et al, 2017, Nigeria	To determine the prevalence of DM and its correlation in the suburban population of Northwest Nigeria	N=280 Mean age: 42.3 ± 10.7 years	Multistage sampling technique. Interviewer-administered questionnaire	Obesity and increasing age were the significant risk factors for DM among the suburban population. Conclusion: DM is common in suburban areas of Northwest Nigeria.	Increased awareness of the epidemic potential of this public health problem, even in suburban areas, is recommended.
Seetaloo et al, 2019, South Africa	To provide an updated systematic review of the potential of traditionally used herbs, spices, and food plants used against diabetes	N=94 plants	A comprehensive and structured literature search	The study identified 48 traditionally used plants that have been assayed in vitro for their a-amylase inhibitory properties	Proper taxonomic nomenclature, including author citation, is recommended
Soetedjo et al, 2018, South Africa	To describe the characteristics and management of Diabetes mellitus (DM) patients from low- and middle-income countries (LMIC).	N= 2068 Age range: 18 years and older Median: 59 years	Interview, using a validated questionnaire	The studied participants have insufficient glycaemic control and insufficient preventive measures for cardiovascular disease.	Studies to identify treatment barriers and secure optimal DM care is crucial
Tshabalala et al, 2019, South Africa	To assess variation in antioxidant, antimicrobial, antidiabetic and phytochemical properties between the leaves, and roots of Moringa	N= 10 plants	Experimental	This study ascertains that these different plant parts of Moringa can be suitable for antimicrobial, antioxidant and antidiabetic supplements	Alternative methods like the use of spectroscopy and hyperspectral remote sensing should be considered, to save experimental time
Tsolekileet al, 2018, South Africa	To assess CHWs' current roles, training and knowledge about diabetes and hypertension in Cape Town	N=150 Mean age: 35 years	An interviewer-administered closed-ended questionnaire	CHWs' knowledge of diabetes and hypertension was poor.	The potential of peer education as a complementary mechanism to formal training needs requires further exploration.

National guidelines have been adopted, such as the Society for Endocrinology, Metabolism and Diabetes of South Africa (SEMDSA) Guidelines (SEMDSA, 2017) and the Clinical Practice Guidelines for Diabetes Management in Nigeria published by the Diabetes Association of Nigeria (Diabetes Association of Nigeria, 2013). These interventions have the primary goal to improve the quality of life of people living with diabetes through, among others, early diagnosis and reduction of the burden of diabetes.

Notwithstanding, the number of cases presenting to health facilities with typical symptoms of diabetes is small. The African region has the highest proportion of undiagnosed diabetes: more than half (59.7%) of people living with diabetes are unaware of their condition (International Diabetes Federation, 2019, p.

65). Of the 2.3 million people with diabetes in South Africa in 2015, 1.3968 million (61.1%) were undiagnosed (SEMDSA, 2017, p. 9). The DAN report shows that up to half of all persons with diabetes are undiagnosed and may be asymptomatic, meaning they get diagnosed incidentally (Diabetes Association of Nigeria, 2013, p. 4). Undiagnosed diabetes may be associated with a higher prevalence of diabetes complications, a significant cause of morbidity and mortality.

According to the International Diabetes Federation, early detection is critical, given that prolonged undiagnosed diabetes can have adverse effects, including a higher risk of diabetes-related complications, increased healthcare use and related costs (International Diabetes Federation, 2019, p. 43). A reasonable number of diabetes cases remain undiagnosed for numerous reasons, such as the use of complementary and alternative medicine, the high cost of diabetes care, the low capability of healthcare systems to tackle diabetes, and ignorance. This chapter aims to review these challenges.

3.1 Complementary and alternative medicine

It is becoming progressively more evident that patients with diabetes do not rely only on prescription drugs to manage their diabetes. Many people believe in complementary or non-conventional medicine. Traditional ways of living and this influences their health-seeking behavior (Kasole et al, 2019), causing them to rely heavily on traditional, complementary and alternative medicine alone or in combination with conventional medicine for T2DM management (James P.B et al., 2018) and (Stephani et al., 2018). About 80% of people in Africa and other developing countries depend on traditional medicines to remedy diabetes and many other ailments (Valdez-Solana, 2015).

In 2016, a group of researchers provided an exhaustive list of widely used plants in the management of diabetes in South Africa. They include, among others, eriocephalus punctulatus (roosmaryn), Hypoxis hemerocallidea (African potato), Dicoma anomala (fever bush and stomach bush), Xysmalobium undulatum (milk bush, milkwort, Uzura, bitterhout, bitterwortel, bitterhoutwortel, and melkbos, wild

cotton, and wave-leaved), Morella serrata (smalblaarwasbessie and berg-wasbessie), Gazania krebsiana (terracotta Gazania; gousblom and botterbloom, elephantorrhiza elephantina (eland's bean, eland's wattle, and elephant's roo), hermannia pinnata (orange Hermannia or doll's rose), commelina Africana (yellow Commelina), haplocarpha scaposa (false gerbera), helichrysum aureum (Leabane), empodium plicatum (golden star), Mimulus gracilis (Sehlapetsu), Pentanisia prunelloides (wild verbena), cannabis sativa (marijuana), aloe vera, asparagus asparagoides (Balogunet et al, 2016). In Nigeria, herbs and medicinal plant products such as amalanth leaves, hare lettuce leaves, nightshade leaves, spider plant leaves, okra pods, moringa leaves and seeds, soursop leaves, black plum back, avocado seed, green tea, onion, garlic, panax ginseng, bitter gourd, ackee fruit, khat, fenugreek, gurmar, bitter leaf, aloe vera, marula, wild cucumber and lemongrass are the most commonly used traditional medicines for the management of T2DM in the country (Kibiti et al, 2015) and (Amaeze et al., 2018).

The uptake of such interventions is expanding rapidly in Nigeria: a 2018 study in Lagos corroborates the high dependence on alternative medicine: about 68% of the 453 patients that were surveyed reported herbal medicine use. Of this number, 35.4 % of the patients used conventional and herbal medicines simultaneously (Amaeze et al., 2018). Of the 140 participants of another study, 67.2% reported using traditional medicines to manage their diabetes, including 58.6% who started using both conventional medicines and traditional medicines (Kasole et al, 2019). Another study indicates that 50% of the 112 patients with T2DM attending two secondary healthcare facilities in the country used herbal medicines alongside their prescription drugs, to manage diabetes (Ezuruike & Prieto, 2016). The use of medicinal plants with antidiabetic, anti-inflammatory, and antioxidant activities has been observed since ancient times for the treatment of T2DM in South Africa (Seetaloo et al., 2019); (Tshabalala et al., 2019). Plant species, including their leaves, stems, and roots, are frequently prepared as infusions or decoctions for oral administration for the management of T2DM (Davids et al, 2016).

Diabetic patients resort to alternative and complementary care treatment options owing to different reasons ranging from the chronic course of diabetes, complexities of treatment plans, ignorance, the efficacy of conventional and traditional medicine, and the exorbitant cost of medication and treatment services (Amaeze et al., 2018) and (Kasole et al, 2019). Also, important to mention in this regard is that attitudes about herbal medicine differ. Believers think it is safe, beneficial and effective: some are of the view that combining conventional and traditional medicines enhances the effectiveness of treatment, but some are not (Kasole et al, 2019).

While complementary and alternative medicine may constitute a crucial element of diabetes management in Nigeria and South Africa, their safety, benefits and effectiveness for diabetes patients have remained a concern. Some researchers concluded that traditional medicine's role in managing T2DM had not been studied (Amaeze et al., 2018). It may be challenging to confirm that it can improve health care. However, some have concluded that "the usage of herbs have been effective against diabetes because they have no adverse effects" (Balogunet et al, 2016). An obstacle with traditional medicine could be that traditional healers are limited in their understanding of diabetes and other diseases. While they may identify patients' diabetes symptoms, a long-time challenge of medicinal plant usage is the dosage. There is limited information on the potential toxicity or mutagenicity resulting from the long-term use of herbal medicines (Odeyemi & Bradley, 2018).

The consequence of medical pluralism could be dreadful. The concurrent use of orthodox and herbal medicines increases patients' risk of herb-drug interactions (HDIs), resulting in potentially severe adverse effects or reduced benefits from prescribed medicines (Spanakis et al., 2019). A study that compares the pharmacokinetic profile of eight identified herbs taken by the patients for the management of diabetes against those of the prescription drugs identified several scenarios of potential HDIs. The study concluded that the lack of clinical predictors makes it more challenging to identify these patients

and, in turn, monitor potential HDIs (Ezuruike & Prieto, 2016). In other words, taking herbal medicines without knowing their identity may increase the risk of unidentified HDIs.

An African study concluded that most medicinal African plants lack safety and pharmacokinetic information, which can be used to prevent potentially clinically relevant HDIs (Ezuruike & Prieto, 2016). The effects of HDIs in the milieu of a defective healthcare system in many developing countries can be deleterious to the society at large and patients in particular (Amaeze et al., 2018). Where patients rely on medicinal plants alone (without conventional medications) for the treatment of T2DM, the possibility of many diabetes cases going undiagnosed could be high. Additionally, the admixture of treatment options and types leads to poor orthodox medication adherence, confusion, and increased mortality and morbidity (Ogbera & Ekpebegh, 2014).

3.2 The high cost of diabetes care

Not only does diabetes causes excessive morbidity and mortality, but it is also pricey. It is a chronic disease that requires unceasing clinical care and management, which consumes significant healthcare resources, directly and indirectly. Health expenditure includes the provision of health services (preventive and curative), family planning activities, nutrition activities and emergency aid designated for health (WHO, Global health expenditure, 2019, p. 29). The yearly global health expenditure on diabetes is expected to reach USD 825 billion by 2030 and USD 845 billion by 2045 (WHO, Global health expenditure, 2019, p. 29).

National direct costs of diabetes (which fluctuate between countries) ranges from I$3.5 billion to I$4.5 billion/year for healthcare items such as drug costs, diagnostic costs, medical supply or disposable costs and consultation costs (Mutyambizi et al, 2018). In Africa, between 2006 and 2016, the annual national direct costs of diabetes, borne mostly by patients, ranged from US$3.5 billion to US$4.5 billion/year, most of which relate to drugs and diagnostic costs (Rosa et al, 2018). Expenditure increases significantly

if a patient has associated complications of diabetes, particularly stroke and amputation (Walker et al., 2018).

The SEMDSA estimated the mean health expenditure per person with diabetes at USD 918.9 (SEMDSA, 2017, p. 9). In 2018, public sector costs of diagnosed T2DM patients in South Africa were roughly ZAR 2.7 billion (US $161 million) and ZAR 21.8 billion (US$ 1.3 billion) (reflecting both diagnosed and undiagnosed patients). This sum is projected to be ZAR 35.1 billion (US $ 2.1 billion) (51% attributable to the management of T2DM, and 49% are attributable to complications) in 2030 (Erzse et al, 2019).

A Nigerian study estimated that the average direct cost of illness per patient with T2DM at NG45 531.19 (US$284.57), while type 1 diabetes mellitus alone was NGN100 032.89 (US$625.21). Accordingly, whereas the average annual cost of illness for patients with both T2DM and hypertension was NGN59 607.66 (US$372.55), that for those with T1DM and hypertension combined was NGN114 109.36 (US$713.18). The annual national direct cost of illness for T2DM patients is in the range of NGN262 billion (US$1 639 122 840.00). In comparison, that of T1DM was valued to be NGN18 billion (US$112 537 001.25) (Suleiman & Festus, 2015).

A 2015 study in Nigeria concluded that the average monthly costs of all prescribed medications per patient for initiation and maintenance of therapy were ₦3333.43±2317.40 (US$18.17±12.60) and ₦4458.09±3064.8 (US$24.30±16.70) respectively ($p < 0.05$). The study indicates that of all the drugs prescribed per month per patient, diuretics and sulphonylureas were comparatively less pricey, accounting for ₦531.70 [US$2.90] and ₦559.10 [US$3.10] correspondingly for initiation of therapy, and ₦768.1 [US$4.20] and ₦631.1 [US$3.40] for maintenance of therapy. However, the most expensive of all the medicines were angiotensin receptor blockers which accounted for ₦4,368.8 [US$23.8] for initiation and ₦4,810.50 [US$26.20] for maintenance of therapy, as well as insulins (at ₦2,448.20 [US$13.30] for initiation and ₦2,457.10 [US$13.40] for maintenance of therapy) (Ganiyu & Erah, 2015).

Compared with people living in high-income countries, those in Nigeria and South Africa, among other low-and middle-income countries, pay a larger out-of-pocket share of health expenditure as they lack access to health insurance and publicly-available medical services (IDF Atlas, 2015, p. 58). Perhaps it is because the overall healthcare budget of developing countries, with a focus on NCDs, is low (Pastakia SD, 2017). Consequently, personal and family support have become the primary coping strategy to finance their medical bills (Okoronkwo IL et al., 2015). For example, almost 80% of patients in Nigeria finance their medical bills from personal or family as insurance coverage of medications and tests is low (Ogbera A & Ekpebegh C, 2014).

This is problematic as some diabetes patients earn less than $125/month, which may be insufficient to cover the annual cost of diabetes estimated at $400.52 (Ipingbemi & Erhun, 2015). With 62% of Nigerians earning less than US$1000/year (Awodele & Osuolale, 2015), it is, therefore, unsurprising that low income may hinder a substantial number of patients from achieving their health goals. In the absence of health insurance facilities, this low income and high cost of diabetes can limit the use of HbA1c for the diagnosis of diabetes—it "cost the equivalent of 19 USD to perform an HbA1c test" in one medical facility (Ogbera A & Ekpebegh, 2014).

During care to save costs of medicines and to improve access, a reasonable number of patients have had their medicines substituted with generic medicines without their consent, with unpredicted consequences, including confusion and consequent lack of adherence. While 35.6 % of patients enrolled for a study rejected substitution at one time and insisted on doctors' prescription, 19.6 % discontinued the use of their medicines after substitution because they were not sure of the brand supplied (Oyetunde et al, 2014).

3.3 Compliance with diabetes guidelines

The World Health Organization concluded in 2016 that 126 countries reported having a national guideline for diabetes management that is wholly or partially implemented (WHO, Global Report on Diabetes, 2016, p. 70). Only 20 Sub-Saharan African countries have an operational action plan for

diabetes, meaning health systems are unprepared for the effective delivery of diabetes care in this region (Atun R et al., 2017). With regards to the national response to diabetes, that is diabetes guidelines, Nigeria has an operational policy/strategy/action plan for diabetes such as a plan to reduce physical inactivity, but with no operational policy/strategy/action plan to reduce overweight and obesity and no diabetes registry exists in the country (WHO, Nigeria, 2016).

The Diabetes Association of Nigeria developed the Clinical Practice Guidelines for Diabetes Management in Nigeria. The guidelines were drawn to provide and promote standardized clinical guidelines for diabetes care; define minimum standard of care; and improve the quality of care given to people living with diabetes in Nigeria through early diagnosis, prevention of premature mortality and morbidities, promotion of self-care practices and empowerment of diabetes patients, and reduction of the burdens of diabetes. Accordingly, the standard of care involves, among others, maintaining HbA1c below 6.5%, which should minimize the risk of developing complications (Diabetes Association of Nigeria, 2013, p. 1).

Like Nigeria, South Africa has operational policies/strategies/action plans for diabetes, including plans to reduce physical inactivity, overweight and obesity. However, it has no diabetes registry (WHO, South Africa, 2016) to provide critical information on people with diabetes. To improve diabetes outcomes in South Africa, however, the Society for Endocrine Metabolism and Diabetes South Africa (SEMDSA) has provided a comprehensive set of guidelines based on several local and international trials. The guidelines are known as the SEMDSA Guidelines for the Management of Type 2 Diabetes. They are intended to inform general patterns of care, improve diabetes efforts to prevent diabetes, and decrease the burden of diabetes complications in diabetes patients (SEMDSA, 2017). Additional guidelines for diabetes care in South Africa include Diabetic Footcare Guidelines for Primary Healthcare Professionals, the Management of Diabetic Foot Ulcers, Continuous subcutaneous insulin infusion therapy in type 2 diabetes, and New guidelines for the use of insulin infusion pumps.

The benefits of adherence to diabetic guidelines have been documented (Sharif et al., 2015). For example, a study conducted in 2016 concluded that "adherence to screening, physical activity and medication guidelines were associated with lower risks of diabetes complications and death. The relative importance of adherence differed among outcome measures" (Chen et al., 2016). SEMDSA guidelines are targeted at the resource-limited South African context. All required tests and examinations are readily available in both the public and private sectors (Rampersad et al, 2019). But while the Clinical Practice Guidelines for Diabetes Management in Nigeria and the SEMDSA Guidelines have laudable intentions, doctors and other health practitioners have criticized compliance in real-life practice.

SEMDSA guidelines indicate that "tight glycaemic control and appropriate monitoring can prevent or delay the development of diabetic complications." While measurements of blood pressure and blood glucose were 100% compliant, others were not: anthropometric measurements (height, weight and body mass index), dietitian referral and foot examinations were the least compliant, being performed 4.2%, 5.0% and 7.8% of the time respectively." The study concluded that the "screening for chronic complications of type 2 DM was poor in most of the patients. Evaluation of selected records demonstrated compliance with the SEMDSA guidelines in only 4.2% of patients" (Rampersad et al, 2019),

Another study indicated that 83% of the patients had high values of glycated hemoglobin (HbA1c). Lipid examination was rarely performed, and a comprehensive foot examination was carried out in only 6% of patients. Although blood pressure and weight were regularly checked, these examinations were performed by the nursing staff, and medical staff generally did not respond to abnormal results" (Igbojiaku O.J., 2013). The result also shows that "only 24% (180 out of 750) of the patients had their HbA_{1c} checked in the preceding year. Of the 180 who had their HbA_{1c} checked, only 16.7% (30 out of 180) had values within the target (< 7%). Twenty-two patients had the HbA_{1c} check repeated, of whom only two had normal values. Only two patients had their HbA_{1c} checked on more than two occasions, and both had values higher than the target." (Igbojiaku O.J., 2013)

In 2017 a study was conducted to determine if T2DM patients attending a public sector community health centre in South Africa were having their ABCs measured, were treated with appropriate cardioprotective agents and finally, were achieving guideline-based targets. The study concluded that "there were a significant number of patients who were not tested nor received adequate pharmacotherapy or achieved their ABC targets." Moreover, testing of ABCs occurred in 68.8% for HbA1c, 95.4% for BP, and 58.6% for LDL-C and achievement of ABC targets was: 19.3% (HbA1c < 7%), 22.0% (BP < 140/80 mmHg), and 56.3% (LDL-C < 2.5 mmol/l) (Pinchevsky et al, 2017). Poor compliance with SEMDSA guidelines places diabetes patients at heightened risk for the advancement of diabetes-related complications.

In Nigeria, default rates for different screening in diabetes have also been reported. With regards to retinal screening guidelines, non-compliance occurred in more than 56% of studied participants. Defaulting was associated with not having had a previous eye examination (p=0.027). Very few (32%) had had their eyes examined at least once since the diagnosis of the disease (Onakpoya et al., 2015). Poor adherence to antidiabetes medication could cause therapeutic failure, leading to the manifestation of diabetes-related complications, such as retinopathy, neuropathy, nephropathy, etc., reduced quality of life, and increased healthcare costs.

Nevertheless, poor medication adherence among the cohorts of a 2015 study was concluded. Of the 303 patients included in the final analysis, 19.8% of respondents were judged to be highly adherent. Medium and low adherers were 30.0% and 50.2%, respectively (Jackson et al., 2015). In another study to determine the role of diabetes treatment satisfaction in medication adherence and glycemic control among ambulatory type 2 diabetic Nigerians, over 50% of the participants were adjudged adherent to diabetes guideline—diabetic treatment satisfaction, medication adherence, and glycemic control rates were 85.8%, 72.5%, and 61.7%, respectively (Pascal & Nkwa, 2016). Many other researchers have reported non-adherence to antidiabetic medications (Onwuchuluba et al, 2019) or satisfactory adherence of diabetes patients to their medications (Fadare et al, 2015) in Nigeria.

3.4 Low capability of healthcare systems to tackle diabetes

Recent research in developing countries indicates that efforts for the prevention of diabetes remain rudimentary, the quality of care is largely reduced, and there is a delay in seeking treatment hence a substantial number of diabetic patients do not achieve treatment goals (Misra et al., 2019). In terms of health systems and care organizations, barriers such as insufficient human resources, ad hoc policies, reduced availability and affordability of medicines, and inadequate support systems (e.g. nutritionists, diabetes educators) exist (Beran, 2015).

Table 3: Availability of medicines, essential technologies and procedures

Availability of medicines, basic technologies and procedures		**Nigeria**	**South Africa**
Insulin	**Medicines in primary care facilities**	No	Yes
Metformin		Yes	Yes
Sulphonyl urea		Yes	No
Blood glucose measurement	**Basic technologies in primary care facilities**	Yes	Yes
Oral glucose tolerance test		Yes	Yes
HbA1c test		No	No
Dilated fundus examination		No	No
Foot vibration perception by tuning fork		No	No
Foot vascular status by Doppler		No	No
Urine strips (glucose and ketone measurement)		Yes	Yes
Retinal photocoagulation	**Procedures**	No	Yes
Renal replacement therapy by dialysis		No	No
Renal replacement therapy by transplantation		No	No

Source: Adapted from WHO 2016 (WHO, Nigeria, 2016) and (WHO, South Africa, 2016).

Table 3 summarizes the availability of medicines, basic technologies and procedures in the public health sectors in Nigeria and South Africa, outlining different classes of anti-diabetic drugs to include insulin, metformin and sulphonyl urea by controlling blood glucose levels, blood pressure and lipid. While on WHO's model list of essential medicines, the table indicates that insulin is not commonly present in

primary care facilities in Nigeria. A 2018 study at a University Teaching Hospital, Oyo State, Nigeria confirmed the scarcity of insulin usage in Nigeria (Olamoyegun et al, 2018). Table 3 also indicates that metformin is commonly available in primary health care services in both countries. However, sulphonyl urea, a glucose-lowering drug (as it helps to increase the release of insulin from the pancreas), is not generally present in primary health facilities in South Africa.

Table 3 shows that necessary technologies for early detection, diagnosis and monitoring of diabetes are generally unsatisfactorily available in primary health facilities in Nigeria and South Africa. Blood glucose measurement, oral glucose tolerance test, and urine strips (glucose and ketone measurement) are usually available through HbA1c test, dilated fundus examination, foot vibration perception by tuning fork, and foot vascular status by doppler are generally not available in primary health care settings in Nigeria and South Africa. The Diabetes Association of Nigeria had earlier highlighted the limitation of the HbA1c test in Nigeria due to, among others, higher cost (Diabetes Association of Nigeria, 2013, p. 4).

Besides drug therapy, non-drug management, defined to include (1) diabetes self-management education (DSME); (2) self-monitoring of blood glucose, and (3) foot care (Diabetes Association of Nigeria, 2013, p. 11), is also crucial for the management of T2DM. According to SEMDSA 2017 recommendations, diabetes self-management education and support (DSME/S) should be managed by accredited healthcare professionals. They have been appropriately trained in the execution of evidence-based principles. Trained community health workers should provide education through home visits, create awareness and encourage adherence (SEMDSA, 2017, p. 22). DSME curriculum should include explanations by the physician or nurse of the nature of diabetes and its potential hazards and how they can be recognized early and prohibited or treated (Diabetes Association of Nigeria, 2013, p. 11). DSME is advocated at diagnosis, annually, when pregnancy and other new complicating factors arise, transitioning into different life stages (Powers et al., 2015).

DSME has improved glycaemic control, a strong predictor of disease progression and the development of diabetes complications (Chrvala et al, 2016). Notwithstanding the importance of DSME, a study to describe the elements of diabetes management in Nigeria, areas for improvement, and proposed strategies to optimize care concluded that the nurses and medical officers or physicians present at primary health centres have very basic or rudimentary knowledge—DSME. The study added that although the secondary health centers almost always have nurses, pharmacists, dietitians and a few general practitioners, diabetologists/endocrinologists, diabetes educators and chiropodists are scarce (Fasanmade & Dagogo-Jack, 2015, p. 823).

There has been a growing use of Community Health Workers (CHWs) to deliver T2DM self-management support with excellent clinical outcomes (Bonaventure Amandi Egbujie, 2018). CHWs can alleviate the dearth of healthcare professionals (Alaofè H, 2017); (Egbujie et al., 2018). Roles played by CHWs consist of patient education, identification and referral of high-risk individuals to physicians, delivery of medication, and provision of social support through home visits to improve knowledge, health behavior, and health outcomes related to prevention and management of diabetes in developing countries (Alaofè H, 2017). To perform these duties, they require proper training and supportive supervision (Abrahams-Gessel et al, 2015); (Källander et al., 2015), as well as resources and a systematic referral process to ensure that diabetes patients receive DSME consistently (Powers et al., 2015). CHWs, diabetes educators (nurses, dieticians or pharmacists who are trained through an accredited programme) should meet specific competency, including good interpersonal skills, to train and support CHWs (Amod et al., 2017, p. 22).

While DSME can facilitate knowledge and skills required for diabetes self-care, a limited capacity to effectively deliver healthcare to those with diabetes has been reported in South Africa. A study conducted in Cape Town shows that only 52% of CHWs reported some formal NCD-related training, while less than half of the trained CHWs (n = 35; 44%) had received follow-up refresher training. In other words,

CHWs' basic knowledge about diabetes and hypertension remains poor while training is unstandardized and haphazard (Tsolekileet al, 2018).

A weak health system makes it hard to deliver sustained and effective diabetes interventions. Nigeria lacks nurses who specialize in diabetes care. Nurses do not have the right to prescribe medications (Fasanmade OA and Dagogo-Jack S., 2015, p. 824). Physicians do have the license to prescribe medications. But the physician/patient ratio is very inadequate, suggesting that diabetes clinics (most of which are run for less than seven hours/week) are characteristically overburdened with few physicians seeing hundreds of patients with diabetes in the space of just a few hours (Fasanmade OA and Dagogo-Jack S., 2015, p. 824).

With the resource constraints in public sector settings in South Africa (Pinchevsky et al, 2017) and a lack of time and resources to conduct a systematic assessment, local health providers may not be fully aware of diabetes severity of their patients (Attaei et al., 2017); (Soetedjo et al., 2018). In some cases, the quality of the DSME provided has been criticized: some of the 2015 study participants claimed that doctors were always in a hurry to prescribe medication for them and that the advice of health care workers was not practical. They were often told to eat healthily, avoid fatty meals, and eat fruit and vegetables, all of which require money to buy, and they are poor (Adeniyi et al., 2015).

CHAPTER 4: DISCUSSION AND ANALYSIS

4.1 Discussion of results

This research project was designed to enable the researcher to investigate the challenges and opportunities to detection and diagnosis of T2DM in Nigeria and South Africa and explore the opportunities in enhancing the management of this disease in these sub-Saharan countries. By employing a social-ecological perspective, the researcher analyzed and explained the relationship between factors that influence the prevalence of T2DM in Nigeria and South Africa. These factors included the high dependence on complementary and alternative medicine, treatment and cost of T2DM, low capability of healthcare systems to tackle diabetes, and poor adherence to diabetes guidelines. These categories will be independently evaluated, and emerging themes will be summarized under the proper barrier/enabler title.

4.1.1 Complementary and alternative medicine

The use of non-prescription drugs and other self-management practices that are not fully integrated into the dominant healthcare systems in Nigeria and South Africa are central themes for the detection and diagnosis, and management of T2DM. Most of the literature pointed to the high dependence of diabetes patients on complementary and alternative medicines. For example, different comments on herbal medicine use among T2DM patients in Nigeria are below:

Excerpt 1: Nigeria

A 2018 study (Amaeze et al., 2018, p. 580) concluded that "of the 453 patients that were surveyed, 305 (67.3%) reported herbal medicine use, among whom 108 (35.4%) used herbal and conventional medicines concurrently; 206 (67.5%) did not disclose use to their physician." A key finding of a 2016 study in Nigeria (Ezuruike & Prieto, 2016) was that "over 50% of diabetic patients in Nigeria use herbal medicines alongside their conventional drugs for their disease management…"

Excerpt 2: South Africa

À study (Davids et al, 2016, p. 3) conducted in Matzikama municipal district, Western Cape Province, South Africa found that "the usage of what is referred to as "traditional" medicines is often reported to be as high as 80%...Medicinal plants are widely used by…T2DM sufferers who employ diverse plant species to manage the symptoms of both conditions…the use of THM [traditional herbal medicine] continues to be a potential source of new and alternative strategies to manage chronic conditions such as HBP and T2DM." Moreover, "foods and other medicinal plants …have been traditionally used for ages [to manage diabetes mellitus and combat the side effects of antidiabetic drugs] (Seetaloo et al., 2019).

Herbal medicinal products are the subject of growing interest regarding their health benefits, perhaps because "the conventional drugs that are used for the management of diabetes have been observed to have some adverse effects. Essentially, medicinal plants have been noted to have lesser side effects; hence, the need to explore rich and potential plants with antidiabetic activity became necessary" (Nkala et al., 2019). This study may suggest that the traditionally used medicinal herbs, spices and food plants for the management of T2DM have minimal side effects compared with non-medicinal plants. However, "a serious concern is the potential appearance of clinically significant drug–herb interactions in patients" (Spanakis et al., 2019). More than 60% of [study participants] were unaware of the identity of the herbal medicines being taken, which in turn highlight a complete ignorance of the risks of HDIs" (Ezuruike & Prieto, 2016). Accordingly, taking herbal medicines without knowing their identity may increase the risk of unidentified HDIs, and, in turn, monitor potential HDIs. The safety, benefits, and effectiveness of herbal medicines, specifically for diabetes patients, have not been studied adequately (Amaeze et al., 2018), making it challenging to confirm that it can improve healthcare.

These limitations may constitute a significant reason for hesitance against the use of herbal products and medicinal plants into the health care system. Most users of traditional, alternative and complementary medicine fail to disclose it to their healthcare providers due to, among others, "fear of receiving improper

care, healthcare providers' negative attitude and a lack of enquiry about TCAM use from healthcare providers" (James et al., 2018). This failure is also concerning.

A strategy to overcome the barrier to the use of complementary and alternative medicine could include informing healthcare practitioners about their simultaneous use. Additionally, further study is required to understand the biological effects of compounds present in often used herbal medicines, including their anti-diabetic potential.

4.1.2 Treatment and cost of T2DM

The result shows that the cost of treatment and management of T2DM has been a major concern for patients living with diabetes in Nigeria and South Africa. This cost includes pharmacological costs (insulin and oral anti-diabetic drugs), hospitalization, cost of diabetes-related tests (HBA1c, lipid profile, urea and electrolytes, cholesterol, microalbumin, ECG and retinal screening), and outpatient consultations.

Excerpt 1: Nigeria

The results show that in Nigeria, the average direct cost of illness/ T2DM patients was between US$284.57 to $356, while that of T1DM was US$625.21. The yearly national direct cost of illness for T2DM patients is between $1,521,014.644 to US$1 639 122 840.00, while that of T1DM is about US$112 537 001.25 (Suleiman & Festus, 2015) and (Okoronkwo IL et al., 2015). The average monthly costs of prescribed medications/patient were US$18.17±12.60 and US$24.30±16.70, with the most expensive of all the medicines being angiotensin receptor blockers which accounted for US$23.8 for initiation and US$26.20 for maintenance of therapy as well as insulins (US$13.30) for initiation and US$13.40 for maintenance of therapy) (Ganiyu & Erah, 2015).

Excerpt 2: South Africa

According to the findings (Erzse et al, 2019), the total direct cost attributable to 240 thousand T2DM patients diagnosed, treated, and controlled in a community in South Africa in 2018 was USD 198 million. Direct costs were broken down by the treatment and management of T2DM. Over half of the cost (USD 102 million) "was attributable to treating and managing T2DM, while the cost of complications was estimated at USD 96 million. The study also estimated the additional cost of treating all of those in need, both diagnosed and undiagnosed cases, at ZAR 19.1 bn, representing an 8.9-fold increase in expenditure, accounting for approximately 12% of the national health budget."

The review indicates that people living with diabetes mellitus in Nigeria and South Africa have a high risk for high economic burden and catastrophic expenditure. In Nigeria, for instance, the "health insurance scheme … is poorly developed and currently, the majority of health insurance facilities do not provide coverage that allows for provision of optimum standard of care for persons living with DM" (Ogbera A & Ekpebegh, 2014). Out of pocket expenditure (personal or family saving) is an essential means of funding health care for most Nigerians now and in the foreseeable future (Okoronkwo IL et al., 2015).

Some diabetes patients earn less than $125/month, covering the annual cost of diabetes estimated at $400.52 (Ipingbemi & Erhun, 2015), according to the findings. Nearly 62% of Nigerians earn less than US$1000/year (Awodele & Osuolale, 2015), meaning a substantial number of patients may be hindered from achieving their health goals because of incapacity to pay. This is very problematic since diabetes is a chronic illness that requires frequent healthcare access to health expenditure. Diabetes is indeed preventable and controllable. Nevertheless, the increasing cost of care could impede access to quality care and achievement of global health goals, leading to high mortality, morbidity, and productivity losses. The high cost of diabetes could limit the use of HbA1c for the diagnosis of diabetes—it "cost the equivalent of 19 USD to perform an HbA1c test" in one medical facility (Ogbera A & Ekpebegh, 2014).

Generic substitution without informing concerned patients remains a strategy to reduce the costs of diabetes medicines and improve access. While this may constitute a way out of the cost issue, it has been problematic as it could result in confusion and nonadherence. While 19.6 % of patients stopped using their medicines after the substitution, as they were unsure of the brand supplied, 35.6 % have rejected substitution at one time and insisted on doctors' prescription. And while 14.9 % agreed that brand substitution confused, 24 % reported receiving brands that resulted in more side effects. Furthermore, about 58.6 % indicated “that they never had a discussion with their pharmacists about the reasons for generic substitution and switches” (Oyetunde et al, 2014). To avoid misunderstanding and discourage abstinence from drug use, a discussion with patients about the need for generic substitution is crucial.

With rising diabetes prevalence in Nigeria and South Africa, the overall cost of diabetes will increase, presenting a substantial economic burden on people/families with diabetes. This, too, is challenging since diabetes is a chronic illness that requires frequent healthcare access, requiring huge costs. Increased financial resources, among other urgent actions to prepare health and social security systems to alleviate the effects of diabetes, are required to deliver effective services to people with T2DM in Nigeria and South Africa. These barriers (having the potential to increase the numbers of persons with the complications of diabetes) could be avoided if the concerned governments increase the budgetary allocation for health as recommended by the WHO. Finally, generic medicines must be integrated into routine diabetes care as a strategy of further minimizing the burden of health care expenditure on people (and families with people) living with diabetes.

4.1.3 Capability of healthcare systems to tackle diabetes

The review indicates that specific healthcare system barriers exist in the case study. Examples include insufficient human resources, poor accessibility and availability of medicines, technologies and procedures, and inadequate support systems. These barriers could create a care gap between the clinical

goals drawn in evidence-based guidelines for the management of T2DM and actual clinical practice in Nigeria and South Africa.

Excerpt 1: Medicines, technologies and procedures in primary care facilities

The analysis shows that diabetes medications such as insulin, basic procedures (such as retinal photocoagulation, renal replacement therapy by dialysis, and by transplantation), and necessary technologies (such as HbA1c test, dilated funds examination, foot vibration perception by tuning fork, and foot vascular status by doppler) are not generally available in primary care facilities in Nigeria. Moreover, sulphonylurea, and basic procedures (such as renal replacement therapy by dialysis and by transplantation), and technologies (such as HbA1c test, dilated funds examination, foot vibration perception by tuning fork, and foot vascular status by doppler) are not generally available in South Africa.

Besides the scarcity of insulin usage in primary health care in Nigeria (Diabetes Association of Nigeria, 2013, p. 4) (Olamoyegun et al, 2018), the availability of the HbA1c test is limited in Nigeria (Olamoyegun et al, 2018). Most of these primary care centers rarely have "more than urine testing for glucose and very few have blood glucose meters…metformin and sulfonylureas as available medications…dietitians, nutritionists, diabetes educators, and chiropodists are virtually absent" (Fasanmade & Dagogo-Jack, 2015, p. 823). With limited resources, it may be difficult for healthcare professionals at such centres to manage or follow-up diabetes patients with/out complications. Perhaps this might have contributed to T2DM rising prevalence in these countries.

Excerpt 2: Health care professionals

According to the results, dietitians, nutritionists, diabetes educators, and chiropodists are almost absent at primary health centres in Nigeria while nurses and a few medical officers or physicians present at such centres have very basic or rudimentary knowledge. Additionally, the secondary health centers lack diabetologists/endocrinologists, diabetes educators and chiropodists; nurses who specialize in diabetes care are almost absent, the physician/patient ratio in Nigeria is very poor; diabetes clinics are typically

overburdened with few physicians seeing hundreds of patients with diabetes in the space of just a few hours (Fasanmade & Dagogo-Jack, 2015, p. 823). The hectic nature of these clinics may imply (1) physicians spend limited time seeing a patient, and (2) diabetes patients are typically managed by health care professionals who rarely have more than restricted subspecialty diabetes training.

The review also shows that South Africa has a "burden of patient load and a shortage and misdistribution of physicians, which adds further to the clinical inertia related to patient management" (Govender et al, 2017). Because of time, resources, and human resources constraints, healthcare providers may not be fully aware of their patients' diabetes severity. Some diabetic patients (Adeniyi et al., 2015) made different claims:

"The healthcare workers care less about the patients, but I understand them because they care for 200 patients in a day." (Participant 11; F, 63 years)"

"No advice from the health care workers regarding the control of my sugar, I only hear from other people outside who have experience in living with diabetes." (Participant 11; F, 63 years)

"I once visited a private doctor who told me that the combination of the pills is not correct for me but the nurses at the clinic kept on giving the wrong pills." (participant 16; F, 72 years).

A study to determine if patients with T2DM attending an urbanized public sector community health centre were having their ABCs measured, were treated with appropriate cardioprotective agents and finally, were achieving guideline-based targets illustrated that a significant number of patients were neither tested nor received adequate pharmacotherapy or achieved their ABC targets. Accordingly, achievement of ABC targets was as follows: 19.3% (HbA1c < 7%), 22.0% (BP < 140/80 mmHg), and 56.3% (LDL-C < 2.5 mmol/l)" (Pinchevsky et al, 2017). This deficiency might have placed these patients at an increased risk for the development of diabetes-related complications.

4.1.4 Compliance with diabetes guidelines

The review indicates that Nigeria and South Africa have a national guideline for diabetes management—the Clinical Practice Guidelines for Diabetes Management in Nigeria and the SEMDSA Guidelines for the Management of Type 2 Diabetes in South Africa. These guidelines have laudable intentions—they aim to provide and promote standardized clinical guidelines for diabetes care and improve the quality of care given to people living with diabetes through early diagnosis, prevention of premature mortality and morbidities. Nevertheless, compliance in real-life practice has been inadequate as the review shows.

Excerpt 1: SEMDSA guidelines

For example, "while measurements of blood pressure and blood glucose were 100% compliant, others were not: anthropometric measurements (height, weight and body mass index), dietitian referral and foot examinations were the least compliant, being performed 4.2%, 5.0% and 7.8% of the time respectively… the "screening for chronic complications of type 2 DM was poor in the majority of patients" (Rampersad et al, 2019). A 4.2% compliance rate could enhance diabetes prevention efforts to plummet the burden of diabetes in South Africa even more difficult.

About "eighty-three per cent of the patients [at a regional hospital in KwaZulu-Natal, South Africa] had high values of glycated haemoglobin (HbA1c)…comprehensive foot examination was carried out in only 6% of patients. Although blood pressure and weight were regularly checked, these examinations were performed by the nursing staff. Medical staff generally did not respond to abnormal results" (Igbojiaku O.J., 2013) Accordingly, "Only 24% (180 out of 750) of the patients had their HbA_{1c} checked in the preceding year. Of the 180 who had their HbA_{1c} checked, only 16.7% (30 out of 180) had values within the target (< 7%). Twenty-two patients had the HbA_{1c} check repeated, of whom only two had normal values..." By not complying with SEMDSA recommendations, improving diabetes efforts to prevent diabetes, and decrease the burden of diabetes complications in diabetes patients may be challenging.

Regarding the measurement of patients' ABCs at a community health centre in South Africa the analysis illustrated (Pinchevsky et al, 2017) that "testing of ABCs occurred in 68.8% for HbA1c, 95.4% for BP, and 58.6% for LDL-C and achievement of ABC targets was as follows: 19.3% (HbA1c < 7%), 22.0% (BP < 140/80 mmHg), and 56.3% (LDL-C < 2.5 mmol/l). The study indicated that a significant number of patients were neither tested nor received acceptable pharmacotherapy or reached their ABC targets. In other words, patients were not achieving guideline-based targets. Poor compliance with SEMDSA guidelines could place diabetes patients at amplified risk for the advancement of diabetes-related complications.

Excerpt 1: Clinical Practice Guidelines for Diabetes Management in Nigeria

The results show default rates for different screening in diabetes have been reported in Nigeria (Onakpoya et al., 2015): only 32% of the patients had had their eyes examined at least once since diagnosis of the disease – a meager rate even though 79% of the patients reported knowledge that diabetes could damage their eyes. Over 56% of patients defaulted from retinopathy screening in the study, meaning non-compliance with diabetes guidelines occurred in over half of the studied participants. While medication adherence seems to be satisfactory in one study (Fadare et al, 2015) and over 50% in another (Pascal & Nkwa, 2016), it was generally unsatisfactory in a 2019 study (Onwuchuluba et al, 2019) and by Jackson et al. (Jackson et al., 2015). The latter study concluded that among the 303 study participants, 19.8% "were judged to be highly adherent. Medium and low adherers were 30.0% and 50.2%, respectively."

If "adherence to screening, physical activity and medication guidelines were associated with lower risks of diabetes complications and death" (Chen et al., 2016), poor adherence to diabetes guidelines by medical personnel can, therefore, cause therapeutic failure, resulting in diabetes complications, which puts patients at a higher risk of developing potentially avoidable complications. The conclusion is that "higher rates of default from retinal screening were associated with duration of diabetes diagnosis and

lack of previous eye examination." (Onakpoya et al., 2015). Therefore, appropriate screening should comprise education on diabetic eye complications soon after the diagnosis of diabetes.

4.2 Strength and limitations

This study has two significant limitations which may have impacted the findings and conclusions:

- The time available to gather the data, complete the literature review and interpret the results was limited, which compromised the prospect of contacting the diabetic associations in Nigeria and South Africa
- Certain assumptions were made based on pre-2015 data, especially regarding guidelines for diabetes management in Nigeria and WHO traditional medicine strategy and Diagnostic criteria and classification of hyperglycemia. This might have reduced the statistical power of the study.

This is the first study on T2DM management challenges in two of the four countries with the highest prevalence of diabetes in the African region. Therefore, the outcome and recommendations will be of utmost significance to policymakers, healthcare authorities, non-governmental organizations, and clinicians to properly plan and manage this disease. This may, in turn, avoid complications that could result in significant morbidity in the form of preventable blindness, end-stage renal diseases, limb amputations, and premature cardiovascular disease.

4.3 Further research

To secure optimal T2DM care in Nigeria and South Africa, my future research will focus on

- Identifying bioactive compounds in commonly used traditional medicines and their efficacy.
- Validating the anti-diabetic activity of the identified plants
- Determining the facilitators of and barriers to the successful implementation of CHW interventions
- Conducting a more systematic assessment of diabetes costs in Africa.

- Identifying treatment barriers and securing optimal DM care is crucial
- Classifying the active ingredients of potent plants
- Investigating further barriers to the implementation of guidelines in South Africa.

CHAPTER 5: RECOMMENDATION AND CONCLUSION

The overarching aim of this study was to identify the current challenges in the management of T2DM in Nigeria and South Africa, and opportunities in overcoming them. The analysis indicates that certain factors are associated with the escalating diabetes epidemic in Nigeria and South Africa. These include:

- The continuous use of complementary and alternative medicine;
- The high costs of diabetes;
- The low capability of healthcare systems to tackle diabetes; and
- Poor adherence to diabetes guidelines.

This study makes the following recommendations:

5.1 Addressing the risk of complementary and alternative medicine

To avoid the risks of HDIs in diabetes patients and the barrier to the use of complementary and alternative medicine, it is crucial that

- Health care practitioners be informed about the simultaneous use of herbal and conventional medicine; and
- The biological effects of compounds present in commonly used herbal medicines, such as their anti-diabetic potential, be studied and understood.

5.2 Minimizing the cost of T2DM

To minimize the cost of T2DM in Nigeria and South Africa, and hence prevent the increased number of persons with the complications of diabetes, it is important that

- The governments of Nigeria and South Africa increase the budgetary allocation for health as recommended by the WHO; and
- Generic medicines be integrated into routine diabetes care.

5.3 Enhancing the capability of health care systems to tackle T2DM

As the analysis indicates, Nigeria and South Africa are developing countries that are plagued with poor healthcare services and systems and near nonexistent health statistics. A weak health system makes it hard to deliver sustained and effective diabetes interventions. Therefore, it is crucial that:

- Healthcare professionals and diabetes patients, including affected family members, put in place a concerted effort in ensuring that optimal care for persons with T2DM is attainable.

5.4 Improving compliance with diabetes guidelines:

To address resource constraints, manpower deficiency and high dependence on traditional medicines in Nigeria and South Africa, and guarantee better patient outcomes, it is necessary that

- A more extensive implementation of guidelines be instituted and promoted; and
- Collaboration between policymakers, healthcare providers, the pharmaceutical industries, herbalists, users of anti-diabetic medications, and national agencies for food and drug management and control to ensure adequate regulation of the importation of medicines be encouraged.
- A wider implementation of evidence-based guidelines such as the DAN and SEMDSA recommendations be introduced to guarantee better diabetes patient outcomes.

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