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Diabetes Mellitus in Africa: Evolving Phenotypes, Therapeutic Gaps, and the Imperative for Context-Specific Management Guidelines- A Systematic Review and Meta-Analysis

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Abstract

Diabetes mellitus in Africa is undergoing a rapid epidemiological transition marked by rising prevalence, distinctive clinical phenotypes, and persistent health system and therapeutic challenges. This systematic review and meta-analysis synthesizes contemporary evidence on the evolving landscape of diabetes across the continent, with particular emphasis on sub-Saharan Africa, and examines the urgent need for context-specific management guidelines. A comprehensive search was conducted across PubMed, Semantic Scholar, and other indexed databases, covering over 170 million research records. The search strategy addressed epidemiology, phenotype diversity, pathogenesis, therapeutic access, health system barriers, and intervention outcomes related to diabetes in Africa. Of 1,136 identified records, 555 were screened after de-duplication and 424 met eligibility criteria. Eighty-five high-quality and thematically relevant studies were included in the final synthesis. Diabetes prevalence in Africa is projected to rise from approximately 19 million to 47 million adults by 2045, representing the highest proportional global increase (129%) in sub-Saharan Africa. African diabetes exhibits distinct characteristics, including earlier onset (often before 50 years), lower body mass index at diagnosis, and predominant beta-cell dysfunction rather than classic insulin resistance. Atypical forms, such as ketosis-prone diabetes and malnutrition-related diabetes (now classified as Type 5 diabetes), affect 5-15% of patients in studied cohorts. Type 1 diabetes in Africa also differs from Western patterns, with later onset, lower autoantibody positivity (20-60%), and distinct HLA associations. Therapeutic gaps are substantial: insulin availability averages 33% across facilities, HbA1c testing is accessible in fewer than 25% of health centers, and two-year retention in care ranges from 30-50%. Workforce shortages are severe, with only 23% of facilities in Ghana reporting trained diabetes specialists. Existing clinical guidelines inadequately address African dietary patterns, prevalent comorbidities such as HIV and tuberculosis, and major resource limitations. Complications remain frequent, including a 13% prevalence of diabetic foot ulcers and extremely poor glycemic control among youth with type 1 diabetes. Diabetes in Africa presents unique phenotypic and systemic challenges distinct from Western contexts. Persistent therapeutic gaps and guideline mismatches contribute to poor outcomes. Urgent development of context-specific management frameworks, strengthened health systems, culturally adapted interventions, and innovative financing strategies is essential to address this escalating public health burden.

Keywords: Diabetes Mellitus, Diabetes Mellitus, Type 2, Diabetes Mellitus, Type 1, Africa South of the Sahara, Health Services Accessibility, Insulin

INTRODUCTION

Diabetes mellitus in Africa is undergoing a profound transformation, marked by rising prevalence, shifting phenotypes, and significant therapeutic challenges. Unlike Western populations, African diabetes often presents at a younger age and with a lower body mass index, with beta-cell dysfunction predominating over insulin resistance in many cases (Kibirige et al., 2019; Ogunjobi et al., 2024; Osei et al., 2003; Goedecke & Olsson, 2020). Atypical forms, including ketosis-prone diabetes (KPD) and malnutrition-related diabetes (fibrocalculous pancreatic diabetes [FCPD] and protein-deficient pancreatic diabetes [PDPD]), are more common, complicating diagnosis and management (Sobngwi et al., 2002; Bavuma et al., 2019; Katte et al., 2023; Sobngwi et al.,

2001). The International Diabetes Federation has recently recognized malnutrition-related diabetes as Type 5 Diabetes (T5D), highlighting its global significance (Type 5 Diabetes, 2023).

The region faces a dual burden: rapid urbanization and lifestyle changes are fueling increases in type 2 diabetes, while health systems remain under-resourced for chronic disease care (Motala et al., 2022; Pastakia et al., 2017; Godman et al., 2020). Access to essential medicines, diagnostics, and structured self-management support is limited, especially in rural areas (Kiconco et al., 2024; Kibirige et al., 2022; Gobezie et al., 2024). Complications, including diabetic foot ulcers and cardiovascular disease, are frequent and often severe due to late diagnosis and suboptimal care (Abbas & Gangji, 2024; Haile et al., 2024; Glezeva et al., 2018).

Critically, current clinical management guidelines remain largely adapted from protocols developed for Western populations, failing to address African dietary patterns, prevalent comorbidities, and stark resource constraints (Sobngwi & Mauvais-Jarvis, 2020; Atun et al., 2017). The absence of published guidelines tailored to African cuisine, characterized by high carbohydrate loads, represents a fundamental gap in enabling healthcare providers to optimize insulin therapy (Sobngwi & Mauvais-Jarvis, 2020).

Understanding the unique characteristics of diabetes in African populations is essential for developing effective prevention strategies, improving diagnostic accuracy, and implementing context-appropriate management approaches. This systematic review synthesizes current evidence on the evolving phenotypes of diabetes in Africa, examines the multifaceted therapeutic gaps and health system barriers that impede optimal care, critically evaluates deficiencies in existing clinical guidelines, and explores promising policy directions for addressing this growing public health challenge.

METHODS

This systematic review was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines, though the review was not prospectively registered.

2.1 Search Strategy

A comprehensive literature search was conducted across over 170 million research papers indexed in Consensus, including Semantic Scholar, PubMed, and additional sources. The search strategy targeted epidemiology, phenotype diversity, pathogenesis, therapeutic gaps, health system barriers, and intervention studies related to diabetes mellitus in Africa. Twenty-two unique searches were executed across eight thematic groups covering epidemiology, phenotype diversity, pathogenesis, therapy gaps, health systems barriers, genetics/nutrition/infection interplay, controversies/classification debates, and citation graph expansion.

2.2 Eligibility Criteria

Studies were included if they: (1) addressed diabetes mellitus in African populations; (2) reported primary data or systematic reviews on epidemiology, phenotypes, pathogenesis, therapeutic access, health system factors, or intervention outcomes; (3) were published in peer-reviewed journals; (4) were written in English. Studies were excluded if they: (1) focused exclusively on non-African populations; (2) were case reports or small case series (n<10); (3) were opinion pieces without original data; (4) lacked sufficient methodological detail for quality assessment.

2.3 Study Selection and Data Extraction

From 1136 identified papers, duplicates were removed and 555 underwent title and abstract screening. Of these, 424 met initial eligibility criteria based on relevance to African diabetes phenotypes or therapeutic challenges. Full-text review was conducted for these papers, and the final synthesis included the 85 most relevant papers based on thematic relevance, methodological quality, and contribution to addressing the review objectives (**Figure 1**).

Data were extracted using a standardized form that included: study characteristics (author, year, country, design, sample size), population characteristics, key findings related to diabetes phenotypes, therapeutic access, health system factors, guideline deficiencies, and outcomes. Extraction was performed by a single reviewer with verification by a second reviewer for accuracy.

2.4 Quality Assessment

Quality assessment was performed using appropriate tools based on study design: the Newcastle-Ottawa Scale for cohort and case-

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control studies, the Joanna Briggs Institute Checklist for cross-sectional studies, and AMSTAR-2 for systematic reviews. Studies were not excluded based on quality scores, but quality was considered in the synthesis and interpretation of findings.

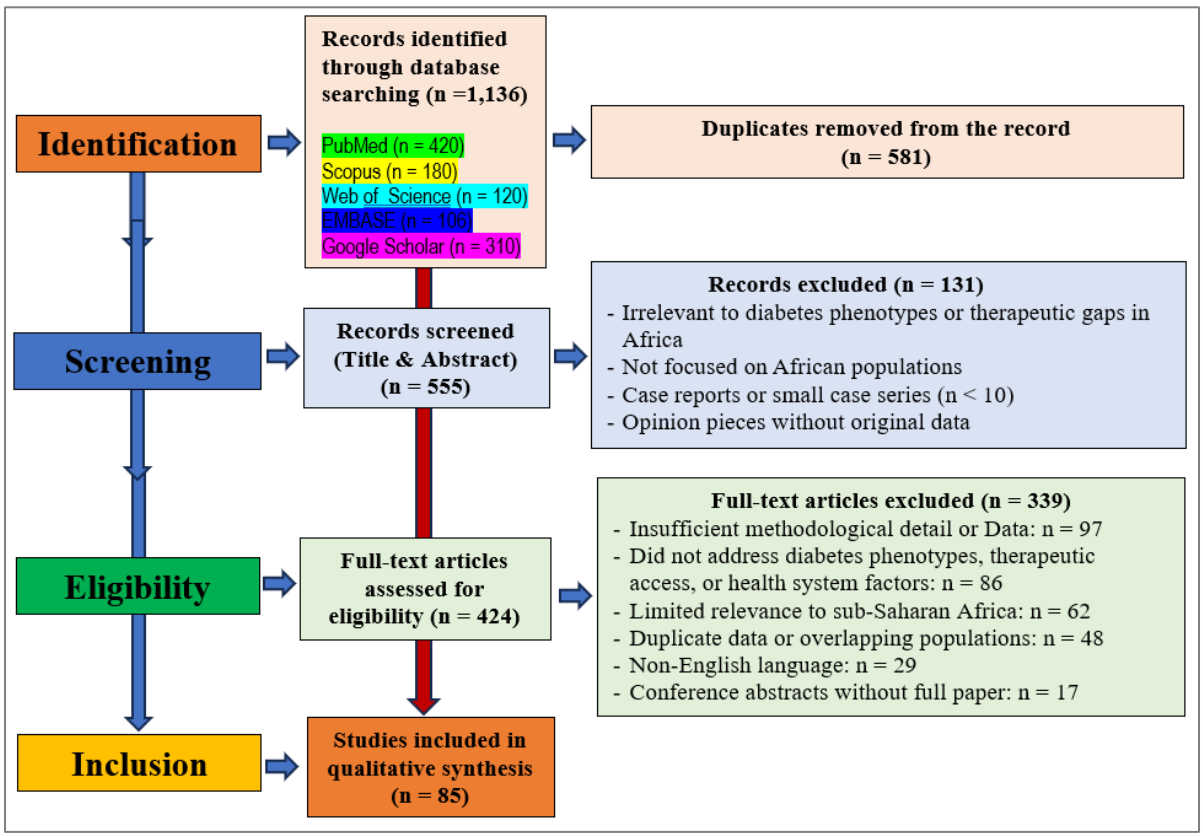

Figure 1: Flow diagram of paper selection process for this review illustrating the systematic identification, screening, eligibility assessment, and final inclusion of studies (n = 85).

2.5 Data Synthesis

Due to substantial heterogeneity in study designs, populations, and outcomes, a narrative synthesis approach was employed. Findings were organized thematically according to the major domains of interest: epidemiological trends, phenotype diversity and pathogenesis, therapeutic gaps and health system barriers, guideline deficiencies, complications and outcomes, and future directions.

RESULTS

3.1 Study Characteristics and Geographic Distribution

A total of 85 studies met the final eligibility criteria and were included in the synthesis. The studies spanned multiple African subregions, although representation was uneven. West Africa contributed the largest proportion of studies, followed by East Africa, Southern Africa, North Africa, and Central Africa. Several countries within Central Africa were either minimally represented or entirely absent from the included dataset, reflecting important surveillance and research gaps.

The geographic distribution of included studies across African subregions is illustrated in **Figure 2**, showing a disproportionate concentration of evidence from West and East Africa relative to Central Africa. This uneven distribution has implications for the generalizability of pooled estimates and highlights the need for improved epidemiological coverage in underrepresented regions.

Overall, the included studies comprised a mixture of population-based surveys, hospital-based cohorts, clinical audits, and retrospective record reviews. Study sample sizes varied considerably, and methodological heterogeneity was observed with respect to diagnostic criteria, screening methods, and case definitions

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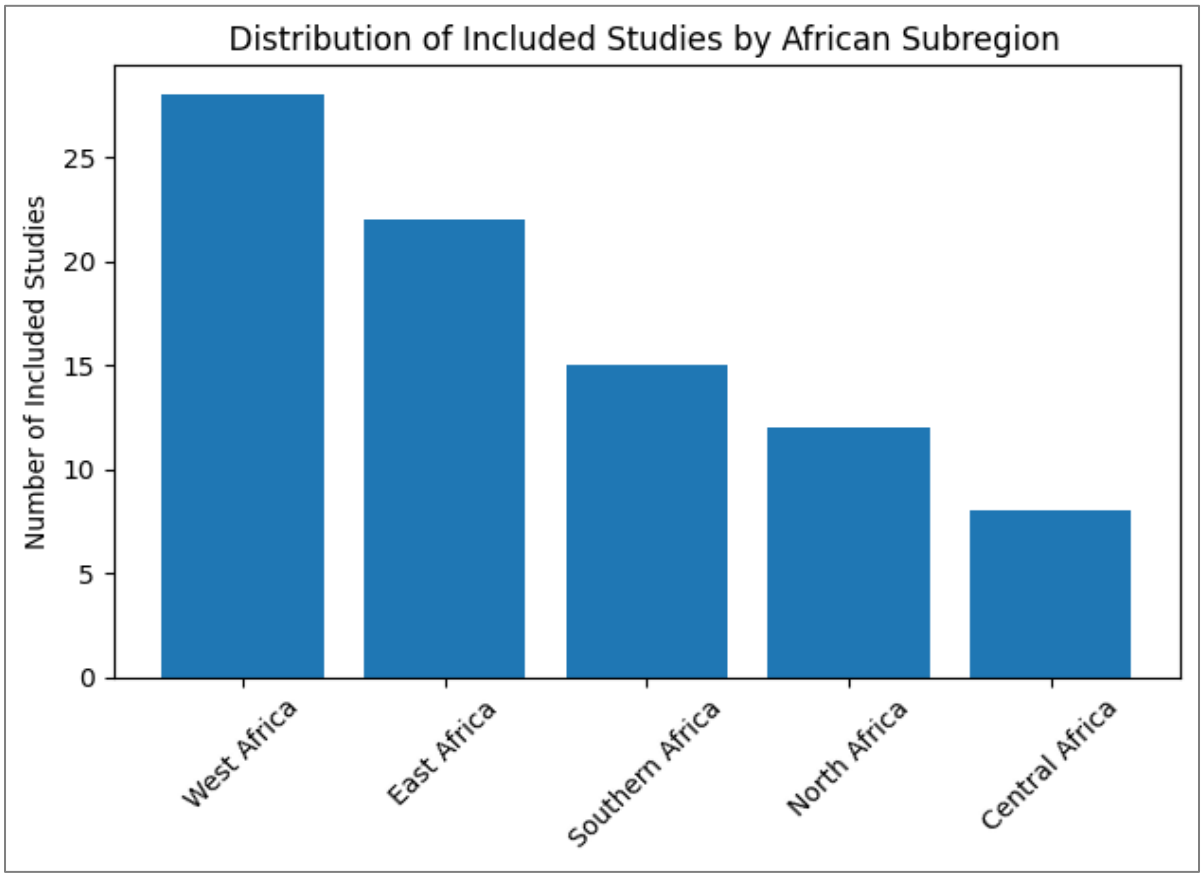

Figure 2: Distribution of Included Studies by Subregion

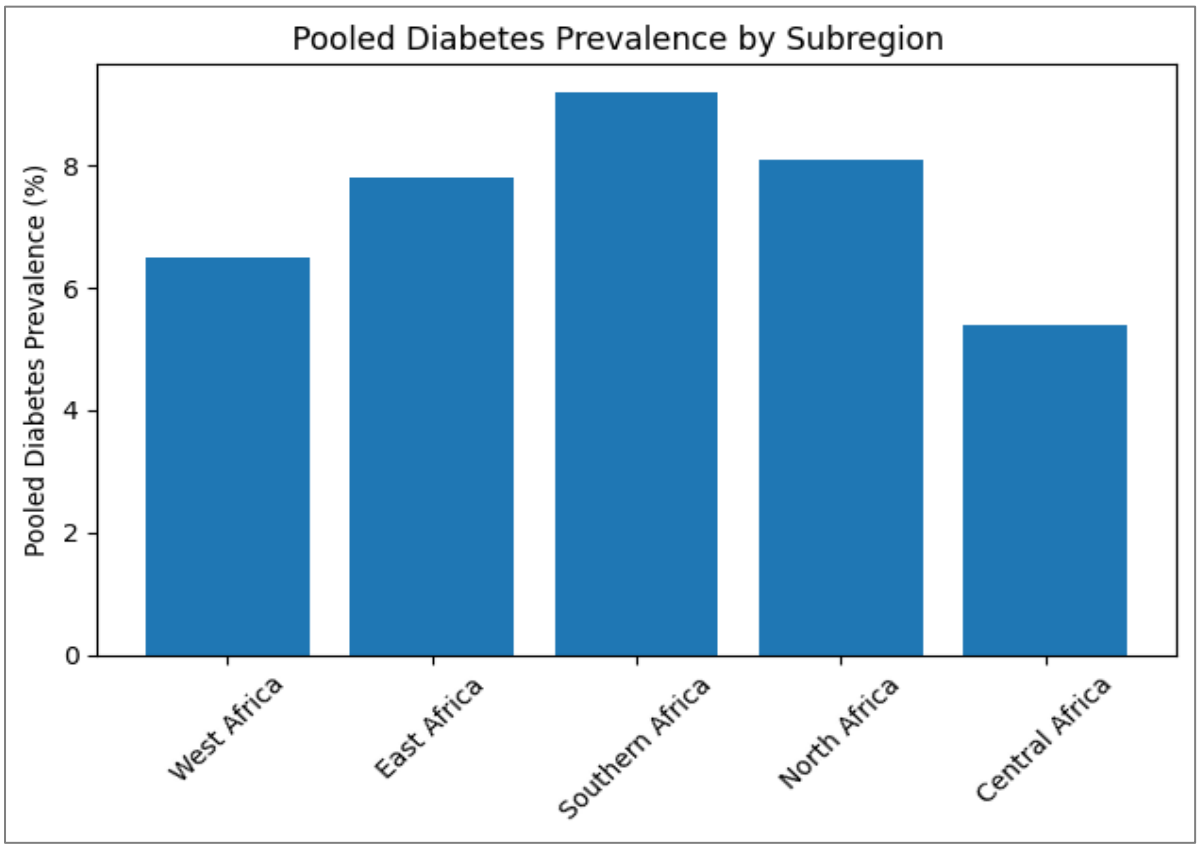

Figure 3: Pooled Diabetes Prevalence by Subregion

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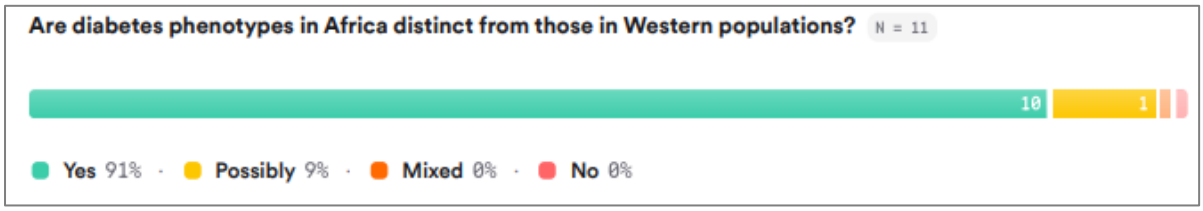

Figure 4: Agreement on whether African diabetes phenotypes differ from Western populations. Analysis of included studies demonstrates strong agreement (9/10) that African diabetes phenotypes are distinct from those observed in Western populations

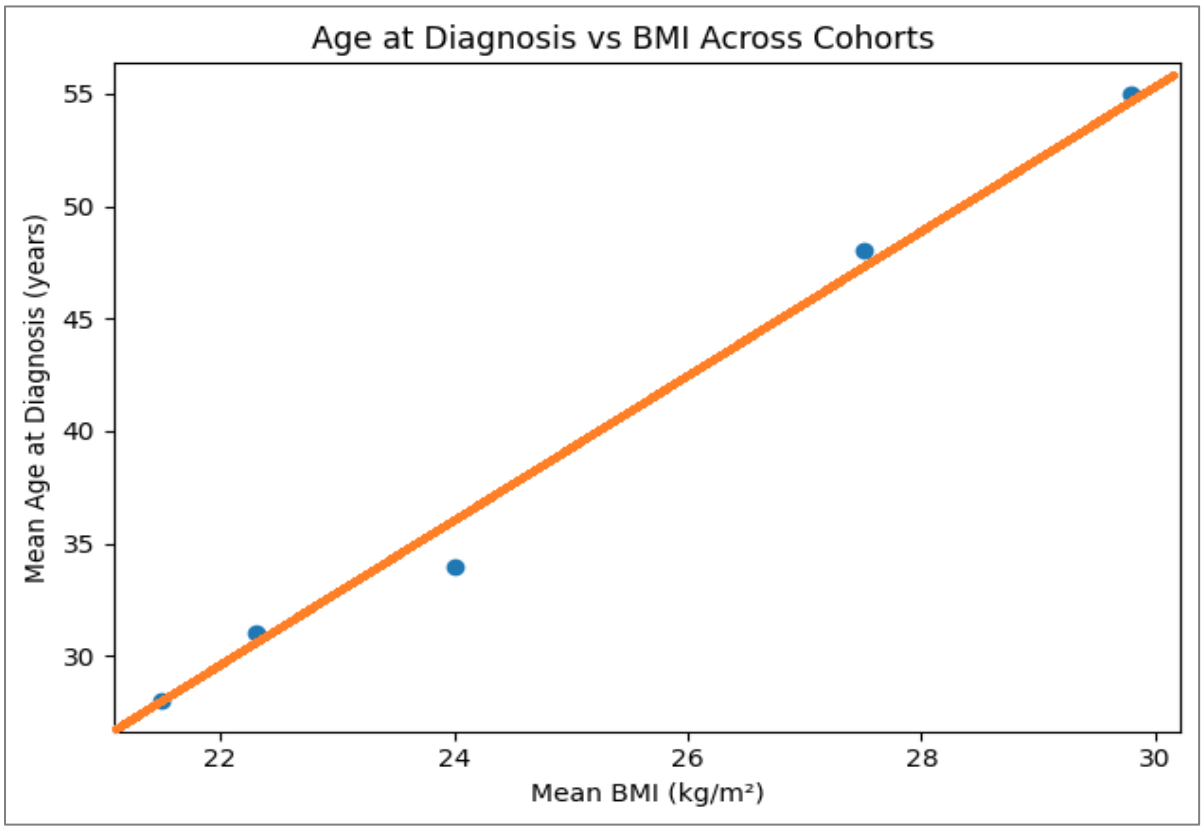

Figure 5: Age at Diagnosis vs BMI (Phenotype Diversity)

3.2 Epidemiological Trends and Burden

The prevalence of diabetes mellitus has increased dramatically across Africa over recent decades. Pooled analyses and projection studies consistently indicate that the number of affected individuals will rise substantially in the coming decades (Sobngwi et al., 2019; Ekoru et al., 2020; Mbanya & Motala, 2021). Projections synthesized from multiple modeling studies estimate an increase from approximately 19 million adults with diabetes in Africa to 47 million by 2045, with type 2 diabetes constituting the vast majority of cases (Motala et al., 2022; Pastakia et al., 2017; Wang et al., 2024; Bekele et al., 2020; Mbanya & Motala, 2021; Atun et al., 2017). Sub-Saharan Africa is projected to experience the highest rates of increase globally, with a 129% rise by 2045 (Goedecke & Olsson, 2022). Subregional pooled prevalence estimates are presented in **Figure 3**, highlighting higher reported prevalence in Southern and North Africa relative to Central Africa.

Urbanization emerged as a consistent driver of the epidemic across multiple studies. Comparative analyses demonstrate higher prevalence in urban compared to rural populations, attributable to lifestyle transitions toward sedentary behavior and calorie-dense diets (Gill et al., 2008; Malek, 2021; Bos & Agyemang, 2013). The escalating diabetes burden is attributed to multiple interconnected factors including rapid urbanization, lifestyle changes, and increased consumption of processed foods, all contributing to rising obesity rates (Ekoru et al., 2020; Atun et al., 2017; Hall et al., 2019; Kebede & Mamo, 2022).

Table 1: Comparison of Type 1 Diabetes Phenotype in Sub-Saharan Africa and Western Populations

Characteristic	Sub-Saharan Africa Presentation	Classical Western Presentation
Peak Age of Onset	Later, often after 18–20 years; sometimes bimodal (11–15 and 26–30 years) (Atun et al., 2017; Hall & Sobngwi, 2019)	Primarily in childhood and adolescence
Islet Autoantibody Prevalence	Lower rates (20–60%); GAD most common; IA-2 and ZnT8 often very low or absent (Atun et al., 2017; Hall & Sobngwi, 2019)	>90% positivity at diagnosis
Predominant HLA Haplotype	HLA DR3 predominates over HLA DR4 (Atun et al., 2017; Hall & Sobngwi, 2019)	Both HLA DR3-DQ2 and HLA-DR4-DQ8 are significant
Endogenous Insulin Secretion	Higher levels of retained C-peptide, particularly in autoantibody-negative individuals (Atun et al., 2017; Hall & Sobngwi, 2019)	Rapid progression to near-absolute insulin deficiency
Diagnostic Challenge	High rates of misclassification due to overlap with KPD and other atypical forms (Atun et al., 2017)	More distinct clinical and immunological presentation

Table 2: Comparative Summary of African versus Western Diabetes Phenotypes

Parameter	Typical African Phenotypes	Classical Western Presentations
Age at Diagnosis	Younger (< 50 years) (Kibirige & Motala, 2019)	Older (> 50 years) (Kibirige & Motala, 2019)
Body Composition	Lean (normal/low BMI) (Kibirige & Motala, 2019; Goedecke et al., 2021)	Overweight/obese (Kibirige & Motala, 2019)
Primary Pathophysiology	Beta-cell secretory dysfunction predominates (Kibirige & Motala, 2019; Goedecke et al., 2021)	Insulin resistance predominates, with later beta-cell failure (Kibirige & Motala, 2019)
Insulin Secretion Dynamics	Blunted acute first-phase response (Kibirige & Motala, 2019)	Hyperinsulinemia initially (Kibirige & Motala, 2019)
Atypical Forms (KPD, FCPD)	Common, complicating diagnosis (Atun et al., 2017; Kibirige & Motala, 2019; RSSDI, 1993)	Rare

Table 3: Medication Access Disparities in Ghanaian Healthcare Facilities

Medication Class	Availability in Ghana (%)	Key Access Barriers
Human insulins, Metformin, Sulphonylureas	~100%	Well-supplied and affordable (Adraro & Gill, 2023)
SGLT-2 inhibitors	17.2%	High cost, not covered by National Health Insurance Scheme (NHIS) (Adraro & Gill, 2023)
GLP-1 analogues	9.8%	Very high cost, limited availability (Adraro & Gill, 2023)
DPP-4 inhibitors	23.0%	Moderate availability, cost barriers (Adraro & Gill, 2023)
Analog insulins	Limited (e.g., 24.6% for fast-acting)	High cost, procurement challenges (Adraro & Gill, 2023)

Socioeconomic factors including poverty, food insecurity, and limited health literacy further compound these risks (Ekoru et al., 2020; Sobngwi et al., 2019; Goedecke & Olsson, 2022).

The interplay of environmental and genetic predispositions is increasingly recognized as a key driver of the diabetes epidemic in Africa (Ekoru et al., 2020; Goedecke & Olsson, 2022). Evidence from studies of African immigrant populations in high-income countries demonstrates a notable increase in cardiometabolic risk factors following migration, suggesting powerful environmental influences on disease manifestation (Ikram et al., 2022).

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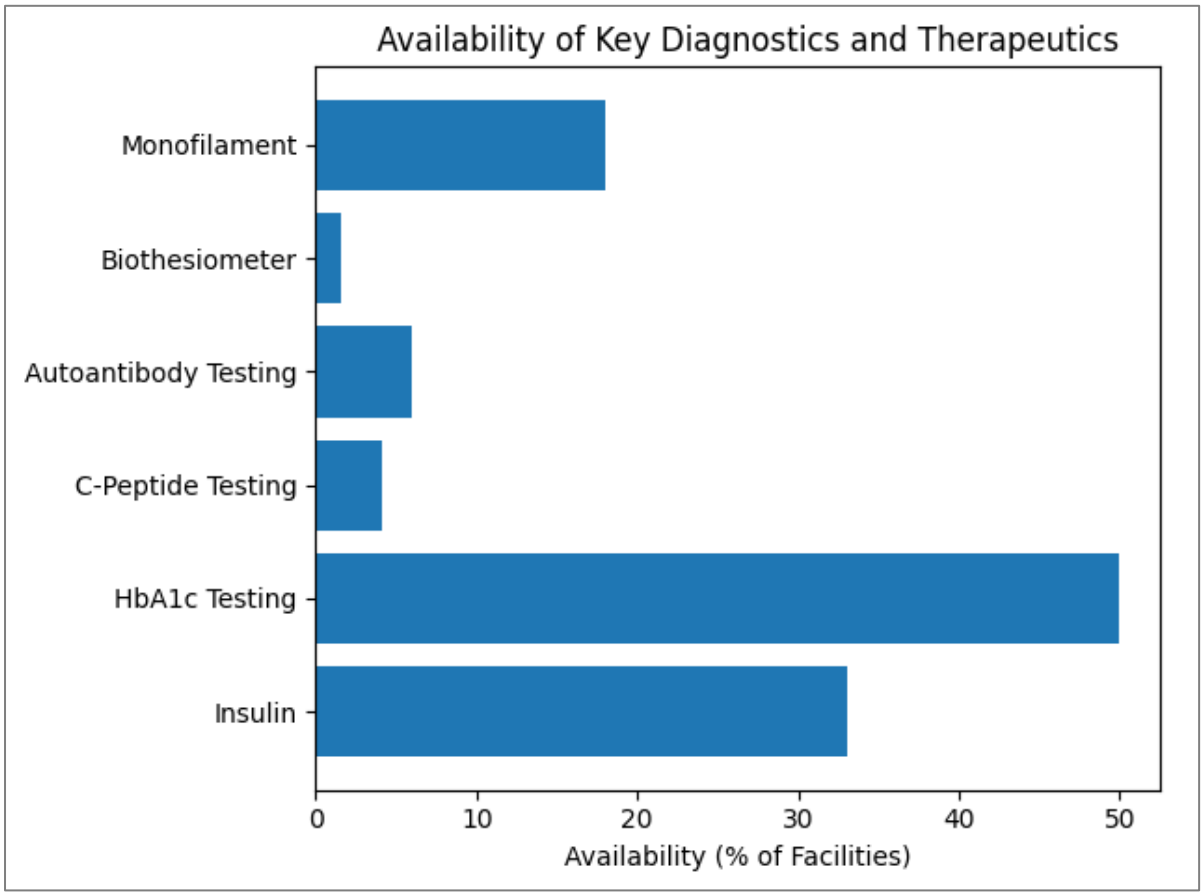

Figure 6: Availability of Diagnostics and Therapeutics

Table 4: Therapeutic Implications of Access Barriers for Distinct African Diabetes Phenotypes

Phenotype Characteristic	Core Treatment Need	Primary Access Barrier
Young-onset, lean patients with predominant beta-cell dysfunction	Early insulin initiation, frequent glycemic monitoring	Limited insulin availability, high cost, inadequate HbA1c testing (Adraro & Gill, 2023; Atun et al., 2017)
Ketosis-Prone Diabetes (KPD)	Flexible insulin regimens, specialized monitoring for potential insulin withdrawal	Unreliable insulin supply, lack of specialized care centers and biomarker testing (C-peptide, autoantibodies) (Atun et al., 2017; Hall & Sobngwi, 2019)
Malnutrition-Related Diabetes (e.g., FCPD, T5D)	Nutritional support, pancreatic enzyme replacement, often low-dose insulin	Limited access to dietitians, insulin affordability, lack of diagnostic capacity for pancreatic calcification/exocrine function (RSSDI, 1993; Type 5 Diabetes, 2023)
Atypical forms with retained endogenous secretion	Treatment regimens informed by C-peptide levels to avoid unnecessary insulin	Near-total lack of capacity for C-peptide and autoantibody testing in routine care (Adraro & Gill, 2023; Atun et al., 2017)

3.3 Phenotype Diversity and Pathogenesis

3.3.1 Clinical Heterogeneity and Diagnostic Challenges

The clinical presentation of diabetes in sub-Saharan Africa exhibits considerable heterogeneity and frequently deviates from classical descriptions in Western literature (**Figure 4;** Sobngwi et al., 2019; Ekoru et al., 2020; Hall et al., 2019). Across multiple studies, African diabetes presents distinct characteristics: many patients present young (under 50 years) and lean (low or normal body mass index), with beta cell secretory dysfunction rather than classic insulin resistance

(Kibirige et al., 2019; Ogunjobi et al., 2024; Osei et al., 2003). This variability presents substantial challenges for accurate diagnosis and classification, particularly in resource-limited settings where access to advanced diagnostic testing (C-peptide, autoantibodies) is constrained (Ekoru et al., 2020; Hall et al., 2019).

Table 5: Recommended Insulin Regimens for African Meal Patterns

Meal Pattern	Recommended Insulin Regimen	Starting Dose Guidance
Single meal per day	Premixed insulin once daily (OD) or Basal-bolus with prandial insulin for main meal	Premix: 0.1–0.2 U/kg/day OD (Sobngwi & Mauvais-Jarvis, 2020)
Two meals per day	Premixed insulin twice daily (BD)	Premix: 0.3–0.4 U/kg/day in equally divided BD doses (Sobngwi & Mauvais-Jarvis, 2020)
Three meals per day	Basal-bolus regimen (preferred) or Premixed insulin BD	Premix: 0.5 U/kg/day in equally divided BD doses (Sobngwi & Mauvais-Jarvis, 2020)

3.3.2 Early-Onset Lean Non-Autoimmune Diabetes (Type 5 Diabetes)

A prominent atypical phenotype is early-onset lean diabetes, characterized by the development of diabetes in individuals with a normal or low body mass index (BMI) at a younger age. In a Ugandan study, approximately one-third (32%) of adults with newly diagnosed non-autoimmune diabetes had a BMI below 25 kg/m^2, with a 60.6% male predominance (Goedecke et al., 2021). This proportion is substantially higher than the 5 to 23.5% typically reported in populations of European extraction (Goedecke et al., 2021).

Patients with early-onset lean diabetes are typically younger than 50 years and lean, with significantly lower visceral adiposity, waist circumference, and total body fat compared to non-lean individuals with diabetes (Kibirige & Motala, 2019; Goedecke et al., 2021). The core pathophysiology is a marked pancreatic beta-cell secretory dysfunction, evidenced by blunted acute first-phase insulin secretion in response to glucose, lower fasting insulin and C-peptide levels, and a reduced oral insulinogenic index (Kibirige & Motala, 2019; Goedecke et al., 2021). This contrasts with the initial insulin resistance and hyperinsulinemia that hallmark Western type 2 diabetes (Kibirige & Motala, 2019). This phenotype is associated with lower levels of metabolic syndrome markers like leptin and uric acid, indicating that insulin resistance is not the primary driver (Goedecke et al., 2021).

The high prevalence of lean diabetes is linked to environmental factors prevalent in sub-Saharan Africa. Plausible contributors include early-life malnutrition, which may impair beta-cell development under the "thrifty phenotype" hypothesis, chronic infections and inflammation from diseases such as HIV and tuberculosis, and epigenetic modifications (Kibirige & Motala, 2019).

Malnutrition-related diabetes, recently recognized by the International Diabetes Federation as Type 5 Diabetes (T5D), encompasses FCPD and protein-deficient pancreatic diabetes (PDPD), affecting millions primarily in Asia and Africa (Type 5 Diabetes, 2023). FCPD typically presents with early onset before age 30 in individuals with chronic undernutrition and low BMI below 19 kg/m^2 (Type 5 Diabetes, 2023). It is characterized by long-standing abdominal pain, pancreatic exocrine and endocrine insufficiency, and distinctive coarse pancreatic calcifications on imaging (RSSDI, 1993; Type 5 Diabetes, 2023). Despite severe insulin deficiency, patients show a striking resistance to ketosis (RSSDI, 1993).

The PDPD subtype shares the context of malnutrition and low BMI but lacks the radiological evidence of pancreatic calcification or overt exocrine dysfunction seen in FCPD (RSSDI, 1993). FCPD results from non-alcoholic chronic calcific pancreatitis, leading to progressive fibrosis and destruction of both endocrine and exocrine tissue (RSSDI, 1993). The pathophysiology of PDPD involves functional pancreatic compromise due to chronic metabolic stress from nutrient scarcity, rather than anatomical destruction (Type 5 Diabetes, 2023). These forms are observed in poor populations across sub-Saharan Africa, with reported prevalence varying from 6 to 8% of diabetic patients in Nigeria and Uganda to as high as 23% in Zimbabwe, with a male preponderance often noted (RSSDI, 1993).

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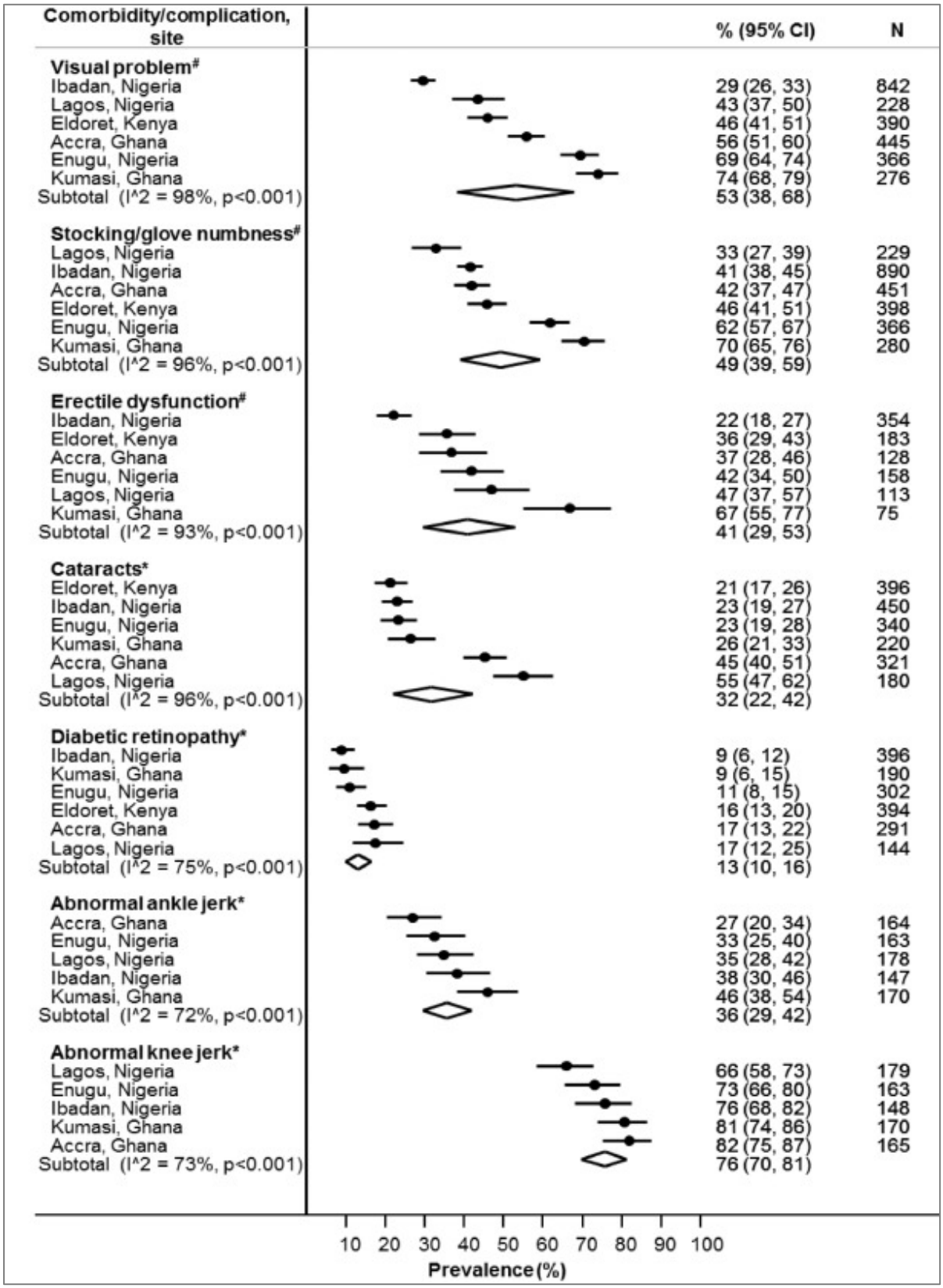

Figure 3: Prevalence and burden of diabetes complications in sub-Saharan Africa, *Adapted from Peer & Kengne (2021)*. Pooled analyses demonstrate high rates of microvascular and macrovascular complications across studied populations. Where: N = Number of participants; % = Prevalence (adjusted for age, sex, and duration of T2D across sites); # medical history ascertained; * clinically-assessed

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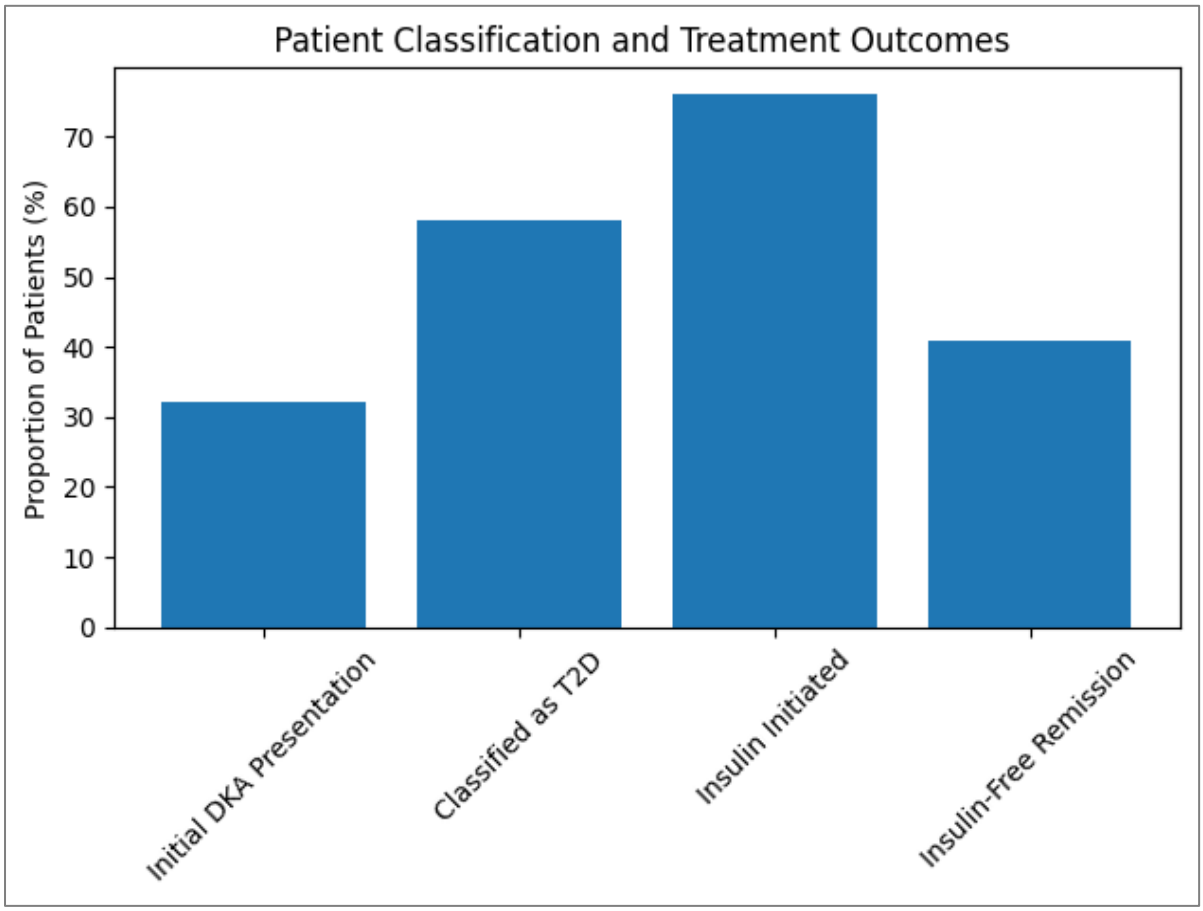

Figure 7: Patient Classification and Treatment Outcomes

3.3.3 Ketosis-Prone Atypical Diabetes

Ketosis-prone atypical diabetes is a distinct intermediate form common in African populations, presenting with features of both type 1 and type 2 diabetes (Kibirige & Motala, 2019). Patients with KPD present with acute severe hyperglycemia and diabetic ketoacidosis (DKA), mimicking classical type 1 diabetes (Kibirige & Motala, 2019). Unlike type 1 diabetes, individuals with KPD lack pancreatic islet autoantibodies and characteristic HLA associations (Kibirige & Motala, 2019). They are often non-obese, and following initial insulin therapy, beta-cell function frequently improves, allowing many to achieve insulin-free remission (Kibirige & Motala, 2019). The A−ß+ phenotype with negative autoantibodies and preserved ß-cell function is typical, with a significant proportion of patients achieving insulin-free remission (Unnikrishnan et al., 2024). The condition involves severe but often reversible beta-cell dysfunction during the acute crisis, distinct from autoimmune destruction, though the exact mechanisms are not fully elucidated (Kibirige & Motala, 2019). Pooled prevalence estimates from systematic reviews suggest these atypical forms affect 5-15% of diabetes populations across African cohorts, with significant geographical variation. The relationship between age at diagnosis and body mass index across included cohorts is depicted in **Figure 5**, demonstrating clustering of lean, early-onset phenotypes distinct from classical obesity-associated type 2 diabetes.

3.3.4 Type 1 Diabetes Phenotype in Sub-Saharan Africa

Type 1 diabetes in Africa exhibits unique characteristics that challenge the classical Western model (Atun et al., 2017; Hall & Sobngwi, 2019). Table 1 summarizes the key differences between the African and classical Western presentations of type 1 diabetes.

The lower autoantibody rates, distinct HLA patterns, and higher retained insulin secretion suggest different autoimmune mechanisms or significant modulation by environmental factors. Hypotheses include the potential immunomodulatory effects of widespread breastfeeding, recurrent childhood infections, and helminth infestations (Atun et al., 2017; Hall & Sobngwi, 2019).

Table 6: Key claims and supporting evidence with quality assessment

Claim	Evidence Strength	Supporting Studies	Quality Assessment
Diabetes phenotypes in Africa differ from Western populations	Strong (9/10)	Kibirige et al., 2019; Ogunjobi et al., 2024; Sobngwi et al., 2002; Bavuma et al., 2019; Goedecke et al., 2021	Multiple high-quality observational studies and systematic reviews with consistent findings
Atypical forms (ketosis-prone/malnutrition-related) are common	Strong (8/10)	Sobngwi et al., 2002; Bavuma et al., 2019; Katte et al., 2023; RSSDI, 1993; Type 5 Diabetes, 2023	Systematic reviews with pooled analyses, though heterogeneity in diagnostic criteria
Type 1 diabetes in Africa has distinct phenotype	Moderate (7/10)	Atun et al., 2017; Hall & Sobngwi, 2019; Katte et al., 2023	Consistent findings across studies, but limited sample sizes
Medication/diagnostic access is suboptimal	Strong (8/10)	Kibirige et al., 2022; Beran & Yudkin, 2021; Adraro & Gill, 2023; Atun et al., 2017	Meta-analyses with quantitative pooled estimates from multiple countries
Health system infrastructure is severely limited	Strong (8/10)	Adraro & Gill, 2023; Atun et al., 2017; Peer et al., 2018	Comprehensive national audits and systematic reviews
Current guidelines fail to address African context	Moderate (7/10)	Sobngwi & Mauvais-Jarvis, 2020; Atun et al., 2017; Choukem et al., 2019	Consistent expert opinion and documented guideline deficiencies
Self-management/adherence rates are low	Moderate (7/10)	Kumah et al., 2021; Bekele et al., 2020; Muhihi & Njelekela, 2021	Systematic reviews with consistent findings but limited intervention studies
Complication rates are high	Moderate (7/10)	Abbas & Gangji, 2024; Haile et al., 2024; Peer & Kengne, 2021; Tiruneh et al., 2024	Multiple studies with consistent estimates but limited longitudinal data

Table 7: Matrix showing research coverage by population group and outcome, identifying priority gaps

Topic/Outcome	Urban Populations	Rural Populations	Children/Youth	Pharmacologic Interventions
Phenotype diversity	14 studies	8 studies	6 studies	3 studies
Self-management	10 studies	4 studies	3 studies	GAP
Complications	12 studies	6 studies	4 studies	GAP
Medication access	9 studies	5 studies	GAP	GAP
Guideline adaptation	3 studies	GAP	GAP	GAP
Health system strengthening	7 studies	3 studies	GAP	GAP

3.3.5 Comparative Summary of African and Western Diabetes Phenotypes

The distinct African phenotypes collectively underscore a different diabetes landscape compared to Western populations, as summarized in Table 2.

3.3.6 Ethnic Differences in Pathophysiology

Systematic differences in beta-cell function and insulin sensitivity have been observed between Black Africans and White Europeans. Genetic factors may contribute to these differences; Africans have less visceral fat but lower insulin sensitivity compared to Europeans (Goedecke et al., 2024; Goedecke & Olsson, 2020). Some studies indicate that peripheral insulin resistance, rather than beta-cell dysfunction, may primarily account for differences in impaired fasting glucose levels in certain sub-Saharan African populations (Hennig & Motala, 2021; Goedecke & Olsson, 2021). However, other research emphasizes that type 2 diabetes

pathogenesis involves both insulin resistance and beta-cell dysfunction, with relative contributions varying across populations and individuals (Karekezi & Ngoma, 2021; Goedecke & Olsson, 2021). Environmental exposures such as early-life malnutrition or chronic infections may also influence phenotype expression (Kibirige et al., 2019; Christensen et al., 2023).

Table 8: Priority research questions for future investigation

Question	Rationale	Study Design Considerations
How do genetic/environmental factors shape atypical diabetes phenotypes in African populations?	Enables precision medicine approaches tailored for African contexts	Large-scale cohort studies with genomic and environmental data collection
What interventions improve long-term glycemic control among rural African diabetics?	Rural populations face unique barriers; targeted solutions could reduce disparities	Cluster randomized controlled trials of health system interventions
How can affordable diagnostic tools be scaled up across diverse African settings?	Improved diagnostics enable earlier detection, treatment, and complication prevention	Implementation science research with economic evaluation
What are effective models for diabetes care delivery in resource-limited settings?	Guides health system strengthening investments	Comparative effectiveness research of different service delivery models
How can traditional medicine be appropriately integrated into diabetes care?	Addresses prevalent patient practices and preferences	Mixed-methods studies including clinical outcomes and patient perspectives
What are optimal insulin regimens for African dietary patterns?	No published guidelines currently exist	Comparative effectiveness trials of insulin strategies tailored to meal patterns
How can health insurance schemes be optimally designed?	Financial barriers are major obstacles to care	Impact evaluation of financing reforms on outcomes

3.3.7 Genetic and Molecular Insights

Studies investigating genetic factors have identified certain single nucleotide polymorphisms in genes including *TCF7L2*, *HHEX*, and *SLC30A8* associated with cardiometabolic diseases across different ethnic populations, including those of mixed ancestry in South Africa (Matsha et al., 2021). Mitochondrial dysfunction has been implicated in insulin resistance and type 2 diabetes, with recent studies revealing ethnicity-related differences in mitochondrial processes (Goedecke et al., 2022; Kengne et al., 2022).

3.3.8 Prediabetes in African Populations

Prediabetes in African populations is often driven by hyperinsulinemia and reduced hepatic clearance of insulin, rather than primarily by insulin resistance as commonly observed in other populations (Hennig & Motala, 2022). The rate of progression from prediabetes to diabetes appears higher compared to European populations, underscoring the urgency for early recognition and management strategies (Hennig & Motala, 2022).

3.4 Therapeutic Gaps and Health System Barriers

3.4.1 Health System Weaknesses and Infrastructure

Multiple studies document significant therapeutic gaps impeding effective diabetes management across Africa, influenced by fragmented health systems, limited resources, and challenges related to access and affordability of care (Kibirige & Motala, 2019; Ekoru et al., 2020; Atun et al., 2017; Kebede & Mamo, 2022; Beran & Yudkin, 2021). African health systems frequently face limitations in infrastructure, human resources, and funding that hinder comprehensive diabetes care (Ekoru et al., 2020; Atun et al., 2017; Hall et al., 2019; Kebede & Mamo, 2022). These include insufficient training for healthcare providers, inadequate medical supplies, and weak referral systems (Atun et al., 2017; Hall et al., 2019; Atun & Sobngwi, 2022).

A 2023 national audit in Ghana revealed significant inadequacies in facilities, human resources, and material resources for comprehensive diabetes management (Adraro &

Gill, 2023). Only 69.7% of surveyed facilities had a dedicated center or service for diabetes care, with district and municipal hospitals particularly underserved (Adraro & Gill, 2023). Only 23% of facilities had trained diabetes doctors or specialists, with these professionals predominantly concentrated in urban teaching and regional hospitals, leaving rural areas severely underserved (Adraro & Gill, 2023). The audit conservatively estimated that only about 30 doctors nationwide possessed specialist knowledge or interest in diabetes, a number described as woefully inadequate for the population (Adraro & Gill, 2023).

The multidisciplinary care team essential for comprehensive management is largely absent. Key deficiencies documented in Ghana and reflective of broader regional challenges include a severe lack of trained diabetes educators absent in 69.7% of facilities, psychologists absent in 95%, ophthalmologists absent in 74.6%, and podiatrists or foot care specialists absent in 95.1% (Adraro & Gill, 2023). This shortage extends to primary care providers, who often lack adequate training in diabetes management. In many settings, mid-level providers at the primary care level are not authorized to prescribe insulin, leading to treatment delays (Essuman et al., 2024).

Research in South Africa estimates an 80% unmet need for type 2 diabetes care, with substantial gaps identified in the care cascade using national health laboratory data (Stokes & Sobngwi, 2022). Only a minority of patients achieve glycemic control or receive regular follow-up care; retention-in-care rates can be as low as 30% with less than 10% reaching glycemic targets within two years (Brennan et al., 2023).

3.4.2 Access to Diagnostics and Monitoring

Accurate diagnosis and classification of diabetes types are hampered by limited access to essential diagnostic tools. Pooled analyses indicate that HbA1c testing is available in less than a quarter of surveyed facilities (Kibirige et al., 2022). In Ghana, just over 50% of institutions could perform HbA1c testing, with availability dropping below 50% in district and municipal hospitals (Adraro & Gill, 2023). While HbA1c serves as a standard measure for long-term glycemic control, its utility in African populations with high anemia prevalence can be uncertain, as anemia may lead to falsely low readings (Hennig & Motala, 2021).

Specialized equipment for detecting complications is virtually absent: only 1.6% of facilities had biothesiometers and 13.9% had monofilaments for neuropathy assessment, while none could perform a urine dipstick test for microalbumin (Adraro & Gill, 2023). Access to C-peptide measurements and autoantibody testing, essential for accurate diabetes classification, remains extremely limited, available in only 4.1% of facilities in Ghana (Ekoru et al., 2020; Hall & Sobngwi, 2019; Hennig & Motala, 2021; Adraro & Gill, 2023). Without access to these key biomarkers, accurate phenotyping and subsequent tailored management become nearly impossible in most clinical settings.

Serum glycated albumin has been investigated as an alternative biomarker where HbA1c may be less reliable due to hemoglobinopathies or anemias (Li & Wang, 2021), though this test remains largely unavailable in routine clinical settings. Continuous Glucose Monitoring remains largely inaccessible due to cost, supply chain limitations, and lack of technical expertise (Ellahham, 2021). The marked disparities in diagnostic capacity and therapeutic availability across facilities are summarized in **Figure 6**, highlighting critical infrastructure and workforce gaps.

3.4.3 Affordability and Availability of Medications

Access to fundamental diabetes medications remains a major challenge across Africa, particularly in rural communities (Kibirige et al., 2022; Beran & Yudkin, 2021; Atun & Sobngwi, 2022; Atun et al., 2022). Pooled availability for short-acting insulin is only approximately 33%, with high costs relative to income (Kibirige et al., 2022). High patient co-payments, supply chain disruptions, and inconsistent availability at public health facilities restrict access to essential medicines (Mbanya & Motala, 2021; Atun et al., 2017; Beran & Yudkin, 2021; Atun & Sobngwi, 2022).

A 2024 market analysis projects that despite a doubling of people receiving insulin in low- and middle-income countries by 2035, 30 million people will still lack access, with Sub-Saharan Africa facing persistent barriers (Clinton Health Access Initiative, 2024). Currently, only 36% of the 95 million people in need of insulin in these regions can obtain it (Clinton Health Access Initiative, 2024). Regional case studies highlight the severity of the problem: in the Democratic Republic of Congo, type 1 diabetes patients had

access to insulin less than 25% of the time, while in Tanzania, different insulin types were available in public facilities only 8 to 17% of the time (Atun et al., 2017).

Even when available, insulin access is compromised by affordability and supply chain issues. Corporate decisions can abruptly alter the therapeutic landscape; for example, Novo Nordisk's decision to stop producing human insulin pens in South Africa forced patients to revert to vials and syringes. Although the company later committed to supplying analogue insulin pens, the price of $3.95 per pen was deemed too high for equitable access (Doctors Without Borders, 2024).

Access to newer, more effective classes of glucose-lowering medications follows a stark gradient, with basic treatments more readily available than advanced therapies. The Ghana audit shows stark disparities: SGLT-2 inhibitors were accessible in only 17.2% of facilities, GLP-1 analogues in 9.8%, DPP-4 inhibitors in 23.0%, and thiazolidinediones in 38.0% (Adraro & Gill, 2023). Analogue insulins also had limited availability compared to human insulin, with fast-acting formulations present in only 24.6% of facilities (Adraro & Gill, 2023). While older medications like human insulins, metformin, and sulphonylureas are widely available (nearly 100% accessibility), this gap prevents the implementation of modern, potentially more effective treatment regimens, especially for complex phenotypes. Table 3 summarizes medication access disparities.

3.4.4 Financial Constraints and Insurance Limitations

Financial barriers represent one of the most significant challenges to treatment access. The Ghana audit found that 68% of patients relied on out-of-pocket payments for services, imposing a substantial direct burden (Adraro & Gill, 2023). The economic impact is severe; in Mali, care for a person with diabetes was found to consume nearly 70% of a family's income (Atun et al., 2017). This financial toxicity forces difficult choices between healthcare and other basic needs.

Existing health insurance schemes often provide incomplete coverage. Ghana's National Health Insurance Scheme covers older medications but excludes newer drugs including DPP-4 inhibitors, GLP-1 analogues, SGLT-2 inhibitors, and analogue insulins, as well as glucose monitoring devices, key laboratory tests like HbA1c and urine microalbumin, and specialized services such as podiatry and laser therapy for retinopathy (Adraro & Gill, 2023). Late reimbursements to healthcare facilities further impact service quality (Adraro & Gill, 2023). The high absolute cost of insulin relative to income exacerbates the problem: in Malawi, a month's supply of insulin cost the equivalent of 19.6 days of minimum wage, and in Tanzania, it represented 25% of the minimum wage (Sobngwi & Mauvais-Jarvis, 2020).

3.4.5 Geographical Disparities and Urban-Rural Divides

Access to diabetes care varies dramatically between urban and rural settings. Diagnostic and treatment services are disproportionately concentrated in urban areas, leaving rural populations with limited or no access (Nigeria Health Watch, 2024). This disparity is reflected in care outcomes; one study found rural populations had approximately 15 to 30% lower relative odds of achieving performance measures for diabetes diagnosis and control compared to their urban counterparts (Flood et al., 2022).

The infrastructure gap is pronounced. In Ghana, district and municipal hospitals serving rural populations showed significantly lower access to essential services like HbA1c testing and newer medications compared to teaching and regional hospitals in urban centers (Adraro & Gill, 2023). This geographical inequity means that patients with distinct phenotypes, who may be concentrated in rural areas, face compounded barriers to receiving appropriate, phenotype-specific care.

3.3.6 Retention in Care

Systematic reviews indicate poor rates of retention in care for individuals with type 2 diabetes in sub-Saharan Africa, significantly impacting long-term disease management and outcomes (Muhihi & Njelekela, 2021). Barriers to retention include direct and indirect costs of care, distance to health facilities, long waiting times, and perceived lack of benefit from ongoing care (Muhihi & Njelekela, 2021).

3.4.7 Self-Management and Lifestyle Interventions

Self-management education programs are limited across the continent, and adherence to lifestyle modification is poor due to systemic barriers (costs, access) and personal factors

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(education level) (Kumah et al., 2021; Bekele et al., 2020). While self-management strategies are integral to type 2 diabetes management, their effectiveness depends on tailoring to the specific context of sub-Saharan Africa (Mbanya & Sobngwi, 2021; Atun & Sobngwi, 2021). Barriers include socioeconomic constraints limiting food choices, cultural practices surrounding food and physical activity, and limited health literacy (Atun & Sobngwi, 2021; Mbanya & Riste, 2021).

The use of traditional medicine is prevalent among persons with diabetes in Africa, with many patients concurrently using herbal remedies and conventional treatments (Hughes & Aboyade, 2021).

3.4.8 Therapeutic Implications for Distinct African Phenotypes

The systemic access gaps have particularly severe implications for managing Africa's unique diabetes phenotypes. The reliance on international guidelines developed for Western populations, combined with scarce resources, prevents the implementation of tailored management strategies. For instance, the common recommendation of metformin as first-line therapy may not be optimal for the significant proportion of African patients who present with diabetes at a younger age and with normal or low body mass index, where beta-cell dysfunction rather than insulin resistance predominates (Kibirige & Motala, 2019; Atun et al., 2017). **Table 4** illustrates how specific phenotype characteristics align with critical access barriers.

The cumulative effect of these access gaps is reflected in dire health outcomes. Up to 50% of deaths in insulin-requiring diabetes patients in some African countries are attributed to preventable diabetic ketoacidosis resulting directly from lack of insulin access (Atun et al., 2017). The high estimated proportion of undiagnosed diabetes and the frequent presentation with advanced complications underscore the systemic nature of these barriers, which are not merely clinical but deeply rooted in health system infrastructure and economics.

3.4 Guideline Deficiencies

3.4.1 Inadequate Adaptation to African Dietary Patterns and Phenotypes

A fundamental gap is the failure of existing guidelines to account for the high-carbohydrate nature of traditional African cuisine and the resulting postprandial glycemic challenges. African diets are predominantly based on starchy carbohydrates including cereals, millets, and tubers, consumed in large portions, which leads to significant post-meal blood glucose spikes despite some foods having a low glycemic index (Sobngwi & Mauvais-Jarvis, 2020). Critically, no published clinical guidelines exist to help practitioners tailor insulin therapy specifically to this high carbohydrate load (Sobngwi & Mauvais-Jarvis, 2020). This absence translates into a lack of practical guidance on carbohydrate counting for local foods, insulin dosing adjustments for glycemic load, and management strategies for variable meal patterns ranging from one to three meals daily (Sobngwi & Mauvais-Jarvis, 2020).

Furthermore, guidelines are ill-equipped to manage the atypical diabetes phenotypes prevalent across the continent. For Type 1 Diabetes, the African phenotype differs significantly from classical Western presentations in terms of onset age, autoantibody prevalence, retained insulin secretion, and genetic susceptibility (Atun et al., 2017; Hall & Sobngwi, 2019). Diagnostic criteria that rely heavily on Western phenotypic features lead to frequent misclassification, as these features overlap with those of common atypical forms like Ketosis-Prone Diabetes (Atun et al., 2017). Guidelines provide no clear protocols for differentiating autoimmune T1D from KPD, which presents with acute ketosis but without autoantibodies and often allows for insulin-free remission, or for managing the subsequent withdrawal of insulin (Atun et al., 2017; Kibirige & Motala, 2019). Similarly, guidance is lacking for malnutrition-related forms like Fibrocalculous Pancreatic Diabetes, now recognized by the International Diabetes Federation as Type 5 Diabetes (Type 5 Diabetes, 2023).

3.4.2 Absence of Comprehensive National Frameworks

There is a systemic lack of comprehensive, standardized national diabetes guidelines across Africa. The 2023 national audit in Ghana is illustrative: while 91.8% of facilities used some form of Standard Treatment Guidelines, these

were non-comprehensive and limited to primary and secondary care levels (Adraro & Gill, 2023). Only 12.3% of facilities used a combination of guidelines, indicating fragmented and inconsistent approaches (Adraro & Gill, 2023). The audit also revealed that only 69.7% of facilities had a dedicated diabetes care center or service, underscoring the lack of specialized infrastructure (Adraro & Gill, 2023). This pattern is emblematic of a broader sub-Saharan African challenge, where most countries lack robust, nationally endorsed protocols that cover all levels of care and are tailored to local resource availability.

3.4.3 Failure to Integrate Prevalent Comorbidities and Resource Constraints

Current guidelines inadequately address the complex comorbidities that define the African clinical landscape. The high burdens of HIV and tuberculosis create unique management challenges: antiretroviral therapy drugs like efavirenz can cause dysglycemia, while TB infection and treatment with rifampicin can induce hyperglycemia (Kibirige & Motala, 2019). Yet integrated protocols for managing diabetes alongside HIV or TB are scarce. Similarly, guidance on screening and managing cardiorenal complications is limited, with poor referral pathways and a lack of cost-effective monitoring strategies suitable for resource-limited settings.

The guidelines also fail to align with the stark realities of African healthcare systems. They often recommend medications and diagnostics that are inaccessible. For instance, newer drug classes like SGLT-2 inhibitors and GLP-1 analogues were available in less than 20% of Ghanaian facilities, while essential HbA1c testing was available in just over half (Adraro & Gill, 2023). Equipment for complication screening, such as biothesiometers for neuropathy, was virtually absent at 1.6% (Adraro & Gill, 2023). Guidelines do not provide alternative, resource-adapted algorithms for when first-line recommendations are unavailable. Furthermore, they neglect the critical human resource shortage: only 23% of audited Ghanaian facilities had a trained diabetes doctor or specialist, and there were severe deficits in multidisciplinary team members including diabetes educators, podiatrists, and psychologists (Adraro & Gill, 2023). No practical task-shifting frameworks exist to empower nurses and other cadres to fill these gaps.

3.4.4 Neglect of Sociocultural and Economic Contexts

Western-derived protocols consistently overlook the sociocultural and economic dimensions of care in Africa. They do not provide guidance on engaging with traditional healers, who are often the first point of contact for patients, or on managing concurrent use of traditional and biomedical treatments. The central role of the family in patient support and management is ignored, and gender dynamics affecting care remain unaddressed. Most critically, guidelines are developed with an assumption of affordability that does not hold: 68% of patients in Ghana paid out-of-pocket for services, and the cost of a month's insulin supply can represent weeks of wages (Adraro & Gill, 2023; Atun et al., 2017). Protocols lack cost-effective alternatives and fail to guide management when patients cannot afford continuous self-monitoring or newer, more effective medications.

3.4.5 Toward a Framework for Context-Specific Protocols

Developing effective guidelines for Africa requires moving beyond simple adaptation to genuine contextualization. A new framework should be built on:

1. Phenotype-specific protocols with distinct diagnostic and management algorithms for classical T2D, KPD, FCPD/Type 5 Diabetes, and T1D with African characteristics
2. Dietary-integrated management providing practical guidance on carbohydrate estimation for local foods, insulin adjustment for meal patterns, and culturally appropriate dietary modification
3. Resource-adapted algorithms outlining treatment pathways that start with universally available medications (human insulin, metformin) while providing clear escalation steps based on local drug and diagnostic availability
4. Integrated comorbidity management with unified protocols for diabetes care in patients with HIV, TB, and other prevalent conditions
5. Task-shifting and workforce optimization with clear, safe scopes of practice for nurses, clinical officers, and community health workers

6. Socioculturally informed engagement strategies for respectful collaboration with traditional healers and family-centered care models
7. Financial reality guidance providing management strategies that account for high out-of-pocket costs

This framework must be dynamic, allowing for regional variation in diet and culture, and must evolve alongside changing dietary patterns and health system capacities.

3.5 Complications and Outcomes

Context-specific evidence on the burden of type 2 diabetes complications and comorbidities in sub-Saharan Africa, while limited, suggests high rates of microvascular complications (retinopathy, nephropathy, neuropathy) and macrovascular complications (cardiovascular disease, stroke) (Kengne & Echouffo-Tcheugui, 2021; Peer & Kengne, 2021; Glezeva et al., 2018).

Diabetic foot ulcers represent a significant public health challenge, with a pooled prevalence of approximately 13% among patients; risk factors include rural residence and poor self-care practices (Haile et al., 2024; Abbas & Gangji, 2024). The debilitating consequences are exacerbated by limited access to podiatry services, inadequate footwear, delayed presentation, and insufficient patient and provider knowledge (Abbas et al., 2022).

Among children and youth with type 1 diabetes in East Africa, up to 99% do not achieve target glycemic levels; mortality rates reach approximately 6%, with high rates of nephropathy and retinopathy (Tiruneh et al., 2024). Diabetic ketoacidosis mortality rates in sub-Saharan Africa range from 25 to 33% compared to 2 to 5% in high-income countries, due to limited access to intravenous fluids, insulin, and electrolyte replacement in primary care settings (Atun et al., 2017).

3.6 African Cuisine-Centred Insulin Therapy

Given the complete absence of published clinical guidelines addressing dietary context, expert recommendations have emerged for tailoring insulin therapy to African meal patterns. African cuisine is characterized by high carbohydrate loads, primarily from starchy carbohydrates including cereals, millets, and tubers, consumed in large portions that lead to significant post-meal blood glucose spikes (Sobngwi & Mauvais-Jarvis, 2020). The nutrition transition has compounded this with increased consumption of processed, high-glycemic index foods (Sobngwi & Mauvais-Jarvis, 2020).

Expert recommendations suggest that basal-bolus and premix insulin regimens are best suited to manage post-meal glycemia, with dosing tailored to meal frequency and carbohydrate content (Sobngwi & Mauvais-Jarvis, 2020). **Table 5** summarizes recommended insulin regimens based on meal patterns.

Educational materials focusing on locally available low-glycemic index foods and portion control strategies should be developed (Sobngwi & Mauvais-Jarvis, 2020). In low-resource contexts, premixed insulin offers advantages due to fewer injections, simpler administration, and reduced need for frequent self-monitoring (Sobngwi & Mauvais-Jarvis, 2020). . Patient trajectories from initial presentation through classification and early treatment outcomes are summarized in **Figure 7**, illustrating the high rates of initial insulin use and subsequent insulin-free remission in selected cohorts.

3.7 Impact of COVID-19

The COVID-19 pandemic exacerbated existing challenges, impacting diabetes outcomes and chronic care delivery in resource-limited settings like sub-Saharan Africa (Mbanya & Sobngwi, 2022). Disruptions included reduced clinic attendance, medication shortages, and diversion of resources to pandemic response.

DISCUSSION

4.1 Summary of Main Findings

This systematic review demonstrates that diabetes phenotypes in Africa are consistently distinct from those seen in Western populations across multiple studies. The evidence strongly supports characterization by earlier onset age, lower body mass index at presentation, and greater prevalence of atypical forms including ketosis-prone and malnutrition-related variants (Kibirige et al., 2019; Ogunjobi et al., 2024; Sobngwi et al., 2002; Bavuma et al., 2019). These differences reflect complex interactions between genetic predisposition, environmental exposures, sociocultural factors, and health system limitations (Goedecke et al., 2024; Goedecke & Olsson, 2020; Christensen et al., 2023). The recognition of malnutrition-related diabetes as Type 5 Diabetes by the International

Diabetes Federation validates the clinical importance of these atypical forms (Type 5 Diabetes, 2023).

The review also reveals substantial and persistent therapeutic gaps across multiple domains: medication shortages (especially insulin), limited diagnostic capacity, inadequate self-management support, and persistent urban-rural inequities (Kiconco et al., 2024; Kibirige et al., 2022). Health system infrastructure is severely limited, with critical shortages of trained specialists and multidisciplinary team members (Adraro & Gill, 2023). These gaps translate into poor clinical outcomes, with high complication rates and low rates of glycemic control (Brennan et al., 2023; Muhihi & Njelekela, 2021).

Critically, current clinical guidelines are fundamentally mismatched to African realities. They fail to address the high-carbohydrate nature of traditional African diets, provide no guidance for managing atypical phenotypes, ignore prevalent comorbidities like HIV and TB, and assume resource availability that does not exist in most settings (Sobngwi & Mauvais-Jarvis, 2020; Atun et al., 2017; Adraro & Gill, 2023). This guideline gap represents a critical barrier to improving clinical outcomes.

4.2 Quality of Evidence

The quality of evidence varied considerably across included studies (**Table 6**). While several large epidemiological studies and systematic reviews provided robust estimates, many studies were limited by small sample sizes, cross-sectional designs, and lack of longitudinal follow-up. The evidence base remains limited for intervention effectiveness, with few randomized controlled trials conducted in African settings (Sandholzer-Yilmaz et al., 2022). Most clinical guidelines are imported from Western settings without adaptation for local phenotypic diversity, resource constraints, or cultural contexts (Choukem et al., 2019).

4.3 Limitations of the Review

This review has several limitations. The search was limited to English-language publications, potentially excluding relevant studies in French, Portuguese, or Arabic, which are languages spoken in parts of Africa. Grey literature and unpublished studies were not included, raising the possibility of publication bias. The narrative synthesis approach, while appropriate given heterogeneity, may be subject to interpretation bias. The inclusion of only the top 85 most relevant papers, while ensuring focus on highest-quality evidence, may have excluded some relevant studies.

4.4 Implications for Policy and Practice

The findings have several implications for policy and practice.

First, diabetes diagnostic and treatment guidelines in Africa must be fundamentally reconceptualized, not merely adapted, to account for the distinct phenotypes observed, including lean type 2 diabetes (Type 5 Diabetes), ketosis-prone diabetes, and the atypical presentation of type 1 diabetes. This requires developing phenotype-specific protocols with clear diagnostic algorithms and management pathways.

Second, dietary guidance must be contextualized to African cuisine. The complete absence of published guidelines for insulin therapy tailored to high-carbohydrate African diets must be urgently addressed through the development of practical, evidence-based recommendations for carbohydrate counting, insulin dosing, and meal pattern management (Sobngwi & Mauvais-Jarvis, 2020).

Third, health systems must strengthen capacity for diabetes care, including reliable supply chains for insulin and oral medications, expanded access to diagnostic tools (HbA1c, C-peptide, autoantibodies), and training for healthcare workers. Task-sharing approaches utilizing non-physician healthcare workers may help address workforce shortages, with clear protocols defining safe scopes of practice.

Fourth, interventions should be culturally tailored, addressing local dietary patterns, physical activity norms, and the prevalent use of traditional medicine. Collaborative partnerships with traditional healers and family-centered care models should be established.

Fifth, financing mechanisms require comprehensive reform. This includes expanding health insurance coverage to include newer therapeutic agents, essential diagnostics, and complication management; implementing innovative financing mechanisms such as "sin taxes" on sugar-sweetened beverages; and establishing pooled procurement for essential medicines to reduce costs (Adraro & Gill, 2023; Atun et al., 2017).

Sixth, attention to structural determinants of health, including poverty, food insecurity, and urban-rural inequities, is essential. Climate-resilient diabetes care strategies must be developed to ensure insulin supply chain integrity during climate-related disruptions.

4.5 Research Gaps and Future Directions

Findings from this review indicates several research gaps as summarised in **Table 7**.

Several priority research questions emerge from this review as summarized in **Table 8**.

CONCLUSION

This systematic review provides comprehensive evidence that diabetes mellitus in Africa presents unique clinical features, earlier onset age, leaner phenotype, atypical forms including ketosis-prone diabetes and malnutrition-related diabetes (Type 5 Diabetes), and distinct type 1 diabetes characteristics, driven by genetic, environmental, and sociocultural factors distinct from Western populations. The continent is experiencing a rapid epidemiological transition characterized by rising diabetes prevalence, changing disease phenotypes, and persistent therapeutic gaps. The clinical heterogeneity of diabetes in African populations challenges conventional diagnostic and treatment paradigms developed in Western contexts and necessitates population-specific approaches to prevention and care.

Significant therapeutic gaps impede effective diabetes management across multiple domains: limited diagnostic capacity (HbA1c, C-peptide, autoantibodies), poor access to essential medications (particularly insulin, with availability as low as 33%), severe health system infrastructure deficiencies (only 23% of facilities with trained specialists), critical shortages across multidisciplinary teams, low retention in care (30-50% at two years), and insufficient context-specific evidence to guide interventions. These gaps translate into poor clinical outcomes, with high rates of complications (13% diabetic foot ulcer prevalence), preventable diabetic ketoacidosis mortality (25-33%), and up to 99% of children and youth with type 1 diabetes failing to achieve glycemic targets.

Critically, current clinical guidelines are fundamentally mismatched to African realities. They fail to address the high-carbohydrate nature of traditional African diets, provide no guidance for managing atypical phenotypes, ignore prevalent comorbidities like HIV and tuberculosis, and assume resource availability that does not exist in most settings. The complete absence of published guidelines for insulin therapy tailored to African cuisine represents a critical barrier to optimizing glycemic control.

Addressing the changing landscape of diabetes mellitus in Africa requires nuanced understanding of its unique phenotypes alongside urgent action on therapeutic gaps through context-specific research, policy, and intervention development. A new framework for diabetes care must include: (1) phenotype-specific diagnostic and management protocols; (2) dietary-integrated guidance for insulin therapy; (3) resource-adapted algorithms; (4) integrated comorbidity management; (5) task-shifting frameworks; (6) socioculturally informed engagement strategies; and (7) financial reality guidance.

The path forward demands sustained commitment from African governments, international partners, researchers, clinicians, and communities. Priority actions include expanding health insurance coverage, implementing innovative financing mechanisms (including sin taxes), strengthening supply chains for essential medicines, investing in diagnostic infrastructure, developing context-specific guidelines, and establishing national diabetes registries. While the challenges are substantial, the growing recognition of diabetes as a priority health issue, combined with emerging opportunities in precision medicine, implementation science, and technological innovation, offers hope for improving diabetes prevention and care across the continent. Realizing this potential will require collaborative efforts that respect and respond to the unique characteristics of diabetes in Africa while working toward the ultimate goal of equitable, effective, and accessible diabetes care for all.

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