

Diabetes in sub-Saharan Africa: aligning biology, culture, and health systems for improved outcomes



The four paper Series on diabetes in sub-Saharan Africa in *The Lancet Diabetes & Endocrinology* and *eBiomedicine* offers a comprehensive account of a region facing one of the fastest global increases in diabetes prevalence, alongside persistently high rates of undiagnosed disease, early complications, and premature mortality.¹⁻⁴ Collectively, the papers show that diabetes in Africa is no longer a marginal non-communicable disease, but a central driver of multimorbidity, unfolding within health systems historically designed for acute, vertically funded care.

A major contribution of the Series is its emphasis on heterogeneity. Diabetes in sub-Saharan Africa does not conform neatly to models derived from high-income settings. The first paper¹ highlights emerging phenotypes, including a substantial burden of type 2 diabetes in lean individuals (BMI <25 kg/m²) and non-autoimmune insulin-deficient diabetes; phenotypically distinct from classical type 1 diabetes in its absence of conventional autoimmune markers, yet characterised by severe insulin deficiency, and ketosis-prone presentations. These phenotypes suggest distinct metabolic and developmental pathways shaped by ancestry, early life adversity, including malnutrition, and infectious exposures. Importantly, although studies of African immigrants in the USA and European countries have provided valuable insights,⁵ they remain insufficient to fully understand these distinct manifestations, as migrant populations are shaped by selection effects, environmental transitions, and health system contexts that differ substantially from contexts across the African continent. These patterns challenge core assumptions underlying both major diabetes types, namely obesity-centric screening and prevention frameworks, and islet autoimmunity models— as each risks overlooking substantial proportions of Africans with, respectively, lean type 2 diabetes and insulin-deficient diabetes. This point underscores the need to integrate pathophysiological insight into public health and clinical strategies.

The second paper² extends this argument by documenting cascading failures in diabetes care delivery: inadequate awareness and delayed diagnosis,

inequitable access to essential medicines and diagnostics, and the absence of locally adapted clinical guidelines in most countries. The consequences— persistently low attainment of treatment targets, premature microvascular and macrovascular complications, and clustering of multiple long-term conditions—reflect not only failures in care delivery, but also the inadequacy of imported frameworks for populations whose health systems were previously optimised to address infectious diseases such as HIV and tuberculosis. Framing diabetes within a multiple long-term conditions model is therefore important, especially in sub-Saharan Africa, where syndemics of communicable and non-communicable disease intersect biologically and where integrated approaches might offer important pleiotropic benefit for improving diabetes outcomes by leveraging existing platforms and systems. However, these complex clinical realities also raise questions about how risk stratification, prevention thresholds, and treatment priorities should be adapted to reflect both biological diversity and competing health risks.

The third paper³ outlines strategies to strengthen diabetes care through health-system reform, task-shifting, digital tools, and lifestyle interventions, while acknowledging the powerful influence of socioeconomic conditions, stigma, and cultural beliefs. Notably, the paper recognises that many promising models remain limited by weak evidence on long-term sustainability, scalability, and retention. This caution is well placed. Across the Series, integration emerges as a necessary, but insufficient, condition for progress unless accompanied by adequate resourcing, workforce support, and attention to patient experience and trust.

The fourth paper⁴ brings a genetic lens to these challenges, highlighting how Africa remains under-represented in the genomic evidence base underpinning diabetes precision medicine. Although novel African-specific risk variants and proof-of-concept applications in monogenic and atypical diabetes are emerging, their clinical translation is constrained by limited genomic infrastructure, lack of affordable testing, and unresolved challenges in biomarker interpretation,

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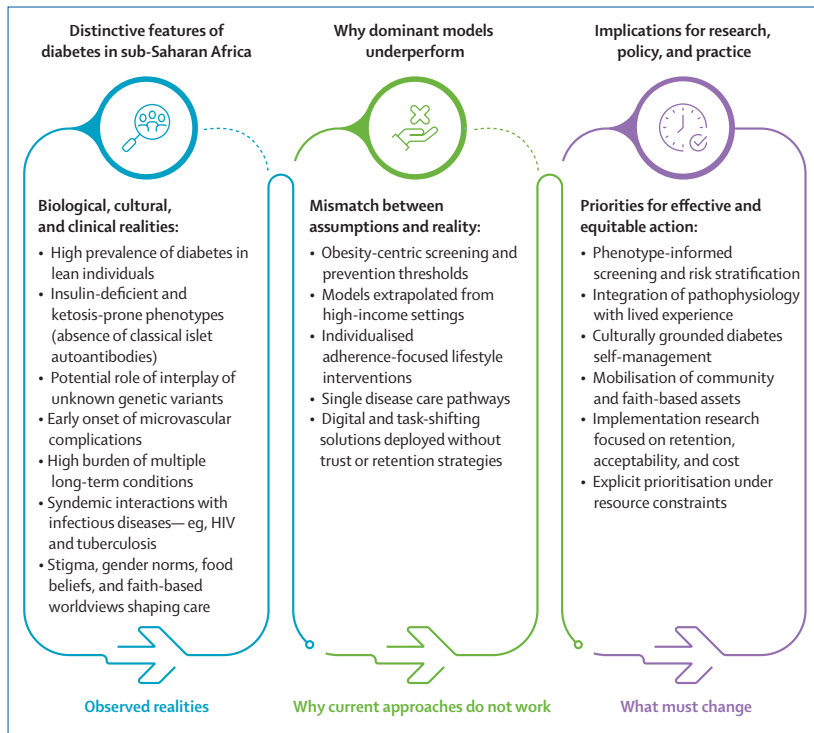


Figure: Diabetes in sub-Saharan Africa is shaped by distinctive biological phenotypes, cultural meanings, and health-system constraints that challenge dominant models derived from high-income settings. This framework illustrates how obesity-centric, single-disease, and adherence-focused approaches do not address the lived realities of diabetes in the region, and highlights priorities for research, policy, and practice that integrate pathophysiological insight, cultural grounding, and implementation feasibility.

including glycosylated haemoglobin. Without addressing their gaps, precision medicine risks reinforcing, rather than reducing, existing global inequities in diabetes care.

Across all four papers, a crucial gap emerges: an escalating diabetes burden in sub-Saharan Africa, unfolding within health systems structurally unprepared. These system failures intersect with cultural realities that shape illness perception, treatment-seeking, and self-management. Beliefs about food, body size, nutrition-related myths, illness causation, and stigma directly shape dietary practices, physical activity, disclosure of diagnosis and health status, and engagement with care. Lifestyle interventions that assume individual choice, biomedical literacy, and stable food environments risk poor reach and effectiveness if they do not address these realities. Evidence from culturally adapted diabetes self-management programmes suggests that engaging with local narratives, addressing nutrition-related myths, and drawing on community assets—including peer leaders, families, and faith-based institutions—can improve

engagement and outcomes. Yet, such approaches remain underevaluated at scale.

A second gap concerns the translation of emerging biological insight into practice. Although distinct diabetes phenotypes in African ancestry populations are increasingly recognised, they have yet to meaningfully inform screening strategies, clinical algorithms, or prevention targets. Screening, prevention, and treatment strategies continue to be extrapolated from trials done in high-income, predominantly European-ancestry populations, perpetuating frameworks that systematically misclassify or overlook African patients. Without embedding mechanistic studies within longitudinal African cohorts, opportunities for more precise and equitable care will remain largely rhetorical, and global diabetes frameworks will continue to be retrofitted onto populations for whom they were never designed. The cost of inaction is not merely scientific—it is measured in lives lost to preventable complications and in treatments that were never adequately tested in the populations who need them most.

Looking forward, the Series points to a clear agenda (figure). First, investment in data systems and cohorts that integrate epidemiology, pathophysiology, and lived experience is essential. Second, implementation research must move beyond coverage metrics to examine acceptability, trust, retention, and cost under real-world constraints. Third, culturally grounded self-management and prevention strategies should be codesigned with communities and evaluated with the same rigour as pharmacological interventions. Finally, prioritisation frameworks are urgently needed to guide decision making in resource-limited settings, recognising that not all interventions can be scaled simultaneously.

As diabetes prevalence continues to rise across sub-Saharan Africa, the challenge is not simply to do more, but to do differently. By integrating biological diversity, cultural meaning, and health-system realities, the approaches developed in Africa have the potential not only to reduce avoidable complications locally, but also to inform more inclusive models of diabetes care globally.

*Louise M Goff, Anxious J Niwaha
 louise.goff@leicester.ac.uk

Diabetes Research Centre, University of Leicester, Leicester, LE5 4PW, UK (LMG); Department of Non-communicable Diseases, MRC/UVRI & LSHTM Research Unit, Entebbe, Uganda (AJN)

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Diabetes in Sub-Saharan Africa 1

Burden and determinants of diabetes in sub-Saharan Africa

Charles Agyemang*, John Tetteh*, Maimouna Ndour Mbaye, Roberta Lamptey, Samuel Seidu, Kamlesh Khuntit, Andre-Pascal Kengne†

The prevalence of type 2 diabetes is rising rapidly across sub-Saharan Africa; however, its epidemiology, clinical phenotypes, and underlying mechanisms remain insufficiently characterised. This first paper in a Series on diabetes in sub-Saharan Africa synthesises current evidence on the burden, distribution, and determinants of diabetes, including emerging phenotypes and the roles of early life adversity, psychosocial stress, and interactions with infectious disease. We also identify major gaps in surveillance systems, research capacity, prevention, and clinical management across the region. Sub-Saharan Africa is experiencing one of the fastest global increases in diabetes, with the highest proportion of undiagnosed cases and a projected steep rise in intermediate hyperglycaemia and diabetes by 2050. Urbanisation, ageing, obesity, and lifestyle transitions are major contributors; however, a substantial proportion of type 2 diabetes occurs in lean individuals (BMI <25 kg/m²), particularly in rural settings, suggesting distinct metabolic and developmental pathways not captured by models derived from high-income countries. Bidirectional interactions between diabetes and malaria, tuberculosis, HIV, or COVID-19 make disease trajectories complex. Persistent gaps in surveillance, a reliance on modelled estimates, low genomic representation, and constrained access to modern diabetes medications hinder progress. Strengthening health system capacity, improving data infrastructure, and investing in regionally driven research are essential to develop effective, context-specific interventions and advance precision medicine tailored to sub-Saharan African populations.

Introduction

Diabetes is a metabolic disorder defined by hyperglycaemia resulting from impaired insulin secretion, insulin action, or both.¹ Its global burden continues to rise, with all major projections indicating sustained growth in type 2 diabetes.² The International Diabetes Federation (IDF) reported an increase in the number of adults aged 20–79 years living with diabetes from 153 million in 2000 to 589 million in 2024,³ whereas WHO and NCD-RisC estimated 828 million adults aged 18 years or more with diabetes in 2022.⁴ Without effective intervention, the Global Burden of Diseases, Injuries, and Risk Factors Study (GBD) forecasts a 60% increase in prevalence, reaching 1.31 billion people by 2050.⁵

Diabetes substantially elevates the risk of blindness, kidney failure, cardiovascular disease, amputations, and premature mortality.^{1,6,7} Diabetes ranked as the eighth leading cause of death and disability globally in 2019.⁸ The economic impact is profound: global diabetes-related health expenditure reached US\$966 billion in 2021, and is projected to exceed \$1054 billion by 2045.^{9,10} These costs, combined with productivity losses, disproportionately strain health systems in low-income and middle income countries (LMICs).^{1,11,12}

Type 1 and type 2 diabetes are the predominant forms of the disease.^{10,13} Type 1 diabetes typically presents in childhood, whereas type 2 diabetes has been traditionally diagnosed later in life, but in the past few years, has been increasingly diagnosed in adolescents and young adults.¹⁴ Type 2 diabetes is strongly associated with obesity, sedentary behaviour, and genetic susceptibility.^{13,15} It accounts for more than 90% of global diabetes cases, although proportions vary across countries.¹⁶ Gestational diabetes affects over 20 million women worldwide,¹⁷ and

ketosis-prone diabetes (flatbush diabetes) is increasingly recognised, particularly in individuals of African descent, but also in Hispanic and Asian populations.^{18–21}

Approximately 80% of people with diabetes live in LMICs,²² and by 2045, three in four adults with diabetes are projected to reside in these settings.^{8,23} The *Lancet* Commission on diabetes¹ highlights the disproportionate burden in LMICs, where fragile health systems and the coexistence of communicable diseases, such as tuberculosis²⁴ and COVID-19,²⁵ create syndemics that worsens outcomes. Addressing the diabetes burden in LMICs requires robust, context-specific data to guide effective prevention and care strategies. LMICs are highly heterogeneous in diabetes prevalence, driven by differences in social determinants of health, risk factor distributions, access to screening and treatment, and health system capacity.^{23,26}

In this first paper of the Series, we examine the burden, distribution, and determinants of diabetes in sub-Saharan Africa, paying particular attention to emerging phenotypes and the contributions of early life exposures, psychosocial factors, and infectious disease pathways. We also identify key gaps in surveillance and data systems, research capacity, prevention, and clinical management across the region. The second paper in this Series focuses on risk factor control and diabetes-related complications.²⁷ The third paper in this Series reviews strategies to strengthen diabetes care in the region, encompassing health system approaches, digital innovations, lifestyle interventions, and socioeconomic dimensions.²⁸

Diabetes burden in sub-Saharan Africa

The prevalence of diabetes in sub-Saharan Africa is increasing rapidly, although substantial heterogeneity

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*Joint first authors

†Joint senior authors

Department of Public and Occupational Health, Amsterdam Public Health Research Institute, Amsterdam University Medical Centers, University of Amsterdam, Amsterdam, Netherlands (Prof C Agyemang PhD); Division of Endocrinology, Diabetes and Metabolism, Department of Medicine, Johns Hopkins University School of Medicine, Baltimore, MD, USA (Prof C Agyemang); Division of Musculoskeletal and Dermatological Sciences, School of Biological Sciences, Faculty of Biology, Medicine and Health, University of Manchester, Manchester, UK (J Tetteh MSc); Department of Internal Medicine and Specialties, Cheikh Anta Diop University of Dakar, Dakar, Senegal (Prof M N Mbaye PhD); Korle Bu Polyclinic/Family Medicine Department; Korle Bu Teaching Hospital, Accra, Ghana (R Lamptey PhD); Diabetes Research Centre, College of Life Sciences, University of Leicester, Leicester, UK (Prof S Seidu MD, Prof K Khuntit PhD); African Population and Health Research Center, Nairobi, Kenya (Prof A-P Kengne PhD); Non-Communicable Diseases Research Unit, South African Medical Research Council, Cape Town, South Africa (Prof A-P Kengne); Department of Medicine, University of Cape Town, Cape Town, South Africa (Prof A-P Kengne)

Correspondence to:
 Prof Charles Agyemang,
 Department of Public and
 Occupational Health, Amsterdam
 Public Health Research
 Institute, Amsterdam
 University Medical Centres,
 University of Amsterdam,
 Amsterdam 1105AZ,
 Netherlands
 c.o.agyemang@
 amsterdamumc.nl

persists across countries. GBD estimates in the African region and its 47 countries show that, between 1990 and 2021, the age-standardised prevalence rose by more than 90% in southern and central sub-Saharan Africa.⁵ According to 2025 IDF projections, based on a total of 35 data sources from 27 countries from 2005 to 2024, the African region has the lowest global prevalence at 5%, representing 24·6 million adults. However, the region is expected to have the largest proportional increase worldwide—a 142% rise to 60 million adults by 2050.³ The burden of intermediate hyperglycaemia is also projected to grow markedly, with impaired glucose tolerance expected to increase by 138% and impaired fasting glucose by 134%, affecting 135 million and 88 million individuals, respectively, by 2050.³ Given that intermediate hyperglycaemia is a strong predictor of future type 2 diabetes,²⁹ and that individuals of African ancestry face an even higher risk of progression,³⁰ these trajectories underscore the urgency of targeted prevention strategies. Sub-Saharan Africa also has the highest proportion of undiagnosed diabetes globally, at 72·6%.³ Diabetes accounted for an estimated 216 000 deaths in the region in 2024.³ Collectively, these patterns reflect the rapid transition of diabetes in sub-Saharan Africa from a previously uncommon condition to a major contributor to morbidity and mortality.^{31–33}

Type 1 diabetes

Type 1 diabetes remains poorly characterised in sub-Saharan Africa, although available evidence suggests that its incidence is lower than that in other world regions.³ In 2024, the IDF estimated that approximately 352 000 people were living with type 1 diabetes in the African region.³ The prevalence of type 1 diabetes varies substantially across countries within the African subregion. Country-level estimates indicate incidence rates ranging from 1·5 cases per 100 000 people per year

in Tanzania to 10·1 cases per 100 000 people per year in Sudan, varying by setting and age group.³⁴ Type 1 diabetes in sub-Saharan Africa has been associated with high mortality, particularly in the early years after diagnosis, largely attributable to misdiagnosis, inadequate access to insulin, and poor glycaemic control.³⁵ Survival among people with type 1 diabetes is further compromised by delayed presentation, restricted availability of glucose monitoring supplies, and the scarcity of specialised diabetes services, especially for children and adolescents.

In addition, data on the aetiology and epidemiology of type 1 diabetes in sub-Saharan Africa are scarce. Emerging evidence points to a later age of onset in populations of sub-Saharan African descent than in populations of European descent. For example, a study done in South Africa reported a bimodal age of onset distribution among Black South Africans, with peaks at ages 11–15 years and 26–30 years, whereas European South Africans showed a single early peak between ages 0 years and 10 years, with more than 60% of people diagnosed before the age of 10 years.³⁴

The latest findings further highlight the heterogeneity of type 1 diabetes in sub-Saharan Africa. A 2025 study of 894 children and young adults (aged <30 years) from Cameroon, Uganda, and South Africa found that only 35% had autoimmune type 1 diabetes, whereas 65% had a non-autoimmune, insulin deficient form characterised by absent islet autoantibodies and low endogenous insulin secretion.³⁶ Similar patterns, although less frequent, have been observed in individuals of African ancestry in the USA, suggesting a possible ancestry-related subtype of diabetes.³⁶ These observations challenge current classification frameworks, which rely heavily on autoimmunity, underscoring the need for diagnostic and therapeutic approaches tailored to sub-Saharan African populations. The low endogenous insulin secretion seen in many patients also has important implications in settings where traditional diets are typically high in carbohydrates.^{37,38}

Gestational diabetes

Gestational diabetes is an important and growing contributor to the diabetes burden in sub-Saharan Africa. A systematic review and meta-analysis of 20 predominantly cross-sectional and cohort studies involving 10752 sub-Saharan Africa pregnant women estimated a pooled gestational diabetes prevalence of 14·28%, indicating that approximately one in seven livebirths is affected by hyperglycaemia in pregnancy.³⁹ Substantial regional variation was observed when the analysis was stratified by sub-Saharan African regions: eight studies were done in three west African countries (Benin, Ghana, and Nigeria), six studies in four east African countries (Rwanda, Uganda, Tanzania, and Kenya), three studies in central Africa (all in Cameroon), and three studies in two southern African

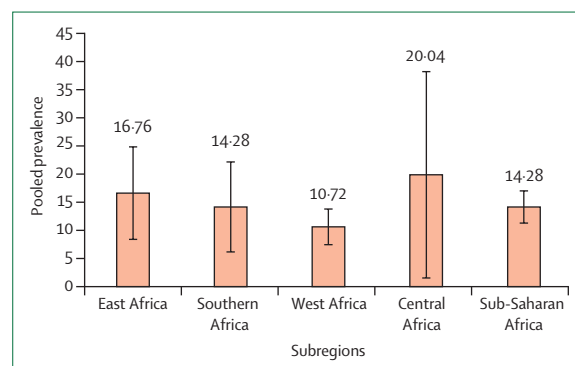


Figure 1: Pooled prevalence of gestational diabetes in sub-Saharan African regions, 2013–18

Data are from Muhe and colleagues.³⁹ Error bars indicate 95% CI. Six studies were done in east Africa, with a total of 2444 participants. Three studies were done in southern Africa, with a total of 2992 participants. Eight studies were done in west Africa, with a total of 4500 participants. Three studies were done in central Africa, with a total of 816 participants. 20 studies were done in sub-Saharan Africa, with a total of 10752 participants.

countries (South Africa and Zimbabwe). In a separate meta-analysis, the pooled prevalence was highest in central Africa (20.04%) and lowest in west Africa (10.72%; figure 1),³⁹ reflecting differences in population risk profiles, screening practices, and diagnostic criteria across sub-Saharan Africa.

Ketosis-prone diabetes

Ketosis-prone diabetes is a clinically and aetiologically heterogeneous form of diabetes characterised by presentation with ketosis or diabetic ketoacidosis in the absence of the classic autoimmune features of type 1 diabetes.⁴⁰ This phenotype has overlapping characteristics of both type 1 and type 2 diabetes, which has led to the use of multiple descriptive terms—including flatbush diabetes, type 1.5 diabetes, latent autoimmune diabetes in adults, idiopathic type 1 diabetes, and ketosis-prone type 2 diabetes—although these labels often reflect incomplete or inconsistent pathophysiological understanding.⁴¹ Patients typically present with acute hyperglycaemic symptoms, such as polyuria, polydipsia, and unintentional weight loss over a short duration (usually <4–6 weeks), and often without identifiable precipitating factors. To address the heterogeneity of this syndrome, the A β classification system has been proposed, which stratifies patients according to the presence of islet autoantibodies (eg, A⁺ or A⁻) and β -cell functional reserve (eg, β^+ or β^-).⁴² This classification has four subgroups: A⁺ β^+ (ie, autoantibodies present, preserved β -cell function), A⁺ β^- (ie, autoantibodies present, absent β -cell function), A⁻ β^- (ie, autoantibodies absent, absent β -cell function), and A⁻ β^+ (ie, autoantibodies absent, preserved β -cell function). The A⁻ β^+ subgroup is the most prevalent (approximately 54%) in longitudinal cohorts, followed by A⁻ β^- (20%), A⁺ β^- (18%), and A⁺ β^+ (8%).⁴³ This classification has important implications for prognosis, likelihood of insulin discontinuation, and long-term metabolic outcomes.

The true prevalence of ketosis-prone diabetes remains uncertain as population-based estimates are scarce and most data are derived from observational cohorts of patients presenting with diabetic ketoacidosis. Available evidence suggests that ketosis-prone diabetes accounts for a substantial proportion of diabetic ketoacidosis presentations in specific ethnic groups, particularly in individuals of African and Hispanic descent. In the USA, studies reported that 20–50% of African American and Hispanic adults presenting with diabetic ketoacidosis meet the criteria for ketosis-prone diabetes, with approximately half of these individuals classified within the A⁻ β^+ subgroup.⁴⁴ Reports from sub-Saharan Africa describe similar proportions, reinforcing the observation that ketosis-prone diabetes is common in populations of African ancestry.⁴⁴ By contrast, studies from Asian and European cohorts indicate a markedly lower prevalence, with ketosis-prone diabetes representing fewer than 10%

of diabetic ketoacidosis presentations in these regions.⁴⁵ These geographical and ethnic differences highlight the influence of genetic, metabolic, and environmental factors on disease expression. A consistent epidemiological feature across studies is the higher prevalence of ketosis-prone diabetes in men, who are affected two-fold to three-fold more frequently than women. This sex difference appears independent of age and degree of obesity. Proposed explanations include differences in sex hormones, visceral adiposity, and insulin sensitivity, although the underlying mechanisms remain incompletely understood.⁴⁶

Although the mechanisms behind β -cell dysfunction in ketosis-prone diabetes are not fully understood, emerging evidence points to a multifactorial process involving metabolic, infectious, and genetic influences.^{44,47} Collectively, these findings support a model in which ketosis-prone diabetes arises from the interaction of metabolic stress, genetic susceptibility, and non-classic immune or infectious triggers, leading to transient or sustained β -cell dysfunction.

Type 2 diabetes

Substantial variation exists in the prevalence of type 2 diabetes across sub-Saharan Africa. In 2024, the age-adjusted prevalence exceeded 10% in several countries, including in São Tomé and Príncipe (12.1%), Comoros (10.8%), and Zambia (10.3%), whereas the prevalence remained below 3% in Zimbabwe (1.5%), Rwanda (2.1%), and Uganda (2.2%; figure 2).³ A meta-analysis of 116 studies done across the African region estimated the overall prevalence of type 2 diabetes to be 6.1%, with substantial heterogeneity between subregions.⁴⁸ The pooled prevalence was 4.8% across 42 studies from west Africa, 5.0% across 12 studies from central Africa, and 5.9% across 37 studies from east Africa. Higher estimates were observed in southern Africa (ie, 9.8% across 17 studies) and north Africa (ie, 13.3% across eight studies), underscoring the marked geographical variation in type 2 diabetes burden across the continent.⁴⁸ A meta-analysis of 11 studies from South Africa reported a pooled type 2 diabetes prevalence of 15.3% in adults aged 25 years or more—over double the IDF estimate for the country (7.2%).⁴⁹ Marked ethnic disparities were also observed: the pooled prevalence was 11.3% in Black South Africans, 23.7% in mixed-ancestry populations, 6.2% in mixed Black African and mixed-ancestry people, and 14.8% in national surveys.⁴⁹ The only study done in South Africans of Indian descent reported a prevalence of 35.2%.⁴⁹

Despite the high and rising burden, the African region has the lowest diabetes-related health expenditure globally (\$10 billion), representing just 1% of global spending. This limited funding is reflected in the lowest age-standardised treatment coverage worldwide, falling below 10% in several sub-Saharan Africa countries.⁴

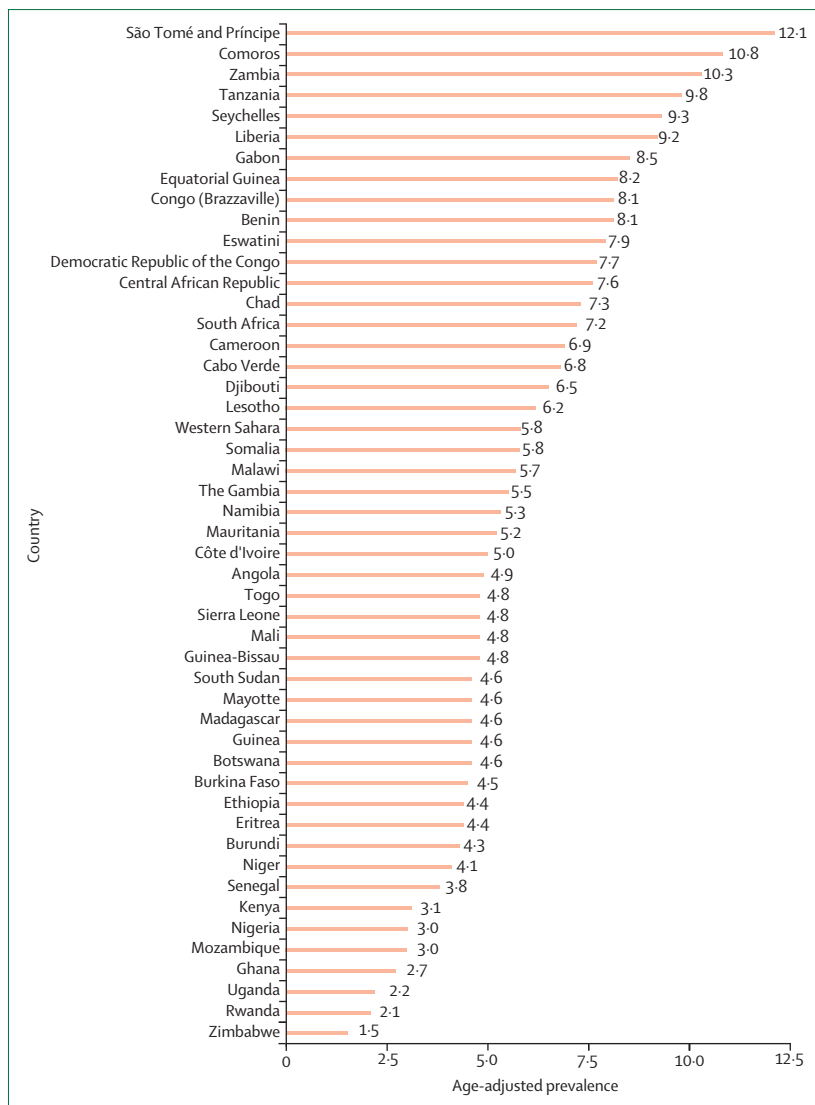


Figure 2: Age-adjusted comparative diabetes prevalence in the Africa region in 2024
Data are from the International Diabetes Federation Diabetes Atlas 2025, 11th edition.³

Longitudinal data on incident diabetes is scarce, as most studies in sub-Saharan Africa are cross-sectional. A 2023 multicountry cohort study of middle-aged adults from four sub-Saharan African countries reported an overall type 2 diabetes incidence of 14.6 cases per 1000 person-years, with the highest incidence in South Africa (21.8 cases per 1000 person-years) and the lowest in west Africa (5.5 cases per 1000 person-years).⁵⁰ In a 3-year follow-up study in mixed-ancestry adults with glucose tolerance in Cape Town, South Africa, rapid deterioration in glucose tolerance was observed, with a cumulative progression incidence of 16.2%, and with changes in key risk factors—particularly adiposity—over time, rather than baseline concentrations, driving the progression to diabetes or worsening glycaemia.⁵¹

Risk factors and determinants of type 2 diabetes in sub-Saharan Africa

Multiple inter-related factors contribute to the rising burden of type 2 diabetes in sub-Saharan Africa (figure 3). The increasing prevalence reflects complex interactions between health behaviours, environmental exposures, and underlying genetic susceptibility, with epigenetic mechanisms proposed as potential mediators of gene–environment interactions. Population ageing, economic development, and rapid urbanisation are key structural drivers. Consistent evidence from systematic reviews shows higher diabetes prevalence in urban than in rural settings across Africa.^{49,52,53} A meta-analysis of 12 rural and nine urban studies in the African region reported a pooled type 2 diabetes prevalence of 4.9% in rural settings and 10.6% in urban settings, highlighting the substantial urban–rural disparity in diabetes burden across the continent.⁴⁸ In a study of five west African countries, the age-adjusted and sex-adjusted prevalences of type 2 diabetes and impaired fasting glucose were 6.2% and 6.6% in urban areas, compared with 2.5% and 3.0% in rural areas, respectively.⁵⁴ Studies on migrants further highlight the influence of environmental and lifestyle transitions. In the RODAM study, Ghanaian migrants living in European cities had markedly higher type 2 diabetes prevalence than their rural peers living in Ghana, with prevalence increases ranging from 3-fold in London to 4.5-fold in Berlin among men, and from 1.8-fold in London to 2.2-fold in Berlin among women.⁵⁵

Sex differences are also evident, with the prevalence of type 2 diabetes generally slightly higher among women than among men, although patterns vary by country. A meta-analysis of 36 studies from eastern, middle, and southern Africa reported that impaired fasting glycaemia was more common in men than in women (odds ratio [OR] 1.56; 95% CI 1.20–2.03), whereas impaired glucose tolerance was less common in men (OR 0.84; 95% CI 0.72–0.98).⁵⁶ Overall, the odds of diabetes were similar between sexes.

In the following sections, we discuss the key modifiable risk factors for diabetes in the sub-Saharan Africa region. Furthermore, we discuss emerging risks associated with type 2 diabetes, such as lifestyle-related factors, the potential role of infection, and genetics and epigenetics, in the rising burden in sub-Saharan Africa.

Lifestyles and environmental factors

Physical inactivity

Physical inactivity is a major contributor to the rising burden of type 2 diabetes in sub-Saharan Africa, particularly in rapidly urbanising settings.³² Modern lifestyle transitions have replaced traditional, physically demanding routines with increasingly sedentary behaviours, contributing to rising rates of obesity, insulin resistance, and type 2 diabetes.^{32,57} Sub-Saharan Africa is urbanising faster than any other world region, and this shift is accompanied by profound changes in physical

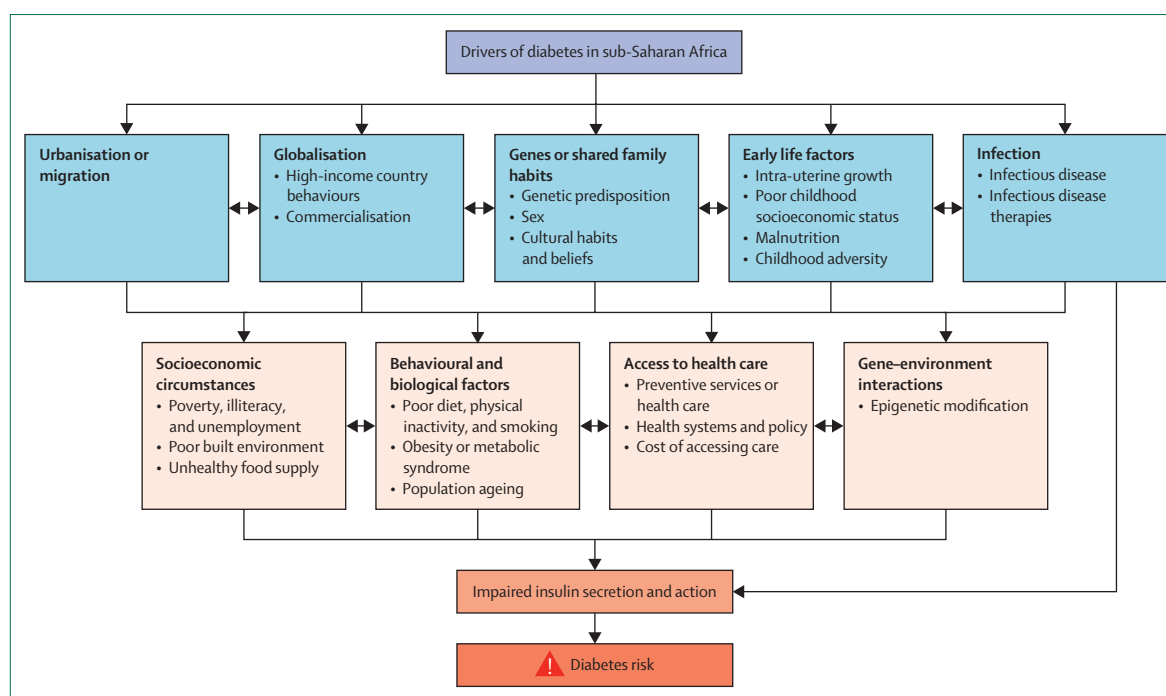


Figure 3: Drivers of type 2 diabetes in sub-Saharan Africa

activity environments and reduced opportunities for active living.^{54,58–60} For example, Issaka and colleagues reported that, in west Africa, the risk of type 2 diabetes was approximately 2.7-fold higher in urban than in rural areas.⁵⁴ Similarly, a systematic review of 41 studies among older adults (aged 55 years and older) in Africa found a substantially higher type 2 diabetes prevalence in urban than in rural settings (19.7% vs 7.9%).⁵⁹ These transitions are often accompanied by increased consumption of processed foods and declining amounts of physical activity.⁵⁷ Sedentary occupations, a reliance on motorised transport, and limited access to recreational spaces further reinforce inactivity.^{57,61,62}

Despite widespread awareness of the benefits of physical activity, many people with diabetes remain inactive. Declines in habitual physical activity, such as walking long distances or engaging in manual labour, alongside increases in sedentary behaviours, including motorised transport use and screen-based activities, have been documented across several sub-Saharan African countries, including among children and adolescents.^{63,64} A systematic review of 105 studies involving 76 027 participants from nine sub-Saharan Africa countries reported high amounts of physical inactivity across east, central, west, and southern Africa (80%).⁶³ Global data also show that more than four in five adolescents aged 11–17 years were insufficiently active (<60 min of physical activity on <5 days per week) in 2016, with sub-Saharan Africa having the second-highest prevalence of insufficient activity, particularly among boys (83.9%).⁶⁴

Importantly, studies from sub-Saharan Africa show that positive attitudes towards physical activity do not consistently translate into behavioural change.^{65–67} Structural barriers, including a scarcity of safe spaces, cultural norms, time constraints, and poverty, frequently impede regular exercise.^{68–70} These findings underscore that awareness alone is insufficient—effective diabetes prevention and control require practical, community-based strategies that address real-world constraints.

Dietary habits

Dietary patterns in sub-Saharan Africa are undergoing a rapid transformation driven by urbanisation, economic growth, and globalisation. These behavioural shifts—characterised by reduced energy expenditure and increased intake of calorie-dense, processed foods—are closely linked to the growing burden of diabetes and other obesity-related chronic conditions in sub-Saharan Africa.^{32,57,71} Traditionally, diets in many sub-Saharan African countries were based on minimally processed foods, such as whole grains, legumes, fruits, vegetables, foods rich in essential nutrients, and dietary fibre. However, in the past two decades, a marked shift towards high-income country dietary patterns has taken place, characterised by increased intakes of processed foods, refined sugars, and unhealthy fats.⁷² These nutritional transitions are recognised as key contributors to the rising incidence of diabetes, particularly type 2 diabetes, across the region.

Evidence from urban centres in countries such as Kenya and Nigeria shows increasing consumption of

sugar-sweetened beverages and fast foods, developments that have contributed substantially to rising obesity rates.⁷³ This pattern of consumption is concerning given the well established role of obesity as a major risk factor for diabetes.⁷⁴ Marketing of sugar-sweetened beverages to children has further accelerated shifts in dietary preferences, fuelling childhood obesity in several sub-Saharan African settings. In a meta-analysis of 47 studies assessing indicators of the nutrition transition in Kenya and Ghana, 29.4% of the population consumed unhealthy foods, and approximately 40% reported consuming sugar-sweetened beverages.⁷⁵ The proportion of the population consuming fruits and vegetables was 51.6 %, with 29.4 % consuming unhealthy foods, and 39.9 % sugar-sweetened beverages. Two-thirds (68.8 %) of the population consumed animal-source proteins.

Role of obesity and metabolic syndrome in diabetes development

Obesity is a well established driver of type 2 diabetes globally, with similar patterns evident in sub-Saharan Africa. Approximately two-thirds of people with diabetes in sub-Saharan Africa have overweight or obesity,⁷⁶ and both general and abdominal obesity are strongly associated with diabetes risk. A meta-analysis of more than 50 community-based studies in Africa (including two from northern Africa) and sub-Saharan Africa involving over 200 000 participants reported similar effect sizes for general and abdominal obesity measures.⁷⁷ Obesity, particularly central obesity, clusters with other cardiometabolic risk factors in African populations, with more than 60% of people with diabetes in sub-Saharan Africa meeting the criteria for metabolic syndrome.^{76,78} Among components of metabolic syndrome, central obesity is the most prevalent (over 62%),⁷⁸ followed by hypertension (approximately 61%),⁷⁹ low HDL cholesterol (37%), and elevated triglycerides (50%).^{78,80}

Long-term trends further underscore the central role of adiposity in diabetes risk. A detailed analysis of changes in mean BMI and diabetes prevalence between 1980 and 2014 in Africa showed that rising diabetes prevalence closely tracked increases in BMI, with a strong positive correlation observed in both men and women across these timepoints.⁸¹

Although overweight and obesity are important modifiable risk factors for type 2 diabetes in sub-Saharan Africa, a substantial proportion of type 2 diabetes cases in the region occur in individuals who are lean (BMI <25 kg/m²).^{82,83} Approximately 90% of people with diabetes are classified as having overweight or obesity in high-income countries,⁸⁴ whereas in sub-Saharan Africa, only about half of individuals with type 2 diabetes fall into these categories.⁵ The prevalence of type 2 diabetes in lean individuals is particularly pronounced in rural settings. A 2019 analysis from the RODAM study, which assessed the health and wellbeing of Ghanaian residents

in Ghana and Europe, reported that 60% of Ghanaians with type 2 diabetes in rural areas were lean, compared with almost 40% in urban areas.⁸²

Emerging evidence suggests that the clinical phenotype of lean diabetes differs from that of overweight-associated or obesity-associated diabetes. In lean individuals, early-life socioeconomic adversity, including malnutrition, maternal infections, and low birthweight, appear to play a central role, alongside early age of onset and the absence of ketosis upon insulin withdrawal.⁸⁵ Conversely, in individuals with overweight or obesity, unhealthy lifestyle factors, such as physical inactivity and poor diet, are more prominent drivers.

The high prevalence of lean diabetes in sub-Saharan Africa has important implications for prevention and management. Uniform strategies adapted from high-income countries risk overlooking these distinct biological pathways and differences in complication risk. For example, prevention strategies that focus predominantly on individuals with overweight or obesity might not identify a large proportion of those at risk of lean diabetes in sub-Saharan Africa.

Socioeconomic status and sociocultural factors

Socioeconomic inequalities and their associations with diabetes prevalence have been widely examined; however, findings are inconsistent across studies from LMICs, including those in sub-Saharan Africa.^{86,87} In South Africa, an analysis of outcomes between 2003 and 2016 found no clear pattern between educational attainment and type 2 diabetes risk among women, whereas men with higher education levels had a greater risk of diabetes than those with lower education.⁸⁸ In the RODAM study, type 2 diabetes prevalence decreased with increasing educational level in urban Ghanaian men, but in rural Ghana, higher education was associated with increased type 2 diabetes prevalence in both men and women.⁸⁹ Similarly, a 2024 study from Cabo Verde reported that higher educational attainment was associated with lower odds of type 2 diabetes, but not prediabetes.⁹⁰ These findings likely reflect differences in underlying risk factor distributions, study methodologies, and population characteristics. Early life socioeconomic circumstances have also been linked to the development of type 2 diabetes in sub-Saharan African populations. In one study, markers of poor childhood socioeconomic status and early life nutritional deprivation were associated with an increased prevalence of type 2 diabetes among Ghanaian men.⁹¹ Although findings on the association between socioeconomic status and type 2 diabetes in sub-Saharan Africa are inconsistent, a clearer socioeconomic gradient is anticipated to emerge as the epidemiological transition progresses, mirroring patterns observed in high-income countries.⁸⁹

Cultural context also plays a central role in shaping health behaviours and perceptions of disease.⁹² In several sub-Saharan African settings, overweight and obesity are

traditionally viewed as markers of wealth, wellbeing, success, and happiness.^{93,94} In South Africa, beliefs that overweight is typical and not a health concern, combined with limited access to physical activity facilities and prevailing social norms, were found to reduce the readiness to lose weight.⁹³ Furthermore, perceptions of diabetes causation and symptomatology are frequently shaped by indigenous belief systems.⁹⁵ In a study from Cameroon, some participants attributed diabetes to curses or witchcraft.⁹⁵ These findings underscore the importance of designing lifestyle interventions and education programmes that are culturally grounded and responsive to local interpretations of the origins of diabetes to ensure their effectiveness.

Psychosocial stress and diabetes

Psychosocial stress is increasingly recognised as a risk factor for the onset and progression of type 2 diabetes, particularly in high-income countries, where its biological and behavioural pathways have been well characterised.⁹⁶ Biologically, psychosocial stress activates the hypothalamic–pituitary–adrenal axis, and chronic activation can lead to dysregulation that predisposes susceptible individuals to type 2 diabetes. Behaviourally, psychosocial stress contributes to unhealthy lifestyle patterns, including poor diet and physical inactivity, which further elevate diabetes risk through both direct physiological mechanisms and indirect behavioural pathways.⁹⁷ However, the relationship between psychosocial stress and type 2 diabetes is poorly understood in sub-Saharan Africa. Evidence from the RODAM study showed that, among Ghanaian migrants in Europe and non-migrant Ghanaians, perceived discrimination and negative life events in the preceding 12 months were associated with type 2 diabetes, whereas stress related to work or home life was not.⁹⁸ Findings from the SANHANES-1 study in South Africa similarly indicated that psychological distress, measured with the Kessler-10 scale, was associated with diabetes.⁹⁹

Beyond risk of onset, psychosocial stress is highly prevalent in people living with diabetes in Africa. A systematic review and meta-analysis of 83 studies published between 2000 and 2024 reported pooled prevalence estimates of 43·3% for depressive symptoms, 38·8% for anxiety symptoms, 48·8% for moderate-to-high diabetes distress, and 43·9% for low mental quality of life.¹⁰⁰ These findings underscore the substantial psychosocial burden experienced by individuals with diabetes across the region. A comprehensive exploration of psychosocial stress and its implications for diabetes in sub-Saharan Africa is provided in the second paper in this Series.²⁷

Infections and diabetes in Africa

A bidirectional relationship has been proposed between type 2 diabetes and several infectious diseases that are highly prevalent in Africa, including malaria, tuberculosis

and HIV infection. In 2023, an estimated 263 million cases of malaria were recorded globally, with 95% occurring in sub-Saharan Africa.¹⁰¹ Evidence suggests a reciprocal interaction between type 2 diabetes and malaria.¹⁰² Infection with *Plasmodium falciparum* species triggers the release of pyrogenic cytokines, leading to systemic inflammation,¹⁰³ a process also implicated in the pathogenesis of type 2 diabetes.^{104,105} Intra-uterine exposure has also been proposed, through the Barker hypothesis of developmental origins of health and disease, as a potential contributor to the rising burden of type 2 diabetes in adulthood and malaria-endemic regions.¹⁰² Malaria during pregnancy is associated with adverse perinatal outcomes, including low birthweight, fetal growth restriction, and impaired cognitive development.¹⁰⁶ These complications have, in turn, been linked to an increased risk of elevated plasma glucose later in life.¹⁰⁷

However, a causal link between malaria and future type 2 diabetes risk remains speculative, as studies have reported conflicting findings regarding the association between diabetes and malaria occurrence, severity, and outcome. A meta-analysis of the scarce available evidence found no clear association between diabetes and either *P falciparum* infection (pooled OR 1·43 [95% CI 0·27–7·39]; four studies) or malaria severity (pooled OR 2·24 [95% CI 0·63–7·92]; two studies).¹⁰⁸ Glucose-6-phosphatase dehydrogenase (G6PD) deficiency is common in several African populations, likely reflecting adaptive selection in malaria-endemic regions, as G6PD deficiency confers partial protection against malaria. Genetic studies have identified variants of G6PD deficiency that are causally associated with diabetes complications, such as retinopathy, which are prevalent in some African populations.¹⁰⁹

Tuberculosis is an infectious disease with a particularly high incidence in Africa, accounting for 24% of the estimated 10·8 million diagnosed cases worldwide in 2023.¹¹⁰ A bidirectional relationship between type 2 diabetes and tuberculosis has been proposed.¹¹¹ Evidence from available studies supports an association between type 2 diabetes and increased risk of tuberculosis, influenced in part by access to care, the degree of glycaemic control and diabetes duration.¹¹² Compared with people without diabetes, those with diabetes have been reported to have a 1·9 times higher risk of developing tuberculosis, with the magnitude of the risk appearing higher in participants with longer duration of follow-up than those with shorter duration (hazard ratio 2·4 vs 1·5).¹¹² This risk of tuberculosis was further elevated among diabetic people with poor disease control, as reflected by high fasting plasma glucose or high glycated haemoglobin concentrations. Among African populations with type 2 diabetes, the prevalence of active tuberculosis has been estimated to be 4·1%,¹¹³ whereas *Mycobacterium tuberculosis* infection affects approximately 40% of African people with diabetes.¹¹⁴ Conversely, the pooled prevalence of

type 2 diabetes among people with tuberculosis in sub-Saharan Africa was 8% in a global systematic review and meta-analysis including 21 studies from Africa,¹¹⁵ and 9.0% across 16 studies in an sub-Saharan African-specific meta-analysis.¹¹⁶ A meta-analysis of nine sub-Saharan African studies reported a pooled OR of 2.77 (95% CI 1.90–4.05) for the association between type 2 diabetes and tuberculosis.¹¹⁷ A 2024 Cochrane review synthesising 48 studies and more than 61 million participants across six WHO regions reported that diabetes is probably associated with a substantially increased risk of developing tuberculosis in both the short and long term. The pooled hazard ratio was 1.90 (95% CI 1.51–2.40), equivalent to an estimated 102 additional cases of active tuberculosis per 100 000 people with diabetes each year, compared with individuals without diabetes (baseline annual incidence of 129 cases per 100 000 people).¹¹² The population-attributable fraction of diabetes for tuberculosis has been estimated at 3.1%, corresponding to more than 0.9 million incident tuberculosis cases in 2024 due to diabetes.¹¹⁸

People with diabetes who develop tuberculosis tend to present with higher bacillary loads, more severe clinical and radiological disease, protracted treatment duration, and poorer outcomes than people without diabetes.¹¹⁹ Among individuals with normoglycemia before tuberculosis infection, dysglycaemia is frequently observed during active disease and might or might not resolve on treatment completion.¹²⁰ The prognostic significance of this transient hyperglycaemia on future type 2 diabetes risk remains unclear.¹²¹ This temporary elevation in glucose at tuberculosis diagnosis is thought to reflect the hormonal response associated with acute infection.

Sub-Saharan Africa has the largest population of people living with HIV, accounting for more than 65% of the global 39.9 million people with HIV in 2023.¹²² The advent and wide uptake of potent antiretroviral therapy, accessible to about 77% of people living with HIV in 2013,¹²² has significantly improved life expectancy. As survival increases, non-communicable diseases (NCDs), including type 2 diabetes, are emerging as major health challenges for people living with HIV in sub-Saharan Africa.¹²³ A systematic review of 61 studies reported a prevalence of type 2 diabetes of 5.1% and high prediabetes prevalence of 15.2% in people living with HIV in Africa.¹²⁴ These estimates are broadly consistent with regional figures from the IDF Diabetes Atlas, which reports a type 2 diabetes prevalence of 5.3% and a prediabetes prevalence of 12.6% for impaired glucose tolerance and 8.0% for impaired fasting glycaemia.¹⁰ The comparative burden of type 2 diabetes and prediabetes in people living with HIV and in the general population suggests that similar risk factors might drive dysglycaemia in both groups. However, diabetes prevalence estimates in people living with HIV in sub-Saharan Africa are limited by important methodological

constraints.¹²⁵ Many studies rely on small, non-representative samples, and larger studies often use retrospective reviews. Both approaches reduce the reliability and stability of prevalence estimates, underscoring the need for robust, population-based data.

The mechanisms underlying the development of type 2 diabetes in people living with HIV and the natural history of dysglycaemia in this population are not fully understood.^{126,127} HIV infection itself, together with some antiretroviral therapies, particularly protease inhibitors, has been linked to increased insulin resistance and an elevated risk of type 2 diabetes. Evidence regarding the impact of integrase inhibitors, especially dolutegravir, which is the main contemporary HIV treatments, has been inconsistent. A meta-analysis of 16 studies from Africa, Europe, and North America reported an overall lower risk of incident diabetes; however, studies done in African populations showed a markedly higher risk (relative risk 2.99, 95% CI 2.53–3.54).¹²⁸

Genetics and epigenetics of diabetes in African populations

More than 600 genetic risk loci associated with type 2 diabetes have been identified globally, predominantly in populations of European and Asian ancestries, but African populations remain markedly under-represented.¹²⁹ The first genome-wide linkage studies conducted in Ghanaians and Nigerians between 1997 and 2000 identified suggestive evidence of linkage in four regions of three chromosomes (12, 19, and 20).¹³⁰ The two largest logarithms of odds scores were for chromosomes 20q13.3 and 12q24, regions already reported to carry diabetes susceptibility genes in many other populations and ethnic groups.¹³¹ Another genome-wide study exploring the potential role of C-peptide in type 2 diabetes genetic susceptibility among people from west Africa found significant linkage evidence on regions 10q23 and 4q15, and suggestive evidence of linkage on regions 15q14 and 18q11.¹³¹ Genome-wide association studies of diabetes risk in Africa have been scarce, with early studies based on modest sample sizes.^{130,131}

A 2019 genome-wide association study by Chen and colleagues,¹³² involving more than 4000 individuals from Ghana, Kenya, Nigeria, and South Africa, identified 21 loci of 100 previously published type 2 diabetes risk loci with shared causal variants in African and non-African populations. The strongest association was observed at the well established *TCF7L2* locus, and a novel risk variant was identified at *AGMO*. Another large genome-wide association study of approximately 10 000 African people from Burkina Faso, Ghana, Kenya, and South Africa, done in the Africa Wits-INDEPTH partnership for Genomics studies (AWI-Gen) cohort, replicated several known fasting glucose loci in the *GCK-YKT6*, *SLC2A2*, and *THORLNC* gene regions.¹³³ This study also identified novel variants, including a variant in the *ANKRD33B* gene associated with fasting

glucose, a variant in the *WDR7* gene associated with fasting insulin, and two variants mapping to the *ADAMTS16* and *B4GALT6* genes associated with insulin resistance.¹³³ Candidate gene approaches have also been used to investigate the genetic determinants of diabetes in African populations.^{134,135} A few studies have applied pedigree or familial designs.¹²⁰ Across these studies, polymorphisms in *ABCC8*, *HP*, *KCNJ11*, *ADIPOQ*, *ENPP1*, *TNF*, and *TCF7L2* have been associated with type 2 diabetes in some African cohorts.¹³⁵ Overall, the genetic architecture of diabetes in Africa remains incompletely characterised. A more comprehensive exploration of diabetes genetics in African populations is provided in the fourth paper in this Series.¹³⁶

Epigenetics studies of diabetes in African populations are scarce, with most work done in South African and Ghanaian cohorts. These studies have replicated several findings observed in other African populations, while also identifying novel epigenetic signatures. A genome-wide DNA methylation study in mixed-ancestry South Africans showed disease-specific and locus-specific DNA methylation changes in peripheral blood according to glucose tolerance status, with additional analyses revealing methylation differences in regions associated with microRNAs.¹³⁷ Global DNA methylation amounts were significantly higher in prediabetes and screen-detected diabetes than in those with typical glucose tolerance, and higher in screen-detected diabetes than in known diabetes on treatment.¹³⁸ Further work in the same population has characterised altered expression of circulating microRNAs associated with glucose tolerance status in the same population,^{139,140} identifying 57 novel microRNAs of 261 that were differentially expressed across glucose tolerance categories.¹⁴⁰ Epigenome-wide association studies in Ghanaians have identified four DNA methylation loci associated with type 2 diabetes—*TXNIP*, *CHLSN*, *CPT1A*, and the novel locus *TPM4*¹⁴¹—as well as one differentially methylated position and one differentially methylated region linked to a composite lifestyle index associated with diabetes risk.¹⁴² A global review of epigenome-wide studies of type 2 diabetes found that only four (*TXNIP*, *ABCG1*, *PPARGC1A*, *PTPRN2*) of 130 differentially methylated genes across various tissues were reported in two or more studies, underscoring the complexity and heterogeneity of epigenetic signatures in diabetes.¹⁴³

Gaps in diabetes surveillance, data collection, research, and management in sub-Saharan Africa

Many sub-Saharan Africa countries continue to face substantial deficiencies in data collection and disease surveillance systems. This scarcity of reliable and comprehensive diabetes data undermines effective public health planning, resource allocation, policy making, and preventive efforts. Historically, health systems in sub-Saharan Africa have prioritised acute infectious diseases, resulting in gaps in infrastructure and capacity for

chronic disease management, including diabetes. A major obstacle to monitoring diabetes in sub-Saharan Africa is the poor health-care infrastructure and low capacity for longitudinal health data collection and linkage. Numerous countries lack robust health information systems capable of consistently tracking diabetes prevalence, incidence, and related outcomes.³³ As a result, many cases remain undiagnosed, distorting the true understanding of diabetes burden.¹⁴⁴ Existing sources, such as the WHO Global Health Observatory and various health surveys, are often outdated, incomplete, or inconsistent, complicating efforts to accurately assess the diabetes landscape.¹⁴⁵ Alarmingly, approximately 45% of countries in the IDF African region do not have quality local data, and only three countries—Cabo Verde, The Gambia, and São Tomé and Príncipe—have conducted relevant studies within the past 5 years.³ In addition, due to substantial gaps in epidemiological data across the African region, many GBD estimates rely heavily on complex statistical modelling rather than on empirical data. These models depend on multiple assumptions and imputations, which might not accurately capture the true burden or distribution of disease in the region. The prevalence estimates produced by both the IDF and the GBD are subject to inherent time lags, making shifts in diabetes patterns across African regions difficult to capture in a timely manner.

One of the main difficulties in data collection is that many community health centres, the primary point of care for people with diabetes, are inadequately equipped and lack trained personnel to comprehensively collect health data, including the use of electronic health records.¹⁴⁶ In rural areas, where access to formal health care is constrained, individuals often rely on unregulated traditional practices, which do not feed into national health information systems. This absence of reliable data not only undermines effective diabetes management, but also restricts countries' ability to monitor trends, design preventive strategies, and efficiently allocate scarce resources.

Another key factor that impedes surveillance efforts is the cultural perception surrounding diabetes and other NCDs. Diabetes is stigmatised in several sub-Saharan African countries, contributing to under-reporting and a reluctance among individuals to seek assistance.⁷¹

The scarcity of locally-driven research perpetuates gaps in data and contributes to ineffective responses to the growing diabetes burden in the region. Clinical guidelines are often adapted from high-income countries and might not align with local epidemiological patterns, health-care infrastructure, or cultural practices. This reliance on externally developed frameworks can result in fragmented initiatives that often do not adequately address local health needs. Furthermore, substantial evidence from high-income countries and from large middle-income settings, such as China and India shows the effectiveness

of lifestyle-based interventions. These interventions—including weight reduction, the adoption of a healthy diet, and increased moderate physical activity—can effectively prevent or delay the onset of type 2 diabetes.^{147–150} However, a notable evidence gap exists regarding context-appropriate and scalable prevention strategies for African populations. The South African Diabetes Prevention Programme (also known as SA-DPP) was established to address this gap by implementing culturally adapted lifestyle interventions focused on diet and physical activity to reduce diabetes risk among South Africans. The effectiveness of this programme has not yet been evaluated.¹⁵¹ Without such evidence, prevention strategies risk being poorly targeted or ineffective.

The complex, bidirectional relationship between diabetes and infectious diseases, including tuberculosis, COVID-19, HIV, and malaria, is insufficiently understood, despite growing evidence of their interplay.^{24,25,106,107} A pressing need exists for high-quality, context-specific data on the health system factors and genetic determinants of diabetes in the region. Similarly, the scarcity of reliable information on the incidence of type 1 diabetes, particularly in children and adolescents, contributes to delayed diagnoses, inadequate care, and avoidable suffering among some of the most susceptible groups.

Diabetes management in sub-Saharan Africa faces substantial challenges, driven largely by limited access to modern diabetes medications and the region's minimal representation in global clinical trials. Although advances in pharmacotherapy, such as GLP-1 receptor agonists, offer considerable benefits for glycaemic control and cardiometabolic outcomes, their availability across sub-Saharan Africa remains severely constrained.²² Access is often concentrated in urban centres and tertiary facilities, leaving rural populations with few therapeutic options. High medication costs further restrict uptake, rendering these treatments inaccessible to many who could benefit from them. Detailed information on diabetes management in sub-Saharan African populations is provided in the third paper in this Series.²⁸

Strengthening diabetes surveillance and data systems in sub-Saharan Africa will require a coordinated, multifaceted approach that addresses current structural gaps and supports effective prevention and management. An important priority is the reinforcement of health information systems through the development of integrated platforms for chronic disease monitoring, the implementation of electronic health records, and the training of health-care personnel in data management.^{152–154} Reducing socioeconomic and geographical barriers to care, particularly in rural areas, through mobile clinics, telehealth services, and the deployment of trained community health workers can enhance both data capture and patient education. Advancing culturally relevant research will depend on the meaningful engagement of local scientists in study design and the development of community-specific interventions.

International partnerships, including collaboration with organisations such as WHO and the IDF, can provide technical support and financial resources, and sustained advocacy for NCD policies can elevate diabetes on national health agendas. Establishing robust monitoring and evaluation frameworks with clear indicators of progress will be essential for accountability and continuous improvement. With these combined efforts, sub-Saharan African countries can strengthen clinical care, catalyse government investment in diabetes initiatives, and ultimately reduce the growing diabetes burden across the region.

Conclusion

Diabetes in sub-Saharan Africa is shaped by a complex interplay of demographic, environmental, sociocultural, biological, and health system factors that differ in important ways from patterns observed in high-income settings. The rapid rise in prevalence, the high proportion of undiagnosed cases, and the emergence of distinct phenotypes—particularly the substantial burden of lean diabetes—underscore the need for a more nuanced understanding of disease mechanisms across diverse African populations. Early life adversity, psychosocial stress, infectious disease comorbidities, and unique metabolic profiles contribute to a heterogeneous clinical presentation that challenges conventional prevention and treatment strategies.

Despite the growing amount of research, major gaps persist. Surveillance systems remain weak, and a reliance on modelled estimates reduces the accuracy of regional burden assessments. Access to modern diabetes therapies is constrained by cost, supply limitations, and urban–rural inequities, and the near absence of sub-Saharan African populations in global clinical trials and genomic studies hampers the development of evidence-based, context-appropriate care. Without targeted investment, these gaps will continue to widen disparities in outcomes and impede progress towards effective diabetes control.

Addressing the rising burden of diabetes in sub-Saharan Africa requires coordinated, regionally driven efforts to

Search strategy and selection criteria

We searched PubMed from database inception to Dec 23, 2025. Search terms included “diabetes”, “type 1 diabetes”, “type 2 diabetes”, “gestational diabetes”, “lean diabetes”, “prevalence”, “incidence”, and a broad range of risk factors. These encompassed lifestyle factors (eg, “dietary behaviours”, “physical inactivity”, “obesity”), psychosocial determinants, socioeconomic status, infectious diseases, and genetic and epigenetic influences. Only articles published in English were included. The search targeted systematic reviews, major narrative reviews, and observational studies examining the epidemiology of diabetes and its risk factors in the Africa region.

strengthen data systems, expand access to affordable diagnostics and therapeutics, and build research capacity that reflects the region's sociocultural and biological diversity. Integrating insights from epidemiology, genomics, early life biology, and social determinants will be essential for developing precision-informed strategies that are responsive to local realities. Without such action, the region faces an accelerating epidemic, with profound implications for health and development.

Contributors

CA, SS, and KK conceived the idea for the review. CA led the writing, supported by JT, who reviewed and verified published data used in this paper. JT, MM, A-PK, and RL led some sections of the manuscript. All authors edited and approved the final manuscript and were responsible for the decision to submit for publication.

Declaration of interests

KK has acted as a consultant or speaker for, or received grants for investigator-initiated studies from Amgen, AstraZeneca, Novo Nordisk, Sanofi, Servier, Lilly, MSD, Boehringer Ingelheim, Oramed Pharmaceuticals, Pfizer, Roche, Daiichi-Sankyo, Applied Therapeutics, Embecta, and Nestlé Health Science. SS received speaker honoraria from AstraZeneca, Boehringer Ingelheim, Janssen Pharmaceuticals, Lilly, Merck Sharp and Dohme, Novo Nordisk, SB Communications, OmniaMed Communications, Abbott, Roche, Napp, NB Medical Education, and Amgen; grants from Sanofi, Novo Nordisk, Boehringer Ingelheim, Servier, and Lilly; advisory board honoraria from AstraZeneca, Lilly, Boehringer Ingelheim, Janssen Pharmaceuticals, Merck Sharp and Dohme, Novo Nordisk, Takeda Pharmaceuticals, Sanofi, Abbott, and Dexcom; educational grants from Boehringer Ingelheim, Lilly, Novo Nordisk, and Takeda Pharmaceuticals; and support for attending meetings or travel and subsistence payments from Abbott, AstraZeneca, Boehringer Ingelheim, Janssen Pharmaceuticals, Lilly, Menarini Novo Nordisk, and Takeda Pharmaceuticals. RL has acted as a consultant or speaker for Novo Nordisk, Boehringer Ingelheim, Sanofi, AstraZeneca, and Novartis. RL has received a grant from Novo Nordisk for an investigator-initiated study. All other authors declare no competing interests.

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Diabetes in Sub-Saharan Africa 2



Diabetes-related complications and multiple long-term conditions in sub-Saharan Africa: determinants and management strategies

Deborah Ikhile*, Samuel Seidu*, Damilola Omodara, Jean Claude Katte, Kaushik Ramaiya, Kamlesh Khunti

Saharan Africa is experiencing a rapid increase in the burden of diabetes, accompanied by increasing rates of microvascular, macrovascular, and pregnancy-related complications. This Series paper synthesises current evidence on diabetes-related complications in sub-Saharan Africa and examines shared cardiometabolic risks, mental health comorbidities, and interactions with communicable diseases through a multiple long-term conditions lens. Widespread late diagnosis and inadequate control of key cardiometabolic risk factors (eg, hypertension, dyslipidaemia, obesity, and hyperglycaemia) drive high complication rates—whereas mental health disorders and infectious disease comorbidities further exacerbate susceptibility. Although risk factor reduction is central to preventing diabetes complications in sub-Saharan Africa, progress is impeded by multilevel barriers spanning individual, interpersonal, health system, societal, and policy domains. To address this growing complexity, we identify priorities for research and implementation, including the development of context-specific guidelines, scalable integrated care models, strengthened surveillance systems, and long-term cohorts co-designed with communities, health-care providers, and policy makers.

Introduction

Diabetes is an increasingly important driver of morbidity and mortality in sub-Saharan Africa, where rapidly rising prevalence intersects with constrained health system capacity and widening socioeconomic inequities.^{1,2} The International Diabetes Federation estimates that 24.6 million adults were living with diabetes in 2024 in Africa, 72.6% of whom were undiagnosed, with these numbers projected to rise by 142% by 2050.² These increases reflect the combined effects of rapid urbanisation, demographic and nutritional transitions, genetic predisposition, and shifts in physical activity and dietary patterns.^{1,3} Also, many individuals first present with advanced complications, reinforcing the need for earlier detection and stronger health-care systems for long-term management.^{4,5}

Microvascular and macrovascular complications now account for a growing proportion of disability and premature mortality globally.^{4,6} Facility-based studies and reviews across sub-Saharan Africa consistently document substantial burdens of retinopathy, nephropathy, neuropathy, coronary artery disease, stroke, and peripheral arterial disease, including among people newly diagnosed with type 2 diabetes.^{3,4,6,7} These patterns reflect the underdiagnosed and undertreated nature of key cardiometabolic risk factors, including hypertension, dyslipidaemia, obesity, and hyperglycaemia.^{3,7} The persistent gaps in diagnostics, such as limited access to HbA_{1c} testing, lipid profiling, and retinal imaging, further restrict opportunities for early detection and risk factor reduction.^{3,4,8}

The burden of complications is further amplified by the high prevalence of multiple long-term conditions (MLTCs) or multimorbidity. Cardiometabolic

comorbidities commonly coexist with diabetes and accelerate vascular injury. Mental health disorders are also prevalent and are associated with worse outcomes, such as poorer glycaemic control, increased risks of complications, higher rates of hospitalisations, and reduced quality of life.^{9,10} These susceptibilities are compounded by interactions between diabetes and major communicable diseases, such as HIV and tuberculosis, which shape metabolic trajectories and contribute to a double burden of communicable and non-communicable diseases (NCDs).^{11,12} Amid these intersecting pressures, sub-Saharan Africa public health-care systems, historically orientated towards acute care, struggle to deliver integrated, continuous MLTC-responsive chronic disease management.¹³

Against such a backdrop, this paper synthesises current evidence on the burden and patterns of microvascular, macrovascular, and pregnancy-related complications of diabetes in sub-Saharan Africa. It examines how MLTCs, including mental health comorbidities and interactions with infectious diseases, shape the complication profiles and influence outcomes. The paper also identifies priorities for prevention, early detection, and the delivery of integrated, long-term care. We build on the first paper in the Series,¹ which explores the epidemiology and determinants of diabetes in sub-Saharan Africa. A third paper in the Series¹⁴ addresses the health system transformations required to enable equitable and sustainable diabetes care across the region.

Diabetes-related complications

Chronic complications of diabetes are broadly classified as microvascular (eg, retinopathy, nephropathy, and

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*Joint first authors

Diabetes Research Centre, College of Life Sciences, University of Leicester, Leicester General Hospital, Leicester, UK (D Ikhile PhD, Prof S Seidu MD, Prof K Khunti PhD); **Institute of Health and Allied Professions, Nottingham Trent University, Nottingham, UK** (D Omodara PhD); **Department of Clinical and Biomedical Sciences, University of Exeter Medical School, Exeter, UK** (J C Katte PhD); **National Obesity Centre, and Endocrinology and Metabolic Diseases Unit, Central Hospital of Yaoundé, Yaoundé, Cameroon** (J C Katte); **Research & Training Unit, Shree Hindu Mandal Hospital, Dar es Salaam, Tanzania** (Prof K Ramaiya MMed)

Correspondence to: Prof Samuel Seidu, Diabetes Research Centre, College of Life Sciences, University of Leicester, Leicester General Hospital, Leicester LE54PW, UK sis11@leicester.ac.uk

or Dr Deborah Ikhile, Diabetes Research Centre, College of Life Sciences, University of Leicester, Leicester General Hospital, Leicester LE54PW, UK di46@leicester.ac.uk

neuropathy) and macrovascular (eg, coronary heart disease, stroke, heart failure, and peripheral arterial disease). Evidence from sub-Saharan Africa shows that microvascular complications are common, but the burden of macrovascular complications remains less well understood due to insufficient data and under-reporting.^{4,15} Pregnancy-related complications are also highly prevalent in sub-Saharan Africa, where gestational diabetes substantially increases maternal and infant health risks.¹⁶

Microvascular complications

Microvascular complications, including diabetic retinopathy, nephropathy, and peripheral neuropathy, are highly prevalent in people living with diabetes in sub-Saharan Africa, with variation across countries. A systematic review and meta-analysis of 109 studies including 63 890 adults with type 2 diabetes (53·3% of whom were women), predominantly from east Africa (n=44, 40·4%), reported pooled prevalence estimates of 38·0% for peripheral neuropathy (95% CI 31·0–45·0%), 32·0% for retinopathy (95% CI 28·0–36·0%), and 31% for nephropathy (95% CI 22·0–41·0%).⁴ Another meta-analysis focusing specifically on diabetic peripheral neuropathy found an even higher pooled prevalence of 46·0% (95% CI 36·2–55·8%), with the highest regional prevalence observed in west Africa: 49·4% (95% CI 32·7–66·1%), based on 23 studies with 269 691 participants.¹⁷ Additionally, a 2025 systematic review and meta-analysis including 16 329 individuals estimated the retinopathy prevalence to be 25·5% (95% CI 20·7–31·0%), with notable regional variation: the prevalence was highest in east Africa (31·8%), followed by south (29·6%) and west Africa (27·4%), and was lowest in central Africa (13·7%).¹⁸ Methodological heterogeneity, including variation in screening tools, diagnostic criteria, and the over-representation of facility-based populations contributes to the wide range of reported estimates,^{4,18} but does not diminish the magnitude of the unmet need across the region.

Diabetes-related complications also affect children and adolescents in sub-Saharan Africa. A cross-sectional study in Mwanza, Tanzania, involving 155 young people aged 5–19 years with type 1 diabetes, found prevalence estimates of 10·3% for retinopathy, 32·9% for nephropathy, and 13·6% for neuropathy, all strongly associated with an HbA_{1c} of more than 10% and longer diabetes duration.¹⁹ High rates of diabetic ketoacidosis at initial presentation further highlight delayed diagnosis and interruptions in continuity of care.²⁰

A notable pattern across the region is the early manifestation of microvascular disease, with complications frequently identified at, or shortly after, diabetes diagnosis.^{5,21} This manifestation reflects prolonged exposure to untreated hyperglycaemia due to delayed detection. Cumulative glycaemic exposure and longer diabetes duration remain the principal drivers of

microvascular injury in sub-Saharan Africa.^{19,21,22} These effects are intensified by the high prevalence of poor glycaemic control across the region—approximately 70·0% in adults—strongly predisposing individuals to retinopathy, nephropathy, and neuropathy progression.²² Similar patterns occur in children, adolescents, and young adults up to age 24 years, for whom sustained hyperglycaemia with HbA_{1c} concentrations above 10%, fuelled by restricted access to insulin, glucose monitoring technologies, and structured diabetes education, accelerates early microvascular damage.^{19,23}

Progression of microvascular disease is further driven by coexisting cardiometabolic conditions, such as hypertension, dyslipidaemia, and obesity, which are increasingly common in sub-Saharan Africa and are known to accelerate renal decline and retinopathy.^{22,24,25} Poor blood pressure control, the estimated prevalence of which is 71% in studies combining type 1 and type 2 diabetes and 68·8% in studies with type 2 diabetes populations, further contributes to additional vascular injury.²⁶ Dyslipidaemia and obesity are also common in adults and children, and contribute to microvascular damage through endothelial dysfunction and inflammatory pathways.^{27,28} The high burden of microvascular complications contributes substantially to morbidity, disability, and health system strain. Diabetic retinopathy is a leading cause of preventable visual impairment, peripheral neuropathy drives much of the diabetic foot disease and lower limb amputation burden, and hypertension increases chronic kidney disease risk and premature mortality.^{3,29,30} These adverse outcomes are intensified by multilevel constraints, which are further detailed in the barriers to management section, underscoring the urgent need for earlier detection, integrated cardiometabolic risk management, and strengthened chronic care systems to reduce preventable complications. A comprehensive discussion of these strategies is provided in the third paper in this Series.¹⁴

Macrovascular complications

Diabetes is increasingly recognised as a substantial driver of cardiovascular disease in sub-Saharan Africa, where its frequent coexistence with hypertension and chronic kidney disease poses a major threat to an already fragile health-care system.^{31,32} As the diabetes epidemic in sub-Saharan Africa continues to grow, end-organ complications, such as myocardial infarction, stroke, heart failure, peripheral arterial disease, and lower limb amputations, all contribute to the increasing NCD crisis, with profound public health implications.^{7,29,33}

Estimates suggest that adults with diabetes in sub-Saharan Africa are at a two-fold to three-fold higher risk of developing cardiovascular disease than those without diabetes, and that the associated excess mortality is greatest among younger, working-aged adults.^{31,34} Myocardial infarction, heart failure, and stroke remain the most common macrovascular complications in these

individuals.^{31,33} A hospital-based review of 261 adults with type 2 diabetes having a first cardiovascular event found that stroke was the most common manifestation (55.2%), followed by heart failure (40.2%) and acute myocardial infarction (4.6%).³³ The low-appearing manifestation of acute myocardial infarction likely reflects substantial underdiagnosis driven by limited access to electrocardiography and cardiac biomarker testing, alongside atypical presentations and the predominance of more readily diagnosed conditions, such as stroke and heart failure.^{35,36} Consequently, current estimates almost certainly underestimate the true burden of acute myocardial infarction in the region. Notably, 77% (n= 201) of individuals having a first cardiovascular event had coexisting hypertension in a hospital-based review by Nkoke and colleagues.³³

Hypertension and chronic kidney disease considerably amplify cardiovascular disease risk in diabetes.³¹ Similarly, global evidence shows that diabetic nephropathy, a leading cause of chronic kidney disease, further predisposes patients to heart failure and stroke via volume overload and vascular dysfunction.³⁷ The synergistic effect of the interactions between these different chronic conditions has led to the concept of a cardio-renal-metabolic syndrome.³⁸ Data on cardio-renal-metabolic syndrome in sub-Saharan Africa are rare. In a study of over 400 adults with diabetes in Ethiopia, more than half (52.4%; 95% CI 47.6–56.9%) had cardio-renal-metabolic syndrome, which was associated with male sex, BMI, and poor access to health care.³⁹

Additionally, in sub-Saharan African cohorts, peripheral arterial disease, often the earliest manifestation of systemic atherosclerosis, is particularly common, with a pooled prevalence in people living with type 1 or type 2 diabetes reported to be 33% (95% CI 29.7–36.2), highlighting the substantial vascular burden associated with diabetes.⁷ This prevalence is higher than the estimates from another meta-analysis reporting 19% (12–25) for peripheral arterial disease in people living with type 2 diabetes.⁴ These differences reflect a heterogeneity in diagnostic criteria, study populations, and regional sampling, and underline the need for standardised definitions and regionally tailored surveillance. Several factors were significantly associated with increased risk of peripheral arterial disease in the meta-analysis by Haile and colleagues, including older age (95% CI 3.4–12.1%), elevated LDL concentrations (1.1–13.1%), higher BMI (1.7–7.6%), and diabetes duration exceeding 10 years (1.1–5.1%).⁷

Macrovascular risk is driven by a convergence of metabolic, demographic, and health system factors. Hypertension, affecting over half of people with diabetes and reaching a prevalence of 70% or more in several cohorts, remains the dominant risk factor alongside dyslipidaemia, obesity, ageing, prolonged diabetes duration, and poor glycaemic control, all of which accelerate atherosclerotic injury.^{4,6,32} Urbanisation raises

cardiometabolic risk through dietary change, physical inactivity, and environmental stress.^{32,40} In parallel, ageing and longer survival on antiretroviral therapy contribute to an increased burden of MLTCs.⁴¹ Scarce vascular diagnostics, non-standardised workflows, and high out-of-pocket costs further delay the detection and management of macrovascular complications.^{3,31} In response, emerging models of integrated care provide a blueprint for mitigating the burden of macrovascular complications, as detailed in the third paper in this Series.¹⁴ Primary care-based interventions incorporating task shifting, point-of-care diagnostics, and bundled treatment protocols have shown promising results in Africa.⁴² Community health worker-led models, digital health platforms, and decentralised chronic disease clinics are further expanding access and continuity of care.^{14,43} Nevertheless, scaleup remains limited by workforce shortages, financial constraints, and weak policy implementation.⁴⁴ The table shows estimates of microvascular and macrovascular complications for type 1 and type 2 diabetes in sub-Saharan Africa, depending on the indicator.

Pregnancy-related complications

Hyperglycaemia in pregnancy, encompassing gestational diabetes and pre-existing type 1 or type 2 diabetes, represents a major and growing maternal health challenge across sub-Saharan Africa.^{16,45} According to current estimates, approximately one in seven livebirths in sub-Saharan Africa is affected by hyperglycaemia, although the true burden is likely higher given inconsistent screening practices, low laboratory capacity, and heterogeneity in diagnostic criteria across countries.⁴⁶ Maternal diabetes increases the risk of pregnancy-related complications, including pre-eclampsia, preterm birth (born before 37 weeks), caesarean delivery, stillbirth, and neonatal morbidity, such as respiratory distress and hypoglycaemia.^{16,47} In the longer term, exposed children face heightened risks of macrosomia-related birth

	Type 1 diabetes	Type 2 diabetes	Combined estimates
Microvascular complications			
Diabetic retinopathy	10.3% ¹⁹	25.5–32.0% ⁴¹⁸	NA
Diabetic nephropathy	32.9% ¹⁹	31.0% ⁴	NA
Diabetic neuropathy	13.6% ¹⁹	38.0–46.0% ⁴¹⁷	NA
Macrovascular complications			
Heart failure	NA	40.2% ³³	NA
Myocardial infarction	NA	4.6% ³³	NA
Peripheral arterial disease	NA	19.0% ⁴	33.0% ⁷
Stroke	NA	55.2% ³³	NA
NA=not applicable.			
Table: Estimates of prevalence of microvascular and macrovascular complications by indicator for type 1 and type 2 diabetes in sub-Saharan Africa			

trauma, childhood obesity, and type 2 diabetes.⁴⁸ Pregestational diabetes carries additional risks of congenital anomalies and perinatal mortality. These risks can be reduced through comprehensive preconception counselling, early glycaemic optimisation, and intensive antenatal surveillance.^{46,47}

Challenges specific to sub-Saharan Africa, including variable antenatal care coverage, scarcity of validated diagnostic tools, restricted access to insulin and glucose monitoring, and weak postpartum linkage to long-term NCD services, exacerbate complications.^{46,49} Therefore, strengthening the management of hyperglycaemia during preconception, antenatal, and postnatal pathways is crucial, given its intergenerational implications.

Risk factor reduction and management

Optimal control of glycaemia, blood pressure, lipids, and weight is central to preventing diabetes complications; however, achievement of guideline targets across sub-Saharan Africa remains markedly suboptimal.^{26,27} Contemporary pooled estimates published in 2022 from 109 African studies involving 63 890 individuals show that only 27% of adults with type 2 diabetes reach the recommended HbA_{1c} targets, 38% reach blood pressure goals, and 42% attain LDL cholesterol targets.⁴ Consistent findings from sub-Saharan African meta-analyses covering more than 21 000 adults report that approximately 30% of people with diabetes meet glycaemic thresholds.²² However, local data report higher rates, underscoring the magnitude of the unmet need—eg, 67.6% with poor control (HbA_{1c} ≥7%) in Kinshasa, Democratic Republic of the Congo.⁵⁰ Suboptimal blood pressure and lipid control frequently co-occur with adiposity. Among Africans with type 2 diabetes, the pooled prevalence of overweight and obesity is estimated to be around 61.4%, with excess weight associated with cardiometabolic risk clustering.^{26,27,51} Moreover, existing estimates probably understate the true burden because they reflect only diagnosed individuals in settings with low diabetes awareness and high rates of undiagnosed diabetes.

Pregnancy introduces additional and often overlooked vulnerabilities. Gestational diabetes remains underdiagnosed owing to inconsistent screening, limited access to oral glucose tolerance testing, and non-standardised antenatal protocols.^{16,52} Selective, risk-based screening can miss over half of gestational diabetes cases in some sub-Saharan African settings, whereas universal one-step strategies detect substantially more cases.⁴⁶ Women with pre-existing diabetes frequently enter pregnancy with suboptimal metabolic control, heightening the risks of adverse maternal and neonatal outcomes.^{45,52} Furthermore, postpartum follow-up is often fragmented, with low rates of glucose testing and little support for weight management or lactation-related metabolic transitions, reflecting deeper system constraints on women's access to maternal care and continuity of care.^{45,52}

Optimal glycaemic control requires intensified insulin therapy when indicated, structured diabetes education, lifestyle modifications, and access to glucose monitoring with regular HbA_{1c} assessment.^{22,53,54} For children and adolescents with type 1 diabetes, the use of continuous glucose monitoring is recommended in major guidelines, with growing evidence of benefits on time-in-range, hypoglycaemia reduction, and quality of life.^{55,56} For blood pressure and lipid management, regular monitoring, the use of angiotensin-converting enzyme inhibitors, angiotensin II receptor blockers, or calcium-channel blockers for hypertension, and statins for LDL cholesterol lowering are standard, with on-treatment blood pressure goals of less than 130/80 mm Hg when safely reachable.^{26,57} However, the availability and affordability of essential medicines (eg, insulins, metformin, and statins), diagnostics (eg, glucometers, HbA_{1c}, and lipid profiles), and monitoring technologies in sub-Saharan Africa remain restricted, constraining implementation at scale.^{58,59}

Obesity management is also pivotal for reducing insulin resistance, improving glycaemic control, and lowering the risk of complications. Context-appropriate lifestyle interventions (eg, nutrition, physical activity, and behavioural support) and diabetes self-management education have shown HbA_{1c} improvements in sub-Saharan Africa, especially when culturally adapted (eg, adapting diabetes education to cultural eating patterns), supported by family, or coupled with device provision and skills training.⁵³ Integrated care models that bridge traditionally single disease-focused programmes can strengthen continuity—for example, pragmatic trials integrating HIV, diabetes, and hypertension management in Uganda and Tanzania improved retention without compromising HIV outcomes.⁶⁰ Although newer cardiorenal-protective pharmacotherapies (eg, GLP-1 receptor agonists and SGLT2 inhibitors) have shown cardiovascular and renal benefits, uptake in sub-Saharan Africa is constrained by pricing and coverage barriers.^{61,62} Notably, the 2025 WHO Essential Medicines List now includes therapies based on GLP-1 for type 2 diabetes (with comorbid obesity, cardiovascular disease, or chronic kidney disease) in an effort to drive access and affordability, although implementation will depend on national adoption and procurement.⁶² In summary, although risk factor reduction remains essential, the realities in sub-Saharan Africa necessitate a dual approach that addresses existing complications while strengthening early detection and proactive prevention.

Diabetes and multiple long-term conditions

The coexistence of two or more chronic conditions in an individual, known as MLTCs, is highly prevalent among people with diabetes in sub-Saharan Africa.⁶ Hypertension remains the most prevalent comorbidity,⁶ and is a crucial risk factor for microvascular and macrovascular complications, as discussed earlier. Mental health

comorbidity is also common, and, uniquely in this region, communicable diseases such as HIV and tuberculosis substantially contribute to the overall disease burden.^{12,63,64} The intersection of diabetes with other NCDs and infectious diseases presents unique clinical, operational, and cultural challenges for health systems already stretched by scarce resources, and requires a shift from single-disease models towards MLTC-based models of care.^{9,12} Framing diabetes within an MLTC model reveals how diabetes interacts with communicable, cardiometabolic, and mental health conditions to produce excess risk of microvascular and macrovascular complications, disability, and catastrophic health expenditure.

The management of MLTCs among people living with diabetes requires coordinated, person-centred models of care. However, across sub-Saharan Africa, health systems remain largely organised around disease-specific programmes,⁶⁵ restricting their ability to address the complex needs of individuals managing diabetes alongside mental health disorders, other NCDs, or chronic infectious diseases. This fragmentation contributes to repeated clinic visits, inconsistent monitoring, polypharmacy, drug–drug interactions, and missed opportunities for early detection of complications.^{15,60}

These systemic limitations highlight the need for context-adapted, integrated care pathways. Priority elements include strengthened self management support, integrated chronic care models, task shifting from secondary and tertiary health-care providers to primary and community health workers, and the use of context-appropriate digital tools, as discussed in the third paper in this Series.¹⁴ Integrated approaches should address coexisting hypertension, mental health conditions, and infectious diseases. Evidence from pilot programmes across the region shows that bidirectional screening, such as NCD–HIV screening services, harmonised treatment protocols, shared electronic health records, and task-shifted delivery models are both feasible and effective.^{66–68}

Culturally grounded interventions are also emerging. Zimbabwe's Friendship Bench and other task-shifting psychological care models have shown efficacy in improving both mental health and diabetes outcomes.^{66,69,70} Peer-led support groups and social networking interventions are also gaining traction, although their scalability and sustainability remain constrained by weak policy frameworks, fragmented funding, and a shortage of trained personnel.⁷¹ Therefore, cultural competence is essential for effective MLTC management. Interventions should engage with local health beliefs and treatment practices, including the potential use of herbal and traditional remedies.⁷² Integration of such practices into formal care should be guided by strong evidence regarding their safety, interactions, and effectiveness. Overall, improving MLTC care for people living with diabetes in sub-Saharan Africa requires integrated,

culturally informed, system-strengthening approaches that address the structural, clinical, and social determinants shaping multimorbidity across the region.

Diabetes and infectious diseases

Infectious diseases remain a major driver of MLTCs among people living with diabetes in sub-Saharan Africa, where the intersecting epidemics of diabetes, HIV, and tuberculosis form a syndemic shaped by interacting biological and structural factors.^{12,64} Diabetes increases susceptibility to tuberculosis, accelerates progression from latent to active disease, and worsens treatment outcomes, including delayed sputum conversion, higher recurrence, and increased mortality.^{64,73} Conversely, tuberculosis-related inflammatory and metabolic stress often precipitates hyperglycaemia or unmasks previously undiagnosed diabetes, reinforcing a bidirectional relationship influenced by poor glycaemic control, systemic inflammation, and HIV co-infection.^{11,64,74} HIV infection and long-term antiretroviral therapy further contribute to insulin resistance, lipodystrophy, dyslipidaemia, and weight gain, collectively amplifying cardiometabolic risk.⁷⁵ Associations between diabetes, HIV, and tuberculosis are examined in detail in the first paper in this Series.¹

Mental health and diabetes: depression and anxiety

Depression and anxiety are among the most prevalent yet under-recognised comorbidities in individuals living with diabetes in sub-Saharan Africa. Despite growing evidence of their substantial impact on disease management and outcomes, mental health conditions remain insufficiently addressed in routine diabetes care. Systematic reviews and primary studies estimate that 15–40% of individuals with diabetes in sub-Saharan Africa have clinically significant depressive symptoms, with higher prevalence observed among women and those with diabetes-related complications.^{10,63,76,77} Anxiety disorders, although less frequently studied, are also common, particularly among people living with diabetes facing high disease burden, complications, and limited access to care.^{78,79} However, the true burden remains underestimated due to the scarcity of validated diagnostic tools and the absence of routine mental health screening in diabetes care. Underdiagnosis is further compounded by low mental health literacy among health-care providers and the poor integration of mental health services into primary care systems.

Depression and anxiety impair self-care behaviours important for preventing complications, including medication adherence, dietary regulation, physical activity, and glucose monitoring. Evidence from Nigeria, Kenya, and Ethiopia indicates that individuals with comorbid depression are more likely to have poor adherence to treatment regimens, reduced physical activity, and diminished social support.^{80–82} These behavioural disruptions contribute to suboptimal

glycaemic control, increased risk of complications such as neuropathy and foot ulcers, and high rates of diabetes-related admissions to hospital and mortality. A study from Tanzania showed a high prevalence of depressive symptoms among individuals with established diabetes, with depression strongly associated with psychosocial stress and adverse clinical factors.⁸³ Moreover, depression is associated with reduced quality of life, functional impairment, and poorer long-term outcomes.⁸⁴

Barriers to effective risk reduction and management of diabetes-related complications

The prevention and management of diabetes-related complications in sub-Saharan Africa are constrained by multilevel barriers across individual, interpersonal, health system, societal, and policy domains. These socioecological factors⁸⁵ (figure) explain persistent gaps in risk factor reduction for diabetes-related complications in the region.

Individual-level barriers

Inadequate diabetes knowledge, low perceived risk, and poor understanding of complication pathways continue to negatively affect self-management across sub-Saharan Africa. Although awareness of behavioural risk factors is

moderate, understanding of long-term complications and the importance of routine monitoring remains poor.^{86–88} This gap in knowledge often delays care seeking and contributes to the high burden of undiagnosed diabetes and hypertension across the region.²¹ These challenges are compounded by poor medication adherence, which is influenced by stigma and discrimination, as highlighted in the societal barriers section, and the added complexities of living with MLTCs, as discussed in the previous section.^{4,26} Financial pressures exacerbate these barriers, with evidence showing that many individuals restrict or delay medication use due to out-of-pocket costs.^{89,90}

Interpersonal-level barriers

Interpersonal dynamics, including family norms, peer influences, and gender relations, substantially shape the context in which diabetes-related complication management occurs. Poor support from family members, caregivers, or peers has been linked to reduced treatment adherence and higher rates of hospital admissions among individuals with type 1 and type 2 diabetes.^{91,92} Poor support intersects with household routines, as communal eating and shared food preparation can make adherence to recommended dietary patterns more

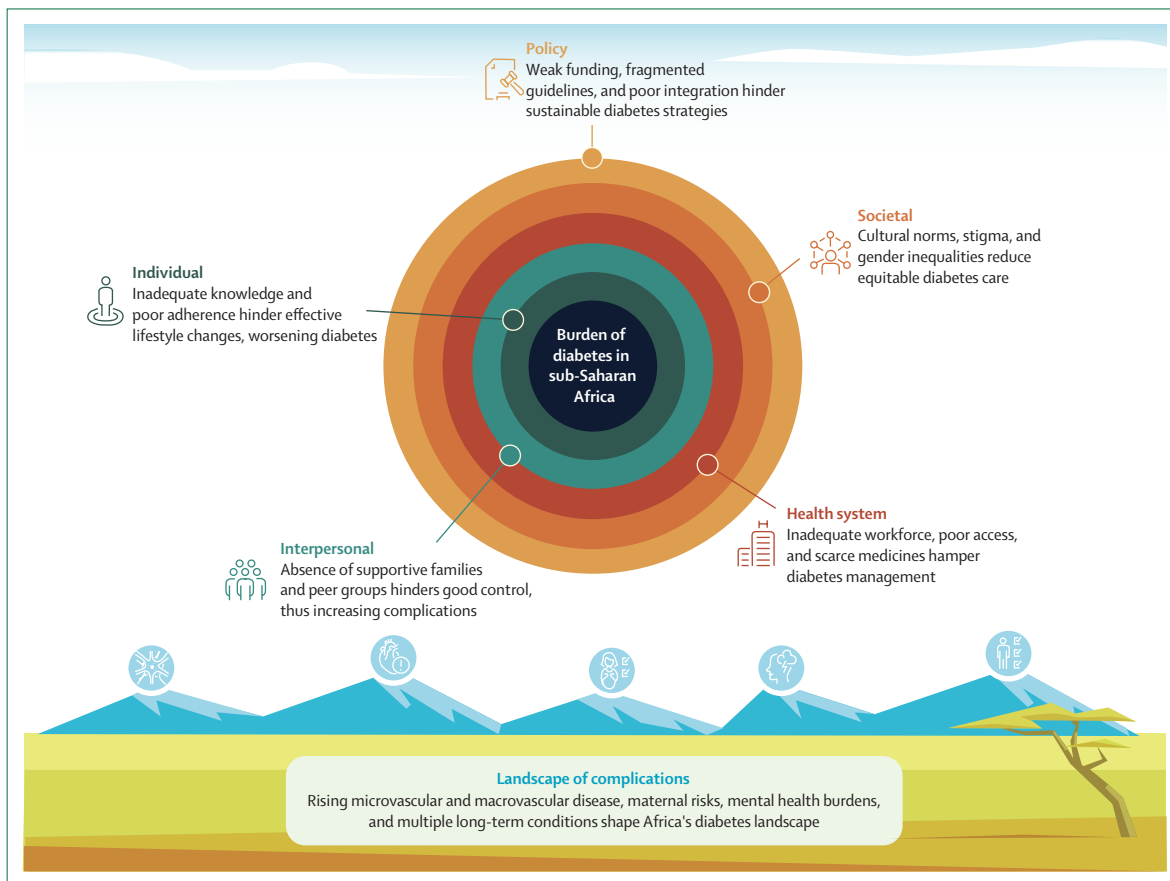


Figure: Socioecological representation of barriers to diabetes-related risk reduction and management

difficult.⁹¹ These factors do not operate in isolation, as gendered power dynamics further constrain women's ability to make health-related decisions, from choosing appropriate foods to accessing care or controlling household finances.⁹³ Together, interpersonal influences create a complex social environment that can considerably hinder sustained and effective long-term diabetes management.

Health system barriers

Health system constraints remain a major impediment to the effective management of diabetes complications in sub-Saharan Africa. The long-standing focus on communicable diseases has contributed to fragmented NCD services and weak surveillance systems.^{60,94,95} These systemic weaknesses intersect with limited access to specialist services, including endocrinology, retinal screening, and nephrology, especially in rural areas.^{8,93} Diagnostic gaps, particularly inadequate availability of HbA_{1c} testing, lipid profiling, albuminuria assessment, retinal imaging, and glucose monitoring devices, also delay the identification of microvascular and macrovascular complications.^{8,89,96} For people with type 1 diabetes, inconsistent insulin supply and little access to continuous glucose monitoring further increase early complication risk.⁹⁷ Access to essential medicines is also inconsistent. Recurrent stock shortages of anti-hypertensives, statins, and insulin often drive individuals to rely on higher-cost private pharmacies or to defer treatment.^{98,99} Under-prescribing, combined with shortages of trained personnel, weak referral pathways, transportation barriers, long travel distances, and variable quality of care, further contributes to missed screening and delayed intervention.^{93,95} These challenges show that, without substantial system strengthening, diabetes complications in sub-Saharan Africa will continue to be detected late and managed suboptimally.

Societal-level barriers

Sociocultural beliefs and stigma also influence diabetes risk and self-management in sub-Saharan Africa. Cultural ideals, such as the preference for higher bodyweight in some communities, might reduce perceived susceptibility.^{86,87} Stigma surrounding insulin use, chronic medication, and gestational diabetes further discourages disclosure and engagement with care.¹⁰⁰ Specifically, adolescents with type 1 diabetes often avoid administering insulin in public because of anticipated discrimination.¹⁰¹ The potential use of traditional medicine, including herbal and spiritual therapies, also shapes diabetes care seeking, as individuals might prefer these systems due to accessibility or cultural alignment.¹⁰² Although not inherently harmful, unregulated traditional treatments can delay diagnosis, interrupt medication use, or interact with prescribed therapies, and their influence often intersects with gender norms and socioeconomic disadvantages (such as women's

restricted decision-making autonomy and financial dependence, and men's reluctance to seek clinical care due to cultural expectations of self-reliance) to compound the challenges faced by people living with diabetes.

Policy-level barriers

Policy-level constraints, including inadequate financing for chronic disease management, weak national NCD strategies, and fragmented procurement systems for essential medicines, continue to undermine management of diabetes-related complications.^{3,59,103} The long-standing prioritisation of donor-supported HIV and tuberculosis programmes has contributed to vertical service structures and restricted fiscal space for expanding workforce capacity, diagnostics, and essential medicines for diabetes.^{94,104,105} Variation in diagnostic criteria and treatment targets further hinders standardised practice.^{3,22} National diabetes guidelines are also absent or inconsistently implemented in several countries, and weak regulatory mechanisms contribute to high medicine prices, recurrent stock shortages, and low adoption of newer therapies.^{59,60} Furthermore, the absence of diabetes registries, routine complication audits, and robust monitoring systems in most sub-Saharan Africa countries restricts the ability to track performance indicators, such as glycaemic control, statin uptake, and screening coverage, further constraining quality improvement and evidence-based planning.^{31,59} These systemic policy gaps highlight the crucial need for stronger governance, sustained financing, and harmonised national frameworks to improve diabetes outcomes.¹⁴

Research gaps and future directions

Addressing research gaps in diabetes complications across sub-Saharan Africa requires tackling persistent deficits in surveillance, care integration, and context-specific evidence, particularly within the realities of MLTCs. Although recognition of the diabetes epidemic and its escalating burden of complications is increasing, the multilevel barriers discussed in the preceding section continue to impede progress. Closing these gaps will require harmonising core indicators, establishing national registries, investing in person-centred and integrated models of care, strengthening context-specific guidance and risk-stratification tools, scaling local innovations that promote prevention strategies, co-designing diabetes research, and expanding implementation science.

Robust, comparable data on complication prevalence and care cascades remain scarce, and heterogeneity in diagnostic thresholds continues to undermine benchmarking and quality improvement.³¹ Future work should harmonise core indicators (eg, screening coverage for HbA_{1c}, blood pressure, and LDL cholesterol control) and adopt standard case definitions across programmes and studies. Strengthening cross-programme linkage of routine data across NCDs, HIV, tuberculosis, and maternal health platforms is equally essential to reflect

Search strategy and selection criteria

We searched PubMed from database inception to Dec 30, 2025, prioritising contemporary evidence whenever possible. Search terms included “diabetes mellitus”, “type 1 diabetes”, “type 2 diabetes”, “diabetes complications”, “microvascular complications”, “macrovascular complications”, “cardiometabolic diseases”, “diabetes and multiple long term conditions”, “diabetes and non communicable diseases”, “diabetes and mental health”, “diabetes and HIV”, and “diabetes and tuberculosis”. The search focused on systematic reviews, major narrative reviews, and observational studies examining diabetes-related complications. We also incorporated data from key organisations, including WHO and the International Diabetes Federation. Only articles published in English were included.

the syndemic nature of disease and to support MLTC-orientated planning.^{104,106} Investment in national and regional registries is also crucial to monitor diseases and clustering trends, and to support feedback cycles in primary care.³¹

A further priority is the development of clinical guidelines and risk assessment instruments tailored to sub-Saharan Africa’s epidemiological, sociocultural, and health system realities, as current management protocols, which are largely adapted from high-income countries, do not adequately address local needs.¹⁰⁷ Locally validated risk scores and context-relevant care pathways incorporating sex, age, ethnicity, and MLTC clustering are required to improve early diagnosis and stratified care.

Integrated service delivery is similarly important, as fragmented, single-disease programmes hinder effective complication management. Evidence increasingly supports embedding diabetes care within HIV and tuberculosis platforms, scaling primary care-led integrated services, and aligning financing, supply chains, and information systems to deliver continuous, person-centred care.^{59,68,104} This reorientation to delivering care for people with MLTCs is essential to shift from reactive, complication-driven care to earlier detection, sustained risk factor control, and prevention of disability.^{9,12,108} Pregnancy-related diabetes warrants elevated attention, given its intergenerational implications.⁴⁸ Research priorities should include scaling preconception services for women with diabetes, implementing context-appropriate universal or risk-based gestational diabetes screening, ensuring reliable access to insulin and glucose monitoring (including continuous glucose monitoring when feasible), and establishing robust postpartum transition pathways into chronic NCD care to reduce pregnancy complications.^{46,47,49}

Emerging fields, such as precision health, genomics, and environmental risk profiling, offer promising avenues for improving risk prediction and understanding

disease heterogeneity in African populations, supported by initiatives such as RODAM and AWIGen.^{109,110} However, translation into clinical practice remains poor, and will require substantial investment and partnerships between local and international institutions. Research into type 5 diabetes, recognised globally as a distinct malnutrition-related phenotype, should also be expanded to clarify its mechanisms, diagnostic criteria, and management strategies, especially as it disproportionately affects lean (BMI <18.5 kg/m²) adolescents and young adults (age <30 years) in low-resource settings.¹¹¹ Strengthening health systems research remains foundational—particularly efforts to reinforce supply chain resilience, data infrastructure, and workforce capacity.

Given their high prevalence and resource constraints affecting chronic disease management in sub-Saharan Africa, addressing cardiometabolic risks should be a priority within risk-reduction strategies.⁹ Systematically documenting and learning from successful national and local innovations, including community-based, task-shifted, and digital-enabled chronic care models, is central, with implementation research needed to determine how, why, and under what conditions these approaches can be scaled. Finally, long-term cohort studies are needed to characterise disease trajectories, MLTC progression, and therapy effectiveness, including interactions with infectious diseases, maternal health, and mental health.¹¹² Across all of these domains, research should be co-designed with local communities and policy makers to ensure relevance, uptake, and long-term sustainability.

Conclusion

Diabetes complications in sub-Saharan Africa arise from a combination of late diagnosis, persistently suboptimal cardiometabolic risk factor control, and a syndemic interplay between mental health conditions and infectious comorbidities, such as HIV and tuberculosis. These clinical drivers are compounded by multilevel barriers spanning individual, interpersonal, community, and health system domains. Addressing this complex environment requires integrated, context-specific approaches embedded within existing chronic disease platforms and supported by strengthened primary care systems and reliable diagnostic and medication supply chains.

Contributors

KK and SS conceived the idea for the review and were responsible for funding acquisition and supervision. All authors were involved in the methodology, writing of the original draft, and review of the manuscript. DI was involved in project administration and organised and formatted the manuscript for submission. All authors reviewed and approved the final manuscript.

Declaration of interests

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Diabetes in Sub-Saharan Africa 3

Strengthening diabetes care in sub-Saharan Africa: health systems, digital innovations, lifestyle interventions, and socioeconomic dimensions

Shabana Cassambai*, Pamela Godia*, Silver Bahendeka, Damilola Omodara, Deborah Ikhile, Samuel Seidu†, Kamlesh Khuntit

The prevalence of diabetes, particularly type 2, in sub-Saharan Africa is rising at an alarming rate. This surge has exposed deep structural challenges, including an over-reliance on hospital-based services and strong cultural and faith-based influences that shape health-seeking behaviours. These factors, combined with socioeconomic inequalities and urbanisation, contribute to poor glycaemic control. Several strategies have been proposed to tackle this problem, including task shifting, integrated models that make use of HIV care infrastructure, digital health tools such as SMS reminders, culturally adapted lifestyle and nutrition programmes, community-based and faith-based interventions, and public–private partnerships. Despite these promising approaches, evidence of long-term sustainability, scalability, cost-effectiveness, and the impact of these interventions remains scarce. Additionally, stigma, gender-related barriers, and patient-reported outcomes are insufficiently studied in sub-Saharan Africa. Large-scale, longitudinal research is urgently needed to assess health system strengthening and culturally grounded models. Achieving effective diabetes care will require resilient, inclusive systems that integrate clinical, community, and digital innovations within the sociocultural and economic realities of the region.

Introduction

The most recent International Diabetes Federation Diabetes Atlas data suggest that the burden of diabetes has risen substantially in the past decade, with steeper rates of increase predicted by 2050.¹ This growing crisis is particularly notable in sub-Saharan Africa, where the prevalence is 4.2% of the adult population aged 20–79 years.¹ As highlighted in the first paper in this Series on diabetes in sub-Saharan Africa, type 1 and type 2 diabetes are the most common forms,² with type 2 diabetes accounting for 90% of all cases.³ Alarmingly, projections indicate that the prevalence will increase by 142% by 2050, a rate more than triple the global average increase of 45%.¹ This trajectory highlights an urgent need to refocus global and regional efforts to address the escalating burden of diabetes.

The implications of this increase are profound and multifaceted. Health systems across sub-Saharan Africa, many of which remain under-resourced and structurally orientated towards the management of acute, infectious diseases, are now being compelled to adapt to the sustained and complex demands of chronic disease care.⁴ Historically, these systems have prioritised episodic interventions for infectious conditions such as malaria, tuberculosis, and HIV and AIDS, often supported by vertical programmes and short-term funding cycles. Conversely, diabetes requires a fundamentally different approach—one that is longitudinal, integrated, and patient-centred. Chronic disease management entails continuous monitoring, regular follow-up, multidisciplinary coordination, and long-term access to medications and diagnostics,⁵ which are elements that are frequently lacking in current service delivery models.

This shift places considerable strain on existing infrastructure, workforce capacity, and financing mechanisms. Primary care facilities, which should serve as the cornerstone of chronic disease management, are often inadequately staffed and equipped, with low availability of trained personnel, laboratory services, and essential medicines.^{6,7} Furthermore, the absence of robust health information systems impedes continuity of care, and fragmented referral pathways and weak integration between the different levels of care contribute to poor outcomes. Without strategic investment and systemic reform, the rising burden of diabetes threatens to overwhelm health systems, exacerbate inequities, and undermine progress towards universal health coverage in the region.

Although diabetes prevalence has increased gradually over the past two and a half decades, its overall burden has become increasingly profound, driven not only by rising case numbers, but also by the pervasive underdiagnosis and poor clinical control of people already living with the condition.^{1,8} A substantial proportion of individuals with diabetes remain unaware of their diagnosis, and many of those who do enter the health system face fragmented care, inadequate glycaemic monitoring, and frequent disruptions in continuity of treatment.⁹ These challenges are compounded by high rates of patient attrition along the care course, from diagnosis to sustained management, which collectively reduce the effectiveness of current health interventions.

The persistence of these challenges signals an urgent need to rethink existing care delivery models. Additionally, structural determinants, including limited access to diagnostic tools, shortages of trained

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*Joint first authors

†Joint senior author

Diabetes Research Centre, College of Life Sciences, University of Leicester, Leicester General Hospital, Leicester, UK (S Cassambai PhD, D Ikhile PhD, Prof S Seidu MD, Prof K Khunti PhD); **Department of Public and Global Health, University of Nairobi, Nairobi, Kenya** (P Godia PhD); **Mother Kevin Postgraduate Medical School, Uganda Martyrs University, Kampala, Uganda** (Prof S Bahendeka PhD); **St Francis Hospital Nsambya, Kampala, Uganda** (Prof S Bahendeka); **Institute of Health and Allied Professions, Nottingham Trent University, Nottingham, UK** (D Omodara PhD)

Correspondence to:
Dr Shabana Cassambai, Diabetes Research Centre, College of Life Sciences, University of Leicester, Leicester General Hospital, Leicester LE54PW, UK
sc833@leicester.ac.uk

or

Prof Samuel Seidu, Diabetes Research Centre, College of Life Sciences, University of Leicester, Leicester General Hospital, Leicester LE54PW, UK
sis11@leicester.ac.uk

health-care workers, and inconsistent medication supply chains, intersect with social barriers such as poverty, stigma, low health literacy, and gender-based disparities in health-care access.^{3,9,10}

These overlapping vulnerabilities hinder efforts to establish effective disease management pathways, and perpetuate a cycle of late presentation, complications, and preventable mortality. Moreover, the rapid pace of urbanisation and lifestyle shifts, including an increased consumption of processed foods, reduced physical activity, and rising obesity rates, have intensified the epidemiological transition and increased diabetes risk in populations previously considered low risk.²

The high prevalence of undiagnosed diabetes, coupled with widespread suboptimal risk factor management and substantial loss to follow-up in the continuous care course, underscores the necessity for sustainable and contextually adapted models of diabetes care in sub-Saharan Africa.^{2,8}

The aim of this narrative review is to explore methods to strengthen diabetes care, particularly type 2, in sub-Saharan Africa, including health systems, digital innovations, lifestyle interventions, and socioeconomic dimensions. This is the third paper in the Series on diabetes in sub-Saharan Africa—the first paper² reviews the burden and determinants of diabetes and the second paper¹¹ focuses on the determinants and management of diabetes complications.

Problems and barriers in diabetes care in sub-Saharan Africa

Health system challenges

Diabetes care in most of sub-Saharan Africa faces substantial systemic limitations. The health-care model remains largely centralised, with services concentrated in urban hospitals and specialised diabetes centres. This concentration is largely due to higher prevalence reported in urban settings than in rural areas (6.0% vs 2.5%), disadvantaging rural communities in accessing care.¹² Urban-based services create geographical inequities, leaving rural populations with little or no access to timely care. These facilities primarily focus on diagnosing cases, initiating treatment, and managing complications, particularly for patients with advanced disease. Although such centres are essential for managing complex clinical presentations, they often function under severe constraints. Scarce resources, inadequate funding, and a persistent shortage of trained health-care personnel strain the system and make meeting the growing demand difficult.¹³ This centralised model leads to overburdened facilities, long waiting times, and diagnostic delays, which undermine early interventional efforts.⁹ Moreover, primary care facilities rarely manage diabetes, leading to missed opportunities for community-level screening, patient education, and long-term follow-up. Weak health infrastructure, particularly in remote areas, exacerbates these issues. The imbalance between patient load and

available providers contributes to fragmented and inconsistent care, which is often insufficient to support the continuity essential for chronic disease management.¹⁴

Socioeconomic burden

The socioeconomic dimensions of diabetes in sub-Saharan Africa are both profound and pervasive, with far-reaching consequences that extend well beyond the health sector. Individuals and households often bear the brunt of diabetes-related costs through both direct medical expenses, such as medications, diagnostic tests, transportation, and dietary needs, and substantial indirect losses. These indirect costs include reduced workforce participation, absenteeism, early retirement, and premature death, which together might account for over 60% of the total household financial burden. For example, life table modelling in South Africa estimated that diabetes led to approximately 13 million lost productivity-adjusted life-years, equating to nearly US\$70 000 in lifetime lost earnings per person.¹⁵

Unlike communicable diseases, the chronic and progressive nature of diabetes requires ongoing self-management and long-term resource commitment. This long-term care burden is particularly challenging for low-income households, in which a diabetes diagnosis often results in a substantial shift in family priorities, including the diversion of education or food budgets towards health care. Furthermore, socioeconomic disadvantage is strongly linked to worse glycaemic outcomes, with low income, rural residence, poor formal education, and lack of insurance coverage emerging as major risk factors for poor control and complications.¹⁶ These disparities deepen social inequities and perpetuate a cycle of health and economic vulnerability.

Lifestyle and nutrition transitions

A major contributor to the escalating prevalence of diabetes in sub-Saharan Africa is the rapid transformation of dietary patterns and lifestyle behaviours across the region. Historically, traditional diets in sub-Saharan Africa were composed of fibre-rich whole grains, legumes, fruits, and vegetables—nutritional profiles that supported metabolic health and helped regulate blood sugar concentrations. However, economic development, urbanisation, and globalisation have accelerated a shift characterised by an increased intake of refined carbohydrates, added sugars, processed foods, and saturated fats.^{17,18} These energy-dense, nutrient-poor diets contribute substantially to weight gain, insulin resistance, and the early onset of type 2 diabetes.

In parallel, physical activity levels have declined sharply due to shifts in occupational structures, an increased reliance on motorised transport, and the proliferation of sedentary leisure activities.² Urban living environments, often lacking accessible recreational infrastructure, further restrict opportunities for exercise. Additionally, alcohol consumption has emerged as a notable

behavioural risk factor in population-based studies.¹⁹ Research from Nigeria indicates that alcohol users have more than a four-fold higher risk of developing diabetes than non-users, underscoring the additive effect of lifestyle behaviours on metabolic risk.¹⁹ Collectively, these shifts foster an obesogenic environment that fuels the diabetes epidemic and poses considerable challenges for prevention and public health planning in sub-Saharan Africa.

Cultural beliefs and faith influences

In many regions of sub-Saharan Africa, cultural and religious worldviews substantially influence how individuals interpret and respond to chronic illnesses such as diabetes. Illness is often not solely seen through a biomedical lens, but can be attributed to spiritual forces, including witchcraft, curses, or ancestral displeasure.^{20,21} As a result, individuals might prioritise consultation with traditional healers, spiritualists, or religious leaders over visits to clinics or hospitals. This prioritisation can lead to substantial delays in seeking formal medical care, which hamper early diagnosis and timely management.^{20,21}

Due to these challenges, religious and faith-based organisations hold considerable potential to improve diabetes care in sub-Saharan Africa. These institutions often command strong trust and moral authority within communities, particularly in locations where the health-care system is perceived as distant or under-resourced. When effectively engaged, faith-based organisations can act as crucial partners in health education, debunking harmful myths, promoting positive health-seeking behaviours, and supporting adherence to treatment. They can also offer crucial psychosocial support, which is essential for managing chronic diseases over time. In this capacity, faith-based organisations can help bridge the gap between culturally rooted beliefs and biomedical models of care, contributing to more holistic and community-aligned approaches to diabetes management.^{22–24}

Stigma and social determinants

Stigma presents a formidable barrier to effective diabetes care in sub-Saharan Africa, shaping both individual behaviours and systemic responses. Diabetes-related stigma, affecting between 12% and 70% of adults in the region, manifests in various forms, ranging from subtle social exclusion to overt discrimination.²⁵ Whether internalised or externally imposed, this stigma discourages individuals from disclosing their condition, seeking medical support, or consistently adhering to treatment. Stereotypes that portray people with diabetes as lazy, weak, or responsible for their own illness further compound these challenges, fostering a culture of blame and shame. The psychological toll is considerable, often leading to anxiety, depression, and reduced self-esteem, factors that directly impair engagement with care and glycaemic control.²⁵

Importantly, the burden of stigma does not fall equally on all populations. Gender is a substantial modifier of diabetes experiences in sub-Saharan Africa, with women often bearing a disproportionate share of the psychosocial and clinical consequences. Cultural expectations around caregiving, diet, and body image can exacerbate stigma among women, who can be more vulnerable to social judgement or economic dependence. These pressures could limit women's ability to prioritise self-care or negotiate for supportive environments. Not surprisingly, evidence shows that women in sub-Saharan Africa frequently have poorer glycaemic outcomes than men, including higher fasting glucose and HbA_{1c} concentrations.^{26,27} This intersection of stigma and gender highlights how deeply social and cultural determinants shape health behaviours and outcomes, underscoring the need for interventions that are both stigma-sensitive and gender-responsive.

Solutions and promising models

Health system innovations

In response to the aforementioned systemic challenges, some health systems in sub-Saharan Africa have begun to explore innovative approaches to strengthen care delivery. Hospitals have trialled integrated care models that combine diabetes management with other non-communicable disease (NCD) programmes, improving the efficiency and coordination of services.^{28–30} Integrated, primary care-led models that deliberately optimise task shifting, clinic workflows, monitoring systems, and procurement pathways can enable evidence-based care to be delivered in a cost-effective and scalable manner, without sacrificing equity or clinical outcomes.¹¹ Some evidence exists regarding the benefits of integrated care models for improving cardiometabolic disease care in low-income and middle-income countries. One systematic review across ten randomised controlled trials (n=4864) from six sub-Saharan Africa countries showed that integrated care for cardiometabolic multiple long-term conditions modestly improved blood pressure, with a reduction in systolic blood pressure of -4.9 mm Hg (95% CI -7.4 to -2.3) versus usual care.³¹ Evidence from Uganda suggests that such models could expand access to care for people living with diabetes, highlighting the potential of a more decentralised, multidisciplinary approach to care.³² However, these models can have limitations, with community health workers (CHWs) needing training, remuneration, and support for travel. Furthermore, concerns were raised by patients about the ability of CHWs to manage diabetes and hypertension, emphasising the need to empower and provide structured training for CHWs.³² Despite these challenges, the Chronic Care Model offers a well established framework for structuring diabetes services in sub-Saharan Africa (figure). Its emphasis on proactive, organised care aligns with regional needs, and has been contextualised to include decentralisation to primary care, patient

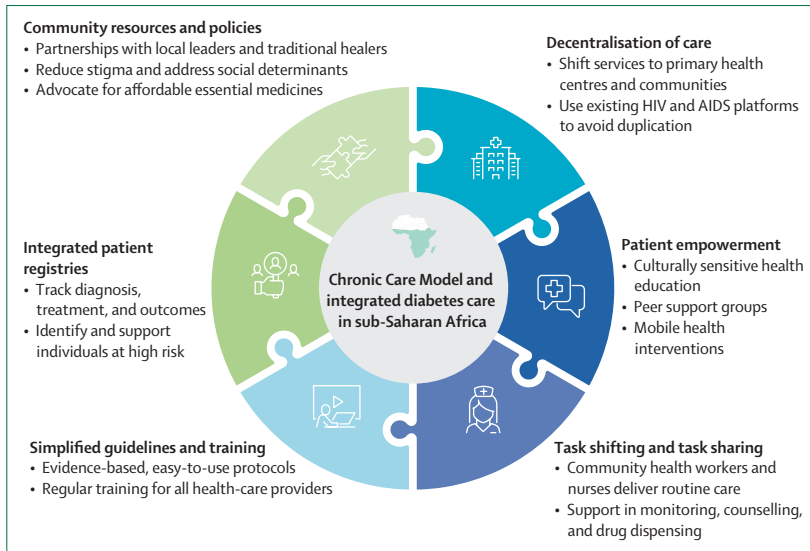


Figure: Components of the Chronic Care Model and integrated diabetes care in sub-Saharan Africa
Adapted from Harrison and Jordan.¹⁴ Authors' representation of evidence provided in the best fit framework for integrated care in sub-Saharan Africa.

empowerment, task shifting, simplified clinical guidelines, basic patient registries, and community partnerships.^{33–37} Integrated care models that repurpose HIV and AIDS infrastructure to deliver concordant cardiometabolic multiple long-term conditions combining diabetes, hypertension, and cardiovascular risk management within strengthened primary care have shown feasibility and cost-effectiveness, especially in one-stop-shop service models,^{38,39} consistent with WHO implementation frameworks such as the HEARTS technical package.⁴⁰

However, challenges have arisen in delivering integrated care. Reductions in foreign aid from early 2025 risk undermining the HIV and AIDS care infrastructure in sub-Saharan Africa, with unintended consequences for the delivery of many chronic diseases, including diabetes. Therefore, alternative, more sustainable models for diabetes infrastructure should be proactively explored and developed. These models include diabetes self-care interventions with tailored approaches that have shown improvements in outcomes in sub-Saharan Africa,⁴¹ nurse-led diabetes self-management programmes, SMS reminders, and family support. Peer-based and CHW-based diabetes self-management programmes have also shown benefits in low-income and middle-income countries, but have been inadequately assessed.⁴² The cutback in foreign aid will go far beyond simple financial shortages.⁴³ The health workforce, pharmaceutical supply chains, laboratory services, community-based delivery, and health information systems are fundamental elements that support long-term HIV care. Access to antiretroviral therapy and preventive services has already been disrupted by sudden funding cuts,^{44,45} raising the risk of poor adherence, loss of viral suppression, and

subsequent transmission. Simultaneously, outreach, retention, and monitoring are being weakened by clinic closures and staff reductions, especially for services that assist key populations. Disruptions to laboratory monitoring and procurement jeopardise the quality and safety of care, with prevention programmes and community organisations disproportionately impacted.

Through integrated, shared infrastructure, the most effective chronic care HIV programme platforms in sub-Saharan Africa can be modified to serve diabetes and other NCDs.^{40,46} Some examples of these programmes include co-located chronic illness clinics, task-shifted community delivery models, shared data and laboratory systems, pooled supply chains and procurement, and more sustainable domestic or hybrid finance methods. Aid reduces the danger of HIV service fragmentation in the short term—integrated chronic care systems, in which HIV platforms serve as the foundation for diabetes and other NCD treatment, are the most practical answer in the medium term, as opposed to separate, continued vertical programmes.

Community-based and culturally grounded care

From an implementation science perspective, effective scale-up of diabetes care in resource-constrained settings requires treating resources not simply as constraints, but as central objects of intervention. Emerging work in global implementation research emphasises that the goal is not only to increase funding or inputs, but also to design, test, and refine care delivery strategies that maximise the impact of the existing workforce, infrastructure, and supply chains, while maintaining or improving the quality and reach.⁴⁷ Community-based care models have emerged as an important strategy for extending diabetes services to underserved populations, particularly in low-resource and rural settings. These models aim to decentralise care by bringing essential services closer to where patients live, thereby reducing barriers such as travel distance, transportation costs, and time away from work or family responsibilities. At the heart of many community-based models are CHWs, who have a pivotal role in delivering diabetes education, monitoring blood glucose concentrations, supporting treatment adherence, and providing early referrals when complications arise. Their close ties to the community enhance trust, cultural relevance, and continuity of care.

In addition to CHWs and local clinics, faith-based organisations have proven to be valuable partners in expanding community-based diabetes services in some low-income and middle income countries. By integrating health promotion into religious teachings and leveraging their widespread community presence, these organisations can align health messages with spiritual and moral values, thereby strengthening their influence and reach. A study conducted in Ghana with faith-based organisations showed improved screening and management of both hypertension and type 2 diabetes.⁴⁸

Another study conducted in Bangladesh showed a reduction in new-onset type 2 diabetes in participants who received a faith-based lifestyle intervention delivered in mosques.⁴⁹ These interventions are particularly effective in mobilising communities for sustained behavioural change, promoting healthier lifestyles through trusted and familiar channels.^{22–24}

Furthermore, peer support groups and culturally tailored diabetes self-management education programmes offer essential psychosocial and practical support. These interventions help individuals develop the knowledge, skills, and confidence needed to manage their diabetes effectively. When culturally adapted, considering language, dietary practices, and social norms, diabetes self-management education programmes have been shown to improve self-care behaviours, glycaemic control, and overall quality of life.^{50–52} Together, these community-centred approaches form a holistic framework for diabetes care that is both accessible and empowering.

Digital health solutions

The ongoing digital transformation of health care presents major opportunities to enhance access and quality of care, particularly in resource-limited settings. Among the most promising innovations are mobile health platforms, which include tools such as SMS reminders, unstructured supplementary service data patient platforms, mobile applications, and teleconsultation services.^{53–55} These technologies have shown considerable potential in promoting medication adherence, improving self-management behaviours, and facilitating communication between patients and providers. For example, SMS-based reminders have been used to prompt timely medication intake and encourage lifestyle modifications in individuals living with chronic conditions such as diabetes. In Ethiopia, a study found that over two-thirds of patients surveyed were willing to use SMS-based reminder systems to support their treatment plans, highlighting broad acceptability and interest.⁵⁶ The study also revealed that uptake of such digital interventions was considerably influenced by demographic-related and treatment-related factors, including age, level of education, and the type of diabetes treatment regimen.⁵⁶ Thus, the strongest effects are observed when digital tools are embedded within existing care pathways and accompanied by task shifting, training, and governance structures, rather than implemented as standalone technological solutions. However, while these findings emphasise the potential of digital health solutions, they also stress the importance of context-sensitive design. Digital tools should be adapted to fit cultural norms, literacy levels, and the local population's access to technological devices to be effective. Moreover, research indicates that psychological factors, particularly self-efficacy, or the belief in one's ability to manage health independently, play a crucial role in the successful adoption and sustained use of

digital health technologies.⁵⁷ As such, digital health strategies should incorporate behaviour change support to maximise impact.

Lifestyle and nutrition interventions

Amid the global shift towards the highly processed diets of high-income countries, characterised by high sugar, fat, and refined carbohydrate contents, scientific interest in the health benefits of traditional African dietary patterns has been renewed. Emerging evidence suggests that indigenous African diets might offer a protective effect against the rising burden of type 2 diabetes across the continent.^{58–60} These diets are typically composed of unrefined whole grains (eg, millet, sorghum, and maize), legumes (eg, beans and lentils), fibre-rich vegetables, and minimal intake of animal fats and processed sugars. Such nutrient-dense, low-glycaemic foods have been linked to improved insulin sensitivity, reduced postprandial glucose spikes, and better long-term glycaemic control.^{58–60}

Several culturally adapted dietary interventions grounded in these traditional food systems have been implemented in various African settings. In Kenya and South Africa, community-based programmes promoting indigenous diets have shown encouraging results, with participants reporting improved eating patterns and measurable improvements in blood glucose concentrations and metabolic markers.^{61–63} These interventions succeeded in part because they embraced cultural familiarity and practical relevance, thereby enhancing participant engagement. Moreover, a systematic review examining the impact of culturally tailored interventions concluded that multidimensional cultural adaptation, such as incorporating local foods, delivering messages in culturally meaningful ways by use of native languages, and employing facilitators from targeted ethnic communities, substantially enhanced behavioural change outcomes.⁶⁴ These findings underscore that dietary education alone is insufficient—the delivery method should resonate with cultural identity and lived experience.

Promoting indigenous African diets, supported by culturally responsive health communication and community involvement, has strong potential for reducing the incidence and severity of diabetes. The promotion of these diets aligns with broader goals of sustainable nutrition, food sovereignty, and chronic disease prevention tailored to local realities.

Public–private partnerships

Although public–private partnerships (PPPs) are often proposed as a mechanism to expand access to chronic disease services, few well documented examples exist of PPPs delivering sustained, equitable diabetes care in sub-Saharan Africa.⁶⁵ Current initiatives primarily concentrate on short-term service provision, supply chains, or vertical programmes instead of comprehensive, system-wide diabetes management. For example, PPPs have been used to strengthen laboratory systems, allowing barriers

related to early infant HIV diagnosis and viral load monitoring to be addressed.⁶⁶ This small evidence base for diabetes care has been highlighted, with considerable uncertainty about the effects of PPPs on universal health coverage outcomes.⁶⁷ One likely explanation is that effective PPPs require strong public sector stewardship, including regulatory capacity, contracting expertise, and accountability mechanisms, which are variably developed across countries. Without adequate governance, PPPs might prioritise efficiency or market viability at the expense of equity, continuity, and public health outcomes.⁶⁷ As such, PPPs should be viewed as context-specific and complementary tools, rather than a primary strategy for scaling diabetes care, unless embedded within strong public health systems and regulatory frameworks. However, the effectiveness of PPPs depends heavily on how they are structured and governed. For PPPs to truly bridge the access gap, they should be guided by principles of equity, accessibility, and accountability. In practice, this entails implementing standardised clinical protocols, ensuring transparency in operations, and establishing shared monitoring and evaluation systems that safeguard service quality across both public and private entities.⁶⁸ We have summarised proposed solutions and promising models addressing barriers to type 2 diabetes care in sub-Saharan Africa (table).

Areas for further research

Despite the progress achieved with innovations such as integrated care delivery, task shifting to CHWs, and

faith-based interventions, substantial gaps in evidence remain. Persistent shortages in infrastructure, trained personnel, and essential supplies continue to undermine health system capacity. Although integrated service delivery, most commonly combining type 2 diabetes care with HIV and AIDs or other NCDs has shown promise, evidence on their long-term effectiveness, sustainability and scaleup is scarce.^{40–42,69–71} Additionally, many health facilities in sub-Saharan Africa might not be prepared to integrate cardiovascular disease care with type 2 diabetes care, and might be hesitant in this combination.⁵¹ Although trials such as the INTE-AFRICA study show the feasibility and potential benefits of integrated care models, successful implementation depends on the strengthening of multiple core components, including adequate supply of medication.⁴⁰ Therefore, larger implementation studies are needed to strengthen the evidence base and establish cost-effectiveness. Effective diabetes care should extend beyond glycaemic control to coordinated management of cardiometabolic risk factors, particularly hypertension and dyslipidaemia.^{72,73} Modelling evidence from South Africa suggests that blood pressure and lipid control can yield greater health and economic benefits than glucose-focused strategies alone.⁷⁴ Given the high coexistence of these conditions among people with diabetes in sub-Saharan Africa, future policies should prioritise comprehensive cardiometabolic risk management, reinforcing the need to scale integrated care models and adopt a multiple long-term conditions lens in diabetes care.^{11,46} In the realm of digital health, enthusiasm

	Solutions and promising models	Research gaps and future directions
Health system challenges—hospital-centric care; low rural reach; shortage of specialists; weak supply chains; fragmented follow-up	Decentralisation to primary care; task shifting to nurses or CHWs; integrated NCD clinics using HIV and AIDS platforms; simplified guidelines and registries	Longitudinal studies on effectiveness of decentralised and task-shifted care; cost-effectiveness analyses of integrated models
Socioeconomic burden—high direct or indirect costs; lost productivity; inequities linked to poverty; insurance gaps; rural residence	PPPs for shared services, procurement, and affordability; embedding diabetes prevention in NCD policy	Evaluation of PPP models in sub-Saharan Africa; economic feasibility studies of large-scale prevention
Lifestyle and nutrition transition—shift to processed high-income country diets; sedentary behaviours; alcohol use	Promotion of indigenous diets (eg, sorghum, millet, legumes, fermented foods); culturally adapted nutrition and lifestyle programmes; community education	Randomised controlled trials of culturally adapted interventions; studies on affordability, availability, and sustainability of healthy diets
Overemphasis on glycaemic control—high coexistence of hypertension and dyslipidaemia in people with diabetes	Integrated care models tailored to sub-Saharan Africa health system constraints, focusing on comprehensive cardiometabolic risk management	Prioritisation of scalable, culturally adapted, integrated care models and adoption of a long-term condition lens for service delivery
Emerging diabetes phenotypes (eg, type 5 diabetes)—insufficient surveillance and unclear diagnostic criteria; interaction of type 5 diabetes with undernutrition and broader food environments	Strengthen health systems for prevention-focused responses; PPP models and community education leveraging CHWs and faith-based organisations	Epidemiological studies to establish diagnostic criteria and map true burden of type 5 diabetes; expand genomic studies to clarify mechanisms and improve classification accuracy; adopt a multidisciplinary approach involving nutritionists, environmental scientists, and allied health professionals
Cultural beliefs and faith influences—spiritual attributions (eg, witchcraft, curses); reliance on traditional healers; misconceptions; delayed care	Engagement of faith-based organisations as partners in education and adherence support; culturally sensitive health communication; peer-support programmes	Rigorous evaluation of stigma reduction and faith-based interventions; strategies for integrating cultural beliefs with biomedical care
Stigma and gender disparities—widespread diabetes stigma (12–70% prevalence); poor self-care; secrecy; psychosocial distress; women often have poorer glycaemic control	Patient empowerment through culturally sensitive diabetes self-management education, peer groups, and digital interventions; gender-targeted approaches	Studies on patient-reported outcomes (eg, quality of life, adherence, stigma); evaluation of gender-sensitive interventions
Digital health challenges—poor infrastructure; low adoption in rural settings; mixed evidence on outcomes	SMS reminders; mHealth apps; telemedicine; contextual tailoring for literacy and culture	Large-scale studies on clinical effectiveness, scalability, and long-term sustainability of digital health tools

CWH=community health worker. NCD=non-communicable disease. PPP=public-private partnership.

Table: Summary of health system, socioeconomic, cultural, and digital barriers to diabetes care in sub-Saharan Africa

is tempered by mixed results. Many interventions in sub-Saharan Africa show feasibility, but either do not rigorously examine or do not show consistent improvements in risk factor outcomes. Few studies have included cost-effectiveness analyses, and issues of scalability and sustainability in low-resource settings remain unresolved.^{42,75,76}

Lifestyle and cultural interventions, although promising, require further evaluation in rigorous trials in sub-Saharan Africa. More evidence is needed to assess the effectiveness of culturally tailored dietary programmes, stigma-reduction initiatives, and gender-sensitive approaches.^{77,78} Equally, patient-centred outcomes, such as quality of life, behavioural adherence, and psychosocial wellbeing, are under-reported, leaving an incomplete picture of what truly matters to patient improvements.⁷⁵⁻⁷⁸

Given the increasing burden of other forms of diabetes in the region, notably type 5 diabetes, future research should explore how health systems can be strengthened to address this burden, ideally through preventive rather than curative strategies. This strengthening will involve improving surveillance and prioritising establishing clear diagnostic criteria to generate reliable epidemiological data that can define the true burden of type 5 diabetes. Investment in genomics research is also essential to elucidate the underlying pathophysiology of type 1, type 2, and type 5 diabetes, especially given the clinical overlaps that have historically led to misclassification.⁷⁹ Understandably, such investment will demand substantial infrastructural and technical resources, which might pose considerable constraints on national health systems. To mitigate these constraints, local, regional, and international partnerships should be explored to pool resources and leverage assets to support bidirectional investments. Furthermore, due to the interaction of type 5 diabetes with the food environment and undernutrition, a multidisciplinary approach engaging with allied health-care professionals, nutritionists, and environmental scientists will be a valuable starting point for developing comprehensive solutions for diabetes management in sub-Saharan Africa.

Therefore, future research should prioritise large-scale, longitudinal studies that can generate robust evidence on the impact of health system strengthening, community-based interventions, and digital innovations. Future research should also explicitly address patient experiences, stigma, and gender disparities, ensuring that new models of care are not only effective, but also equitable, cost-effective, and culturally appropriate.^{80,81} Additionally, researchers should work together with policy makers so that appropriate resources can be allocated to strategies that are shown to be effective.

Conclusion

The escalating burden of diabetes in sub-Saharan Africa is a complex and urgent public health challenge, shaped

Search strategy and selection criteria

We searched PubMed for articles published from Jan 1, 2015, to Jan 23, 2026, to present relevant and contemporary findings. Search terms included “diabetes mellitus”, “Sub-Saharan Africa”, “model of care”, “health services”, “patient education”, “treatment adherence”, and terms related to impact and feasibility. We defined diabetes as HbA_{1c} ≥6.5%, fasting plasma glucose concentration ≥7.0 mmol/L, or 2-h plasma glucose ≥11.1 mmol/L on a 75 g oral glucose tolerance test. The search targeted systematic reviews, major narrative reviews, and observational studies. Reports from international organisations (eg, WHO, International Diabetes Federation, World Bank) and Conference abstracts (eg, European Association for the Study of Diabetes, American Diabetes Association, International Diabetes Federation Africa) were also included to synthesise all available data from sub-Saharan Africa. Only articles published in English were included.

by the interplay of systemic limitations, socioeconomic disparities, cultural norms, and rapid lifestyle transitions. Alongside a steady increase in prevalence, the cumulative impact of underdiagnosis, inadequate care continuity, and social barriers has compounded the crisis, placing considerable strain on already overstretched health systems. Traditional, acute care models are poorly suited to manage chronic conditions such as diabetes, necessitating a shift towards more integrated, longitudinal, and contextually tailored approaches.

Encouragingly, a growing body of evidence highlights promising pathways forward. Health system innovations, such as task shifting, integrated chronic care models, and the use of HIV infrastructure offer scalable templates for reform. Community-based interventions, including culturally grounded education, peer support, and faith-based engagement, show the value of locally anchored care. Digital health tools, although still evolving, have the potential to enhance self-management and monitoring, particularly when designed with cultural and technological contexts in mind. Additionally, the promotion of indigenous diets and strategic public-private partnerships can bridge gaps in both prevention and service delivery.

However, success will depend on sustained investment, multisectoral collaboration, and a firm commitment to equity. Future research should go beyond clinical metrics to include patient experiences, social determinants, and gender-based disparities. Only through comprehensive, inclusive, and locally responsive strategies can sub-Saharan Africa outline a more resilient and equitable strategy to tackle the growing burden of diabetes.

Contributors

All authors were involved in the methodology, writing, and review of the manuscript. SC was involved in project administration. SS and KK were involved in conceptualisation, supervision and funding acquisition.

Declaration of interests

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Diabetes in sub-Saharan Africa 4

Insights into the genetic aetiology of diabetes in Africa

Alisha N. Wade,^{a,b,c} Carolyn Padoa,^{d,e} Adebowale Adeyemo,^f and Inês Barroso^{g,*}

^aResearch in Metabolism and Endocrinology, Department of Internal Medicine, School of Clinical Medicine, Faculty of Health Sciences, University of the Witwatersrand, Johannesburg, South Africa

^bMRC/Wits Rural Public Health and Health Transitions Research Unit, School of Public Health, University of the Witwatersrand, Johannesburg, South Africa

^cDivision of Endocrinology, Diabetes and Metabolism, Perelman School of Medicine, University of Pennsylvania, Philadelphia, PA, USA

^dDepartment of Chemical Pathology, School of Pathology, Faculty of Health Sciences, University of the Witwatersrand, Johannesburg, South Africa

^eSouth Africa and National Health Laboratory Services, Johannesburg, South Africa

^fCenter for Research on Genomics and Global Health, National Human Genome Research Institute, National Institutes of Health, Bethesda, MD, USA

^gExeter Centre of Excellence for Diabetes Research (EXCEED), University of Exeter Medical School, Exeter, UK



Summary

Despite the high public health burden of diabetes in Africa, research into its genetic aetiology has been slow, limiting the continent's ability to benefit from an emerging era of diabetes precision medicine. Some progress is evident. In monogenic diabetes, where a molecular diagnosis enables tailored treatment, two cases from Africa successfully illustrate this approach despite the absence of routine affordable genetic testing, and control data from diverse African populations. Although limited, genome-wide association studies from African populations have discovered novel African-specific type 2 diabetes risk variants. Additionally, application of a type 1 diabetes genetic score helped define a novel type of insulin deficient non-autoimmune diabetes in sub-Saharan Africa. Multiple challenges remain, including interpretation of glycated haemoglobin, a frequently used diabetes biomarker, which is impacted by genetic variants common in the African continent. We review these issues, outline barriers to implementing diabetes precision medicine, and highlight areas for future development.

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Keywords: Diabetes; Genetics; Glycated haemoglobin; Genetic score; Variant interpretation; Africa

Introduction

In Africa, the prevalence of all forms of diabetes is increasing at an alarming rate, with the age-standardised prevalence in adults expected to change from 5% in 2024 to 5.9% in 2050- an increase from 24.6 million adults to approximately 60 million.¹ Although the region has the lowest age-adjusted diabetes prevalence globally, the expected 142% increase between 2024 and 2050 is the largest worldwide.¹ While the incidence of type 1 diabetes (T1D) in those less than 15 years in the region is the lowest in the world at an estimated 2 per 100,000, the 605,000 people of all ages estimated to have died prematurely from T1D in Africa is the third highest globally, decreasing prevalence and potentially underestimating disease burden.² Despite the impact of diabetes in the region, the paucity of high-quality genetic studies in African countries means few individuals can benefit from

the advances in molecular diagnosis of diabetes that reduce misclassification and facilitate optimal therapeutic approaches.³ This review summarises current knowledge on the genetics of diabetes in African populations and highlights the need for continental African genetic research to better define molecular risk factors, develop population-specific risk models and improve diagnostic and therapeutic approaches.

Molecular basis of diabetes in Africa

Diabetes is broadly classified into monogenic diabetes, T1D, type 2 diabetes (T2D), gestational diabetes (GDM) and other specific types of diabetes. Its classification is usually based on clinical characteristics such as age at onset, family history of diabetes, body mass index (BMI), insulin dependence and sensitivity, and laboratory features such as C-peptide levels and the presence of pancreatic β -cell autoantibodies. However, the overlap of clinical and laboratory features between different types of diabetes presents a significant diagnostic challenge and illustrates the importance of appropriate genetic testing to improve classification.

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*Corresponding author. EXCEED, University of Exeter Medical School, Exeter, UK.

E-mail address: ines.barroso@exeter.ac.uk (I. Barroso).

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Monogenic diabetes

The term “monogenic diabetes” refers to a group of conditions caused by penetrant pathogenic variants in individual genes in each affected family.⁴ The main types of monogenic diabetes are neonatal diabetes (NDM) and maturity onset diabetes of the young (MODY). NDM presents within the first 6 months of life and has a reported incidence range of 0.00021%–0.0048% of live births, depending on the population.⁴ MODY normally presents in lean individuals before the age of 25 years who have a strong family history of diabetes, and is reported to affect 1 in 10,000 adults and 1 in 23,000 children worldwide.⁴

Little is known about the epidemiology of monogenic diabetes across Africa. The reported incidence of NDM varies widely between populations, with higher incidence in countries with higher rates of consanguinity.⁵ One of the first studies of NDM in Africa reported an incidence of 4.8 per 100,000 live births in Sudan.⁶ This high incidence cannot be extrapolated to other African countries, as Sudan has a high degree of ethnic diversity, represents only a subset of genetic diversity across Africa and has one of the highest rates of consanguineous marriage.⁷ Globally, mutations in over 40 different genes have been shown to cause different forms of NDM and while mutations in *EIF2AK3* and *KCNJ11* were first described in children from Morocco and East Africa respectively, little is known about the main causes of NDM in Africa.^{4,6,8,9} In the Sudanese study mentioned above, the most common causes of NDM (18.9%) were recessive mutations in *EIF2AK3* causing Wolcott–Rallison syndrome.⁶ This aligns with an earlier study which included families from 79 countries where the degree of parental consanguinity affected the relative frequency of NDM causative mutations.¹⁰ NDM was due to a mutation in *EIF2AK3* in 24% of children of consanguineous parents, whereas, mutations in *ABCC8* and *KCNJ11* accounted for only 12% of these cases. In contrast, in children of non-consanguineous parents, mutations in *ABCC8* and *KCNJ11* accounted for 46% of NDM cases.¹⁰ Consistent with this, mutations in *INS*, *ABCC8* and *KCNJ11* account for over 50% of NDM cases in Europe and North America.⁴

MODY prevalence in continental African populations is unknown. Monoallelic pathogenic mutations in 11 different genes have been reproducibly reported to cause MODY in patients from different countries.¹¹ To date, there are no published data on the prevalence of each of these in African countries, although cases of GCK-MODY and HNF1A-MODY have been identified in Tunisia and Cameroon, respectively.^{12,13} In addition, mutations in *WFS1* leading to a syndromic form of diabetes with optical atrophy and hearing loss were observed in two Moroccan families.¹⁴ Although *WFS1* is not a MODY gene, mutations in the gene are a recognised cause of monogenic syndromic diabetes.

In summary, neither the prevalence nor genetic aetiology of monogenic diabetes are well characterised across different African countries, and the condition is likely to be underdiagnosed due to limited genetic testing.

Type 1 diabetes

T1D is a heterogeneous disease arising from the complex interaction between genetic and environmental factors that triggers islet autoimmunity and the destruction of insulin secreting pancreatic β -cells. T1D commonly presents in childhood with a peak incidence at 5–9 years of age although, in sub-Saharan Africa, a second peak in onset has been observed after the age of 20 years.¹⁵ While latent autoimmune diabetes in adults (LADA—defined by insulin independence for ≥ 6 months, age at onset ≥ 30 years and diabetes-associated autoantibody positivity) is an important consideration in the context of adult-onset T1D, it only accounted for a small percentage (17.8%) of cases in the second peak. Removal of these cases from analyses had little effect on the outcomes suggesting a different aetiology of T1D for this group.¹⁵ A recent study including participants from South Africa, Cameroon and Uganda, confirmed that 65.1% of cases with young-onset (age < 30 years), insulin-treated and clinically diagnosed T1D, have non-autoimmune insulin deficient diabetes.¹⁶ These results suggest that in sub-Saharan Africa T1D is a very heterogeneous condition including classical autoimmune T1D cases, as well as a novel type of non-autoimmune insulin deficient diabetes.¹⁶

Globally, the primary genetic susceptibility locus for T1D is the major histocompatibility complex with the HLA class II *DRB1* and *DQB1* genes conferring the strongest genetic susceptibility.¹⁷ Studies investigating HLA associations with T1D in African populations (Table 1) are limited and primarily originate from north African countries whose populations exhibit strong Middle Eastern and Mediterranean influences. These studies confirm previous susceptibility and protective allele findings from European-ancestry studies, although allele frequencies may differ. Of note, high resolution typing identified DR04:05 as a risk allele, with a frequency of 13.4–19.3%, in Ethiopian, Malian, Moroccan and Sudanese populations whereas the most common European risk allele is DR04:01 (approximately 28.1%).^{17,20,22,23,25} In addition, similar to Asian populations, DR9 is common (9.4–10.6%) and predisposes to T1D in sub-Saharan African populations while it is rare (0.2–0.8%) in European-ancestry populations.^{17,22,24} A novel association of T1D with DQB1*02:02 was seen in an Egyptian and Malian population.^{18,22} Furthermore, DR10 was protective in a Sudanese and Ethiopian population whereas no association was seen in European-ancestry populations.^{17,20,25}

The HLA class I genes (*HLA-A*, *HLA-B*, *HLA-C*) are poorly studied in relation to T1D in Africa (Table 2) making direct comparisons challenging due to differences in HLA typing methodologies, alleles investigated, HLA resolution, inconsistencies in nomenclature, and

Population	Sample size	Risk alleles/haplotypes	Protective alleles/haplotypes	Genotyping	Reference
Egyptian	85 cases and 113 controls	DQB1*0201 DQB1*0202 DQB1*0302	DQB1*0601	PCR-SSOP	Mosaad et al., 2012 ¹⁸
Egyptian	68 cases and 120 controls	DR3-DQB1*02 DR4-DQB1*0302		PCR-SSOP	El-Amir et al., 2019 ¹⁹
Ethiopian	202 cases and 166 controls	DR3-DQB1*02 DRB1*0405-DQB1*02 DRB1*0405-DQB1*0302 DRB1*0401-DQB1*0302	DRB1*0404-DQB1*04 DR15-DQB1*0602 DR11/12/13-DQB1*0301 DR13-DQB1*0603 DR7-DQB1*0303 DRB1*0403-DQB1*0302 DR1/10-DQB1*0501 DR7-DQB1*02 DR13-DQB1*0604	PCR-SSOP	Gudeta et al., 2025 ²⁰
Ethiopian (Amhara)	188 cases and 152 controls	DRB1*03:01 DRB1*04	DRB1*15	PCR-SSP	Balcha et al., 2020 ²¹
Malian	99 cases and 200 controls	DRB1*03:01 DRB1*04:05 DRB1*09:01 DQB1*02:01 DQB1*02:02 DQB1*03:02	DRB1*15:03 DQB1*04:02 DQB1*05:02 DQB1*06:02 DQB1*06:03	NGSgo-MX11-3 system	Noble et al., 2024 ²²
Moroccan	90 cases and 139 family members as controls	DRB1*03:01 DRB1*04:05 DQB1*02:01 DQB1*03:02	DRB1*11 DRB1*15 DQB1*06	PCR-SSP and PCR-SSOP	Drissi Bourhanbour et al., 2015 ²³
South African (Zulu)	47 cases and 630 controls	DRB1*0301 DRB1*04 DRB1*09 DQB1*02 DQB1*0302	DRB1*0302	PCR-SSP	Pirie et al., 2001 ²⁴
Sudanese	56 cases and 198 controls	DRB1*03:01 DRB1*04:02 DRB1*04:05	DRB1*10:01 DRB1*13:02 DRB1*15:02 DRB1*15:03	Roche 454 GS Junior System and MiSeq instrument	Ibrahim et al., 2021 ²⁵
Tunisian	137 cases and 258 controls	DRB1*03 DRB1*04	DRB1*11 DRB1*15	PCR-SSOP	Hajje et al., 2019 ²⁶
European ancestry	607 families consisting of two parents and at least two affected siblings	DRB1*0301- DQA1*0501-DQB1*0201 DRB1*0401- DQA1*0301-DQB1*0302 DRB1*0404- DQA1*0301-DQB1*0302 DRB1*0402- DQA1*0301-DQB1*0302 DRB1*0405- DQA1*0301-DQB1*0302	DRB1*1501- DQA1*0102-DQB1*0602 DRB1*1104- DQA1*0501-DQB1*0301 DRB1*0701- DQA1*0201-DQB1*0303 DRB1*1303- DQA1*0501-DQB1*0301 DRB1*1401- DQA1*0101-DQB1*0503	PCR-based SSOP system	Erlich et al., 2008 ¹⁷

Table 1: Association of HLA class II DRB1 and DQB1 alleles with T1D in African and European samples.

small sample sizes (68–99 cases and 120–200 control participants). Novel class I allele associations were seen in a Malian cohort, except for A*24:02 which is a known risk allele globally.²²

More than 75 non-HLA susceptibility genes have been identified in European-ancestry populations, predominantly by genome-wide association studies (GWAS).²⁸ In Africa, genetic research has relied on candidate gene studies.^{29–34} While associations of *IL-10*, *MALAT1*, *RAGE* and *VDR* with T1D have been seen in Egyptian and South African populations, respectively, due to their small sample size (ranging from a total

sample size of 184–354) and more lenient p-value thresholds, false-positive associations cannot be ruled out.^{29,31,33,34} In addition, weaker genetic associations may be missed due to lack of power. Notably, a preliminary GWAS performed on an Ethiopian cohort with 236 cases and 200 controls found no genome-wide significant associations with T1D, emphasising the need for larger-scale studies across the African continent.²¹

In summary, although unique genetic associations with T1D have been seen in different African populations, progress in the field has been limited by the small sample sizes (ranging from a total sample size of

Population	Sample size	Risk alleles	Protective alleles	Genotyping method	Reference
Egyptian	68 cases and 120 controls	B*8		PCR-SSP	El-Amir et al., 2019 ¹⁹
Malian	99 cases and 200 controls	B*27:05 A*24:02 A*29:02 C*02:02	A*30:01 A*74:01 B*42:01 B*53:01	NGSgo-MX11-3 system	Noble et al., 2024 ²²
European (Denmark; Human Biological Data Interchange; Joslin Diabetes Center; Sardinia) and four T1DGC networks (Asia Pacific; European; North American; United Kingdom)	1753 T1D probands and 1585 affected family-based control chromosomes	A*24:02 A*02:01 B*18:01 C*05:01	A*11:01 A*32:01 A*66:01 B*07:02 B*44:03 B*35:02 C*16:01 C*04:01	PCR-based SSOP system	Noble et al., 2010 ²⁷

Table 2: Associations of HLA-A, HLA-B and HLA-C alleles with T1D in African and European studies.

184–677) and lack of GWAS highlighting the need for larger powered studies across Africa to inform T1D risk determination, improved diagnostic accuracy and the possibility of tailored treatment plans.

Type 2 diabetes

T2D is the most common type of diabetes, often accounting for 80–90% of all diabetes cases globally. Non-genetic factors (e.g. age, obesity and behaviour) and over 600 loci contribute to T2D risk in multi-ancestry studies.³⁵ Progress in identifying genetic risk factors in Africa has been slow, with initial studies including linkage and candidate gene studies that evaluated GWAS-associated loci from predominantly European ancestry populations.^{36–39}

The first set of GWAS of T2D in Africa were published in 2019 (Table 3). The first GWAS included 5231 individuals enrolled from Nigeria, Ghana, and Kenya, in the Africa America Diabetes Mellitus Study (AADM) and identified two genome-wide significant loci-*TCF7L2* (a well-known T2D locus) and *ZRANB3*, a novel T2D locus.⁴⁰ Functional data from zebrafish and *in vitro* cell line models supported a role for *ZRANB3* in T2D risk and aetiopathogenesis. The discovery of *ZRANB3* added to the growing list of T2D risk loci that were first discovered in under-studied populations, such as *KNCQ1* in East Asians and *SLC16A11* in

Mexicans and other Latin Americans.^{42–44} The study also showed transferability of 32 established GWAS-associated T2D loci, thereby identifying a set of T2D loci that are shared with other populations.

The second GWAS was a meta-analysis that included 4347 participants from the AADM study and two South African studies and identified *TCF7L2* as the most significantly associated locus, thereby confirming its role in West Africans, East Africans, and Southern Africans.⁴¹ Notably, fine-mapping of the *TCF7L2* locus identified one signal shared between Europeans and Africans (indexed by rs7903146) and a distinct African-specific signal (indexed by rs17746147). The study also detected one novel candidate locus near *AGMO* (indexed by rs73284431) which is monomorphic in most non-African populations and distinct from previously reported signals in the region.

While these studies have been included in larger collaborative meta-analyses for T2D, no other GWAS for T2D have been published specifically from African populations. A few studies investigated glycaemic traits such as fasting glucose, fasting insulin, HbA1c or HOMA indices.^{45,46} In general, the findings of GWAS for such traits only have a partial overlap with GWAS for T2D though they can elucidate important pathophysiology. The more recent of these studies did a GWAS of fasting glucose, fasting insulin, insulin

Population	Sample size	Gene	Variant (Effect allele)	Reference
Discovery: Ghanaians, Nigerians and Kenyans Replications: South African (Zulu)	Discovery: 5231 (2342 T2D cases, 2889 controls) Replication: 2578 (1602 T2D cases, 976 controls)	<i>TCF7L2</i> <i>ZRANB3</i> <i>HMG2</i>	rs7903146 (T) rs1465146591 (A) rs138066904 (C)	Adeyemo et al., ⁴⁰
Meta-analysis GWAS of South African Zulu, Ghanaians, Nigerians and Kenyans	4347 (2633 T2D cases, 1714 controls)	<i>TCF7L2</i> <i>AGMO</i>	rs7903146 (T) rs17746147 (C) ^a rs73284431 (G)	Chen et al., ⁴¹

^aSecond independent variant at the *TCF7L2* locus.

Table 3: Significant genetic associations with T2D in African studies.

resistance (HOMA-IR) and beta cell function (HOMA-B), in ~10,000 individuals from Burkina Faso, Ghana, Kenya and South Africa within the context of the Africa Wits-INDEPTH Partnership for Genomics Studies (AWI-Gen).⁴⁶ The findings included genome-wide significant associations of fasting glucose with *ANKRD33B*, fasting insulin with *WDR7* and HOMA-IR with *ADMATS16* and *B4GLAT6*, the first two of which are novel associations. Several known GWAS-associated loci with fasting glucose were replicated, including variants in *GCK-YTK6*, *SLC2A2* and *THORLNC*.

In summary, there is a paucity of genome-wide association studies of T2D in Africa. However, the few studies that have been done yielded novel discoveries while confirming several previous findings of risk loci in other populations. The broad genetic diversity of African populations and the heterogeneity in environment, diet and behavioural factors suggest that more studies are needed to fully characterise the genetic risk factors of T2D in Africa.

Gestational diabetes

GDM is defined as diabetes first diagnosed after 15 weeks of gestation that was not present prior to conception, and that is not another type of diabetes first detected during pregnancy.⁴⁷ GDM affects approximately 14% of pregnancies in Africa, on par with the global estimates.⁴⁸

Globally, genetic studies of GDM are lagging relative to T2D. Since GDM is thought to have shared genetic aetiology with T2D, early studies focused on testing established T2D risk loci (e.g. *CDKAL1*, *TCF7L2*, *KCNJ11*, *GCK*, *MTRN1B*) and found they are also associated with GDM.⁴⁹ Few of these studies included Africans, with the only studies from the continent from Egypt and South Africa testing candidate SNPs for association with GDM.^{50,51} However, the sample sizes in these studies were modest (ranging from total sample size of 160–447) and there were therefore the inherent problems of lack of power and the risk of both false-positive and false-negative findings.

More recently, a genome-wide multi-ancestry meta-analysis, including 5485 women with GDM and 347,856 without GDM identified 5 loci associated with GDM (mapping to/near *MTNR1B*, *TCF7L2*, *CDKAL1*, *CDKN2A-CDKN2B* and *HKDC1*).⁵² However, the 1.7% African ancestry individuals included in the study were African Americans from the United States, so in addition to having European admixture, they do not represent the genetic diversity observed in continental African populations.

To date, the largest GDM GWAS (2332 cases and 131,109 women without GDM) from the Finnish FinnGen study, identified 13 loci associated with GDM.⁵³ The authors suggested that the genetic aetiology of GDM should be partitioned into a T2D risk component, and a component primarily reflecting

mechanisms disrupted by pregnancy.⁵³ However, no African participants were included in these analyses and therefore the shared and distinct genetic aetiology of GDM and T2D in Africa remains unexplored.

Impact of genetics on diabetes precision medicine

The translation of genetic knowledge to clinical care has the potential to enable precision medicine. Following the precision medicine EPOS framework, we will discuss how genetic information can be used to aid diabetes diagnosis, risk prediction and classification, treatment selection, and monitoring (Fig. 1).⁵⁴ Improved risk prediction for those at higher likelihood of developing diabetes can inform resource allocation and prevention strategies. Additionally, genetic data provide accurate molecular diagnosis for monogenic diabetes and aid diabetes classification, both required to optimise therapeutic regimens and improve quality of life. Lastly, appropriate interpretation of biomarker thresholds, informed by the impact of genetic variation, are essential for individual diagnosis, monitoring and appropriate treatment escalation, and to understand the population burden of diabetes.

Molecular diagnosis facilitates tailored therapy

The management of monogenic diabetes is arguably one of the biggest successes of the application of genetics in diabetes care, highlighting the importance of making an accurate molecular diagnosis. This is a good example of how accurate personalised diagnosis affects treatment selection (Fig. 1).

NDM and MODY cases are often clinically misclassified as T1D due to their early age of onset. Identification of a pathogenic variant that explains disease occurrence in a patient not only provides an accurate diagnosis but is critical in implementing the appropriate therapy. For example, patients with NDM with mutations in *ABCC8* or *KCNJ11* can usually be effectively managed with oral sulphonylureas rather than insulin.^{55,56} Likewise, sulphonylureas are also standard of care for MODY patients with *HNF1A* or *HNF4A* pathogenic variants.¹¹ In contrast, patients with MODY caused by *GCK* pathogenic variants usually have mild stable hyperglycaemia and low risk of microvascular complications and can be managed without pharmacologic treatment.⁵⁷ The exception is pregnant women who should be treated with insulin if the foetus has not inherited the *GCK* variant to prevent the foetus from becoming large for gestational age.⁵⁸

These advances in personalised care of people with monogenic diabetes have not, however, been extended to Africa. Successful cessation of oral hypoglycaemic therapy and transition from insulin to sulphonylurea therapy have been reported in individuals from Tunisia and Cameroon after identification of *GCK* and *HNF1A*

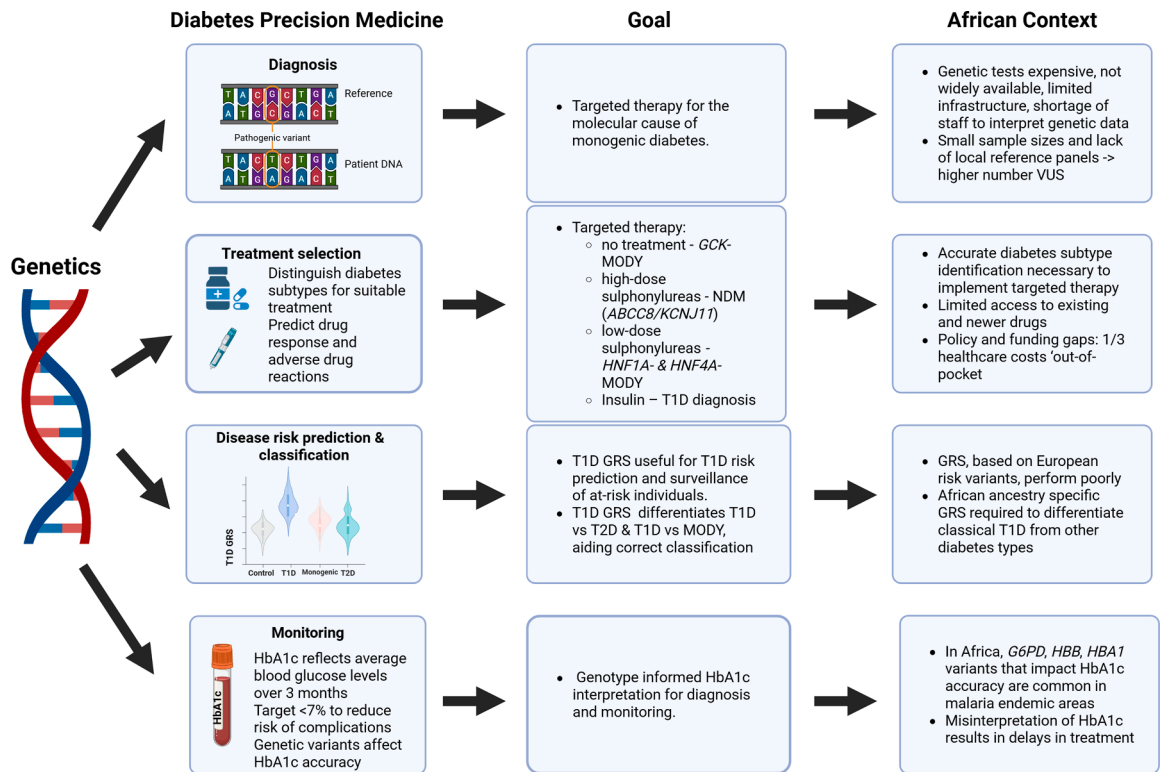


Fig. 1: Diabetes Precision Medicine: General Goals and African Context. Four pillars of precision medicine are represented corresponding to diagnosis, treatment selection, disease risk prediction and classification and monitoring. For each pillar the broader global goal is described as well as the African context. Created in BioRender. Barroso, I. (2026) <https://BioRender.com/gdrl3ym>.

pathogenic variants, respectively.^{12,13} However, the absence of accessible and appropriately tailored genetic testing in most of the continent makes it impossible to identify individuals with monogenic diabetes syndromes on any appreciable scale (Fig. 1).

To help prioritise expensive genetic testing to those individuals most likely to have MODY, MODY probability calculators have been developed. These use standard clinical features to predict which patients presenting with hyperglycaemia are most likely to have MODY and would therefore benefit from genetic testing. This approach is designed to limit expensive genetic testing whilst ensuring the benefits of targeted therapeutics could be realised. However, existing MODY calculators have been developed in European ancestry populations (<https://www.diabetesgenes.org/>) and have been reported to overestimate MODY in some multi-ethnic populations in the United States.^{59,60} Little data are available on their performance in African populations, further hampering their usage to prioritise patients for genetic testing in this region.

In summary, although the identification of a genetic mutation underlying monogenic diabetes is the exemplar of personalised medicine, the ability to implement this approach across Africa has been hampered by the

lack of appropriate MODY prediction models, the expensive nature of genetic testing and lack of infrastructure and human resources to support these efforts.

Use of genetic risk scores in risk prediction and diabetes classification

One of the major opportunities for clinical translation of GWAS is in developing genetic risk scores (GRS) for the prediction of diabetes or to aid disease classification. These scores provide a summary of heritable disease risk encoded in an individual's genome. However, the use of such GRS has come with an increased concern that such tools, built on research findings from predominantly European ancestry individuals, perform poorly among other populations, and would increase health disparities.⁶¹

T1D GRS for disease prediction

Several T1D GRS have been developed to determine an individual's risk of developing T1D. Risk prediction for the development of T1D can facilitate closer monitoring of at-risk individuals and reduce the likelihood of severe metabolic decompensation at the time of presentation, which is critical given the under-resourced health care systems in several parts of Africa.

While several T1D GRSs have been developed that differ in the number of HLA and non-HLA variants present, these are predominantly derived from European populations which may limit their applicability in genetically diverse African populations. A European ancestry derived T1D GRS (30 variants) had reduced predictive power in a self-identified African-American cohort (area under the curve [AUC]:0.752) compared to its application in self-identified White (AUC:0.860) and Asian Americans (AUC: 0.918).⁶² In contrast, a GRS consisting of 19 variants associated with T1D in European populations was able to discriminate between participants with T1D and controls (GRS: 0.189 vs. 0.154) in an Ethiopian population.²¹

The first African-ancestry specific GRS for T1D (AAGRS) was developed in 2019 from African-American data and consisted of seven single nucleotide polymorphisms-five in the HLA region and two non-HLA variants.⁶³ Use of the AAGRS significantly improved the prediction of T1D risk compared to a European based GRS (GRS1) consisting of 30 variants (five HLA and 25 non-HLA) (AUC: 0.871 vs. 0.798).⁶⁴ In addition, the AAGRS was able to differentiate between T1D and T2D (AUC: 0.787).⁶³

A 67-variant GRS (GRS2), including risk alleles common in non-European populations and a broader spectrum of HLA variants, showed improved classification of T1D in self-identified non-Hispanic White (AUC: 0.864 vs. 0.851), Hispanic (AUC: 0.935 vs. 0.825) and Black participants (AUC: 0.851 vs. 0.807) from the SEARCH study in the United States compared to GRS1.^{64,65} The performance of each of GRS1, GRS2 and AAGRS was evaluated in the YODA (Cameroon and Uganda) and SEARCH datasets. GRS2 and AAGRS had significantly higher discriminative power than GRS1 in the Cameroonian (AUC: 0.876, 0.885 and 0.834, respectively), Ugandan (AUC: 0.890, 0.879 and 0.800, respectively) and African American populations (AUC: 0.839, 0.838 and 0.796, respectively).⁶⁶ GRS2 had the greatest predictive power in the American White (AUC: 0.878) and Hispanic datasets (AUC: 0.868) whereas the AAGRS had the lowest power (AUC: 0.810 and 0.789, respectively) in these two groups.⁶⁶ These findings suggest that multi-ancestry GRS may be more applicable in some African populations, but not necessarily others, and further evaluation in more diverse datasets is necessary.

T1D GRS for disease classification

T1D GRS have been useful in differentiating between individuals with clinical features that overlap between different diabetes types. Different versions of T1D GRS have been useful in differentiating individuals who have T1D from those with MODY or T2D.^{64,67} A successful application of the GRS2 was recently reported in Cameroonian, South African and Ugandan participants with youth onset, clinically diagnosed T1D. In this study, approximately 65% of clinically diagnosed T1D

patients were found to be insulin deficient but auto-antibody negative. These individuals had significantly lower genetic susceptibility to T1D measured by GRS2, compared to insulin deficient autoantibody positive patients (GRS: 9.66 vs. 11.76), suggesting a novel type of non-autoimmune insulin deficient diabetes subtype common in sub-Saharan Africa.¹⁶

T2D GRS for disease prediction

Unlike T1D where HLA alone captures a significant proportion of T1D risk, the risk for T2D is distributed among thousands of variants across the genome which overall capture the risk of T2D less well. Therefore, the clinical utility of T2D GRS for diabetes risk prediction is still debated.⁶⁸ Nonetheless, the first evaluation of GRS for T2D in sub-Saharan Africa was done as part of a GRS study of 12 cardiometabolic traits comparing their performance in Africans to African Americans and European Americans.⁶⁹ The predictive utility of GRS was tested in a sample of ~25,000 individuals that included 5200 Africans, 9139 African Americans, and 9594 European Americans. For T2D, the GRS was associated with risk of T2D in all three groups but showed the lowest predictive utility in the Africans, though the measure of this difference is not provided.

A more recent study of GRS for T2D prediction in Africa tested the hypothesis that using African American, European, or multiethnic-derived GRS could improve prediction in continental Africans. The analysis showed that the discriminatory ability of the African American (AUC: 69.8%) and multiethnic GRS (AUC: 69.9%) was similar in a full model with clinical risk factors, but African American-derived GRS was more transferable in the countries represented in the continental African study (AADM) and was more predictive of T2D in the country combined analysis compared with the European and multiethnic-derived scores. The study showed that, given currently available data, African American-derived GRS enhanced prediction of T2D in some continental African populations.⁷⁰

GDM risk scores have been developed but their clinical utility has not yet been validated for any population, and none have been based on data from continental Africa populations.⁷¹⁻⁷⁴

In summary, while there are ongoing efforts to develop T2D GRS and make these more relevant for populations around the world, more work is needed to increase their transferability and applicability to different African populations. In addition, the application of these scores for risk prediction, in combination with other clinical factors, is still an area of ongoing development.

Impact of genetic variants on the accuracy of diabetes biomarkers for precision diabetes diagnosis and monitoring

Glycated haemoglobin (HbA1c) is the established biomarker for monitoring glycaemic control in

individuals with diabetes and is increasingly used for diabetes diagnosis.⁷⁵ HbA1c is an indirect measure of glucose, resulting from the non-enzymatic binding of glucose to haemoglobin inside the red blood cell.⁷⁵ Therefore, HbA1c measurement can be affected by both glycaemic and non-glycaemic factors (for example factors that affect erythrocyte lifespan), including common genetic variants that associate with HbA1c without affecting glycaemia.⁷⁶

Some of these non-glycaemic HbA1c-associated genetic variants are common across different African populations as they convey a selective advantage in malaria-endemic regions. These variants can affect the accuracy of HbA1c as a proxy measure of glucose and limit the applicability of universal HbA1c diagnostic and therapeutic thresholds. For example, the X-linked *G6PD* rs1050828 variant, (NM_000402.4:c.292G>A, p.Val98Met) which causes glucose-6-phosphate dehydrogenase (G6PD) deficiency, reduces the lifespan of the red blood cell and is associated with falsely low HbA1c levels. For any given glucose level, hemizygous men and homozygous women have 0.81% and 0.68% lower HbA1c levels, respectively which likely contributes to the delayed diabetes diagnosis, delayed treatment escalation and increased risk of diabetes complications in people with G6PD deficiency.^{77–83} Consistent with random X chromosome inactivation, heterozygous women have a more modest reduction in HbA1c (0.26%).⁷⁷

G6PD deficiency is common in malaria-endemic regions of the world as it confers relative protection against severe malaria. Central sub-Saharan Africa has the highest incidence of G6PD deficiency worldwide, with the rs1050828 combined with the rs1050829 variant (NM_000402.4:c.466A>G, p.Asn156Asp)

forming the A-haplotype that is common in the sub-continent.^{84–87} Significant allelic heterogeneity exists, with other variants identified in several countries including Ethiopia, Senegal, The Gambia and Eritrea.^{88–94} Investigating the effect of these additional *G6PD* variants on HbA1c is needed to fully understand their potential impact on diabetes diagnosis and management.

Other common variants that protect against severe malaria in different African populations and that associate with HbA1c but not glucose levels include the α -3.7 thalassaemia deletion in a rural Ugandan population cohort, the sickle cell anaemia causal variant rs334 in *HBB*, and variant rs148228241 in an intron of *HBA1*.^{45,76,95} Notably, as many of these variants are associated with falsely low HbA1c measurement, delays in diabetes diagnosis or in treatment escalation can occur, leading to increased risk of complications.

In addition to the above-mentioned variants, common non-glycaemic genetic variants associated with lower HbA1c levels are associated with higher prevalence of retinopathy in European and African ancestry individuals, highlighting the clinical implications of the underestimation of glycaemia that can occur with these non-glycaemic HbA1c-associated variants.⁹⁶

Overall, these findings highlight the importance of recognising the effects of genetic variants that alter the accuracy of HbA1c test as a proxy measure of glucose, so this information can be considered when diagnosing patients and making treatment decisions. However, additional work is required to understand the individual and public health impact of these variants, particularly in different populations in Africa where the prevalence of these genetic variants is hugely variable.

Diabetes subtype	Common genetic associations in African populations	Common genetic associations in European population	Precision medicine implications
Neonatal diabetes	<i>EIF2AK3</i> ^a	<i>ABCC8</i> ^b ; <i>KCNJ11</i> ^b	<i>EIF2AK3</i> : require insulin therapy; investigation for neurologic, skeletal and hepatic features <i>ABCC8</i> ; <i>KCNJ11</i> : can be treated with sulphonylureas; investigation for neurologic features
Maturity onset diabetes of the young	Insufficient data available	<i>GCK</i> ; <i>RFX6</i> ; <i>HNF4A</i> ; <i>HNF1A</i> , <i>HNF1B</i> ^c	<i>GCK</i> : managed with lifestyle modification <i>RFX6</i> : may be treated with non-insulin therapies <i>HNF4A</i> ; <i>HNF1A</i> : highly sensitive to sulphonylureas
Type 1 diabetes	Greater genetic diversity with African specific haplotypes eg. HLA-DR9 Candidate gene studies with small sample sizes, GWAS rare and insufficiently powered	The greatest risk is conferred by the HLA DR3-DQ2 and DR4-DQ8 haplotypes Non-HLA include >75 risk loci, including susceptibility genes <i>INS</i> , <i>CTLA4</i> , <i>IL2RA</i> , <i>IL10</i> and <i>PTPN22</i>	In black African populations the risk of misdiagnosis is high, ancestry-specific risk prediction tools are needed together with new diagnostic criteria and therapeutic strategies
Type 2 diabetes	Limited data; At genome wide significance, <i>TCF7L2</i> (in common with most other populations), <i>ZRANB3</i> and <i>AGMO</i> (novel locus in Africans); 32 replicated loci from previous studies.	Over 600 common genetic associations	Evidence base for GRS for T2D prediction in Africa is poor and its potential clinical utility is currently unknown

^aIn populations with high prevalence of parental consanguinity. ^bIn populations with a low prevalence of parental consanguinity. ^cPrevalence based on an unselected population based cohort.¹⁰⁰

Table 4: Common genetic associations with diabetes in African and European populations and precision medicine implications.

Challenges in the implementation of diabetes-related precision medicine in Africa

Adequate study of the influence of genetics on diabetes in Africa would require the investment of significant financial, infrastructural and human resources. Multi-site studies would be necessary to truly capture the extent of the significant genetic diversity in the continent. In-country infrastructure and capacity development would be essential to ensure African scientists can collect, analyse and longitudinally store samples from their populations, and community engagement would be vital in ensuring participant communities fully understand and can benefit from research endeavours. As it stands, investment in research by African governments is low, with governments in sub-Saharan Africa spending 0.44% of their gross domestic product on research and development in 2007 and those in North Africa spending between 0.48 and 0.91% according to the most recent figures available from the World Bank.⁹⁷

Clinical applications of novel or existing insights into the genetic aetiology of diabetes are, unfortunately, likely to remain inaccessible to much of the continent for some time. While testing for genetic variants has become cheaper, it is still prohibitively expensive for much of Africa, particularly when one considers that nearly a third of health care expenditure in sub-Saharan Africa is out-of-pocket.⁹⁸ The potential benefits of personalised approaches to diabetes management must also be considered in the context of limited access to basic diabetes therapies. In 2021, the age-standardised treatment coverage for diabetes for adults in the World Health Organisation Africa region aged 30 years and older was 26%.⁹⁹ Introduction of personalised approaches to diabetes management will only improve population outcomes if diabetes care as a whole is improved.

Outstanding questions

Much remains unknown about the genetic aetiology of diabetes in Africa (Table 4). Further research initiatives across several different areas are necessary before the promise of diabetes precision medicine can begin to be fulfilled in the continent.

Given the huge genetic diversity across the African continent, the backbone of future research will be more complete characterisation of the genetic architecture in different African populations through the generation of large-scale sequencing data and complex phenotyping from large cohorts of unselected individuals from diverse populations. These datasets will enable rare variant interpretation in monogenic diabetes, and potentially help identify additional variants that are responsive to tailored therapy. Larger-scale GWAS in patients with type 1 and type 2 diabetes from across the continent will help elucidate

Search strategy

Articles for this Review were identified by PubMed searches and included articles from database inception to September 2025, using terms "Diabetes mellitus/genetics" [Mesh] AND "Africa". Additional search terms included "monogenic diabetes", "type 1 diabetes", "HLA", "type 2 diabetes", "gestational diabetes", "HbA1c", "glucose-6-phosphate deficiency" each combined with Boolean term AND "Africa". Articles that were not in English, where the full text could not be accessed, that were not human studies based on titles and abstracts were excluded. Articles were evaluated to confirm that they contained original human genetic research and were studies done on the African continent, those where this was not the case were excluded. Additional references were obtained from references in relevant articles. Additional references citing other reviews and diabetes studies from across the world were also included as background and context.

relevant pathophysiological pathways which may be unique to certain populations in Africa, given the continent's unique population history, diverse geographical features and highly variable environmental exposures.¹⁶

To aid physiologic and pathophysiological characterisation of the different types of diabetes present across different populations in the African continent, deep phenotyping of patients and unaffected individuals will be required. Such phenotyping should include detailed physiologic and imaging studies, as well as further OMIC characterisation in both affected and unaffected individuals (e.g. transcriptomic, proteomic and metabolomic) which will enable more in depth understanding of causal mechanisms and pathways and may identify novel therapeutic targets.

Furthermore, detailed characterisation of the number and prevalence of genetic variants that affect the accuracy of the HbA1c measurement in populations across Africa, is crucial to understand the impact they are having on diagnosis and treatment. Adequate genotype-informed interpretation of HbA1c diagnostic and therapeutic thresholds may be required, or use of alternative biomarkers may be needed, to prevent increased risk of diabetes complications.

Finally, it is critical to expand initiatives to develop genomic medicine expertise in Africa, such as those of The African Genomic Medicine Training Initiative,¹⁰¹ to ensure effective translation from genetic discovery to bedside.

Contributors

All authors performed literature searches. IB and CP drafted Fig. 1, CP drafted Tables 1 and 2, AA drafted Table 3, AW drafted Table 4. All the authors drafted different sections of the manuscript. All the authors edited, read and approved the final version of the manuscript, including Tables and Figure.

Declaration of interests

AW declares support from Novo Nordisk to attend a medical education event. AW is a clinical co-chair for the Research Affairs Core Committee of the Endocrine Society and a member of the Diabetes Guidelines Committee for the Society for Endocrinology, Metabolism and Diabetes of South Africa. AA is funded by National Institutes of Health (NIH) through the Center for Research on Genomics and Global Health (CRGGH). IB declares support from MRC (MR/W014416/1) and infrastructure support from the National Institute for Health and Care Research Exeter Biomedical Research Centre. The views expressed are those of the authors and not necessarily those of the NIHR or the Department of Health and Social Care. IB declares support from Diabetes UK for travel and conference registration expenses for delivery of Dorothy Hodgkin Prize Lecture 2025, and from the European Association for the Study of Diabetes for conference registration and travel expenses as an invited symposium speaker at the 2025 meeting. IB was Co-chair for Wellcome Career Development Interview Committee until September 2025, and is member of Diabetes UK research committee, and is faculty of Diabetes UK IDia programme.

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