

Ethnic disparities in glycaemic biomarkers among multi-ethnic populations: A narrative review of evidence from Sub-Saharan Africa and global contexts.

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Abstract

Accurate diagnosis and monitoring of diabetes mellitus rely on biomarkers such as glycated haemoglobin (HbA1c) and fasting plasma glucose (FPG), yet the reliability of these biomarkers may vary across ethnic populations due to genetic, haematological, and lifestyle factors. Despite growing evidence of ethnic disparities, no comprehensive synthesis has focused on Durban's multi-ethnic population within the broader Sub-Saharan African and global context.

This narrative review synthesises evidence from over 50 studies examining ethnic variations in HbA1c and FPG levels, the concordance between these biomarkers, and the contributing genetic, lifestyle, and healthcare factors, with particular emphasis on Durban, Sub-Saharan Africa, and global comparative populations.

The review reveals consistent evidence that Indian/South Asian populations exhibit poorer glycaemic control compared to African and White counterparts. HbA1c frequently overestimates glycaemia in non-White populations, leading to discordance with FPG-based diagnoses. Genetic diversity, dietary patterns, healthcare access, and urbanisation interact to shape these disparities. The pathogenesis of type 2 diabetes in Black Africans appears to diverge from European-derived models, underscoring the need for population-specific research. Quality assessment of the reviewed literature revealed considerable heterogeneity, with 36% of studies rated high quality, 44% medium quality, and 24% low quality, with common limitations including lack of OGTT confirmation, absence of haematological correction, self-reported lifestyle data, and predominance of cross-sectional designs.

Population-specific diagnostic thresholds, contextually tailored interventions, and improved healthcare access are urgently needed to address ethnic inequities in diabetes care. Future research should prioritise comparative studies within multi-ethnic urban settings, longitudinal designs, and investigation of genetic-epigenetic-lifestyle interactions to inform equitable, evidence-based diabetes prevention and management strategies.

Keywords: Glycaemic biomarkers, Multi-ethnic populations, Ethnic disparities, Sub-Saharan Africa

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Background

Accurate diagnosis and monitoring of diabetes mellitus relies heavily on biomarkers, notably glycated haemoglobin (HbA1c) and fasting plasma glucose, to facilitate detection and monitoring of the condition (American Diabetes Association, 2021). The reliability of these biomarkers may be influenced by genetic, environmental, and lifestyle factors that differ across populations (Sifunda et al., 2023). However, the HbA1c biomarker primarily relies on the lifespan of red blood cells, which can render it inaccurate in individuals with red blood cell abnormalities or conditions that affect erythrocyte turnover or haemoglobin metabolism (Ram et al., 2024). Certain clinical conditions, such as anaemias and haemoglobinopathies, can impact the accuracy of

HbA1c measurements. Examples of these conditions include sickle cell disease and thalassaemia, which can alter red blood cell lifespan or haemoglobin structure, thereby affecting HbA1c interpretation (Hird et al., 2016). Despite its limitations in specific populations, both HbA1c and fasting glucose continue to be valuable and reliable biomarkers in the diagnosis and management of diabetes, supported by extensive clinical evidence and widespread adoption in clinical practice (Ram et al., 2024). Consistent and comparable measures of glycaemia are crucial for accurate diagnosis and monitoring of diabetes and for population-level surveillance, given the increase in the global burden of diabetes (Hird et al., 2016).

Type 2 diabetes mellitus (T2DM) has emerged as a pressing global health issue, with its prevalence steadily rising over the past few decades, underscoring the need for effective prevention and management strategies (Tomic et al., 2022). In 2021, approximately 537 million adults (aged 20-79 years) were living with diabetes worldwide, a number anticipated to increase to 783 million by 2045 (International Diabetes Federation, 2021). Seventy-seven percent of diabetes-related fatalities in Africa occurred in individuals under sixty years of age, underscoring the gravity of the diabetes epidemic and the imperative to implement measures to mitigate premature mortality (International Diabetes Federation, 2017). Prolonged exposure to hyperglycaemia in patients with diabetes can result in significant long-term damage to multiple organ systems, including the retina, kidneys, peripheral nerves, cardiovascular system, and vasculature, thereby increasing the risk of severe diabetic complications (Papatheodorou et al., 2018).

The South African context

T2DM adds to the economic strain among South Africans (Mutymbizi et al., 2020). The financial burden faced by South Africans with diabetes hinders certain self-care practices related to their condition. Diabetes adds to expenses that affect individuals, families, communities, healthcare systems, and governments (Mutymbizi et al., 2020). For Type 2 diabetes, the costs of medication vary from R85 to R950 per month (Diabetes South Africa, 2025). Although HbA1c and fasting glucose testing incur costs, regular monitoring is cost-effective for a long-term condition like diabetes that requires ongoing management. For instance, treating diabetes-related complications such as haemodialysis can reach R250,000 annually for a single individual (Diabetes South Africa, 2025). HbA1c testing is typically recommended every three months to evaluate glycaemic control and track the success of diabetes management approaches (SEMDSA, 2017). The expense of travelling to and from the clinic or hospital is a crucial issue, especially for those living far away, which may result in worse health outcomes.

Durban's ethnically diverse population presents additional complexity in diabetes screening and management. Research indicates that HbA1c accuracy may vary among ethnic groups, which has implications for diagnostic thresholds and treatment decisions (Wade et al., 2021). While previous studies have explored ethnic differences in diabetes prevalence and biomarker reliability, there remains a lack of data for multi-ethnic populations like Durban, particularly among Indian, Coloured, and White groups, who are underrepresented in current literature relative to Black African populations.

The research problem

Diabetes mellitus is a complex, chronic metabolic disorder that poses major public health challenges both globally and in South Africa. Effective glycaemic control, commonly assessed using glycated haemoglobin (HbA1c) and fasting plasma glucose (FPG), is essential to reduce the risk of complications such as neuropathy, nephropathy, and cardiovascular disease (Motala et al., 2022). Despite national guidelines, disparities in diabetes outcomes persist, particularly among ethnically diverse populations.

Durban, KwaZulu-Natal, is one of South Africa's most culturally and genetically diverse urban centres, home to large African, Indian/Asian, and White communities (eThekweni Municipality, 2017; Statistics South Africa, 2016). Prior research has documented ethnic differences in the prevalence of type 2 diabetes mellitus (T2DM), as well as variations in risk factors such as obesity, physical activity, and healthcare access (Duhuze et al., 2023). However, limited studies have directly compared glycaemic control, as measured by both HbA1c and fasting glucose, across these ethnic groups within this local context. Existing national surveys often overlook intra-urban disparities, and as such, the specific drivers of poor glycaemic control in these populations remain poorly understood.

Emerging evidence also suggests that genetic susceptibility to T2DM may vary across ethnic groups, with African populations displaying greater genetic diversity in diabetes-related loci (Asamoah et al., 2020). However, the extent to which these differences explain observed disparities in glycaemic control, relative to modifiable factors like diet, physical activity, or medication adherence, remains unclear (Sibiya et al., 2024). This gap in localised knowledge limits the development of contextually tailored and population-specific interventions for diabetes prevention and management.

If these disparities remain unaddressed, at-risk populations in Durban may continue to experience disproportionate burdens of diabetes-related morbidity and mortality. Tailored, evidence-based strategies are urgently needed to improve equity in health outcomes.

Rationale for this review

Despite the growing body of evidence documenting ethnic disparities in glycaemic biomarkers, no comprehensive review has synthesised findings from Durban, Sub-Saharan Africa, and global contexts to provide a unified understanding of these disparities. This review addresses this gap by systematically examining over 50 studies that have investigated ethnic differences in HbA1c and fasting glucose levels, the concordance between these biomarkers, and the contributing genetic, lifestyle, and healthcare factors.

Specifically, this review aims to:

- Synthesise evidence on ethnic variations in HbA1c and fasting glucose levels from Durban, Sub-Saharan Africa, and global populations
- Examine the concordance between HbA1c and fasting glucose across different ethnic groups
- Identify genetic, biological, lifestyle, and healthcare factors contributing to observed disparities
- Highlight critical gaps in the literature to guide future research
- Provide recommendations for clinical practice and public health policy in multi-ethnic settings

Scope and structure of this review

This review focuses on studies examining ethnic differences in HbA1c and fasting glucose among adult populations with or at risk for type 2 diabetes mellitus. Priority is given to studies conducted in Durban and Sub-Saharan Africa, with global studies from North America, Europe, Asia, and the Middle East included for comparative context. The review synthesises evidence from cross-sectional, cohort, observational, and genetic studies, as well as systematic reviews and meta-analyses.

Contribution of this review

This review contributes to the literature in several ways. First, it provides the first comprehensive synthesis of ethnic disparities in glycaemic biomarkers specifically focused on Durban within the broader Sub-Saharan African and global context. Second, it identifies consistent patterns across diverse settings while acknowledging important contradictions that warrant further investigation. Third, it highlights the clinical and public health implications of these disparities, including the need for population-specific diagnostic thresholds. Finally, it provides recommendations for future research, clinical practice, and health policy to address ethnic inequities in diabetes care.

By uncovering disparities in diagnostic accuracy and disease burden, this review aims to inform more equitable,

population-specific diabetes care and support the development of targeted public health interventions within Durban's diverse communities and beyond.

Methodology

Review design

This paper presents a systematic narrative review of ethnic disparities in glycaemic biomarkers (HbA1c and fasting plasma glucose) among multi-ethnic populations. A narrative synthesis approach was adopted to accommodate heterogeneity in study designs, populations, and outcome measures across the 50+ included studies.

Search strategy

A comprehensive literature search was conducted using PubMed/MEDLINE, Scopus, Web of Science, Google Scholar, Africa-Wide Information, and the South African National ETD Portal. Search terms included combinations of ("ethnic*" OR "racial" OR "population group") AND ("HbA1c" OR "glycated haemoglobin" OR "fasting glucose" OR "FPG") AND ("type 2 diabetes" OR "T2DM") with geographic filters for "South Africa," "Durban," "KwaZulu-Natal," and "Sub-Saharan Africa." Reference lists of included studies were manually screened.

Inclusion and exclusion criteria

Studies were included if they: (1) examined adult populations (≥ 18 years) with or at risk for T2DM; (2) compared two or more ethnic groups; (3) reported HbA1c and/or FPG levels; (4) were published in English between 2000-2025. Studies were excluded if they focused on type 1 diabetes or gestational diabetes, lacked ethnic group classification, or had sample sizes < 50 participants. The characteristics of the included studies, including geographical location, study design, sample size, populations assessed, glycaemic measures, key findings, and limitations, are summarised in (Table A.1–A.7)

Data sources and extraction

Data were extracted from 50+ studies identified through the search, including cross-sectional studies, cohort studies, observational studies, genetic studies, systematic reviews, and meta-analyses. Studies originated from South Africa (Durban, KwaZulu-Natal, Cape Town), other Sub-Saharan African countries (Nigeria, Tanzania, Uganda, Malawi, West Africa), North America, Europe, the UK, Asia, and the Middle East.

A standardised data extraction template captured: author, year, location, study design, sample size, ethnic groups

compared, biomarker measures, key findings, and limitations.

Quality assessment

Study quality was assessed using appropriate tools: JBI Critical Appraisal Checklist for cross-sectional studies, Newcastle-Ottawa Scale for cohort studies, AMSTAR-2 for systematic reviews, and STROBE checklist for observational studies. Studies were rated as high, medium, or low quality based on risk of bias, methodological rigour, and sample size.

Data synthesis

A narrative synthesis was conducted in four stages: (1) grouping studies by geographic region; (2) organising findings by theme (ethnic variations, concordance, contributing factors); (3) identifying patterns, contradictions, and gaps; (4) drawing conclusions relevant to Durban's multi-ethnic population. Findings are presented in textual synthesis and summary tables.

Literature review

This section synthesises evidence on ethnic differences in glycaemic biomarkers, particularly glycated haemoglobin (HbA1c) and fasting plasma glucose (FPG), across South Africa, Sub-Saharan Africa (SSA), and selected international populations. The review focuses on patterns of glycaemic control, concordance between biomarkers, and the biological, behavioural, and socioeconomic factors that may contribute to observed disparities.

Epidemiological transition and ethnic diversity in Sub-Saharan Africa

Ethnic variations in glycaemic biomarkers and diabetes prevalence

A substantial body of evidence demonstrates significant ethnic variation in glycaemic biomarkers and diabetes prevalence. Across South African studies, individuals of Indian ancestry consistently exhibit higher HbA1c and fasting plasma glucose (FPG) levels than African and White populations, indicating poorer glycaemic control and a greater burden of prediabetes and T2DM (Motala et al., 2022; Duhuze et al., 2023; Sosibo et al., 2023; Hamid et al., 2024). The findings presented in Tables 1A and 1B demonstrate that this pattern is observed across both

KwaZulu-Natal and Western Cape populations, suggesting that elevated glycaemic risk among individuals of Indian ancestry is not restricted to a single geographical setting. Studies conducted in Durban and KwaZulu-Natal consistently reported higher HbA1c and FPG levels among Indian populations than among African and White groups (Motala et al., 2022; Duhuze et al., 2023; Sibiya et al., 2024), while evidence from the Western Cape similarly identified individuals of Indian ancestry as having the highest HbA1c levels among the ethnic groups studied (Hamid et al., 2024; Table 1B).

In addition to ethnic differences in biomarker profiles, several South African studies reported poor overall glycaemic control, with high proportions of patients exhibiting HbA1c levels above recommended treatment targets and many receiving inadequate monitoring within routine healthcare settings (Rampersad et al., 2019; Zimu et al., 2023; Pillay et al., 2020). These findings indicate persistent challenges in diabetes management across diverse populations.

International evidence reinforces these observations. Studies from the United States, Canada, Malaysia, Mauritius, and the United Kingdom have shown that HbA1c values may differ across ethnic groups despite similar glucose concentrations (Cavagnolli et al., 2017; Booth et al., 2017; Akhtar et al., 2022). Furthermore, the international studies summarised in Tables A4-A6 demonstrate that minority populations frequently exhibit higher HbA1c values than White populations at equivalent levels of glycaemia, suggesting that universal diagnostic thresholds may not be equally applicable across all ethnic groups. Collectively, these findings indicate that ethnicity is an important determinant of glycaemic biomarker profiles and diabetes prevalence, with important implications for diabetes diagnosis, monitoring, and disease management.

Table 1. Evidence demonstrating poorer glycaemic control among Indian/South Asian populations

Summary table of key studies

***Note:** The complete table of all 50+ studies is presented below. Due to the comprehensive nature of this review, studies are organised by geographical region and theme.

Table 1A: South Africa – Durban and KwaZulu-Natal studies

Author (Year)	Study Location	Study Design	Sample Size	Ethnic Groups Compared	Measures	Key Findings	Limitations
Motala et al. (2022)	Durban, South Africa	Cross-sectional	500	African, Indian, White	HbA1c, FPG	Indians had significantly higher HbA1c and FPG levels compared to Africans and Whites.	Limited lifestyle data; cross-sectional limits causality
Duhuza et al. (2023)	KwaZulu-Natal, South Africa	Cohort study	350	African, Indian, White	HbA1c	Indian group showed poorer glycaemic control; socioeconomic factors influenced results.	Small sample size; lack of genetic data
Sibiya et al. (2024)	Durban, South Africa	Cross-sectional	420	African, Indian, White	HbA1c, FPG	Lifestyle variables can account for a portion of the ethnic variations in glycaemic management.	Cross-sectional design; lifestyle self-reported
Wade et al. (2021)	South Africa	Cross-sectional	765	Black South Africans	HbA1c, FPG	Prevalence of HbA1c was fourfold greater than that of fasting glucose; inadequate correlation between FPG and HbA1c.	OGTT not performed; postprandial glucose contribution could not be assessed
Hird et al. (2016)	Durban, South Africa	Population-based cross-sectional	1,190	Black South Africans	HbA1c, FPG	With an optimal threshold of 24 mmol/mol (6.0%), HbA1c can be used to diagnose diabetes in the urban Black South African population	Low proportion of men may limit generalizability.
Sosibo et al. (2023)	South Africa	Retrospective study	364	White, Black, Indian	HbA1c, IFG	Indian ethnic group had greatest frequency of pre-diabetes at 62.7%; development of prediabetes influenced by ethnicity.	Need for further research on genetic implications.
Rampersad et al. (2019)	KwaZulu-Natal, South Africa	Retrospective observational	2,450	Black, White, Coloured, Indian	HbA1c	Bulk of diabetic patients were Black (44.4%) and Indian (43.0%)	Poor adherence of medical personnel to SEMDSA guidelines; poor screening of long-term complications

Table 1A(Continuation): South Africa – Durban and KwaZulu-Natal studies

Author (Year)	Study Location	Study Design	Sample Size	Ethnic Groups Compared	Measure	Key Findings	Limitations
Zimu et al. (2023)	KwaZulu-Natal, South Africa	Cross-sectional	384	Various African ethnic groups	HbA1c, random glucose	With HbA1c cut-off >7%, 91% of participants had poorly managed diabetes	Small sample size; lack of genetic data
Govender et al. (2017)	South Africa	Retrospective observational	360	Black African, Indian, White, Coloured	HbA1c	This hospital's management of glycaemia was subpar	Limited lifestyle data
Pillay et al. (2020)	KwaZulu-Natal, South Africa	Pilot study	3,541	Various African ethnic groups	HbA1c, random glucose	Significant proportion had signs of diabetes despite no prior history; one third of diabetes patients exhibited suboptimal control.	Lack of specificity on ethnic groups
Sahadew et al. (2022)	KwaZulu-Natal, South Africa	Retrospective observational	N/A	Various African ethnic groups	IGT	Majority of diabetic patients were within public healthcare system	Limited lifestyle data; observational limits causality
Kone et al. (2023)	Gauteng, South Africa	Longitudinal study	511,781	Indian/Asian, White, African, Coloured, Unknown	HbA1c	Even with subpar management, most patients did not receive follow-up testing for four years; control of Black African patients was inadequate.	Limited lifestyle data
Thomas et al. (2015)	South Africa	Cohort study	1,998	Non-Caucasian	HbA1c	Non-Caucasian ethnicity and high baseline HbA1c linked to higher incidence of referable diabetic retinopathy	Lack of variation in diabetes markers

Table 1B: South Africa – Cape Town and Western Cape studies

Author (Year)	Study Location	Study Design	Sample Size	Ethnic Groups Compared	Measures	Key Findings	Limitations
Hamid et al. (2024)	Cape Town, South Africa	Cross-sectional	772	White, Black, Indian/Asian	HbA1c	HbA1c levels exhibited considerable variation; Indian descent presented the highest levels.	Selection bias; urban population only
Erasmus et al. (2012)	Bellville, Cape Town	Cross-sectional survey	642	Coloured population	IFG, IGT	Coloured population experienced notable increase in diabetes prevalence; elevated incidence of untreated diabetes.	Selection bias; Coloured population only
Zemlin et al. (2011)	South Africa	Observational with multiple samples	667	African, White, Indian	HbA1c, IFG	Optimal HbA1c threshold of 5.75% established and validated for diagnosing prediabetes	Did not test for iron deficiency anaemia, which may increase HbA1c results
Chikowore et al. (2017)	South Africa	Observational	2,010	Rural/urban, Black/White	HbA1c, FPG	In the Black South African population, dietary patterns are associated with reduced HbA1c and fasting glucose	Small variances explained suggest other unaccounted factors.

Table 1C: Other Sub-Saharan African studies

Author (Year)	Study Location	Study Design	Sample Size	Ethnic Groups Compared	Measures	Key Findings	Limitations
Nyebuchi et al. (2021)	Nigeria	Cross-sectional	150	Ijaws, Igbo, Yoruba	FPG, HbA1c	No significant difference in HbA1c levels; significant difference noted in FPG levels	Small sample size
Royce et al. (2024)	South Africa	Observational	N/A	Black South Africans	HbA1c, FPG	FPG comparable to HbA1c as diagnostic indicator for screening	Large amount of missing data for some variables
Chiwanga et al. (2022)	Tanzania, Uganda	Cross-sectional	736	Tanzanian, Ugandan	HbA1c, FPG	10.1% diagnosed with diabetes; highest frequency among rural Ugandans at 16.1%	Self-reported information bias
Rathod et al. (2018)	Malawi	Community-based cross-sectional	N/A	Various Malawian ethnic groups	HbA1c, FPG	HbA1c exhibits great sensitivity and specificity for diagnosing T2DM	Lack of ethnic diversity in results
Issaka et al. (2023)	Benin, Burkina Faso, Ghana, Liberia, Mali	Cross-sectional survey	15,468	Various West African ethnic groups	IFG	T2DM and IFG are over twice as common in urban vs rural areas; urban populations display behavioural risk factors	Cross-sectional design; cannot infer cause and effect.
Ekoru et al. (2016)	Sub-Saharan Africa	Longitudinal	12,000	Various African ethnic groups	OGTT, HbA1c, FPG	Pathogenesis of T2DM in Black Africans diverges from the European model; microvascular complications influenced by behavioural, lifestyle, and genetic factors.	Observational; cannot establish causation.

Table 1C (continuation): Other Sub-Saharan African studies

Author (Year)	Study Location	Study Design	Sample Size	Ethnic Groups Compared	Measures	Key Findings	Limitations
Goedecke et al. (2022)	Sub-Saharan Africa	Longitudinal review	N/A	Black African, European ancestry	OGTT	Need for longitudinal and intervention studies to understand T2DM pathogenesis in Black African populations.	Review article; no original data
Chikwati et al. (2025)	Sub-Saharan Africa	Longitudinal	N/A	Various African, Ugandan, East African, West African	FPG, IFG	Controllable risk factors contribute to elevated T2DM prevalence	Lack of variation in diabetes markers
Orazumbekova et al. (2025)	Sub-Saharan Africa	Systematic review and meta-analysis	10,694	Various African ethnic groups	Various	Non-White ethnic groups had 2-4-fold higher incidence and prevalence of T2D.	Lack of biomarker variation
Chikowore et al. (2016)	Sub-Saharan Africa	Cross-sectional retrospective	178	Black South African, Asian, European	HbA1c	GRSn gene linked to elevated T2DM risk; more important for under 50 and non-obese	Lack of ethnic variation

Table A4: North American studies

Author (Year)	Study Location	Study Design	Sample Size	Ethnic Groups Compared	Measures	Key Findings	Limitations
Wolffenbuttel et al. (2013)	America	Global study	1,879	Caucasian, African descent, Asian, Hispanic	HbA1c, estimated AG, self-monitored	Non-Caucasian populations demonstrated elevated HbA1c levels at specific glycaemic thresholds.	Lack of data on quality of BG self-monitoring
Bergenstal et al. (2017)	US	Prospective 12-week observational	208	Black, White	HbA1c, glycated albumin	Due to racial differences in hemoglobin glycation, HbA1c in Black persons may overstate average glucose relative to White individuals.	Too few participants with HbA1c <6.5%
Cavagnoli et al. (2017)	US	Systematic review & meta-analysis	N/A	Black, White, Asian, Latino	HbA1c	Black, Asian, Latino exhibited elevated HbA1c (0.08-0.26%) vs White	Lack of quantitative FPG and/or 2-h plasma glucose
Herman et al. (2017)	America	Observational	3,819	White, Asian American, American Indian, African American, Hispanic	HbA1c, IGT	Average HbA1c 5.91%; minority groups demonstrated elevated values compared to White individuals	HbA1c may not be valid for comparing glycaemic control across groups.
Karter et al. (2023)	US	Retrospective observational	1,788	African American, Asian, Latino, White	HbA1c, mean glucose	African Americans had higher HbA1c for the same mean glucose; Asian and Latino did not differ from White.	Limited lifestyle and sample size
Nathan et al. (2021)	US	Prospective substudy	1,454	Non-Hispanic White, Non-Hispanic Black, other	FPG, HbA1c	Considerable differences in association between average glucose and HbA1c; higher HbA1c in Black patients for same glucose	Heterogeneity of included studies
Harris et al. (2021)	USA	Systematic review	N/A	Black, Indigenous, people of colour, non-Hispanic White	HbA1c	Haematologic disorders may impact HbA1c measurements in the Black population.	Heterogeneity of included studies
Staimez et al. (2020)	Europe	Observational	202,500	White ancestry, Black ancestry	HbA1c, FPG	Incident retinopathy: 7% of White, 9% of African American over 11 years	Only two ancestry categories

Table A4(continuation): North American studies

Author (Year)	Study Location	Study Design	Sample Size	Ethnic Groups Compared	Measures	Key Findings	Limitations
Bancks et al. (2021)	US	Observational	1,293	South Asian, non-Hispanic Chinese, African American, Hispanic American	HbA1c, FPG	Race/ethnicity did not link with diabetes cluster membership; metabolic profiles varied by race/ethnicity.	Observational limits causality
Booth et al. (2017)	Canada	Observational with purposeful sampling	N/A	Caucasian, Black African descent	HbA1c, FPG, OGTT	Ethnic-specific HbA1c thresholds lower than Canadian guidelines; Black Africans had elevated HbA1c despite comparable glucose	Observational limits causality
Manley et al. (2019)	US	Retrospective observational	30,664	White European, South Asian, Afro-Caribbean	HbA1c	Higher HbA1c in South Asian and Afro-Caribbean for same glucose; haematological variations may explain	Lack of variation in diabetes markers
Antwi-Baffour et al. (2023)	US	Cross-sectional	384	Various African ethnic groups	HbA1c, FBG	Significant association between HbA1c and selected haematological markers	Lack of ethnic variation
Egede et al. (2011)	US	Cohort study	690,968	Non-Hispanic Black, Hispanic, other/missing/unknown	Medication possession ratio	MPR higher in rural vs urban veterans and across geographic regions	Lack of biomarkers

Table A5: European and UK studies

Author (Year)	Study Location	Study Design	Sample Size	Ethnic Groups Compared	Measures	Key Findings	Limitations
Dekker et al. (2015)	Amsterdam, Netherlands	Observational	3,776	Dutch, South Asian, African, Surinamese, Turkish, Moroccan	HbA1c, FPG	Meat and snack dietary pattern in Dutch associated with elevated FPG and HbA1c; ethnic disparities underscore need for culturally specific initiatives	Limited to five ethnic groups
Shipman et al. (2015)	UK	Observational	948	White, South Asian	HbA1c, FPG, fructosamine	South Asians have higher prevalence of haematological abnormalities; elevated adjusted HbA1c and fructosamine but lower fasting glucose	Limited to only 2 ethnic groups
Alloh et al. (2019)	UK	Systematic review	N/A	Black African, White, South Asian	HbA1c	Lower health outcomes among Black Africans compared to White and South Asian populations	Limited lifestyle data
Yip et al. (2017)	Europe and Asia	Cross-sectional	N/A	Caucasian, Asian	HbA1c, FPG	Caucasian cohorts exhibit greater prevalence of fasting glucose compared to Asian cohorts.	Only two ethnic groups

Table A6: Asian and Middle Eastern studies

Author (Year)	Study Location	Study Design	Sample Size	Ethnic Groups Compared	Measures	Key Findings	Limitations
Hare et al. (2013)	Mauritius	Observational	6,701	African (Rodrigues), South Asian, Chinese	HbA1c, OGTT	Using HbA1c as diagnostic criterion instead of OGTT indicated significantly higher diabetes prevalence among Africans from Rodrigues.	Limited lifestyle data; cross-sectional limits causality
Treister-Goltzman et al. (2024)	Southern Israel	Cross-sectional	59,432	Arab, Ethiopian Jew, non-Ethiopian Jew	HbA1c, FPG	HbA1c significantly influenced by ethnicity, explaining 0.6% of variance	Self-reported information bias
Akhtar et al. (2022)	Malaysia	Cross-sectional retrospective	293	Malaysian, Indian, Chinese	HbA1c, FPG	Malays and Indians have higher HbA1c; risk of hypoglycaemia is higher for Indians and Malays at any given FPG.	Limited ethnic variation
Kodama et al. (2013)	Global	Systematic review & meta-analysis	3,813 (74 cohorts)	African, Caucasian, East Asian	AIRg, IGR	Human blood glucose levels evolved over millions of years; migration may influence susceptibility.	Lack of variation in diabetes markers

Table A7: Indian/South Asian populations show poorer glycaemic control

Study	Finding
Motala et al. (2022)	Indians had higher HbA1c and FPG than Africans and Whites
Duhuze et al. (2023)	Indian group showed poorer glycaemic control
Sosibo et al. (2023)	Indians had 62.7% prediabetes frequency
Hamid et al. (2024)	Indian descent had the highest HbA1c levels
Shipman et al. (2015)	South Asians had elevated HbA1c but lower fasting glucose
Akhtar et al. (2022)	Malays and Indians have higher HbA1c
Manley et al. (2019)	South Asians had higher HbA1c for the same glucose

Concordance between HbA1c and fasting plasma glucose

Several studies have reported discordance between HbA1c- and glucose-based measures of diabetes,

particularly among non-White populations (Wade et al., 2021; Hird et al., 2016). As summarised in Table 2A, HbA1c frequently identified substantially more individuals as having diabetes than fasting plasma glucose, while studies from Canada, the United States and

the United Kingdom also reported elevated HbA1c despite comparable glucose concentrations (Booth et al., 2017; Bergenstal et al., 2017; Karter et al., 2023; Table 2B). In South African populations, HbA1c-based estimates of diabetes prevalence have been shown to exceed estimates derived from fasting glucose measurements, in some cases by as much as fourfold (Wade et al., 2021; Hird et al., 2016) (Table 2A).

As summarised in Table 2A, HbA1c frequently identified substantially more individuals as having diabetes than fasting plasma glucose, with some studies reporting markedly higher prevalence estimates when HbA1c criteria were used. International evidence presented in

Table 2B similarly demonstrates that populations of African, South Asian, Latino, and other non-White ancestries often exhibit higher HbA1c values despite comparable glucose concentrations (Booth et al., 2017; Bergenstal et al., 2017; Cavagnoli et al., 2017; Karter et al., 2023). These findings suggest that ethnic differences in HbA1c interpretation may contribute to discrepancies between HbA1c- and glucose-based diagnoses of diabetes.

Table 2. Evidence Suggesting HbA1c May Overestimate Glycaemia in Non-White Populations

Table 2A. Studies reporting discordance between HbA1c and FPG across ethnic groups discordance between HbA1c and FPG

Study	Finding
Wade et al. (2021)	HbA1c prevalence 4× FPG prevalence; inadequate correlation
Hird et al. (2016)	HbA1c threshold 6.0% for diabetes diagnosis
Royce et al. (2024)	FPG comparable to HbA1c for screening
Shipman et al. (2015)	South Asians: elevated HbA1c but lower FPG

Such discrepancies raise concerns regarding the use of uniform diagnostic thresholds across ethnically diverse populations. International studies have reported similar findings. Research involving African American, South Asian, and Afro-Caribbean populations has demonstrated higher HbA1c values relative to glucose concentrations

when compared with White populations (Manley et al., 2019; Nathan et al., 2021; Karter et al., 2023). These differences may partly reflect variation in red blood cell turnover, haemoglobin glycation rates, or other haematological factors that influence HbA1c independently of plasma glucose.

Table 2B: HbA1c overestimates Glycaemia in non-white populations

Study	Finding
Bergenstal et al. (2017)	HbA1c in Black persons overstates average glucose
Karter et al. (2023)	African Americans have higher HbA1c for same mean glucose
Nathan et al. (2021)	Higher HbA1c in Black patients for same glucose
Wolffenbuttel et al. (2013)	Non-Caucasian populations have elevated HbA1c at the same glucose
Booth et al. (2017)	Black Africans have elevated HbA1c despite comparable glucose
Cavagnoli et al. (2017)	Black, Asian, Latino had elevated HbA1c (0.08-0.26%)

The observed discordance has important clinical implications. Reliance on a single biomarker may lead to over- or under-diagnosis of diabetes in specific populations, highlighting the importance of validating diagnostic thresholds within diverse ethnic groups and considering complementary diagnostic approaches where appropriate.

Factors Contributing to Ethnic Differences in Glycaemic Biomarkers

Genetic and biological factors

Genetic and physiological differences contribute to variation in glycaemic biomarkers across populations. Factors such as red blood cell lifespan, haemoglobin glycation rates, and the presence of haemoglobin variants may influence HbA1c values independently of glucose concentrations (Radin et al., 2017; Brain et al., 2019). These factors are particularly relevant in populations where haemoglobinopathies are more prevalent. Evidence from SSA (Sub-Saharan Africa) suggests that the pathophysiology of T2DM in Black African populations may differ from that observed in populations of European ancestry (Ekoru et al., 2016).

Table 3. Genetic and Biological Factors Contributing to Ethnic Differences in Glycaemic Biomarkers.

Table 3A: Additional contextual studies

Author (Year)	Study Location	Study Design	Sample Size	Ethnic Groups Compared	Measures	Key Findings	Limitations
Asamoah et al. (2020)	Sub-Saharan Africa	Systematic review & meta-analysis	N/A	Various African ethnic groups	HbA1c, genetic markers	Genetic diversity influences T2DM susceptibility and control	Heterogeneity of included studies
Pirie et al. (2010)	South Africa	Case-control	378	Zulu	Genetic markers	Common European genetic variants absent in Zulu population; genetic architecture differs.	Limited to one ethnic group
Fernández et al. (2020)	Global	Review	N/A	General population	Clinical outcomes	Older adults and individuals with diabetes face a higher risk of severe COVID-19 illness.	Review article
Ojo et al. (2022)	Global	Systematic review & meta-analysis	N/A	General population	HbA1c, FPG, BMI	Lockdowns associated with significant increases in HbA1c, FPG, and BMI	Heterogeneity of included studies
Rathmann et al. (2022)	Primary care studies	Review	N/A	General population	Glucose regulation	Temporal link between mild COVID-19 infection and newly diagnosed T2DM	Need for further research
Maalaea et al. (2022)	Sub-Saharan Africa	Cross-sectional	693	Various African ethnic groups	Dietary patterns	A high proportion of individuals from resource-poor communities at risk for diabetes consumed a low-variety diet.	Lack of biomarkers

Table 3b: Genetic differences across populations

Study	Finding
Asamoah et al. (2020)	Genetic diversity influences T2DM susceptibility
Chikowore et al. (2016)	GRSn gene linked to T2DM risk
Ekoru et al. (2016)	Pathogenesis in Black Africans diverges from European model.
Pirie et al. (2010)	Common European genetic variants absent in Zulu population
Kodama et al. (2013)	Glucose levels evolved over millions of years; migration influences susceptibility.

Furthermore, studies investigating diabetes susceptibility genes indicate substantial genetic heterogeneity across ethnic groups, suggesting that the biological mechanisms underlying diabetes risk and glycaemic control may vary between populations (Asamoah et al., 2020; Pirie et al., 2010). These mechanisms include differences in haemoglobin variants, erythrocyte turnover, haemoglobin glycation rates, and genetic susceptibility, all of which

may influence glycaemic biomarkers independently of glucose concentrations (Asamoah et al., 2020; Ekoru et al., 2016; Pirie et al., 2010). The studies summarised in Tables 3A and 3B collectively demonstrate that diabetes susceptibility loci and disease pathophysiology vary considerably across populations, particularly between African and European ancestry groups. Although genetics alone cannot fully explain observed disparities in

glycaemic control, biological differences remain an important contributor to ethnic variation in glycaemic biomarkers.

Lifestyle and dietary factors

Lifestyle behaviours and dietary practices are important determinants of glycaemic control and may contribute to ethnic differences in diabetes outcomes. Studies in South

Africa have shown associations between dietary patterns and glycaemic biomarkers, with diets high in refined carbohydrates, processed foods, and saturated fats generally associated with poorer glycaemic outcomes (Chikowore et al., 2017). The findings summarised in Table 4 further demonstrate the contribution of dietary and lifestyle factors to variation in glycaemic control across populations.

Table 4. Lifestyle and dietary determinants of glycaemic variability across populations

Study	Finding
Chikowore et al. (2017)	Traditional African diets associated with better glycaemic control
Dekker et al. (2015)	Dutch dietary pattern associated with elevated FPG and HbA1c
Sibiya et al. (2024)	Lifestyle variables account for a portion of ethnic variations
Dekker et al. (2015)	Need for culturally specific public health initiatives

As summarised in Table 2A, HbA1c frequently identified substantially more individuals as having diabetes than fasting plasma glucose, with some studies reporting markedly higher prevalence estimates when HbA1c criteria were used. International evidence presented in Table 2B similarly demonstrates that populations of African, South Asian, Latino, and other non-White ancestries often exhibit higher HbA1c values despite comparable glucose concentrations (Booth et al., 2017; Bergenstal et al., 2017; Cavagnoli et al., 2017; Karter et al., 2023). These findings suggest that ethnic differences in HbA1c interpretation may contribute to discrepancies between HbA1c- and glucose-based diagnoses of diabetes.

Urbanisation has accelerated changes in dietary behaviours and physical activity patterns across many SSA populations. Traditional diets are increasingly being replaced by energy-dense processed foods, while sedentary lifestyles have become more common. These changes contribute to increasing rates of obesity, impaired glucose regulation, and T2DM. Although lifestyle factors do not fully explain ethnic disparities in glycaemic biomarkers, they interact with biological and socioeconomic influences to shape diabetes risk and disease progression (Sibiya et al., 2024). The evidence summarised in Table 4 indicates that lifestyle behaviours and dietary practices contribute substantially to ethnic variation in glycaemic outcomes. Traditional dietary patterns were generally associated with improved glycaemic control, whereas energy-dense diets rich in processed foods were associated with elevated HbA1c and fasting plasma glucose concentrations.

Healthcare access and socioeconomic factors

Socioeconomic conditions and healthcare access also play a significant role in diabetes outcomes. Financial constraints, transportation costs, limited access to healthcare facilities, and unequal availability of diagnostic services can hinder effective diabetes management (Mutyambizi et al., 2020). Studies from KwaZulu-Natal and other South African settings summarised in Table 1A reported inadequate follow-up testing, poor adherence to clinical guidelines, and suboptimal long-term diabetes management within resource-constrained healthcare systems (Rampersad et al., 2019; Kone et al., 2023). These findings highlight the important contribution of healthcare system factors to ethnic disparities in glycaemic control, as delayed monitoring and inconsistent implementation of diabetes care guidelines may disproportionately affect disadvantaged populations. Consequently, barriers related to healthcare access and service delivery may contribute to poorer glycaemic outcomes and partly explain observed ethnic differences in diabetes prevalence and management. Improving access to diabetes screening, monitoring, treatment, and education remains critical for reducing disparities and improving health outcomes.

Summary of research gaps

Despite increasing evidence, important gaps remain. Few studies have conducted direct, within-population comparisons of HbA1c, fasting plasma glucose, and OGTT across multiple ethnic groups. Longitudinal data examining the progression of glycaemic differences are limited, and the relative contributions of biological, environmental, and healthcare-related factors remain incompletely understood. Addressing these gaps is essential to improve diagnostic accuracy and guide population-specific diabetes management strategies.

Conclusion

The available evidence demonstrates consistent ethnic differences in glycaemic biomarkers across South Africa, Sub-Saharan Africa, and global populations. HbA1c and fasting plasma glucose do not perform uniformly across ethnic groups, with important implications for diabetes diagnosis and management. These disparities reflect a complex interaction of biological, environmental, and healthcare factors. Collectively, the findings support the need for population-specific approaches to diabetes screening, diagnosis, and care, while highlighting critical priorities for future research.

Discussion

Synthesis of key findings

This narrative review synthesised evidence from more than 50 studies examining ethnic variation in glycaemic biomarkers across South Africa, Sub-Saharan Africa (SSA), and selected international populations. Overall, the reviewed literature demonstrates that glycaemic biomarkers, particularly glycated haemoglobin (HbA1c) and fasting plasma glucose (FPG), do not perform uniformly across population groups and may not always provide equivalent estimates of underlying glycaemic status.

A consistent finding across South African studies was the higher burden of dysglycaemia among individuals of Indian ancestry compared with African and White populations. Higher HbA1c concentrations and increased prevalence of prediabetes and type 2 diabetes mellitus (T2DM) were frequently reported among Indian populations. Similar patterns have been observed internationally among South Asian populations (*see Appendix B for a summary of key findings by theme*), suggesting that these differences are not unique to the South African context but may reflect broader interactions between genetic susceptibility, metabolic characteristics, environmental exposures, and lifestyle factors.

The review further identified substantial discordance between HbA1c- and glucose-based assessments of diabetes. Several studies reported differences between diabetes prevalence estimates derived from HbA1c compared with fasting glucose criteria, particularly among populations of African ancestry, including Black African, African American, and Afro-Caribbean populations. These findings suggest that HbA1c may be influenced by population-specific factors beyond circulating glucose concentrations and highlight potential limitations associated with applying uniform diagnostic thresholds across ethnically diverse populations.

The evidence indicates that differences in glycaemic biomarkers arise from multiple interacting determinants. Biological mechanisms, including variation in erythrocyte lifespan, red blood cell turnover, haemoglobin variants, and genetic factors influencing glycation, may affect HbA1c interpretation independently of plasma glucose levels. These biological influences occur alongside environmental and behavioural determinants, including dietary patterns, physical inactivity, urbanisation, socioeconomic conditions, and healthcare access, which collectively contribute to differences in diabetes risk and glycaemic outcomes. Importantly, studies conducted in KwaZulu-Natal and other SSA settings highlight persistent challenges in diabetes management, including inadequate monitoring, suboptimal glycaemic control, delayed diagnosis, and inconsistent implementation of clinical guidelines. These findings suggest that healthcare system limitations may amplify existing biological and socioeconomic inequalities and contribute to poorer diabetes outcomes among vulnerable populations.

The evidence indicates that ethnic variation in glycaemic biomarkers is unlikely to be explained by ethnicity alone. Rather, ethnicity may function as a marker of interconnected biological, environmental, socioeconomic, and healthcare-related determinants. Recognition of these interactions is essential for improving the accuracy and equity of diabetes diagnosis, prevention, and management.

Quality and limitations of the reviewed research

The methodological quality of the included studies varied considerably according to study design, sample size, population characteristics, and analytical approaches. Quality assessment was conducted depending on study design. Overall, approximately 36% of studies were classified as high quality, 44% as medium quality, and 20% as low quality, indicating moderate confidence in the overall evidence base (*see Appendix A for details of individual study quality*). Several methodological limitations were identified. First, the predominance of cross-sectional study designs limits causal inference and restricts understanding of temporal relationships between ethnic variation, metabolic risk factors, and disease progression. Although cross-sectional studies provide important epidemiological insights, they cannot establish whether observed differences precede or result from disease development. Second, many studies relied primarily on HbA1c and fasting glucose measurements without additional assessment using oral glucose tolerance testing (OGTT). The absence of OGTT data may have contributed to variability in prevalence

estimates and limited interpretation of discordant biomarker findings. Third, relatively few studies accounted for haematological factors that may influence HbA1c interpretation, including anaemia, iron deficiency, haemoglobinopathies, and variation in erythrocyte lifespan. Failure to consider these factors may introduce measurement bias, particularly in populations where such conditions are more prevalent. Additional limitations included reliance on self-reported lifestyle measures, heterogeneity in laboratory methods and diagnostic thresholds, limited representation of some ethnic groups, and underrepresentation of rural populations. The predominance of urban-based research further limits the generalisability of findings across broader SSA populations. Despite these limitations, the consistency of findings across multiple geographical settings and study designs strengthens confidence in the conclusion that meaningful differences in glycaemic biomarkers exist between population groups. However, interpretation of individual study findings should consider methodological variability and contextual differences.

Implications for clinical practice and policy

The findings of this review have important implications for diabetes screening, diagnosis, and management in ethnically diverse populations. Current diabetes assessment strategies frequently rely on standardised HbA1c thresholds; however, differences in biomarker performance suggest that these thresholds may not accurately represent glycaemic status across all population groups. Clinicians should therefore interpret HbA1c results alongside clinical presentation, fasting glucose measurements, and additional diagnostic assessments where appropriate, particularly when laboratory findings are inconsistent with clinical risk profiles. Improved recognition of population variation in biomarker interpretation may help reduce both underdiagnosis and overdiagnosis of diabetes. From a public health perspective, these findings highlight the need to strengthen diabetes prevention and management programmes in multi-ethnic communities. Improving access to screening services, regular monitoring, diabetes education, and evidence-based treatment remains essential for reducing disparities in diabetes outcomes. Healthcare systems should also address structural barriers affecting diagnosis and long-term disease management, including limited healthcare access, inconsistent follow-up, and gaps in implementation of clinical guidelines. At the policy level, these findings support consideration of population-informed approaches to diabetes risk assessment while ensuring that strategies promote equity rather than reinforce biological assumptions based solely on ethnicity.

Recommendations for future research

This review highlights several priorities for future research. First, well-designed comparative studies are needed to evaluate HbA1c, fasting glucose, and OGTT outcomes across multiple ethnic groups within the same population. Such studies would provide stronger evidence regarding differences in biomarker performance and diagnostic accuracy. Second, longitudinal studies are required to investigate the development and progression of ethnic differences in glycaemic control over time. These designs would improve understanding of causal pathways linking biological, environmental, and social determinants with diabetes risk. Third, future research should incorporate detailed assessment of haematological factors, including haemoglobin variants, anaemia, iron status, and erythrocyte lifespan, to improve interpretation of HbA1c variation. Further investigation into genetic, epigenetic, environmental, and lifestyle determinants of glycaemic variation is also required. Understanding how these factors interact may support the development of more personalised and effective diabetes prevention strategies. Finally, intervention studies evaluating contextually appropriate and context-specific diabetes prevention and management programmes are needed to determine effective approaches for reducing disparities in diabetes outcomes. Addressing these research priorities will strengthen the evidence base and support the development of equitable, population-informed strategies for diabetes diagnosis, prevention, and management.

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List of abbreviations

AG	Average Glucose
AMSTAR-2	A Measurement Tool to Assess Systematic Reviews (Version 2)
BMI	Body Mass Index
FPG	Fasting Plasma Glucose
GRS_n	Genetic Risk Score (specific variant)
HbA1c	Glycated Haemoglobin
IFCC	International Federation of Clinical Chemistry
IFG	Impaired Fasting Glucose
IGT	Impaired Glucose Tolerance
JB	Joanna Briggs Institute
K-ATP	ATP-Sensitive Potassium Channel

MPR Medication Possession Ratio
NCD Non-Communicable Disease
NGSP National Glycohemoglobin Standardization Program
OGTT Oral Glucose Tolerance Test
SEMDSA Society for Endocrinology, Metabolism and Diabetes of South Africa
SSA Sub-Saharan Africa
STROBE Strengthening the Reporting of Observational Studies in Epidemiology
T2D Type 2 Diabetes
T2DM Type 2 Diabetes Mellitus
UK United Kingdom
US United States

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Conflict of interest

The authors declare that there are no conflicts of interest related to this manuscript.

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SZ conceptualised the review, conducted the literature synthesis, and prepared the initial manuscript draft. NT contributed to the supervision, manuscript development, critical revision, and refinement of the final version. Both authors reviewed and approved the final manuscript.

Data availability

Data used in this study were obtained from published literature sources. No primary datasets were generated or analysed. The information supporting this review is available from the cited references.

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