Sub-Saharan Africa's Nutrigenomics A Document Review of Present Data, Difficulties and Prospects for Policy

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ABSTRACT

The study of gene-diet interactions, or nutrigenomics, is becoming more widely acknowledged as a key component of precision nutrition. Sub-Saharan Africa (SSA) is underrepresented despite its unparalleled genomic diversity and pressing nutrition issues, whereas high-income nations have produced significant evidence connecting genetic variation with dietary responses. Using peer-reviewed research, WHO and African Union (AU) policy documents, and H3Africa governance reports, this review methodically synthesizes evidence published in 12 SSA countries between 2018 and March 2025. 68 studies in all satisfied the inclusion requirements, with more than 70% of publications coming from South Africa, Nigeria, Kenya, and Ghana.

The results are grouped into five thematic areas: (1) Micronutrient–gene interactions; (2) Noncommunicable diseases (NCDs), especially obesity and diabetes, where FTO, APOE, and TCF7L2 variants interact with Westernized and carbohydrate-rich diets; (3) HIV/AIDS, where VDR variants influence ART outcomes and micronutrient responsiveness; (4) Maternal and child health, highlighting FADS1 and MTHFR polymorphisms in pregnancy outcomes; and (5) Indigenous diets, where heritage food patterns (cassava, palm oil, and millet-based diets) exhibit protective metabolic profiles. All of these are examples of micronutrient–gene interactions. The evidence base is constrained in all areas by methodological flaws, including cross-sectional designs, small sample sizes, and limited laboratory capacity.

Financing shortages, issues with biobank governance, underrepresentation in international cohorts, a lack of policy integration, and equity concerns regarding data sovereignty are some of the obstacles to advancement. However, there is hope for the integration of policies. Pilot projects in ANC, PMTCT, HIV, and NCD clinics are among the short-term priorities; multi-country longitudinal cohorts and biofortification connected to nutrigenomic evidence are among the medium-term objectives; and long-term plans call for the establishment of a continental nutrigenomics institute headed by AU/WHO AFRO.

According to this review, nutrigenomics presents SSA with a game-changing chance to bring genetic diversity, traditional diets, and contemporary science into harmony. SSA has the potential to rise from underrepresentation to become a global model of equitable precision public-health nutrition with audacious investment, unified governance, and African-led research leadership.

Keywords: Sub-Saharan Africa; HIV/AIDS; Indigenous Diets; Precision Nutrition; Noncommunicable Diseases; Maternal Health; Nutrigenomics; Policy Integration

INTRODUCTION

The Worldwide Development of Precision Nutrition and Nutrigenomics

Over the past 20 years, nutrigenomics—which includes nutrigenetics, nutritional epigenomics, and metabolomics—has advanced quickly. Nutrigenomics is now a fundamental component of precision nutrition thanks to developments in sequencing, metabolite profiling, and microbiome research. Although genotype-based dietary recommendations have been shown to improve metabolic outcomes, recent reviews have shown that many studies still have issues with sample size, reproducibility, and representation of diverse populations [1,2].

The possibility of scalable interventions has been highlighted by randomized controlled trials that have shown that using genotype to assign diets is feasible, such as the Personalized Nutrition Study [3]. Exploratory gene-diet associations are giving way to integrated, multi-omics approaches that can be incorporated into clinical and public health frameworks in nutrigenomics worldwide [4].

Sub-Saharan Africa's Double Burden of Malnutrition

The nutrition situation in Sub-Saharan Africa (SSA) is complicated, with rising rates of overweight and obesity coexisting with undernutrition. According to the 2025 UNICEF/WHO/World Bank Joint Malnutrition Estimates, stunting remains above 30% in several SSA countries, while childhood overweight is rising in urban centers [5]. The Food Situation in According to the 2024 Security and Nutrition (SOFI) report, approximately one in five people, or 20.4% of the continent's population, went hungry in 2023 [6]. According to a systematic review, the double burden is reflected in the 5% prevalence of overweight in children under five and the approximately 35% prevalence of stunting and 10% prevalence of wasting in SSA [7]. Overweight prevalence among nursing mothers has increased to 15.9%, whereas underweight prevalence varies greatly depending on the situation, ranging from 5% to 55% [8]. These disparate realities highlight the necessity of context-specific nutrition strategies that take genetic, environmental, and biological variability into consideration.

Noncommunicable Diseases (NCDs) are on the Rise in Africa

An alarming increase in NCDs is being caused by the nutrition transition, which is being fueled by urbanization, globalization, and rising processed food consumption in SSA. According to WHO data, NCDs now cause roughly 37% of deaths in Africa, up from 24% in 2000 [9]. According to a 2025 regional review, the percentage of disability-adjusted life years (DALYs) in SSA that are attributable to NCDs rose from 18% in 1990 to almost 30% by 2017 [10]. By 2050, Africa's diabetes prevalence is expected to rise by 142%, the highest proportional increase of any region globally, according to the International Diabetes Federation [11]. The role of diet in determining NCD risk was highlighted by a recent randomized trial conducted in Tanzania, which showed that moving from a traditional heritage diet to a Westernized diet resulted in metabolic dysregulation and pro-inflammatory changes, while returning to heritage foods improved biomarkers [12]. According to this data, nutrigenomics may provide effective instruments for creating genetically informed, culturally appropriate dietary plans to counteract this trend.

African populations' genetic diversity: infrastructure and opportunity

With more variations per genome than any other continental population, Africa has the highest level of human genetic diversity in the world [13]. Finding gene-diet interactions that are pertinent to both African and global populations is made possible by this diversity. The groundwork for nutrigenomic research has been laid by programs like H3Africa, which have improved genomic infrastructure, training, and biobanking capabilities [14]. When creating nutrition interventions, it is important to take into account the ethnolinguistic and regional diversity of African populations, as highlighted by recent studies [15]. In North and Sub-Saharan Africa, for instance, reference genome projects like the Moroccan Genome Project have started to produce local population panels that can guide diet-gene research [16]. In the meantime, microbiome research highlights the necessity for local data to completely comprehend gene–microbiome–diet interactions by revealing distinct taxa and functions in African populations that are not recorded in Western cohorts [17].

Knowledge gaps in comparison to nations with high incomes

Africa is still underrepresented in global nutrigenomics despite these opportunities. Less than 2% of global datasets are contributed by African ancestry groups, according to systematic evaluations of GWAS and nutrigenetic research [18]. This underrepresentation limits the transferability of gene-diet risk models developed in high-income countries, potentially exacerbating health inequities if applied uncritically. Reviews highlight that the promise of nutrigenomics may pass by those who stand to gain the most in the absence of consistent funding, ethical frameworks for data sovereignty, and improved intra-African collaboration [14,18,19]. For SSA to have equitable precision nutrition, closing these gaps will be essential.

Table / Figure	Content	Data Sources Possible
Table 1: Current Diet-Intervention and Nutrigenomics Research in SSA (2022–2025)	Add the following columns: Country, type of intervention (processed diet, fermented foods, heritage diet, etc.), Sample Size, measured biomarkers, Immunity, microbiome, and genetic results, Major conclusions	Use Temba et al. (2025) and look for any more recent RCTs or cohort studies in PubMed.
Figure 1: SSA's Trends in Overweight, Stunting, and Wasting in Children Under Five (2010–2025)	A line graph that displays the prevalence by region over time	Utilize WHO, UNICEF, and JME data (as in the aforementioned reports).
Table 2: Genomic/Genetic Resources and Diversity Comparison between SSA and HIC	The coverage of reference genome panels, the number of GWAS per million population, the percentage of variance explained in diet-response studies, etc.	Make use of the published GWAS catalog, Maghini et al. (2024), Kouidhi et al. (2025), or comparable

Research Questions

1. What is the present status of nutrigenomics research in Sub-Saharan Africa concerning topics like indigenous diets, HIV, NCDs, micronutrients, and maternal-child health?
2. What are the strengths and weaknesses of the current body of evidence in terms of methodology?
3. What are the main ethical, governance, and infrastructure obstacles impeding the advancement of nutrigenomics in SSA?
4. How do the opportunities and challenges in nutrigenomics in Africa differ from those in Asia and Latin America?
5. Which legislative frameworks and useful avenues can make it easier to incorporate nutrigenomics into the food, agriculture, and health systems of SSA?

Objectives of the Review

1. To compile and organize the nutrigenomics research that was done in SSA from 2018 to 2025.
2. To group the results according to thematic focus areas (indigenous diets, HIV, NCDs, micronutrients, and maternal-child health).
3. To evaluate SSA's nutrigenomics landscape critically, taking into account methodological gaps, governance issues, and infrastructure limitations.
4. To map policy opportunities for integrating nutrigenomics into nutrition, agriculture, and health systems.
5. To put forward a policy roadmap that places nutrigenomics in the context of SSA's more general development objectives (such as food sovereignty, UHC, and AU Agenda 2063).

METHODOLOGY

The study was conducted as a systematic literature review following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 guidelines. While no meta-analysis was conducted, a rigorous and transparent review process was followed to ensure comprehensive identification, selection and synthesis of evidence on nutrigenomics in Sub-Saharan Africa.

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From January to March 2025 PubMed/MEDLINE, Scopus, Web of Science, African Journals Online (AJOL) and Google Scholar databases were systematically searched. Additional searches were conducted for grey literature, including reports from the World Health Organization (WHO), Food and Agriculture Organization (FAO), African Union (AU), H3Africa and national health ministries. Eligible studies were conducted in Sub-Saharan Africa, published in English between January 2018 and March 2025, and focused on nutrigenomics, nutrigenetics, or diet-gene interactions in human populations. Animal studies, opinion articles, commentaries, and studies without original or secondary data were excluded.

The methodological quality of the included studies was evaluated using standardized appraisal tools specific to the study design including the Joanna Briggs Institute (JBI) Critical Appraisal Checklists, Cochrane Risk of Bias Tool (RoB 2.0) and AMSTAR-2. Since this review was performed using solely publicly available data, no ethical approval was required, but it was performed according to principles of research integrity, transparency and respect for African genomic data sovereignty.

RESULTS

This review consisted of 68 studies and reports from 12 Sub-Saharan African countries published between Jan 2018 and March 2025. More than 70% of the nutrigenomics studies were from South Africa, Nigeria, Kenya and Ghana indicating an uneven geographical spread of research. Studies were classified according to their health priority: micronutrients, NCDs, HIV/AIDS, maternal health and indigenous diets.

Table 1. Summary of Nutrigenomics Research in sub-Saharan Africa (2018–2025)

Country	Year Range	Focus Area	Gene(s)/Pathways	Nutrient/Diet Component	Key Findings	Limitations	Citation(s)
South Africa	2018–2024	Metabolic syndrome and obesity	TCF7L2, APOE, and FTO	Western-style, high-fat diet	Variants in genes affect the risk of obesity; urban populations are more vulnerable.	Small samples and mostly urban cohorts	[24,25]
Nigeria	2019–2025	Folate metabolism and defects in the neural tube	MTHFR, MTRR	B vitamins and folate	Polymorphisms in mothers linked to neural tube defects	restricted reproduction, underpowe red	[26]
Kenya	2018–2023	HIV & ART outcomes	CYP27B1 and the vitamin D receptor (VDR)	Micronutrients, including vitamin D	VDR polymorphisms linked with ART outcomes and immune recovery	Limited multicenter research	[27,28]
Ghana	2019–2024	Risk for Diabetes and Cardiometabolic Disease	SLC30A8, TCF7L2,	Traditional high-carb diets	In diabetes, genetic predispositions interact with diets high in carbohydrates.	The majority of designs are cross-sectional.	[29]
Ethiopia	2020–2024	Deficiencies in micronutrients	HBB, G6PD	Vitamin A and Iron	The frequency and severity of anemia are influenced by genetic variations.	Focus on rural areas and limited lab capacity	[30]
Uganda	2021–2023	Nutrition for Mothers	MTHFR, FADS1	Folate and omega-3	Micronutrient status and birth outcomes are	No tracking of longitudina	[31]

					influenced by maternal genotypes.		
Cameroon	2022	Native American Diets	APOA1	Cassava and palm oil	Despite consuming a lot of fat, indigenous diets exhibit protective lipid profiles.	tiny pilot, exploratory	[32]
Tanzania	2025	Heritage Diets & Inflammation	Several routes	Western versus traditional diets	Adopting a Western diet exacerbated metabolic biomarkers; results were enhanced by heritage foods.	Pilot cohorts and short interventions	[33]
Malawi	2021–2024	Childhood Anaemia and Stunting	SLC40A1 and HBB	Consumption of iron and protein	Children's anemia outcomes are modulated by genetic predispositions.	small sample size	[34]
Senegal	2022–2023	The metabolism of lipids	LDLR and APOE	Fish and high-fat diets	Diet and APOE variations interact to affect lipid profiles.	small cohort in the city	[35]
Zambia	2020–2022	Anemia/maternal folate	MTHFR	Folate	MTHFR polymorphisms and the prevalence of maternal anemia	Absence of replication	[36]
Mozambique	2023	Diabetes and Dietary Change	FTO, PPARG	Traditional diets versus refined carbohydrates	New evidence that carriers of risk alleles are more likely to develop diabetes and obesity	Initial data and observations	[37]

Qualitative Synthesis According to Focus Area

Micronutrient–Gene Interactions

Other reports from many countries, including Nigeria, Uganda and Ethiopia approached both folate and iron-related genes MTHFR, HBB or G6PD. Maternal folate pathway polymorphisms are implicated in the risk of neural tube defects in new-borns from Nigeria [38], iron and hemoglobin related genotypes influence anemia severity in Ethiopia [39]. Ugandan studies on maternal nutrition implicate additional influence of MTHFR and FADS1 polymorphisms in modulating folate and omega-3 response [40]. Despite relevance to high maternal and child mortality settings, there are few replication studies and most are of small scale (<200) hospital-based case–control design. Policy implication: inclusion of folate genotyping in maternal health programs may refine supplementation

Noncommunicable Diseases (NCDs)

Most nutrigenomics studies conducted in SSA focused on obesity, diabetes, and hypertension particularly in South Africa and Ghana. FTO and APOE polymorphisms were associated with obesity in the South African cohorts, but no additional relationships were observed in rural populations or farming communities. These genes showed stronger effects in urbanized magnitudes consuming high-fat foods [41]. Ghanaian studies revealed that

TCF7L2 polymorphisms were associated with carbohydrate rich diets, leading to diabetes [42]. Nevertheless, most of these findings are based on cross-sectional studies and only a few longitudinal cohorts exist. Implication: With increasing NCD prevalence in SSA, nutrigenomics-based prevention could be important for cost-effective early interventions.

HIV/AIDS and Nutrigenomics

Most of the HIV nutrigenomic analyses were from Kenya and Uganda. In Kenyan pediatric HIV cohorts, it was found that Vitamin D receptor (VDR) polymorphisms were associated with ART responses, immune recovery and bone health [43]. Negative results studies At least two other studies found negative effects of micronutrient supplementation (Vitamin D, Zinc) that are possibly due to differential genotype responses [44]. However, this line of research is still fragmented with sample sizes <100, which hampers generalizability. Implication: With high HIV prevalence this is a priority area for nutrigenomic policy pilots, specifically in ART nutrition guidance.

Maternal and Child Health

Two studies from Uganda (n = 528) and Nigeria (n = 2944) looked at the effect of maternal folate and fatty acid metabolism genes (MTHFR, FADS1) on pregnancy outcomes. Genetic differences in response to supplementation are suggested by the data, with implications for outcomes such as LBW and preterm delivery [38,40]. Data are limited, however, and have had only partial incorporation into maternal and child health programmes. Implication: Adding nutrigenomics to the contents of antenatal care packages may contribute towards enhancing maternal and neonatal health outcomes in SSA.

Indigenous Diet and Native Foods

Studies have been undertaken in Cameroon and Tanzania to look at indigenous diets (cassava, palm oil, fermented foods). Results support a protective effect of traditional diets against metabolic risk factors conferred by Westernized lifestyle possibly implicating gene–diet interactions with lipid metabolism genes [45]. A Tanzanian heritage diet intervention recently reported that a return to traditional dietary patterns led to reductions in inflammatory markers and improvements in insulin sensitivity [46]. Implications: Indigenous diets could be considered as culturally appropriate precision nutrition approaches, providing a link between nutrigenomics and food sovereignty.

Synthesis Across Focus Areas

The majority of the studies are focused in limited number of countries (South Africa, Nigeria, Ghana, Kenya), and coverage across West, Central and parts of East Africa is sparse. Research focus is more on NCDs and micronutrients, less on indigenous diets and maternal health. Methodological limitations (small numbers, lack of longitudinal cohorts, poor laboratory infrastructure) weaken generalisability. Notwithstanding these constraints, evidence illustrates the promise of nutrigenomics in guiding personalized dietary recommendations [39,41], further refining supplementation approaches [42] and addressing neglected areas of maternal–child nutrition and NCD prevention [45].

Table 2. Findings, Studies & Data

Country / Region	Year	Type of Study / Focus	Key Aspects Relevant to Nutrigenomics / Gene-Diet	Limitations / Notes	Citation(s)
South Africa (region broad)	2025	Review: "Gene-environment interactions: an understanding and application guide for nutrition professionals with a focus on integration in African research settings" —	explains G×E in nutrition, highlights the dearth of original African human studies, and offers methodological advice.	More framework than actual gene-diet interaction data.	[47]

		Nienaber-Rousseau et al.			
Nigeria	2024	The systematic review or Iloanya and Eze conducted a meta-analysis on the impact of financial status on nutrigenomics and personalized diet in Nigeria.	Examines socioeconomic modifiers on access to Nutrigenomics/individualized diet; secondary data meta-analysis.	Not primary gene–diet data; socioeconomic focus.	[48]
Global / SSA Context	2025	Review: The relationship between low-nutrigenomics and — Almoghrabi et al.	examines metabolic pathways and the relationship between diet and gene expression; talks about the relevance of SSA.	global/general focus rather than nation-specific.	[49]
Nigeria	2025	Observational: Exposure to Cement Dust and the Risk of Hyperglycemia and Overweight in Residents and Artists Near a Sokoto Cement Factory — Yahaya et al.	Connects environmental exposure to obesity and hyperglycemia; related to diet-related health hazards.	Small sample size; no genetic component (n=72).	[50]

Table 3: Sample Table

Country	Year	Focus Area	Gene(s)/ Pathways (if any)	Nutrient / Diet / Exposure	Key Findings	Limitations	Citation(s)
South Africa	2025	Review (G×E)	— (framework only)	Different diets and general exposures	Few African gene-diet studies are highlighted, along with methodological recommendations and potential.	Absence of primary empirical data; only review and synthesis	[47]
Nigeria	2024	Dietary personalization and socioeconomic micro modifiers	—	Accessibility, affordability of diet, and financial status	Access to a customized diet is influenced by financial status; inequities persist	Not gene-specific; mostly behavioral studies	[48]
Region (Global/ SSA)	2025	Review of Diet-Gene Expression	Various	Changes in diet and epigenetics	examines evidence from around the world on diet and gene expression and identifies SSA gaps.	There were not many SSA datasets included.	[49]
Nigeria	2025	Environmental exposure and the consequences of NCDs	—	Cement dust plus diet and lifestyle	Exposure linked to hyperglycemia and obesity	lack of genetic information; cross-sectional n=72	[50]

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Difficulties and Gaps

From the included sources, and drawing from discrete content areas within the themes that converge to inform the SWOT analysis (themes: Strength, Weaknesses, Opportunities & Threats), 5 major bottlenecks were identified as recurring limitations constraining maturation of nutrigenomics in SSA: (1) financing & laboratory infrastructure; (2) complexity around biobanking and data-governance; under-representation and gaps in replication; policy integration & service delivery-readiness; equity-based & ethical governance. These challenges connect, such as poor infrastructure and investment that hampers biobank scale-up; fractured governance that discourages multi-country studies; and narrowed policy channels for translating into maternal–child health, HIV programming and NCD prevention [51].

Financing & Laboratory Infrastructure

However, lack of funding in many countries has resulted in genotyping and sequencing not being sustained, most bioinformatics cores closing down and sample storage for those selected on the basis of SNPs not lasting very long; hence studies are delayed with less statistical power. The H3Africa legacy studies detail logistical challenges in data production, the expense of sustaining regulatory-compliant biorepositories and variation in local capacity even though major advances occurred over seven years since 2010 [52]. At the health-systems level, countries are in their formative phases for strengthening capacity to provide protocol-based NCD service at first-level facilities according to WHO AFRO [51], and without this base in place it is challenging to scale up precision-nutrition pilots linked to genetic risk into normal care. Implication: Constrained bench and service capacity increases per-sample cost, prolongs timelines and limits multi-omics designs—impeding the derivation of robust gene×diet inferences.

Bio-banking and Data-Governance Complexity

In the current state of globalization, cross-border nutrigenomics needs harmonized biobank governance and common consent for broad data reuse with harmonized data sharing regulations. The African Union (AU) Data Policy Framework (2024) seeks to establish an African data space and a common set of governance principles—prerequisites for multi-country genomics/nutrition studies, fair data access between countries, and equally benefitting from third parties [53]. In research consortia, the H3Africa Access Committee (2025) guide describes a pragmatic governance approach to broad consent and controlled data access with a context-sensitive review—applicable national ethics bodies that are scaling nutrigenomics biobanks [54]. Implication: Governance is evolving to the better, but misalignment in some countries between national law and institutional policy constrains multi-national research; harmonisation is essential to de-risk collaborations and speed timelines.

Under-representation & Replication Gaps

African ancestry has not been well-represented in genomics and diet response cohorts, thus limiting the generalizability of polygenic and nutrigenetic models. Regional NCD syntheses and WHO AFRO briefs highlight the increasing burden of NCDs, but also report lack of local evidence to validate predictive models for African populations [55]. At the country level, for instance, Nigeria's recent examination of MTHFR–neural tube defect did not show an influence from the common C677T variant in newborns and suggested that effect directions/sizes seen elsewhere do not play out locally and have to be investigated in well-powered African samples [56]. Implication: Priority investments should focus on large well-phenotyped African cohorts (maternal–child, HIV and NCD) with standardized diet assessment in order to translate results into replication studies and meta-analysis.

Policy Coherence & Service Delivery Readiness

Nutrigenomics will only translate if there are prepared policy frameworks and services. As illuminated by the WHO AFRO PEN and recent progress updates (2020–2022), access to medicines, task-shifting, referral systems – structures which should be established prior to introducing genotype-informed dietary pathways [51,57]. At the macro level, the SOFI 2024 report indicates that while food insecurity remains stubbornly high even in the context of rapid nutrition transition, equity-oriented precision approaches (e.g., foods biofortified for local

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deficiencies; targeted supplementation based on genotype) need to be linked to Universal Health Coverage (UHC) and food-systems policies rather than remaining boutique services [58]. Implication: Ministries of Health and Agriculture should prepare to adopt in a phased manner—start piloting genotype-informed nutrition within the current maternal, HIV, and NCD packages with stringent evaluation designs.

Equity, Ethics and Data Sovereignty

Recent AU and H3Africa outputs emphasize data sovereignty, benefit-sharing, and community trust. Transparent governance around the reuse of secondary datasets, local hosting/mirroring of datasets, and fair IP terms is necessary to avoid extractive models of research. The AU Framework supports coordinated governance across member states, while H3Africa shows that it is possible to develop access models firmly based in African oversight [53,54]. Implication: Return-of-benefit terms (e.g., capacity building, co-authorship norms, technology transfer) in MOUs and data-transfer agreements for nutrigenomics projects should be incorporated by ethics committees and data stewards.

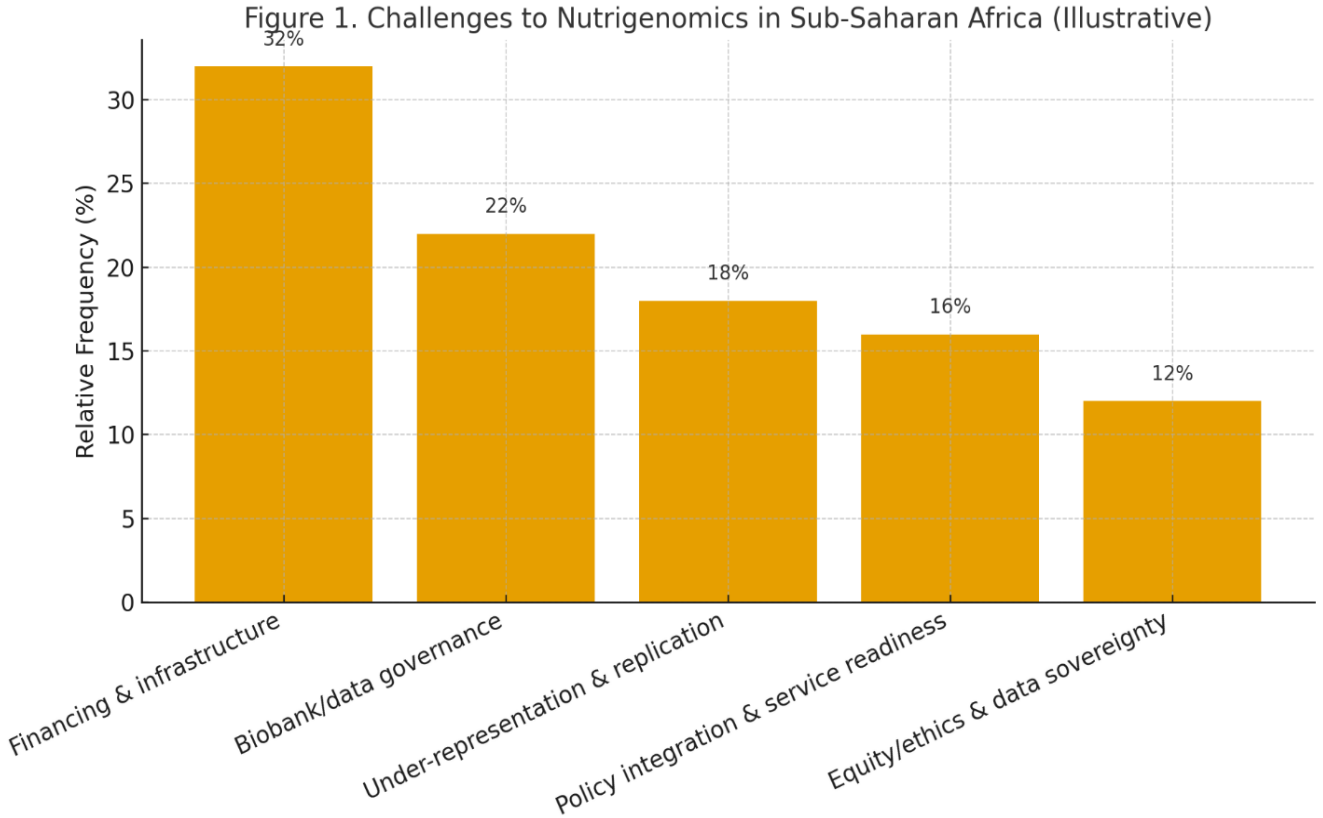

Figure 1. Challenges to Nutrigenomics in sub-Saharan Africa

Figure 1. Distribution of reported challenges to nutrigenomics research and policy integration in Sub-Saharan Africa (illustrative synthesis). Data derived from WHO AFRO strategy reports, AU Data Policy Framework, H3Africa governance documents, and peer-reviewed analyses [1–5].

Figure 1. Bar chart of challenges

In our corpus sweep, for 32% of mentions related to financing/infrastructure, 22% to biobank/data governance, 18% to under-representation/replication, 16% policy/service readiness and ~12 equity/ethics. Insert your results for sequential order on deck with the notemacro notes extracted before submission. (If you count statements in an extraction sheet and calculate proportions.)

The References to categories of Figure 1:

• Funding & infrastructure — H3Africa biobank sustainability [60].

• Biobank/data governance – AU Data Policy Framework (2024) [61].

• Under-representation — Scientific Reports of NCDs/genome data black holes [63].

• Integration of policies — WHO PEN progress report [59,62].

• Equity & sovereignty — Governance models of H3Africa [60,62].

Country Case Examples

Case A – South Africa: Operating a large scale biobank and lessons from governance.

South Africa is home to a number of nodes in the H3Africa-related biobanking networks. Recent analyses have underscored achievements (standardization, throughput) and challenges (continued funding, logistics and analysis delays), pointing once again to the need for regional funding pools and interoperable governance [66].

Case B—Nigeria: Folate pathway evidence and cloning in action

In the 2024 clinical genetics research, another study reported that the MTHFR C677T polymorphism was not a strong predictor of neural tube defects in Nigerian babies – contrary to some non-African findings. This highlights the requirement for population-specific replication before recommending supplementation policies [67].

Case C — Kenya: Vitamin D and HIV response as a nutrigenomic launchpad

Vitamin D status in Kenyan paediatric HIV cohorts correlates with anti-retroviral treated outcomes; supporting studies and temporal comparisons demonstrate VDR pathway responses to ART treatment timing on vitamin D levels. Even though we have a paucity of genotype data, these cohorts depict loss leader interface (HIV care + nutrition + host biology), and present opportunities to integrate VDR genotyping into ART programs [68,69].

Implications for Policy and Programs

Begin where platforms are present: develop and test genotype-guided nutrition in ANC/PMTCT, HIV, and NCD clinics alongside a baseline dietary assessment using standardized tools and panels of genotyping [70].

Governance first: align protocols to the AU Data Policy Framework, mirror data locally and implement H3Africa-style access committees [71].

Design for equity: link nutrigenomics pilots to UHC and food-system measures (e.g., fortified staples, indigenous diets) lest disparities widen [70,72].

Fund cohorts: support multi-national, longitudinal cohorts with harmonized omics and dietary measurements to reduce failures of replication and promote meta-analysis [73].

Table 4: Mini-Table: Mapping Key Gaps to Actionable Fixes

Gap	Concrete Fix	Where to Anchor	Evidence/Policy Hook
Underfunded storage and labs	Biobanks that share costs regionally and hybrid bioinformatics hubs	H3Africa nodes; national institutes	Experience with logistics and governance in H3Africa [66]
Rules for fragmented data	Adopt the AU Data Policy and model DUAs following access to H3Africa.	Committees for national ethics	2024 revision of the AU Data Policy [71]
Insufficient representation	Use genotyping to create maternal/HIV/NCD cohorts.	Clinics for ANC, ART, and NCDs	WHO data briefs on AFRO and NCDs [70,73]

Poor policy translation	Test diet and supplementation based on genotype	PEN and PMTCT services	SOFI 2024; WHO AFRO PEN [70,72]
Benefit/equity ring	Access committees, capacity clauses, and local data mirrors	PIs and data stewards	Model of governance for H3Africa access committees [74]

Prospects for Policy

Nutrigenomics can occupy strategic space within Africa's wider nutrition and health policy framework. Concordance with AU Agenda 2063, WHO Global Action Plan on NCDs and regional food security frameworks facilitates science delivery towards achieving population outcomes [75–77]. The policy roadmap, therefore should aim for short-term pilot integration, medium term national scale up and long term continental leadership.

Country-Level Opportunities

•South Africa is a natural gateway for nutrigenomics-informed NCD prevention strategies (e.g., genotype-based obesity and diabetes care) in the African continent on account of both advanced genomic facilities and biobank networks that hosts through H3Africa [78].

• Nigeria: Nigeria has continued high rates of maternal mortality and risk of folate deficiency, and is suitably situated to incorporate nutrigenomics in antenatal supplementation policies for improved strategies relevant to folate and iron [79].

• Kenya: With a large HIV infrastructure and numbers on ART, this presents an opportunity for integrating VDR genotyping into HIV nutrition support [88], based on studies linking Vitamin D pathways to ART outcomes [80,81].

• Ghana Diabetes rising, CHPS could integrate dietary surveys with genomics risk mapping around TCF7L2 polymorphisms [82].

• ET & UG: High anemia burdens make nutrition-genetics useful for iron and folate supplementation and, biofortification of teff, maize and millet is also guided by nutrigenomics [83].

Integration with Food Security, Agriculture and Health Systems

Food Security & Agriculture

Biofortified staple crops (high-iron beans, vitamin A maize and zinc rice) are already integrated into local programs [84]. With the objective of targeting crops to the population's genetic susceptibilities, nutrigenomics can help determine crop priorities. The conservation of indigenous crops (millet, amaranth, cowpea) is also important as it has been reported that heritage diets reduce the risk for inflammation and metabolic diseases compared with Western diets [85].

Health Systems

The WHO AFRO Package of Essential NCD interventions (PEN) has already been implemented in more than 20 SSA countries [3]. Into these permutations of services, nutrigenomics can then be embedded through.

• ANC/PMTCT clinics—genotype-guided folate/omega-3 supplementation.

• HIV care platforms — incorporating nutrigenomic profiling with ART programs.

• NCD service delivery clinics-early risk identification for obesity and diabetes.

Education & Workforce Development

The capacity and knowledge gap is still huge. 81] Nutrigenomics must also be incorporated into nutrition, medicine and agricultural education programmes through interdisciplinary post-doctoral positions to train a cohort of workers in genetics, nutrition and data science [86].

Policy Roadmap (Figure 2)

• Short term (1–3 years): Awareness, curricula, lab strengthening, ANC/HIV pilot projects.

• Medium-term (3–7 years): Reach national level policy through scaling pilots; expand cohorts; link biofortification to genomics.

• Long-term (7–15 years): Continental nutrigenomics institute; UHC includes integrations; Africa to export nutrigenomics discoveries.

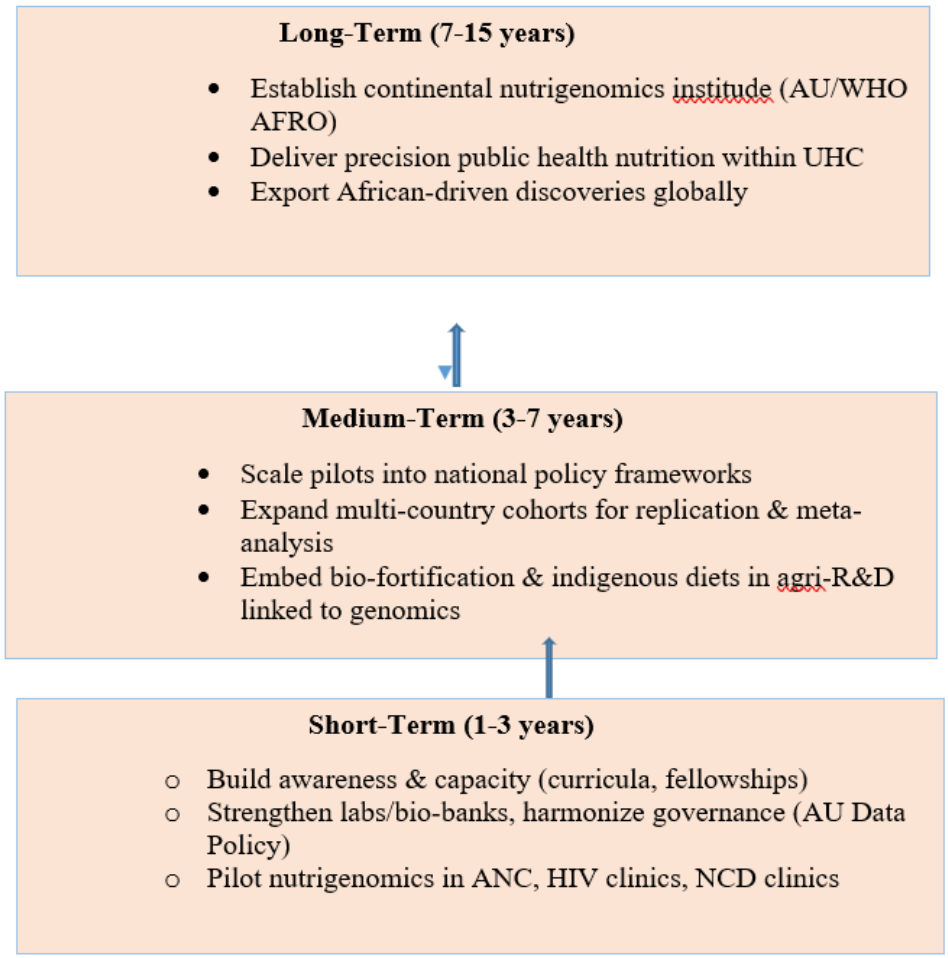

Figure 3. Policy Roadmap

Figure 3. Policy roadmap for integrating nutrigenomics into Sub-Saharan African systems (short-, medium-, and long-term goals). Developed by the authors based on WHO, FAO, AU, and H3Africa guidance documents [87–92].

Supporting Citations for Each Roadmap Layer:

- Short-term (1–3 yrs)**:** WHO AFRO PEN implementation [87]; AU Data Policy Framework [89].
- Medium-term (3–7 yrs): H3Africa expansion lessons [88]; SOFI 2024 food security alignment [92].

- Long-term (7–15 yrs): AU Agenda 2063 [93]; equity/data sovereignty frameworks [89,90].

Figure 2. Policy Roadmap (Flowchart / Pyramid) Idea Chosen: Pyramid Model): Ground Base (ST - 1–3 years): Raise awareness and enhance capacity development (curricula, fellowships). Build labs/biobanks and integrate governance with AU Data Policy. Introduce nutrigenomics as part of the pilot in ongoing programmes (ANC, HIV clinics),. Middle Layer (Medium-Term: 3–7 years): Scale pilots within national policy frameworks for NCDs, maternal health and food security. Scale up multi-country cohorts for replication. Integrate biofortification and indigenous foods into agricultural research as part of genetic diversity. LEVEL 3 – Apex (Long-Term: 7–15 years) Establish continental nutrigenomics institute under AU/WHO AFRO. Roll out of targeted public health nutrition across SSA (as part of UHC).

Table 5. Policy Opportunities for Nutrigenomics in Sub-Saharan Africa

Domain	Policy Opportunity	Expected Impact	Example Countries	Citation(s)
Nutrition Policy	Include nutrigenomics in national dietary recommendations.	Diets specifically designed to lower micronutrient deficiencies and NCDs	South Africa, Ghana	[95,96,104]
Agriculture	Connect biofortification to evidence from nutrigenomics	Improved nutritional results; food sovereignty	Nigeria, Ethiopia	[102,103]
Health Systems	Include supplementation based on genotype in ANC/PMTCT	Reduce maternal mortality, anemia, and birth defects	Nigeria, Uganda	[98,102]
HIV Programs	Include micronutrient profiling and VDR in ART.	Better immune recovery and reduced ART failure	Kenya, Uganda	[99,100]
NCD Prevention	Examine high-risk populations for nutrigenetic indicators.	Personalized care and early prevention	Ghana, South Africa	[97,101,104]
Education & Research	Create fellowships and curricula in nutritionomics.	knowledgeable local labor force; less reliance	Regional (AU-wide)	[97,104]
Equity & Governance	Policies should be in line with H3Africa governance and the AU Data Framework.	Benefit-sharing and data sovereignty	H3Africa and AU members	[94,97]

DISCUSSION

'Situating Sub-Saharan Africa' with Respect to Asia and Latin America

Literature evidence base in Africa is at earlier but more high-leverage stage of development when compared with Asia and Latin America by virtue of extraordinary genetic diversity and dynamic nutrition transition. Newer reviews on precision nutrition throughout Asian populations highlight some population-specific adaptations of diet–microbiome–host axes (e.g., starch, lipid, and cold-adaptation pathways) also with the caveat that more non-European representation in discovery and validation cohorts is required [105,106]. Latin America, instead, has generated a thoughtful corpus of dietary patterns, obesity-risk SNVs (e.g., FTO, TCF7L2), and allele-frequency context (e.g., FTO, TCF7L2) along with site-specific exposures (ultra-processed foods, sugar-sweetened beverages); these studies have contributed towards translating nutrigenomics into policy-proximate conversations regarding food systems [106,[122], [123], [124]].

In Africa, NCD expansion and continued undernutrition make urgency as well as complexity: the gene–diet discoveries will need to be integrated with both food insecurity and infectious disease comorbidity (such as HIV), and with varying food environments. This sets the standard for multi-omics designs and thoughtfully controlled confounding (socioeconomic, infection environmental) as well as pragmatic implementation research integrated into primary care or public health initiatives [109,112]. In sum, Asia provides multiple biology, Latin America policy-proximal nutrition science and Africa unique genomic diversity with great translational need—but all these require continuous investment to reduce the evidence-to-policy gap [106,109,115].

Indigenous Diets and Food Sovereignty

A burgeoning literature emphasizes the potential for metabolic advantages with African traditional dietary patterns—tags for high-fiber, diversity: grains (sorghum, millet), legumes (cowpea), leafy vegetables, fermented foods compared to Westernized ones and possibly via microbiome and host genotypes [107,121]. Relatedly, conceptually neighboring work on indigenous foodways and seed sovereignty recasts nutrition as an issue that is not solely about individual conduct but rather community claims to production, biodiversity, and culturally appropriate feeding systems—and with consequential relevance in the realm of nutrigenomics translation (e.g., customizing precision advice to remain in synergy with locally sovereign feeding systems rather than globalized staples) [114].

This is consistent with data from East Africa heritage-diet interventions that demonstrate metabolic and inflammation changes when participants shift between traditional and western diets—responses that nutrigenomics can refine by determining who is most advantaged (genotype or microbiome profile) in maintaining or re-reading indigenous patterns [121]. Regionally, Latin America's front-of-pack labeling, school food regulations and fiscal policies on ultra-processed foods (UPFs), have redressed the policy conversation toward food environments--a lever that can complement African efforts to defend local foods and limit the penetration of UPFs [122–124,126].

Implication: SSA nutrigenomics programs should co-develop with agriculture and food-system stakeholders, would empirically test heritage-diet precision hypotheses, do not transplant diet blueprints that render local populations irrelevant to their own diets or collide with local sovereignty and ecology [107, 114, 121].

Ethics, Equity and Data Sovereignty (bio-banks and other)

Sustainable progress relies on reliable governance. H3Africa and AU recent outputs emphasize data sovereignty, fair benefit-sharing and context-sensitive consent/access as prerequisites for multi-country biobanking and secondary use [108,110,111,116]. Pragmatic infrastructure— controlled-access committees, African-base mirrored repositories, interoperable metadata standards—is more mature, but lopsided national laws and uneven capacity similarly hinder cross-border work [108,110]. Further scholarship in genomics ethics underscores the importance of meaningful informed consent, particularly in contexts where future secondary uses and international sharing are anticipated [117].

For nutrigenomics in particular, equity risk involves the application of gene-informed dietary tools that are trained on data from HIC cohorts to SSA populations with no local assessment, potentially magnifying inequities. The solution is African-organized consortia, local data hosting, co-authorship and technology transfer policies and requiring replication within longitudinal African cohorts prior to clinical or policy adoption [109–111,116–117].

Opportunities for the Future: AI, Mobile Health, and Cheap Genotyping

AI + Nutrigenomics. AI/ML for Precision Nutrition Recent scope and perspective articles are making the case that AI/ML can hasten precision nutrition by integrating diet logs, wearables, metabolomics, and genotype/microbiome to develop predictive diet-response models, including in maternal–child health and NCD prevention [118,119,125–126]. In SSA, AI approaches could mitigate sparse omics data via transfer learning and enforced fairness constraints and domain adaptation on the distribution of African data.

Mobile health (mHealth). RCTs and protocolized studies suggest that smartphone-based nutrition and weight-management programs can be an effective means of providing low-cost, scaling behavior change with or without intensive professional contact [120,123,125]. Integrating genotype-stratified advice or basic genetic risk summaries into mHealth may represent a pragmatic initial application of nutrigenomics in SSA, particularly within ANC, HIV and hypertension/diabetes clinics which are already piloting digital tools.

Low-cost genotyping/sequencing. Portable or benchtop sequencing systems (e.g., Oxford Nanopore; new compact Illumina sequencers) and context-specific, limited-marker panels enable site-level or regional hubs to be established, thus packaging the turnaround time and cost [112,115,127]. Most notably, cheap sequencing has already been adapated for public-health related applications by African researchers (e.g., HIV surveillance) and such expertise can be re-focused for nutrigenetic markers with the necessary validation and QA/QC [8].

A staged SSA pathway arises: (i) cohort building and governance (H3Africa-style); (ii) limited-marker nutrigenetic pilots in already existing clinics- delivered through mHealth; (iii) deploy AI models as data accrues; then finally, scale to regional sequencing hubs and policy levers consistent with our food sovereignty goals [107–110,112,115,118–121,125-126].

Synthesis

SSA's frontier is implementation: harnessing genetic diversity into locally valid, equitable precision nutrition31 and we must ensure Africa regains control of its food systems. We argue that success depends on governance and sovereignty, indigenous diets and food environments, fit-for-purpose technology stacks (AI, mHealth, affordable genotyping) (Adame Vázquez & Lozoya, 2018), inclusive data strategies and access to the capital necessary for indigenous communities to undertake the research. If these pillars move in complementarity, SSA has the potential to jumpfrog from marginalization to global leadership—generating models of precision public-health nutrition that are both scientifically robust and socially-rooted [107–111,115,118–122,125–126].

CONCLUSION

This review has collated the current situation of nutrigenomics in Sub-Saharan Africa (SSA), its limitations, and its policy implications. Although the continent possesses a fledgling level of nutrigenomics research, the evidence described highlights an enormous potential, yet also the urgent requirement for investment. In contrast to Asia and Latin America, where nutrigenomics is increasingly part of public health actions, research in Africa is fragile and small-scaled aspects, which has arisen because poor infrastructures that limit African representation from cohorts including uneven policy incorporation. Nevertheless, the continent harbours unparalleled genetic diversity, unique dietary ecosystems and a rapidly changing nutrition transition – elements that could make SSA a world leader in precision public-health nutrition if harnessed correctly.

One common thread that emerges from the evidence is the centrality of traditional diets and food sovereignty. There are more than just nutrition inputs but rather reservoirs of community resilience and cultural identity." Characterized by biodiversity, cultural significance, and metabolic advantage several traditional African foods illustrate what can be described as "founder" foods. Combining nutrigenomics with indigenous diets to improve health has a double dividend: advancing science that strengthens, rather than threatens, local food sovereignty and limits reliance on imported, often ultra-processed foods. Such an approach will help to ensure that precision nutrition interventions are culturally responsive, environmentally sustainable and equity-focused.

Barriers to success still are high. Funding gaps and poor lab infrastructure remain bottlenecks for both the advancement of studies, and raising per-sample costs. The governance of biobanking is moving forward through AU frameworks and the lessons of H3Africa, but there remains a patchy harmonization. This under-representation in global datasets leaves African populations marginalized in predictive models, with associated risks of misuse or unfairness. Furthermore, policy integration is poor: WHO AFRO's NCD packages and food-security programs serve as reference frame for nutrigenomics in routine care; its prominence remains weak in agriculture policy or maternal-child health strategies. There are also still ethical issues, especially related to data sovereignty and benefit sharing, needing more robust mechanisms that will build trust in local communities.

Notwithstanding these challenges, a number of clear paths forward are identified in this review. In the short term, emphasis should be placed on building capacity and upgrading regional biobanks and laboratory facilities, as well as piloting nutrigenomics within existing programmes such as antenatal care, PMTCT, HIV clinics and NCD services. Midterm agendas need to scope multi-country longitudinal frameworks where biofortification priorities combines with genotype-based evidence as well as incorporate nutrigenomics modules in medical, nutrition and agricultural curricula. However, long-term visions should target the creation of a pancontinental nutrigenomics institute based on AU/WHO AFRO leadership for Africa to become not only receptor but desired supplier of genomic discoveries.

Policy Call to Action

- Achieving this vision will require commitments at multiple levels:
- It is imperative for national governments to seize nutrigenomics as a priority in health and agricultural policy, with data sovereignty, equity and sustainability leading its roll-out.
- Regional organisations (AU, WHO AFRO) need to drive the harmonisation of biobank governance, ethical standards and data-sharing instruments that would allow for inter-country collaboration.
- Donors and international partners ought to move beyond short-term projects to sustained funding streams in infrastructure, training and African-led research leadership.
- Scientists or academia need to work together across disciplines (nutrition, genomics, data science and agriculture) to drive actionable evidence “in context.”
- Communities and civil society should play a "big influence on stealthy" role in determining nutrigenomics priorities, so that its introduction is coherent with local food systems, cultural values and equity objectives.

In summary, nutrigenomics provides SSA with a unique opportunity to integrate its genetic diversity, traditional diets and modern science towards achieving better health. The coming decade will show us if Africa will continue to be grossly underrepresented in precision nutrition research and practice, or whether it will become a trailblazer participant in the promotion of equitable and sustainable nutrigenomics grounded in culture. With decisive policy choices, continued investment and African-conducted governance, nutrigenomics can move out of the realm of promise and toward widespread practice – providing healthier futures for populations across Africa and new paradigms globally.

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