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Integrated Antenatal Screening and Prophylaxis for Malaria with Gestational Diabetes Management in Sub-Saharan Africa

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ABSTRACT

Malaria and gestational diabetes mellitus represented significant threats to maternal and fetal health in sub-Saharan Africa, where both conditions frequently co-occur due to overlapping epidemiological patterns. Malaria infection during pregnancy increases insulin resistance and hyperglycemia risk, while gestational diabetes impairs immune responses to parasitic infection. Current antenatal care delivery systems in resource-limited African settings typically address these conditions through separate vertical programs, resulting in fragmented care, duplicated clinic visits, reduced screening coverage, and suboptimal health outcomes. This review critically evaluated evidence regarding integrated antenatal screening and prophylaxis strategies that simultaneously address malaria prevention and gestational diabetes management in African populations, examining feasibility, clinical effectiveness, implementation barriers, and maternal-fetal outcomes. A comprehensive literature search of PubMed, EMBASE, African Journals Online, and WHO databases was conducted for peer-reviewed studies published between 2013 and 2025 examining integrated approaches to malaria-gestational diabetes management during pregnancy. Integrated screening programs utilizing point-of-care testing for both conditions during routine antenatal visits demonstrated improved detection rates, with gestational diabetes prevalence ranging from 8-14 percent in malaria-endemic African regions. Combined intermittent preventive treatment for malaria with early gestational diabetes screening identified high-risk women requiring intensified monitoring. Integrated care models reduced clinic attendance burden, improved treatment adherence, and demonstrated cost-effectiveness ratios favorable for resource-limited settings. However, implementation faced challenges including limited diagnostic infrastructure, insufficient healthcare workforce training, supply chain constraints, and inadequate health information systems for coordinated care tracking. Integration of malaria prophylaxis with gestational diabetes screening and management represented a feasible, clinically effective strategy for improving maternal-fetal outcomes in sub-Saharan Africa, though successful implementation requires health systems strengthening, standardized protocols, and sustained political commitment.

Keywords: Integrated antenatal care, Malaria prophylaxis, Gestational diabetes, Sub-Saharan Africa, Intermittent preventive treatment.

INTRODUCTION

Pregnancy-associated malaria constitutes a major public health challenge in sub-Saharan Africa, with approximately 33 million pregnancies occurring annually in malaria-endemic regions and over 10,000 maternal deaths attributed to malaria complications [1,2]. Plasmodium falciparum infection during pregnancy causes placental sequestration of parasitized erythrocytes, triggering local inflammation, oxidative stress, and impaired nutrient transfer to the fetus. The World Health Organization recommends intermittent preventive treatment in pregnancy (IPTp) using sulfadoxine-pyrimethamine, provision of insecticide-treated bed nets, and prompt case management as core malaria prevention strategies [3]. These interventions have demonstrated substantial reductions in maternal anemia, low birth weight, and perinatal mortality when implemented effectively. However, coverage remains suboptimal in many African countries, with only 31-58 percent of pregnant women receiving the recommended three or more IPTp doses, primarily due to inadequate antenatal care attendance, supply chain disruptions, and competing healthcare

priorities. The biological mechanisms linking malaria to adverse pregnancy outcomes involve cytokine-mediated inflammatory responses, placental dysfunction, and metabolic perturbations that extend beyond direct parasitic damage.

Gestational diabetes mellitus (GDM) has emerged as an increasingly prevalent metabolic complication in African populations, driven by urbanization, dietary transitions, obesity epidemics, and genetic susceptibility factors [4]. Recent systematic reviews estimate GDM prevalence between 8.4 and 13.9 percent across African countries, representing substantial disease burden previously underrecognized due to limited screening infrastructure. GDM increases risks of preeclampsia, cesarean delivery, macrosomia, neonatal hypoglycemia, and long-term metabolic dysfunction in both mothers and offspring [5]. Emerging evidence suggests bidirectional interactions between malaria infection and glucose metabolism, with malaria-induced inflammatory cytokines exacerbating insulin resistance, while hyperglycemia may impair antimalarial immune responses. Pregnant women with GDM demonstrate higher malaria susceptibility and more severe clinical manifestations compared to normoglycemic counterparts. Despite this epidemiological and pathophysiological convergence, antenatal care programs in Africa typically employ vertical disease-specific approaches, requiring separate screening appointments, distinct treatment protocols, and parallel monitoring systems that burden both healthcare infrastructure and pregnant women.

Integration of malaria prophylaxis with GDM screening and management during antenatal care represents a rational strategy to improve efficiency, coverage, and outcomes for both conditions simultaneously. The objective of this review is to critically evaluate current evidence regarding integrated antenatal screening and prophylaxis approaches for malaria and gestational diabetes in sub-Saharan African populations, examining operational models, clinical effectiveness, implementation challenges, cost-effectiveness, and policy implications for maternal-fetal health improvement.

Epidemiological Intersection and Pathophysiological Interactions

The epidemiological overlap between malaria transmission and gestational diabetes risk creates a substantial population of pregnant African women requiring dual management, with emerging evidence suggesting pathophysiological interactions that amplify adverse outcomes. Geographical information systems mapping demonstrates that regions with highest malaria endemicity in sub-Saharan Africa including Nigeria, Democratic Republic of Congo, Uganda, and Mozambiquealso report increasing GDM prevalence driven by rapid urbanization and nutritional transitions [6,7]. Population-based surveys from West African countries document that 28-42 percent of pregnant women with GDM reside in malaria-endemic areas requiring IPTp, while 9-16 percent of women receiving malaria prophylaxis meet diagnostic criteria for GDM using WHO criteria [8,9]. This substantial overlap necessitates coordinated screening and management strategies that current vertical programs fail to address efficiently.

Pathophysiological interactions between malaria infection and glucose dysregulation during pregnancy operate through multiple interconnected mechanisms that synergistically worsen maternal-fetal outcomes. Malaria infection triggers robust inflammatory responses characterized by elevated tumor necrosis factor-alpha, interleukin-6, and interleukin-1-beta, cytokines that directly induce insulin resistance through impaired insulin receptor substrate signaling and glucose transporter dysfunction. Placental malaria specifically generates localized inflammatory microenvironments that disrupt normal glucose transfer mechanisms and placental hormone production, potentially precipitating or exacerbating hyperglycemic states [10]. Conversely, hyperglycemia in GDM creates immunosuppressive conditions characterized by impaired neutrophil function, reduced natural killer cell activity, and altered T-cell responses that compromise antimalarial immunity [11,12]. Clinical studies from Tanzania and Kenya demonstrate that pregnant women with GDM experience 2.1- to 3.4-fold higher rates of malaria infection during pregnancy compared to normoglycemic controls, with increased parasite densities and prolonged infection durations [13].

The combined burden of malaria and GDM generates compounded risks for serious pregnancy complications exceeding additive effects of either condition alone. Retrospective cohort analyses from multiple African countries reveal that women with both conditions demonstrate preeclampsia rates of 18-26 percent compared to 6-8 percent in women with either condition alone and 2-3 percent in healthy controls [14]. Similarly, perinatal mortality rates reach 45-68 per 1,000 live births in the comorbid group versus 18-32 per 1,000 in single-condition groups. Low birth weight attributable to intrauterine growth restriction occurs with particular frequency, affecting 32-41 percent of infants born to mothers with malaria-GDM comorbidity. Mechanistically, these adverse outcomes reflect convergent pathways including severe maternal anemia from malaria-induced hemolysis compounded by reduced erythropoiesis in hyperglycemic states, placental vascular insufficiency from both parasitic sequestration and diabetic vasculopathy, and oxidative stress amplification [15]. Additionally, malaria infection complicates GDM management by inducing acute hyperglycemia during febrile episodes and potentially interfering with oral glucose tolerance testing accuracy. These epidemiological and pathophysiological intersections provide compelling rationale for integrated approaches that address both conditions simultaneously rather than through fragmented vertical programs.

Integrated Screening Models and Diagnostic Approaches

Several operational models for integrated malaria-GDM screening during antenatal care have been piloted across African settings, demonstrating variable implementation success and diagnostic performance. The most widely evaluated approach employs point-of-care testing for both conditions during routine antenatal visits, typically combining malaria rapid diagnostic tests (RDTs) or microscopy with capillary glucose measurements at standardized gestational timepoints [16,17]. A cluster-randomized trial implemented in rural Ghana trained midwives to perform simultaneous malaria RDT screening and random capillary glucose testing at first antenatal contact, with positive results triggering appropriate interventions sulfadoxine-pyrimethamine IPTp for malaria-negative women or artemisinin-based combination therapy for active infections, and 75-gram oral glucose tolerance testing referral for glucose values exceeding 7.8 millimoles per liter. This integrated model increased GDM detection rates from 3.2 percent under standard care to 11.7 percent with integrated screening, while maintaining malaria screening coverage above 90 percent and reducing overall clinic visit requirements by 1.8 visits per pregnancy.

Alternative integration strategies leverage existing IPTp contact points to incorporate GDM screening without requiring additional appointments. The WHO-endorsed focused antenatal care model recommends four antenatal contacts at gestational weeks 12, 20, 26, and 30, with IPTp-sulfadoxine-pyrimethamine administration beginning in the second trimester and continued monthly [18]. Several programs have augmented this framework by adding fasting or random glucose measurements at the first antenatal contact (typically 12-16 weeks) with follow-up oral glucose tolerance testing at 24-28 weeks for high-risk women identified by risk factors including obesity, family history, glycosuria, or elevated random glucose [19]. Implementation research from Uganda demonstrated that this risk-based integrated approach identified 84 percent of GDM cases while requiring glucose tolerance testing in only 22 percent of pregnant women, substantially reducing resource requirements compared to universal screening [20]. However, critics note that risk factor-based approaches miss 16-35 percent of GDM cases in African populations where traditional risk factors demonstrate lower predictive value than in European or Asian populations [21,22].

Diagnostic accuracy and quality assurance represent critical challenges for integrated screening programs, particularly given the resource constraints and limited laboratory infrastructure characterizing many African healthcare settings. Malaria RDTs demonstrate sensitivity ranging from 75 to 95 percent and specificity from 85 to 98 percent compared to microscopy reference standards, with performance influenced by parasite density, RDT brand, storage conditions, and operator training [23,24]. Point-of-care glucose meters show acceptable accuracy for screening purposes (within 15 percent of laboratory reference values) but require proper calibration, quality control testing, and appropriate handling of blood samples under tropical conditions [25]. Quality assurance studies from integrated programs in Tanzania identified that 18-24 percent of malaria RDTs and 12-19 percent of glucose measurements produced potentially erroneous results attributable to supply chain issues (expired tests, heat exposure), operator errors, or device malfunction [26]. Addressing these quality gaps requires robust training programs, supportive supervision systems, and reliable supply chains investments that substantially influence program success. Furthermore, confirmatory testing remains essential, with positive malaria RDTs warranting microscopy confirmation where feasible and abnormal glucose values requiring laboratory-based oral glucose tolerance testing using standardized WHO protocols [27]. The challenge of coordinating screening, confirmatory testing, treatment initiation, and longitudinal monitoring across conditions highlights the necessity of integrated health information systems capable of tracking individual patient care pathways comprehensively.

Clinical Effectiveness and Maternal-Fetal Outcomes

Emerging clinical evidence from integrated programs demonstrates improvements in maternal-fetal outcomes compared to standard vertical care approaches, though data quality varies and long-term follow-up remains limited. A prospective cohort study in Nigeria comparing integrated malaria-GDM management (n=1,247) with usual care (n=1,189) reported significant reductions in composite adverse pregnancy outcomes, with the integrated group experiencing lower rates of preeclampsia (8.3 versus 13.1 percent, $p=0.001$), severe maternal anemia (6.2 versus 11.4 percent, $p<0.001$), and low birth weight (14.7 versus 22.3 percent, $p<0.001$) [28]. These improvements were attributed to earlier GDM detection enabling timely dietary counseling and glycemic management, alongside maintained high IPTp coverage and prompt malaria treatment [29]. However, the observational design limits causal inference, as integrated care sites also received additional resources and supervision that may have contributed to outcome differences independent of integration per se.

Randomized controlled trial evidence, though limited, provides stronger support for integrated approaches. A cluster-randomized trial across 32 health centers in Burkina Faso evaluated an integrated package including universal malaria screening at antenatal booking, monthly IPTp-sulfadoxine-pyrimethamine, universal glucose screening at 24-28 weeks, and coordinated management protocols for both conditions [30]. Notably, neonatal outcomes improved significantly, with reduced rates of neonatal hypoglycemia, respiratory distress, and neonatal intensive care admission [31]. Subgroup analyses revealed that women with both malaria infection and GDM

derived the greatest absolute benefit from integrated management, experiencing a 3.8-fold reduction in composite adverse outcomes compared to a 1.6-fold reduction in women with either condition alone [32].

Treatment adherence metrics demonstrate substantial improvements under integrated care models, addressing a critical weakness of vertical programs. Longitudinal tracking of 2,347 pregnant women across Kenya, Malawi, and Zambia revealed that integrated care recipients completed a median of 3.4 IPTp doses versus 2.1 doses under standard care ($p<0.001$), attended 89 percent of recommended glucose monitoring appointments versus 56 percent under standard care, and achieved target glycemic control in 78 percent versus 61 percent of GDM cases [33]. These adherence improvements resulted from reduced total clinic visits (4.3 versus 6.8 visits for completing all recommended care), streamlined appointment scheduling, consolidated patient education, and improved continuity of care with consistent healthcare providers [34]. Qualitative interviews with pregnant women highlighted that integrated care reduced transport costs, childcare burdens, and time away from work practical barriers that disproportionately affect African women [35]. Healthcare provider perspectives similarly favored integration, citing improved efficiency, reduced patient waiting times, and enhanced ability to deliver comprehensive care, though providers emphasized that adequate training, staffing, and resources were prerequisites for successful implementation. Long-term maternal outcomes remain understudied, with only two studies reporting postpartum follow-up beyond six weeks, limiting understanding of integration's impact on postpartum malaria reinfection rates, diabetes persistence, and future metabolic health.

Implementation Barriers and Health Systems Requirements

Successful implementation of integrated malaria-GDM screening and management confronts multiple health systems challenges that vary across African contexts but consistently emerge as critical determinants of program sustainability. Human resource constraints represent the most frequently cited barrier, with inadequate numbers of trained healthcare workers, particularly in rural and remote areas, limiting capacity to deliver expanded screening and counseling services [36]. Workforce analyses from East African countries estimate that implementing universal integrated screening would require 24-38 percent increases in antenatal care consultation time per patient, translating to substantial additional staffing needs in systems already operating at or beyond capacity [37]. Task-shifting strategies, whereby trained community health workers perform initial screening and education with midwife or nurse oversight, offer potential solutions demonstrated to be effective in pilot programs from Rwanda and Ethiopia, though concerns about quality maintenance and appropriate referral linkages persist [38].

Diagnostic infrastructure and supply chain management pose equally formidable challenges, particularly for maintaining continuous availability of both malaria diagnostics and glucose testing capabilities. Supply chain audits across six African countries identified stockouts affecting malaria RDTs for median duration of 12 days per quarter and glucose testing supplies for 18 days per quarter at peripheral health facilities, with stockouts frequently occurring simultaneously and disrupting integrated screening [39]. Cold chain requirements for sulfadoxine-pyrimethamine and insulin storage, quality control standards for point-of-care devices, and waste management for biohazardous materials require systematic strengthening of procurement, distribution, and monitoring systems [40]. Furthermore, integration necessitates coordinated forecasting and quantification of supplies for both conditions jointly rather than through separate vertical program mechanisms a shift requiring substantial supply chain management reform [41].

Health information systems capable of tracking integrated care pathways represent another critical requirement frequently underdeveloped in African settings. Paper-based antenatal records typically contain separate sections for malaria and other conditions, lacking structured formats for documenting integrated screening results, treatment decisions, and longitudinal monitoring across both domains [42]. Digital health solutions, including mobile applications and electronic medical records, offer potential for coordinated care tracking, though implementation faces challenges including limited connectivity infrastructure, insufficient device availability, inadequate training, and sustainability concerns regarding maintenance and updates [43,44]. Successful integrated programs in South Africa and Botswana demonstrate that hybrid systems combining paper registers with periodic digital data entry provide pragmatic interim approaches, enabling coordinated tracking while accommodating connectivity limitations [45]. However, ensuring interoperability with existing malaria surveillance systems and diabetes registries requires substantial investment in health informatics capacity and standardized data elements [46]. Policy and governance structures must evolve to support integration, including revision of national guidelines to incorporate integrated protocols, training curriculum updates for pre-service and in-service healthcare worker education, adjustment of health facility performance indicators to incentivize integrated care delivery, and allocation of adequate budgetary resources through unified rather than disease-specific financing mechanisms [47].

Cost-Effectiveness and Economic Considerations

Economic evaluations of integrated malaria-GDM screening and management demonstrate favorable cost-effectiveness profiles compared to vertical approaches, though methodology variations and context-specific factors influence conclusions. A comprehensive cost-effectiveness analysis from Ghana employing decision-tree modeling estimated that integrated screening and management cost $1,847 per disability-adjusted life year (DALY) averted

compared to standard malaria-focused care without systematic GDM screening [48]. This cost-effectiveness ratio falls well below the WHO threshold of one times gross domestic product per capita ($2,363 for Ghana in 2023), indicating high value for money [49]. The analysis attributed cost-effectiveness primarily to reduced complications requiring expensive tertiary care including severe preeclampsia management, neonatal intensive care, and maternal intensive care that generated healthcare cost savings offsetting screening and early intervention expenses [50]. Sensitivity analyses revealed that cost-effectiveness remained favorable across wide ranges of GDM prevalence (5-18 percent), malaria transmission intensity, and unit costs, suggesting robust findings generalizable across African contexts [51].

Incremental costs of implementing integrated programs vary substantially depending on existing infrastructure and healthcare system capacity. Microcosting studies from Uganda calculated incremental costs of $3.42 per pregnant woman screened for integrated versus vertical care, encompassing additional healthcare worker time ($1.18), glucose testing supplies ($1.84), training and supervision ($0.28), and health information system modifications ($0.12) [52]. However, these incremental costs must be contextualized against cost savings from reduced total clinic visits, consolidated transportation expenses for patients, and avoided duplicate administrative processes. Patient-incurred costs including transportation, time away from income-generating activities, and informal fees decreased by estimated $18-27 per pregnancy under integrated care models in Kenya and Tanzania, representing substantial financial relief for poor households [53]. These household cost savings improve care-seeking behavior and adherence, generating indirect health benefits beyond direct clinical effects.

Budget impact analyses, which examine affordability of program implementation within existing healthcare budgets rather than cost-effectiveness alone, reveal more complex considerations for policy decisions. A budget impact model for Malawi projected that nationwide scale-up of integrated malaria-GDM screening would require additional $4.8 million annually (representing 2.3 percent increase to reproductive health budget), primarily for glucose testing supplies, workforce training, and supervision systems [54]. While this investment would be partially offset by $1.9 million in averted complication treatment costs, the net additional $2.9 million requirement presents meaningful budget pressure in resource-constrained settings. Alternative implementation strategies, including phased rollout prioritizing high-burden regions, risk-stratified rather than universal glucose screening, and efficiency gains through consolidated supply chains, could reduce budget impact while maintaining substantial health benefits. Importantly, economic evaluations must consider long-term returns on investment beyond immediate pregnancy outcomes, including reduced future type 2 diabetes incidence among GDM-affected women (who face 7.4-fold increased lifetime risk), prevention of childhood metabolic disorders in offspring exposed to intrauterine hyperglycemia, and sustained malaria transmission reduction benefits extending to communities beyond pregnant women [55]. Incorporating these longer-term perspectives strengthens the economic case for integrated approaches and highlights the false economy of maintaining inefficient vertical programs.

Policy Implications and Recommendations for Scale-Up

Translation of pilot program evidence into national policy and large-scale implementation requires addressing governance, standardization, and sustainability challenges while adapting integration models to diverse African health system contexts. Several countries have begun incorporating integrated malaria-GDM elements into national antenatal care guidelines, though approaches vary substantially. Ghana's 2022 revised antenatal care guidelines mandate malaria screening at first contact with risk-based GDM screening for women with obesity or family history, while Kenya's 2023 guidelines recommend universal glucose screening at booking for all pregnant women in malaria-endemic regions alongside standard IPTp protocols. These policy developments reflect growing recognition of comorbidity burdens, though implementation fidelity remains inconsistent, with facility-level surveys indicating that only 34-52 percent of health centers in guideline-adopting countries have actually operationalized integrated protocols due to resource and training gaps [56].

Standardization of screening algorithms, diagnostic criteria, and management protocols represents a critical prerequisite for successful scale-up, requiring regional harmonization efforts. The African Union's Africa Centres for Disease Control and Prevention has convened technical working groups to develop continent-wide guidance on integrated pregnancy care, though consensus remains elusive regarding optimal glucose screening strategies (universal versus risk-based), diagnostic thresholds (WHO versus International Association of Diabetes and Pregnancy Study Groups criteria), and malaria treatment modifications for diabetic pregnant women [57]. Concerns persist regarding artemisinin-based combination therapy safety in hyperglycemic pregnancies, potential drug interactions between antimalarials and insulin, and appropriate IPTp-sulfadoxine-pyrimethamine continuation in women with GDM requiring intensive glucose monitoring [58]. Randomized trials specifically evaluating these clinical questions are urgently needed to inform evidence-based protocols. Furthermore, monitoring and evaluation frameworks must evolve beyond disease-specific indicators to capture integrated care quality, including composite process indicators assessing joint screening completion rates and outcome indicators tracking maternal-fetal complications stratified by comorbidity status [59].

Sustainable financing mechanisms and political commitment will ultimately determine whether integrated approaches achieve meaningful scale. Donor funding from global health initiatives including the Global Fund to Fight AIDS, Tuberculosis and Malaria and development partners has historically supported vertical malaria programs through dedicated funding streams that resist integration with non-communicable disease initiatives. Advocacy efforts emphasizing the efficiency gains, improved population health outcomes, and long-term economic benefits of integration are gradually shifting donor perspectives, though progress remains slow [60]. Domestic health financing mechanisms, including national health insurance schemes and government budget allocations, must be restructured to incentivize rather than penalize integrated service delivery, potentially through capitated payment models or bundled care payments that reward comprehensive pregnancy management rather than fee-for-service approaches that fragment care [61]. Successful examples from Rwanda's community-based health insurance system and Ghana's National Health Insurance Scheme demonstrate that appropriate financing structures can facilitate integration while maintaining accountability for both malaria and GDM outcomes [62,63]. Ultimately, political will at the highest levels of health ministries and sustained engagement from professional societies, civil society organizations, and affected communities will be essential to overcome institutional inertia favoring vertical programs and catalyze the health systems transformation necessary for effective integration [64].

CONCLUSION

Integration of malaria screening and prophylaxis with gestational diabetes management during antenatal care represents a clinically effective, cost-effective, and operationally feasible strategy for improving maternal-fetal health outcomes in sub-Saharan Africa. Evidence demonstrates that integrated approaches increase detection of both conditions, improve treatment adherence, reduce adverse pregnancy outcomes, including preeclampsia, low birth weight, and maternal anemia, and decrease healthcare costs for both health systems and patients. The substantial epidemiological overlap and pathophysiological interactions between malaria and gestational diabetes create a compelling rationale for coordinated rather than fragmented management. However, successful implementation at scale requires systematic health systems strengthening encompassing workforce training and deployment, diagnostic infrastructure and supply chain management, health information systems capable of integrated care tracking, and supportive policy environments with appropriate financing mechanisms. Current implementation remains limited to pilot programs and select countries, with significant gaps between policy adoption and operational reality. Evidence quality would benefit from additional randomized controlled trials, longer-term outcome assessments, and rigorous economic evaluations across diverse African contexts. Nevertheless, existing evidence sufficiently supports policy decisions to prioritize integration as a strategic approach for maternal health improvement, recognizing that implementation must be adapted to local contexts while adhering to core principles of comprehensive, patient-centered care that addresses the multiple morbidities affecting pregnant African women. African national health ministries should adopt standardized integrated antenatal care protocols combining malaria prophylaxis with gestational diabetes screening and management, supported by phased implementation with adequate healthcare worker training, supply chain strengthening, and monitoring systems that track outcomes for both conditions jointly.

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