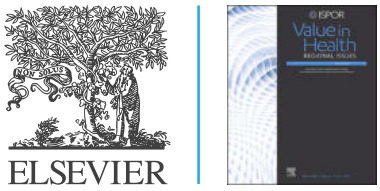

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Economic Evaluation

The Cost and Budget Impact of Malaria Vaccine Introduction in Uganda

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ABSTRACT

Objectives: The World Health Organization recommends deploying the RTS,S/AS01 malaria vaccine in high-burden regions. Although effective in reducing malaria cases, affordability challenges hinder widespread adoption in low-resource settings. This study examines the cost and budget impact of introducing the vaccine into Uganda's expanded immunization program.

Methods: A budget impact analysis based on prospective studies conducted in Uganda and sub-Saharan Africa, with unit costs per dose obtained from existing literature. The primary outcome was the number of malaria cases averted among eligible children. The budget impact was calculated by comparing total vaccination costs to savings from reduced malaria treatment costs, incorporating sensitivity analyses for varying vaccine coverage and malaria incidence levels.

Results: The treatment costs for complicated malaria in children under 5 were estimated at $1.1 million before vaccination, decreasing to $297 465 afterward. The estimated annual vaccination rollout cost was $29 million, representing 24% of Uganda's immunization budget and about 3.5% of total health budget. Over 5 years, the total budget impact was $145.5 million, with a net cost of $141 million. The impact varied with coverage levels, ranging from $106.3 million at lower coverage to $175.6 million at higher coverage.

Conclusions: Implementing the malaria vaccine would lead to significant increase in Uganda's immunization budget and the overall health sector budgets. To ensure sustainability, the government should prioritize funding and adopt cost-effective strategies, such as targeting high-transmission areas and expanding prevention efforts, to maintain affordability and achieve long-term success.

Keywords: budget impact, healthcare financing, malaria vaccine, vaccine costs.

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Introduction

Malaria is a major global public health concern accounting for about 263 million cases and resulting into 597 000 deaths in 2023. In 2023, the World Health Organization (WHO) Africa region contributed 94% of these cases and 95% of all malaria deaths. Children under 5 years of age are the most vulnerable, contributing 76% of deaths in 2023. In Uganda, malaria is the leading cause of death for all ages,[1] imposing a significant economic burden by increasing healthcare costs, reducing productivity, and hindering economic growth. Uganda's health expenditure as a percentage of gross domestic product remains modest, with total health spending fluctuating between 1.8 trillion shillings in 2016 and 2017 and an estimated 4.4 trillion shillings in 2025 and 2026, representing roughly 6.2% of the national budget. The limited investment reflects ongoing underfunding, hindering progress toward Universal Health Coverage by 2030 and challenging sustainability of malaria control efforts.

Globally, countries are committed to reducing global malaria incidence and mortality rates by at least 90% by 2030. To achieve this, countries have deployed a range of strategies, including vector control strategies and prompt case management. By 2023, nearly 73% of households in sub-Saharan Africa had at least 1 insecticide-treated net (ITN), showing an increase from about 5% in 2000 and from 68% in 2015.[2] In 2023, the proportion of the population sleeping under an ITN was reported to be 52%, representing a significant increase from just 2% in 2000.[2] Meanwhile, the coverage of indoor residual spraying in malaria-endemic countries declined globally from 5.3% in 2010 to 1.6% in 2023.[2] This decline reflects some progress in malaria reduction in several countries; however, in Uganda, the trend has been associated with a resurgence of malaria cases as indoor residual spraying coverage has been withdrawn. This situation highlights the need to explore additional preventive tools, such as vaccines, to complement existing interventions and sustain malaria control efforts.

In October 2021, the WHO recommended widespread use of the RST, S/AS01 malaria vaccine in areas with moderate to high *Plasmodium falciparum* transmission.[3] This guidance was based on clinical trials demonstrating the vaccine's proven efficacy and

effectiveness after 3 booster doses,[4,5] necessitating a 4-dose schedule for children aged 6 to 18 months. To integrate the vaccine into existing immunization programs, 2 additional visits, 1 in the first year of life and another in the second year, have been added to the routine schedule. Beyond its demonstrated efficacy and effectiveness,[4] previous cost-effectiveness analyses support the vaccine's value as a public health intervention. For example, a Markov cohort simulation study involving 41 sub-Saharan African countries found that, compared with no vaccination, the RTS, S/AS01 vaccine was found to be cost-effective when valued against the gross-domestic-product-per-capita threshold. It demonstrated a favorable incremental cost-effectiveness ratio of $200 and $225 per disability-adjusted life-year (DALY) averted in children and infants, respectively.[6]

Another cost-effectiveness study conducted in 43 African countries found that the RTS, S/AS01 malaria vaccine was cost-effective compared with routine malaria control interventions, with a median cost-effectiveness ratio of $188 (range $78-$22 448) per DALY averted.[7] Similarly, a study conducted in Bangladesh demonstrated that the introduction of the RTS, S/AS01 vaccine was cost-effective, showing a favorable incremental cost-effectiveness ratio of $2629 per DALY averted in the health system perspective.[8] However, evidence indicates that the vaccine's cost-effectiveness is higher in populations with low coverage or no access to ITNs. As a result, some experts recommend that countries prioritize expanding existing malaria interventions, such as increasing ITN coverage before introducing the vaccine, or target vaccine deployment in areas lacking ITNs.[9] Additionally, factors such as local malaria transmission intensity, prevalence rates, mosquito insecticide resistance, and the capacity of health systems to deliver the vaccine should be carefully considered during implementation.[10]

The 2023 Lusaka agenda on domestic resource mobilization emphasizes strengthening national capacities to generate sustainable health financing,[11] reducing reliance on external aid, and fostering innovative financing mechanisms.[11] This approach aligns the global shift toward enhancing domestic health financing and minimizing dependency on external funding and household out-of-pocket expenditure.

Traditional aid models are now complemented by domestic investments, private sector engagements, and innovative financial tools. Simultaneously, US government policies have shifted to prioritize health system strengthening and disease control, shaping global funding priorities and program strategies.[12] In Uganda, ongoing health financing dialogs and stakeholder engagement aim to optimize resource allocation and ensure the financial sustainability of health programs, including immunization.[13] The Uganda National Expanded Program on Immunization exemplifies this effort, striving to expand vaccine coverage and integrate new interventions, such as the malaria vaccine. As Uganda prepares for malaria vaccine introduction on scale, understanding its cost and budget impact is crucial for shaping policy, ensuring affordability, and sustaining immunization programs amid changing global and domestic financing.

Despite strong clinical and economic evidence supporting the malaria vaccine, a budget impact analysis is essential to assess Uganda's financial capacity for the immunization program expansion. The health sector faces ongoing financial constraints and increasing uncertainty in global health financing, amid a high disease burden and emerging priorities like noncommunicable disease. This study aims to evaluate the costs and financial implication of introducing the RTS, S/AS01 vaccine over a 5-year period. The analysis provides insights from the national health system perspective on the vaccine's impact on the national immunization budget.

Methods

Study Design

A budget impact analysis of the health system was conducted to compare costs before and after malaria vaccine introduction, with all analyses performed using Excel. Prevaccine costs included malaria treatment expenses for both complicated and uncomplicated malaria cases. Postvaccine costs were derived from literature, based on the cost per fully vaccinated child.[6,7,11] We estimated the proportion of eligible children who would receive the vaccine and the associated costs. The analysis also included the percentage of vaccinated children who might still contract malaria, along with their healthcare utilization patterns, including inpatient and outpatient management. Costs were calculated assuming that all uncomplicated cases would be managed as outpatients, whereas severe cases would be admitted as inpatients, in line with the national treatment protocol.

The analysis incorporated key probabilities: the likelihood of a child contracting uncomplicated malaria,[14] or complicated malaria after vaccination.[15] To estimate the distribution of outpatient and inpatient malaria cases, we utilized data from the Uganda National Malaria Program, which indicate that malaria accounts for nearly 50% of outpatient visits across all age groups.[16]

A 5-year time horizon was chosen for the budget impact analysis because it is sufficient to capture the long-term effects of the malaria vaccine on resource utilization and health outcomes. We anticipated that, by the end of year 5, the vaccine would significantly reduce malaria cases and mortality. Accordingly, we calculated the annual cost of the malaria vaccine program from June 2024 to July 2029. The eligible vaccination population was estimated using 2022 data on surviving infants in Uganda from the WHO immunization portal. All financial analyses were conducted in excel, with local currency values converted to US dollars at the 2023 exchange rate of 1 USD = 3723.87 Ugandan shillings.[17] We also assumed a 3% annual inflation rate for the estimated malaria treatment costs over the 5-year period.

Malaria Vaccine Costs

To estimate the total vaccination cost per year, we adopted the WHO guideline for costing new vaccines.[18] Total vaccine per year was estimated as $c = p * n$ in which p is the cost per dose of the new vaccine, and n is the number of doses supplied by the program for the first year estimated as $n = i * b * d * [1/(1 - w)] * [1 + r]$, in which i is the immunization coverage rate, b is birth cohort, d is number of doses per fully immunized child, w is wastage rate (%), and r is reserve stock (%). We used the same formula to estimate the number of vaccine doses needed for the other 4 years of analysis. According to estimates from studies within the sub-Saharan African region,[6,19,20] the average price per dose of malaria vaccine dose was estimated at $5 with a range of $2 to $10. However, considering the national health system perspective, we used the price per fully vaccinated child (FVC).

A recent cost estimate for vaccine financing in Uganda, based on unpublished data from the national vaccine program, was found to be $52.87. To improve comparability and increase the relevance of our findings, we also analyzed cost estimates from studies conducted in similar sub-Saharan African contexts, which yielded an average cost of $42.30 per FVC.[6,19,20] To ensure the relevance of our findings across different periods, we adjusted all historical cost estimates for inflation using an annual rate of 3%.[21] Notably, Uganda's national immunization program provides vaccine coverage data for existing vaccines, but for the purpose of this

study, we assumed a static vaccine coverage rate of 78%, as estimated in population-based study from a similar setting in Kenya.[22]

The estimated cost per FVC was derived from a composite analysis based on data from comparable settings in other sub-Saharan African countries.[6,19,20] This estimate encompassed all major components of the vaccination program, including planning, cold chain assessment and management, staff training, social mobilization, vaccine wastage, program supervision, monitoring, and overall program management.[7,20]

The WHO recommends an acceptable vaccine wastage rate of 5% when estimating the total cost of vaccine introduction. In our analysis, we did not calculate the wastage rate separately because it was incorporated into the estimates for the cost per FVC.[20] Additionally, the reserve stock rate was not explicitly estimated; instead, we assumed efficient management of these vaccines from central warehouse stores to health facilities.

Malaria Treatment Costs

For our budget impact analysis, we assessed the direct treatment costs associated with severe and uncomplicated malaria cases by comparing costs before and after integrating the malaria vaccine into the national program over a 5-year period. Cost estimates for managing these cases were derived from published literature.[7] According to the Uganda National Malaria Control Policy, uncomplicated malaria cases are typically managed as outpatients through home-based management or integrated community case management, whereas complicated malaria cases in small and critically ill children are treated as inpatients under close medical supervision in public health facilities.[23]

To estimate the annual treatment costs over 5 years, we assumed a 3% annual increase in the proportion of surviving infants eligible for vaccination. We determined the distribution of severe and uncomplicated cases after vaccination by sourcing probability estimates and case severity from relevant literature for our excel calculations. Baseline proportions of severe and uncomplicated malaria cases without vaccination were based on data from the Uganda Health Management Information System, which reported that in 2021, malaria accounted for 16.14% of hospital admissions and 46% of outpatient visits among children under 5.[24,25] The proportion of cases without vaccination was calculated using incidence rate of 250 per 1000 individuals in the vaccine-eligible population. We also considered high and low malaria incidence scenarios in our sensitivity analysis to account for variability.

Additionally, we estimated the total cost of malaria treatment to the Ugandan healthcare system under scenarios both with and without the vaccination program. The provider cost per case of severe and uncomplicated malaria were derived from previously published cost estimates.[26] We assumed that 82% of all malaria care-seeking occurs in public facilities.[27] To project treatment cost savings over 5 years, we multiplied the number of cases averted by the malaria vaccine program by the healthcare cost per malaria case.[7] The costs associated with malaria prevention were not included in the budget impact analysis because we assumed the Ugandan government would continue investing in malaria prevention strategies, such as long-lasting insecticide nets, indoor spraying, and awareness campaigns because these measures target populations beyond those eligible for vaccination. The study adhered to the principles of good practice for conducting budget impact analysis as outlined by the ISPOR Task Force.[28]

Sensitivity Analysis

To evaluate the robustness of our model findings, we performed deterministic sensitivity analysis examining both low and high scenarios for malaria incidence and vaccine coverage. Malaria transmission rates were categorized based on WHO-recommended transmission levels, with the low scenario set at 100 cases per 1000 population and the high scenario at 450 cases per 1000 population. Additionally, we varied vaccine coverage by ±20%, resulting in a high-coverage scenario of 98% and a low-coverage scenario of 58% among eligible children over the 5-year period. This approach allowed us to assess the impact of variability in transmission and coverage on the model's outcome.

Results

The budget impact analysis revealed the potential financial implication of including the malaria vaccine in Uganda immunization program over a 5-year period, targeting an estimated vaccine-eligible population of 8.85 million children. The introduction of the vaccine was linked to a decline in malaria cases, dropping from an estimated 341 995 cases without vaccination to 141 381 cases with vaccination. This represents nearly 200 614 cases averted over the 5-year time horizon.

Budget Impact Analysis

Table 1 presents the data used to estimate the vaccination costs in the base-case calculation. The number of malaria cases, including complicated and uncomplicated cases with or without the vaccine are presented in Figure 1. The total treatment costs based on the estimated number of complicated and uncomplicated malaria cases and their provider treatment costs, was calculated. For the 8.85 million vaccine-eligible children at risk of acquiring malaria over 5 years in Uganda, the expected budget due to malaria treatment costs (without vaccines) was $6 009 962 (Table 2).

After vaccine introduction, malaria cases declined, with an estimated 200 614 cases averted (Fig. 1). Over 5 years, total provider costs for treating severe and uncomplicated malaria in children under 5 decreased from $6 009 962 to $1 579 283. The resulting financial savings are estimated to be $3 243 073 for severe cases and $1 187 606 for uncomplicated cases. The projected total budget with vaccine implementation is $145 521 605, indicating a potential net budget impact of $141 090 926 over the 5-year period.

Sensitivity Analysis

The budget impact analysis was considered under additional scenarios of low and high malaria incidence, and under low and high vaccine coverage as presented in Figure 2 and Appendix Table 1 in Supplemental Materials. In both scenarios, the inclusion of malaria vaccine into the national expanded program for immunization in Uganda would lead to increased financial burden to government over the 5-year time horizon. However, this should be balanced against the benefits of reduced malaria burden and lower treatment costs to government and households. The total net budget impact for the low- and high-vaccine-coverage scenario would be $106 253 046 and $175 552 904, respectively (Fig. 2).

Discussion

The study provides a budget impact analysis of introducing malaria vaccination into Uganda's national immunization program. Using existing costs and epidemiological data, we estimated a significant reduction in malaria cases and treatment

Table 1. Vaccine resource inputs for estimation of the total vaccination cost.

Parameter	Base case	Adjusted	Sources
Estimated malaria vaccine coverage (%)	78.0		Moturi et al[15,22]
Population of surviving infants	1 668 269.0		Gavi Zero-Dose Learning Hub[16]
Estimated malaria episode after full vaccination (%)	47.0		Samuels et al[15,17]
Malaria cases without vaccine, base case (per 1000 population)	250.0		World Health Organization (WHO)[18]
Proportion of complicated malaria cases with vaccination (%)	4.0		Samuels et al [15,17]
Proportion of complicated malaria cases without (%)	10.0		World Health Organization (WHO)[18]
Cost per RTS,S dose	$5.0		Galactionova et al[7], Sauboin et al,[6] Penny et al[10], Topazian et al[9], Sicuri et al[19], Baral et al[20]
Vaccine cost per FVC	$40.2	$42.3	Baral et al,[20] Sauboin et al[6], Topazian et al[9], Sicuri et al[19], Baral et al[20]
Uncomplicated malaria treatment costs	$1.2	$1.3	Batura et al[26]
Complicated malaria treatment costs	$19.6	$21.4	Batura et al[26]

costs over 5 years. The projection of short-to-medium-term costs and savings to the immunization budget, offers valuable insights for policymakers on the financial feasibility and impact of integrating the RTS, S/AS01 malaria vaccine into Uganda's health financing strategy.

Our results showed that the estimated annual vaccination cost was $29.1 million, totaling to $145 million over 5 years. The introduction of the vaccine is projected to generate potential healthcare cost savings of $4.4 million over this period, primarily driven by a reduction in both severe and uncomplicated malaria cases treated in public health facilities.

In the 2020 to 2021 fiscal year, Uganda's Ministry of Health estimated that vaccinating against 14 diseases cost $120 million annually. Introducing the new malaria vaccine is projected to add about $29 million per year, representing a 24% increase, bringing the total immunization budget to $149 million. This would account for nearly 18% of the country's overall health sector budget of $820 million. Specifically, the malaria vaccine alone would represent about 3.5% of the national health budget. Despite the significant costs, malaria causes 6.5% of all-age mortality in Uganda,[1] underscoring the need for substantial resource allocation to combat it. Moreover, the long-term health and economic benefits of the vaccine, such as reduced morbidity, mortality, and reduced economic burden to households attributed to malaria treatment are likely to outweigh the additional investment.[6,29]

The introduction of the malaria vaccine has the potential to significantly reduce malaria cases, thereby freeing up valuable health sector resources and decreasing household costs.

Our study estimated an 83.5% reduction in malaria admissions and a 56% decrease in outpatient cases. In 2021, malaria was the leading cause of hospital admissions and outpatient visits among children under 5 in Uganda, accounting for over 305 899 hospital admissions and 3.1 million outpatient cases, although these figures may be underestimated because of poor record keeping in the private sector. A decline in malaria cases could enable healthcare workers to focus on other services and optimize resource use. Given the high costs associated with treating severe malaria,[24] the vaccine could significantly reduce household out-of-pocket expenses and alleviate productivity losses attributed to caregiving. Malaria accounts for a substantial 17.3% of household health expenses in Uganda, which has one of the highest out-of-pocket health spending rates in sub-Saharan Africa, exceeding 40% of total health expenditure. In support to our finding and argument, a related study from Malawi showed that the RTS, S/AS01 vaccine prevented 94 000 clinical cases and nearly 400 deaths, highlighting its potential public health and economic benefits.[30]

Given Uganda's limited health budget and competing priorities, expanding funding for the malaria vaccine may be challenging despite the potential benefits of the vaccine. The country should consider strategies to both raise additional funds and reduce costs. Evidence indicates that existing malaria prevention strategies, such as insecticide-treated nets, are cost-effective.[31] However, the malaria vaccine would particularly be most

Figure 1. Estimated number of malaria cases before and after malaria vaccine for the first cohort of vaccine-eligible infants.

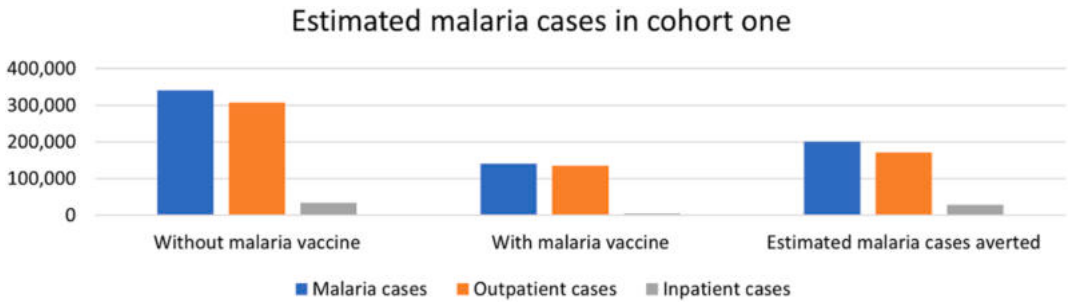


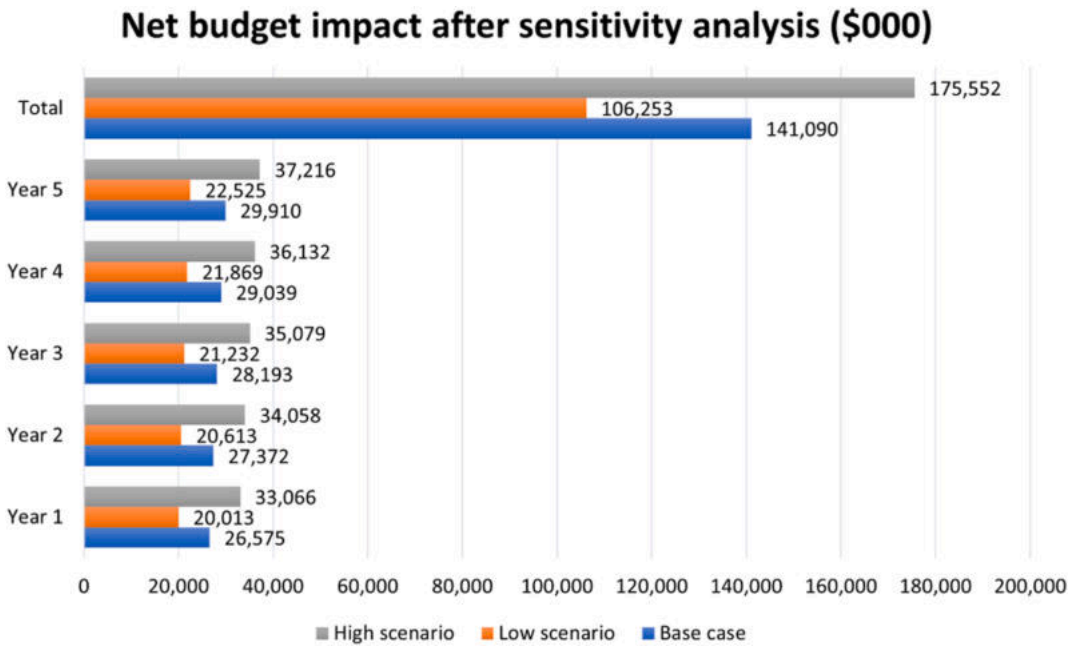
Table 2. Budget impact analysis results.

Annual cost outcomes ($)	Year 1	Year 2	Year 3	Year 4	Year 5	Total
Before vaccine						
Vaccine introduction costs	0	0	0	0	0	0
Malaria treatment costs	1 132 004	1 165 964	1 200 943	1 236 971	1 274 080	6 009 962
Total costs	1 132 004	1 165 964	1 200 943	1 236 971	1 274 080	6 009 962
After vaccine						
Vaccine introduction costs	27 409 660	28 231 949	29 078 908	29 951 275	30 849 813	145 521 605
Malaria treatment costs	297 465	306 389	315 581	325 048	334 800	1 579 283
Total costs	27 707 125	28 538 338	29 394 489	30 276 323	31 184 613	147 100 888
Budget impact						
Vaccine budget impact	27 409 660	28 231 949	29 078 908	29 951 275	30 849 813	145 521 605
Malaria treatment budget impact	−834 539	−859 575	−885 362	−911 923	−939 280	−4 430 679
Net budget impact	26 575 121	27 372 374	28 193 546	29 039 352	29 910 533	141 090 926

effective in settings where access to these other prevention methods is limited or coverage remains suboptimal. Therefore, Uganda could focus on increasing ITN coverage, especially in high-burden areas, before introducing the vaccine there. Switching to pyrethroid-piperonyl butoxide nets in regions with high resistance could also improve effectiveness. Additionally, strengthening early detection and treatment of malaria through the Integrated Community Case Management program and timely referrals can reduced complications and improve outcomes, particularly in areas not yet targeted by vaccination.

Our study has limitations. First, we did not adjust the $5 per dose vaccine unit cost for comparability with recent costing studies; however, inflation could increase its real value. Additionally, we did not include vaccine cost variation scenarios in our analysis, which we consider a limitation. We recommend that future studies with longer analytic time horizons incorporate vaccine to better capture potential fluctuations and their impact on budget projections. Second, we estimated the economic value of the malaria vaccine from the health system perspective, given our data. As a result, the overall benefits are likely underestimated because they do not include household-level gains, such as increased productivity from fewer workdays lost by patients and caregivers. Lastly, our malaria case estimates, based on Uganda's Health Management Health Information System, may underestimate the true burden due to missing private sector data. Future research should adopt a societal perspective to fully capture the vaccine's overall economic and financial impact.

Figure 2. Sensitivity analysis using low and high scenarios for vaccine coverage and malaria incidence for under 5 children.



Conclusion

The study shows that introducing the malaria vaccine would increase Uganda's immunization budget by approximately 24% and raise the overall health sector budget by 3.5%. To ensure long-term sustainability and affordability of the vaccine program, the government should prioritize spending, adopt innovative financing strategies, and seek additional funding. Cost-effective approaches, such as targeting high-transmission areas and expanding other malaria prevention measures, such as insecticide-treated nets, can help make vaccine rollout more affordable. Advances in vaccine technology that reduce dosage requirements could further decrease costs, underscoring the importance of meticulous planning.

Author Disclosures

Author disclosure forms can be accessed below in the Supplemental Material section.

Supplemental Material

Supplementary data associated with this article can be found in the online version at https://doi.org/10.1016/j.vhri.2026.101608.

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REFERENCES

1. Ministry of Health. Annual Health Sector Performance Report 2023/24. Ministry of Health. https://library.health.go.ug/sites/default/files/resources/Annual%20Health%20Sector%20Performance%20Report%20%20FY%202023_24.pdf; 2024. Accessed March 25, 2025.
2. World Health Organization (WHO). *World Malaria Report 2024: Addressing Inequity in the Global Malaria Response*. World Health Organization (WHO); 2024. https://www.who.int/teams/global-malaria-programme/reports/world-malaria-report-2024. Accessed March 27, 2025.
3. World Health Organization (WHO). *WHO Guidelines for Malaria*. Geneva: World Health Organization (WHO); 2023.
4. Parums DV. Current status of two adjuvanted malaria vaccines and the World Health Organization (WHO) strategy to eradicate malaria by 2030. *Med Sci Monit Int Med J Exp Clin Res*. 2023;28:e939357-1.
5. Dicko A, Ouedraogo J-B, Zongo I, et al. Seasonal vaccination with RTS, S/AS01E vaccine with or without seasonal malaria chemoprevention in children up to the age of 5 years in Burkina Faso and Mali: a double-blind, randomised, controlled, phase 3 trial. *Lancet Infect Dis*. 2024;24(1):75–86.
6. Sauboin C, Van Bellinghen L-A, Van De Velde N, Van Vlaenderen I. Economic impact of introducing the RTS, S malaria vaccine: cost-effectiveness and budget impact analysis in 41 countries. *MDM Policy Pract*. 2019;4(2):2381468319873324.
7. Galactionova K, Tediosi F, Camponovo F, Smith TA, Gething PW, Penny MA. Country specific predictions of the cost-effectiveness of malaria vaccine RTS, S/AS01 in endemic Africa. *Vaccine*. 2017;35(1):53–60.
8. Sarker AR, Sultana M. Cost-effective analysis of childhood malaria vaccination in endemic hotspots of Bangladesh. *PLOS One*. 2020;15(5):e0233902.
9. Topazian HM, Schmit N, Gerard-Ursin I, et al. Modelling the relative cost-effectiveness of the RTS, S/AS01 malaria vaccine compared to investment in vector control or chemoprophylaxis. *Vaccine*. 2023;41(20):3215–3223.
10. Penny MA, Verity R, Bever CA, et al. Public health impact and cost-effectiveness of the RTS, S/AS01 malaria vaccine: a systematic comparison of predictions from four mathematical models. *Lancet*. 2016;387(10016):367–375.
11. Witter S, Baker P. *Tracking Delivery on the Lusaka Agenda*. Washington D.C.: Center for Global Development; 2024.
12. Carroll M, Ruzgar N, Fedatto M, Schultz K, Cheung M. 'Show me the money': an analysis of US global health funding from 1995 to 2019. *J Glob Health*. 2024;14:04173.
13. Odoch WD. *Assessment of the Influence of Sustainable Development Goals Declaration on Health Financing Reforms for Universal Health Coverage in Uganda: A Stakeholders' perspective*. Pretoria: University of Pretoria; 2023.
14. Ministry of Health. *National Malaria Annual Report 2017-2018, Kampala, Uganda*. Kampala: Ministry of Health, National Malaria Control Program SMEU; 2019.
15. Samuels AM, Ansong D, Kariuki SK, et al. Efficacy of RTS, S/AS01E malaria vaccine administered according to different full, fractional, and delayed third or early fourth dose regimens in children aged 5-17 months in Ghana and Kenya: an open-label, phase 2b, randomised controlled trial. *Lancet Infect Dis*. 2022;22(9):1329–1342.
16. Alunyo JP, Akello SR, Wenani D, et al. Trends and Distribution of Malaria Mortality Among Children and Adolescents Aged 0-17 Years, UgandaUganda National Institute of Public Health (UNIPH). https://uniph.go.ug/trends-and-distribution-of-malaria-mortality-among-children-and-adolescents-aged-0-17-years-uganda-2023-descriptive-analysis-of-medically-certified-cause-of-death-data/; 2023. Accessed April 5, 2025.
17. World Bank Group. Official exchange rate (LCU per US$, period average). https://data.worldbank.org/indicator/PA.NUS.FCRF; 2023. Accessed May 6, 2025.
18. World Health Organization (WHO). *Guidelines for Estimating Costs of Introduction New Vaccines Into the National Immunization System*. Geneva: World Health Organization, BioLogicals DoVa; 2002.
19. Sicuri E, Yaya Bocoum F, Nonvignon J, et al. The costs of implementing vaccination with the RTS, S malaria vaccine in five sub-Saharan African countries. *MDM Policy Pract*. 2019;4(2):2381468319896280.
20. Baral R, Levin A, Odero C, et al. Cost of introducing and delivering RTS, S/AS01 malaria vaccine within the malaria vaccine implementation program. *Vaccine*. 2023;41(8):1496–1502.
21. Grassi S. Understanding Inflation Dynamics in the United States: An Analysis of 2024. https://www.researchgate.net/profile/Stefano-Grassi/publication/384766504_Understanding_Inflation_Dynamics_in_the_United_States_An_Analysis_of_2021-2024/links/6706d89156f2ab4a3418ef7c/Understanding-Inflation-Dynamics-in-the-United-States-An-Analysis-of-2021-2024.pdf. Accessed April 2, 2025.
22. Moturi AK, Jalang'o R, Cherono A, Muchiri SK, Snow RW, Okiro EA. Malaria vaccine coverage estimation using age-eligible populations and service user denominators in Kenya. *Malar J*. 2023;22(1):287.
23. Ministry of Health. Knowledge Management Portal. Uganda National Malaria Control Policy Ministry of Health Program NMC. https://library.health.go.ug/communicable-disease/malaria/uganda-national-malaria-control-policy-2011; 2011. Accessed March 27, 2025.
24. Hailu A, Lindtjørn B, Deressa W, Gari T, Loha E, Robberstad B. Economic burden of malaria and predictors of cost variability to rural households in south-central Ethiopia. *PLOS One*. 2017;12(10):e0185315.
25. Ministry of Health. *Annual Health Sector Performance Report FY 2020/21*. Uganda: Ministry of Health; 2021. https://library.health.go.ug/sites/default/files/resources/Annual%20Health%20Sector%20Performance%20Report%202020-21-1.pdf. Accessed March 11, 2026.
26. Batura N, Kasteng F, Condoane J, et al. Costs of treating childhood malaria, diarrhoea and pneumonia in rural Mozambique and Uganda. *Malar J*. 2022;21(1):239.
27. World Health Organization (WHO). *World Malaria Report 2023*. Geneva: World Health Organization (WHO); 2023.

28. Sullivan SD, Mauskopf JA, Augustovski F, et al. Budget impact analysis—principles of good practice: report of the ISPOR 2012 Budget Impact Analysis Good Practice II Task Force. *Value Health*. 2014;17(1):5–14.
29. Ndikumukiza C, Yunusa I, Nkurunziza J, et al. Adoption of RTS, S malaria vaccine for children younger than 5 years in Rwanda: a budget impact analysis. *Explor Res Clin Soc Pharm*. 2021;3:100063.
30. Ndeketa L, Mategula D, Terlouw DJ, Bar-Zeev N, Sauboin CJ, Biernaux S. Cost-effectiveness and public health impact of RTS, S/AS01 E malaria vaccine in Malawi, using a Markov static model. *Wellcome Open Res*. 2021;5:260.
31. Goodman CA, Coleman PG, Mills AJ. Cost-effectiveness of malarisa control in sub-Saharan Africa. *Lancet*. 1999;354(9176):378–385.