




Cost of introducing and delivering malaria vaccine (RTS,S/AS01_E) in areas of seasonal malaria transmission, Mali and Burkina Faso

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To cite: Diawara H, Bocoum FY, Dicko A, *et al.* Cost of introducing and delivering malaria vaccine (RTS,S/AS01_E) in areas of seasonal malaria transmission, Mali and Burkina Faso. *BMJ Global Health* 2023;**8**:e011316. doi:10.1136/bmjgh-2022-011316

Handling editor Lei Si

► Additional supplemental material is published online only. To view, please visit the journal online (<http://dx.doi.org/10.1136/bmjgh-2022-011316>).

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Received 3 December 2022

Accepted 24 March 2023



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ABSTRACT

Background The WHO recommends use of the RTS,S/AS01_E (RTS,S) malaria vaccine for young children living in areas of moderate to high *Plasmodium falciparum* malaria transmission and suggests countries consider seasonal vaccination in areas with highly seasonal malaria. Seasonal vaccination is uncommon and may require adaptations with potential cost consequences. This study prospectively estimates cost of seasonal malaria vaccine delivery in Mali and Burkina Faso.

Methods Three scenarios for seasonal vaccine delivery are costed (1) mass campaign only, (2) routine Expanded Programme on Immunisation (EPI) and (3) mixed delivery (mass campaign and routine EPI), from the government's perspective. Resource use data are informed by previous new vaccine introductions, supplemented with primary data from a sample of health facilities and administrative units.

Findings At an assumed vaccine price of US \$5 per dose, the economic cost per dose administered ranges between \$7.73 and \$8.68 (mass campaign), \$7.04 and \$7.38 (routine EPI) and \$7.26 and \$7.93 (mixed delivery). Excluding commodities, the cost ranges between \$1.17 and \$2.12 (mass campaign), \$0.48 and \$0.82 (routine EPI) and \$0.70 and \$1.37 (mixed delivery). The financial non-commodity cost per dose administered ranges between \$0.99 and \$1.99 (mass campaign), \$0.39 and \$0.76 (routine EPI) and \$0.58 and \$1.28 (mixed delivery). Excluding commodity costs, service delivery is the main cost driver under the mass campaign scenario, accounting for 36% to 55% of the financial cost. Service delivery accounts for 2%–8% and 12%–23% of the total financial cost under routine EPI and mixed delivery scenarios, respectively.

Conclusion Vaccine delivery using the mass campaign approach is most costly followed by mixed delivery and routine EPI delivery approaches, in both countries. Our cost estimates provide useful insights for decisions regarding delivery approaches, as countries plan the malaria vaccine rollout.

WHAT IS ALREADY KNOWN ON THIS TOPIC

- ⇒ Malaria parasite transmission is highly seasonal across the African Sahel subregion. WHO recommends provision of the RTS,S/AS01_E malaria vaccine, in areas with highly seasonal malaria or areas with perennial malaria transmission with seasonal peaks.
- ⇒ Seasonal vaccine delivery may require new approaches and adaptations to existing routine childhood vaccination strategies, with potential cost consequences. No known evidence is available on the costs of seasonal delivery approaches for malaria vaccines.

WHAT THIS STUDY ADDS

- ⇒ This is one of the first studies to examine the costs of seasonal RTS,S vaccine delivery under alternative scenarios of vaccine delivery.
- ⇒ The non-vaccine economic cost of delivery per dose ranges between \$0.48 and \$2.12 across the three alternative scenarios considered. Vaccine delivery using a targeted mass campaign approach is most costly, followed by mixed delivery and routine EPI approaches requiring relatively fewer adaptations of existing routine immunisation programmes.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

- ⇒ Countries planning to adopt and roll out the malaria vaccine in seasonal transmission settings should consider alternative vaccine delivery approaches, as guided by the local epidemiology, for achieving the desired impact. The options have varying cost implications to governments as evidenced by the findings in this study.
- ⇒ Final vaccine product price and the choice of delivery strategies will be important to assess the affordability and sustainability of delivery of the malaria vaccine.

INTRODUCTION

Malaria parasite transmission is highly seasonal across the African Sahel subregion with more than 60% of the burden occurring during the rainy season.¹ Clinical trials in Burkina Faso and Mali evaluating RTS,S/AS01_E (RTS,S) malaria vaccine use in areas with seasonal malaria transmission provided encouraging results suggesting substantial reductions in malaria disease burden by using the RTS,S vaccine alone or in combination with seasonal malaria chemoprevention (SMC).² Drawing on this body of evidence, the WHO recommendation on widespread use of the RTS,S malaria vaccine invites countries to consider providing the vaccine seasonally, in areas with highly seasonal malaria or areas with perennial malaria transmission with seasonal peaks.^{3,4}

RTS,S use in the seasonal context may require new approaches to vaccine delivery. Feasible and sustainable modalities of seasonal vaccine delivery are yet to be determined and will likely be country specific, necessitating adaptations to routine childhood vaccination strategies with potential cost consequences. Country decisions around adopting new interventions are guided by feasibility of implementation as well as economic and other considerations, especially in resource-constrained settings. Understanding economic factors and cost of implementation is critical to inform the value of each delivery approach and assess the modalities to help inform decision-making and planning around further use of the vaccine. Some evidence of the economic feasibility of delivering a malaria vaccine is available.^{5–7} However, there is no known evidence on the costs of seasonal delivery approaches for malaria vaccines.

This study examines the cost of introducing and delivering the malaria vaccine in Mali and Burkina Faso, countries with seasonal malaria transmission. We evaluate the costs to the health systems in these countries, under alternative delivery approaches or scenarios within the context of seasonal transmission. Findings from this analysis will allow in-country and global policymakers to better understand the cost implications of implementing a new vaccine under alternative delivery scenarios and to assess the financial and economic feasibility of each option. Additionally, the cost estimates generated from the analysis could be used to inform cost-effectiveness and budget-impact analyses of the malaria vaccine to support country decision-making on the expanded use of the vaccine in seasonal settings.

METHODS

Study setting

Childhood vaccinations, in Burkina Faso and Mali, are managed by the respective National immunisation programmes and are delivered primarily as a routine service across all health facilities. Under routine immunisation, some outreach programmes are also regularly organised by health facilities to vaccinate eligible children closer to their communities. Additional ad hoc

vaccination campaigns are organised on a need basis, for example, for polio, measles, COVID-19, and their delivery is often supported by partner agencies. Coverage of routine childhood immunisation is relatively high in both countries.

Scope and perspective

RTS,S is not currently used as a routine intervention in Mali or Burkina Faso. We, therefore, take a prospective (cost projection) approach to project costs of malaria vaccine introduction and delivery to the health system from the perspective of the two governments. The analysis considers costs incremental to the existing immunisation programme that may be incurred under an alternative implementation scenario. Cost estimates are generated for a period of 5 years starting in 2022 and assume national introduction in both countries. Any direct expenses identified as necessary for vaccine introduction and delivery are considered financial costs to the government. Such costs may be supported by external donor agencies or through new vaccine introduction grants from Gavi, the Vaccine Alliance (Gavi) in the future.

Target age group and schedule

The malaria vaccine is targeted for children between the ages 0–5 years. Children in their first year are considered eligible for the first dose, with the first three doses given to children at approximately monthly intervals. The current WHO recommendation is to give a four-dose schedule of the RTS,S vaccine to children approximately 12–18 months following the third dose, with an optional five-dose schedule for areas with highly seasonal malaria parasite transmission.³ This study followed the ongoing clinical trials in Burkina Faso and Mali² looking at the benefits of the malaria vaccine given in conjunction with SMC, where over the course of 5 years, a child could receive a total of seven doses of the vaccine. While the current recommendation is to provide up to five doses of vaccine, evaluating costs of additional annual doses can provide insights into possible costs for the addition of annual doses through age 5.

Scenarios for costing

Routine childhood immunisation programmes primarily target children under 2 years of age and deliver vaccines on an age-based schedule. Using a seasonal approach to RTS, S vaccine delivery, children would likely receive a vaccination annually up to 5 years of age, well beyond the target age group of the Expanded Programme on Immunisation (EPI). Additionally, seasonally targeted delivery at the start of the disease transmission season is desired for the vaccine to be most impactful. These elements require adaptation of current routine immunisation programmes. Alternative vaccine delivery scenarios were generated with inputs from global experts as well as extensive consultations with in-country stakeholders, including decision-makers for new vaccine introduction and malaria programme managers. The discussions also

built on and drew on insights from a qualitative study on feasibility and acceptability of the RTS,S vaccine and SMC delivery in country.⁸

Scenario 1: Mass campaign

Under this scenario, three separate targeted campaigns, undertaken each year before the malaria parasite transmission season, are organised to vaccinate children with the first three doses of the vaccine. Children under 5 years of age, who complete the first 3 doses in year one, receive subsequent annual doses (doses 4–7) during the same mass campaign events.

Scenario 2: Routine EPI

Under this scenario, all doses are delivered through the existing routine immunisation delivery system. While children are encouraged to receive vaccination right before the transmission season, eligible children are given their vaccination any time throughout the year for the first three doses. Children completing first three doses are given subsequent annual doses also via the routine immunisation delivery system before the transmission season.

Scenario 3: Mixed delivery

Under this scenario, the vaccine is delivered using a combination of the mass campaign approach and the existing EPI delivery system. The first three doses are delivered to eligible children through the routine EPI schedule, as in scenario 2. Subsequent annual doses given to children who have completed first three doses are delivered via one targeted mass campaign each year before the transmission season.

Costing approach

We used an activity-based costing approach where specific activities under each scenario are identified and costed individually by mapping them with the potential resource requirements to generate cost estimates. The level of detail on the delivery strategies and activities, derived through stakeholder consultation, focused on the core components of costing. All activities are grouped into standard categories for the vaccination programme, such as procurement, planning, training, communication, sensitisation, social mobilisation and service delivery, that is, vaccine administration.^{9–11} Within each category, the levels and types of subactivities vary by implementation scenario and country, reflecting needs and current capacities as well as cost consequence. Detailed description of cost categories and subactivities by scenario are included in online supplemental appendix table 1.

We adapted the Malaria Vaccine Introduction Planning and Costing Tool (MVICT), developed and used previously to estimate the cost of malaria vaccine delivery,⁵ to account for the seasonal nature of the intervention in this analysis. The MVICT is a Microsoft Excel-based costing tool developed by PATH in collaboration with the WHO and Levin & Morgan LLC. The tool estimates the unit cost by activity and subactivities based on user

assumptions for any given scenario. The tool can be made available to the readers on request.

Costs were further categorised as introduction (or initial set up) and recurrent costs as well as financial and economic costs.

Introduction costs consist of the value of resources that last longer than 1 year and include costs associated with purchasing capital resources (such as cold chain equipment) as well as non-recurring activities for introduction, such as initial training, social mobilisation and communication material development. Recurrent costs include operational costs of the programme such as the value of procuring vaccines, distribution, monitoring and supervision, personnel time as well as costs of short-term training activities that typically last less than a year.

Financial costs represent direct outlays of resources needed for vaccine delivery and include costs of resources purchased for programme implementation such as injection supplies, outreach allowances and per diem, resources used in training and new communication materials. Economic costs represent the opportunity costs of all resources and include all financial costs plus the value of existing resources within the existing immunisation programme that are used, specifically, salaries of current health personnel for their time used in malaria vaccine delivery as well as donated items. The cost of vaccine doses is excluded from the financial cost and included only in economic cost estimates under the assumption that the necessary vaccine doses would be donated to the government. Costs of other immunisation supplies, as well as vaccine procurement add-on costs (such as shipping and handling), are assumed to be financial costs to the government.

Costs of capital items were annualised over their respective estimated useful life years. Expenditures associated with initial setup were considered capital costs and were annualised and discounted at 3% over an assumed useful life of 5 years.

Data

Activity maps detailing specific subactivities required for vaccine implementation under each scenario were developed in discussions with the EPI programmes and were guided by recent new vaccine introduction experiences and programme expectations at the time of study conduct (April through December 2021). Key data inputs and assumptions regarding input resource requirements and unit costs (see online supplemental appendix table 2) were collected as part of the costing interviews with in-country stakeholders and administrative/financial record review. These data were informed by the recent new vaccine introduction in each study country.

To inform potential recurrent costs, we collected primary data from representative samples of health administrative units, vaccine stores and health facilities at regional, subregional/district and facility levels in two regions in each country. Districts and health facilities were selected by considering potential differences

Table 1 Key data input and assumptions used in the analysis

Input	Burkina Faso	Mali	Data source
Vaccination schedule and target population			
Target age group for vaccination		0–5 years	Assumption supported by clinical trial ²
Age and timing for first three doses		5–17 months at first vaccination	
Maximum number of doses per child		7	
Number of surviving infants in year 2018	805 961	783 972	Annual statistical yearbooks ^{13–15}
Population growth rate	3.00%	3.36%	
Coverage and drop out			
Coverage, dose 1		100%	Assumptions informed by EPI
Drop out, dose 1 to 2		4%	
Drop out, dose 2 to 3		8%	
Coverage, dose 4–7		80%	
Vaccine product characteristics			
Vaccine presentation (dose per vial)		2	GSK ⁵
Vaccine packaged volume (cm ³ /dose)		9.2	
Vaccine wastage		10%	Assumed
Injection devices and safety boxes wastage		10%	
Vaccine/injection device and safety boxes (buffer stock)		25%	
Vaccine product cost assumptions (USD)			
Vaccine price per dose		\$5 (\$2–\$10)	Assumed ¹⁶
Cost per injection syringe		\$0.20	
Cost per reconstitution syringe		\$0.05	Assumed, MVIP
Cost per safety box (100-syringe capacity)		\$1.00	
Procurement add-on charges on as a % of product cost			
Freight, insurance, inspection	7.60%		Assumed (observed during MVIP in Ghana)
Handling fee	3.00%		
Service delivery			
Proportion of children vaccinated in routine outreach sessions	23%	40%	Primary data collected during health facilities survey
Average time spent per vaccination (routine fixed clinic)	10 min	18 min	
Average children vaccinated per campaign site	200	500	Assumed
Average children vaccinated per routine outreach session	50	50	
Salaries			
Staff salary per month; range by staff cadre	64 000–525 487 CFA	16 377–40,155 CFA	17
Average vaccinators' salary per month	53 333 CFA	22 778 CFA	
Others			
Exchange rate (1USD=)	575.6	575.6	18
Useful life years for introduction activities*		5 years	Assumed
Discount rate		3%	
*Not applicable for recurring activities. CFA, West African Franc; GSK, GlaxoSmithKline; MOH, Ministry of Health; USD, US dollar.			

*Not applicable for recurring activities.

CFA, West African Franc; GSK, GlaxoSmithKline; MOH, Ministry of Health; USD, US dollar.

Table 2 Target population, projected vaccinations and total costs (in USD), 2022–2026

Metric	Burkina Faso		Mali	
Projected outputs				
Target population for vaccination	4 539 545		4 796 000	
Projected vaccinations	19 132 211		20 186 822	
Projected number of children completing the first three doses	4 009 326		4 235 827	
Projected costs	Financial	Economic	Financial	Economic
Scenario 1: mass campaign				
Total cost, annualised	29 563 102	145 247 375	49 787 354	171 187 930
Total introduction cost, annualised	2 731 879	3 376 512	6 395 712	7 499 521
Total recurrent cost	26 831 223	141 870 863	43 391 641	163 688 409
Scenario 2: routine EPI				
Total cost, annualised	18 067 278	131 965 973	24 564 962	144 969 203
Total introduction cost, annualised	2 840 869	3 586 112	9 399 259	11 099 610
Total recurrent cost	15 226 408	128 379 861	15 165 703	133 869 594
Scenario 3: mixed delivery				
Total cost, annualised	21 579 227	136 245 677	38 811 304	159 669 492
Total introduction cost, annualised	2 715 720	3 379 695	10 391 365	11 584 202
Total recurrent cost	18 863 507	132 865 983	28 419 938	148 085 290
EPI, Expanded Programme on Immunisation.				

that are anticipated to drive variation in cost of delivery. See list of districts and health facilities selected for data collection in online supplemental appendix table 3.

Quantities of vaccine and supplies are derived based on the projected birth cohorts/target population adjusted for the anticipated coverage provided by the national immunisation programmes. Any data gaps were supplemented by assumptions guided by country experiences with previous vaccine introductions. The consolidated data on all subactivities and the assumptions on respective input resources and unit costs used to generate the final cost estimates were all validated with the EPI programme representatives in each country. All cost data were collected in the local currency in 2021 units. Cost estimates are reported in both local currency units and in 2021 USD units.

Capacity consideration and shared input

We estimated the cold chain capacity (volume) requirement based on quantity of RTS,S doses needed and projected the costs of additional cold chain expansion at all levels. In Mali, new capital investments, especially vehicles for the EPI programme, were identified as necessary to fill in health system capacity constraints and were included in the cost estimates. To account for the incremental resource requirements for distribution in a routine setting, inputs shared with the existing system are attributed to RTS,S based on direct allocation (10%). The contribution of vaccinators to the malaria vaccine implementation is estimated based on time required to administer the vaccine under the routine EPI scenario, as

reported by health workers during facility surveys. While there is the possibility of coadministered, we do not make specific assumptions on codelivery of RTS,S vaccine with other existing childhood vaccines in EPI schedule as we focus on the costs incremental to the existing vaccines. For a mass campaign, service delivery costs are estimated by accounting for the total number of days for each mass campaign session and the associated resource need. For all other resources, we assume 100% existing spare capacity in the immunisation system to accommodate malaria vaccine introduction and delivery.

Cost estimates

The key outputs of the analysis are reported as the incremental cost per dose administration, cost of delivery per dose, cost per first three dose completion and cost of delivery per first three dose completion. Annualised cost of the introduction/initial setup costs for the study duration were added to the recurrent costs across all activity categories during the same period to generate the total cost of the programme. The cost per dose administered is calculated by dividing the total cost of the programme by the total number of doses administered throughout the duration of the analysis under a given scenario. The cost of delivery per dose is calculated by subtracting the commodity cost (vaccine and immunisation supplies) and the procurement add-on costs from the total cost and dividing by the total number of doses delivered. Costs per first three dose completion is calculated by dividing the total cost of the programme by the total number of children who receive at least the first three doses of vaccine.

Table 3 Unit cost estimates of seasonal malaria vaccine delivery, by vaccination scenario (in USD)

	Burkina Faso				Mali			
	Cost of delivery per dose*	Cost per dose administered†	Cost of delivery per first three doses completion‡	Cost per first three doses completion§	Cost of delivery per dose*	Cost per dose administered†	Cost of delivery per first three doses completion‡	Cost per first three doses completion§
Financial cost								
Mass campaign	\$0.99	\$1.71	\$3.97	\$7.37	\$1.99	\$2.71	\$7.68	\$11.08
Routine EPI	\$0.39	\$1.11	\$1.10	\$4.51	\$0.76	\$1.47	\$2.40	\$5.80
Mixed delivery	\$0.58	\$1.29	\$1.98	\$5.38	\$1.28	\$2.00	\$5.76	\$9.16
Economic cost								
Mass campaign	\$1.17	\$7.73	\$4.94	\$36.23	\$2.12	\$8.68	\$9.16	\$40.41
Routine EPI	\$0.48	\$7.04	\$1.62	\$32.91	\$0.82	\$7.38	\$2.97	\$34.22
Mixed delivery	\$0.70	\$7.26	\$2.69	\$33.98	\$1.37	\$7.93	\$6.44	\$37.69

*The cost of delivery per dose is calculated by subtracting the commodity cost (vaccine and immunisation supplies) and the procurement add-on costs from the total cost and dividing by the total number of doses delivered.

†Cost per dose administered is calculated by dividing the total cost of the programme by the total number of doses administered throughout the duration of the analysis under a given scenario.

‡Cost of delivery per first three doses completion is calculated by dividing the total cost of the programme net of commodity costs, by the total number of children who receive at least the first 3 doses of vaccine.

§Cost per first three dose completion is calculated by dividing the total cost of the programme by the total number of children who receive at least the first three doses of vaccine. See online supplemental appendix table 4 for calculations.

EPI, Expanded Programme on Immunisation.

Cost of delivery per first three doses completion is calculated by dividing the total cost of the programme net of commodity costs, by the total number of children who receive at least the first three doses of vaccine (see online supplemental appendix table 4 for calculations).

Sensitivity analysis

Baseline cost estimates are generated using the input values and assumptions in table 1. To understand the implications of input value choices on cost estimates, one-way sensitivity tests are performed for a subset of critical input data, over a range of alternative values, including vaccine price and coverage. Cost estimates under alternate input assumptions are reported separately.

Patient public involvement

No patients were involved in this study. We have included roles and relationships between different members of the research team in the reflexivity statement (see online supplemental file).

RESULTS

Target population, projected vaccinations and total costs

Table 2 shows the number of vaccinations throughout the analysis period, 2022–2026. At an assumed coverage level at baseline (same for all scenarios, table 1), about 4.79 million and 4.5 million surviving infants are targeted for vaccination in Mali and Burkina Faso, respectively (table 2).

Unless otherwise noted, all cost estimates are based on an assumed vaccine price of US\$5.00 per dose. The total financial cost (excludes vaccine cost), for the duration of the analysis, is estimated to range from \$24.6 to \$49.8 million (Mali) and \$18.1 to \$29.6 million (Burkina Faso) (table 2). The economic cost for the 5-year period ranges from \$144.9 to \$171.1 million (Mali) and \$131.9 to \$145.2 million (Burkina Faso). The total programme cost includes annualised introduction costs and annual recurrent costs for a seven-dose RTS,S vaccine schedule (four-dose primary schedule plus three annual doses) for the duration of the analysis.

Unit cost estimates

Across the three delivery scenarios, the financial cost per dose of vaccine administration to the target population is estimated to range from \$1.47 to \$2.71 (Mali) and \$1.11 to \$1.71 (Burkina Faso). The economic cost per dose of vaccine administration ranges from \$7.38 to \$8.68 (Mali) and \$7.04 to \$7.73 (Burkina Faso). The cost of delivery per dose, excluding vaccine and other immunisation supplies cost, ranges from \$0.76 to \$1.99 (Mali) and \$0.39 to \$0.99 (Burkina Faso), across the three scenarios. The cost per first three dose completion is estimated to range from \$5.80 to \$11.08 (Mali) and \$4.51 to \$7.37 (Burkina Faso) (see table 3 and online supplemental appendix figure 1). Across both countries, a mass campaign is the costliest approach to vaccine delivery and the routine EPI delivery is the least costly option.

Table 4 Unit cost estimates (in USD) at various coverage assumptions

		Sn1: Mass campaign		Sn2: Routine EPI		Sn3: Mixed delivery	
Metric	Coverage	Financial	Economic	Financial	Economic	Financial	Economic
Mali							
Cost per dose administered	High (100%)	2.71	8.86	1.47	7.38	2.00	7.93
Cost per dose administered	Medium (70%)	3.26	9.26	1.79	7.71	2.48	8.44
Cost per dose administered	Low (50%)	3.99	10.04	2.22	8.15	3.12	9.11
Cost per dose administered	EPI anticipated*	3.29	9.27	2.89	8.92	3.02	8.89
Cost of delivery per dose	High (100%)	1.99	2.12	0.76	0.82	1.28	1.37
Cost of delivery per dose	Medium (70%)	2.54	2.7	1.08	1.15	1.77	1.88
Cost of delivery per dose	Low (50%)	3.28	3.48	1.5	1.59	2.41	2.56
Cost of delivery per dose	EPI anticipated*	2.58	2.74	2.18	2.3	2.31	2.46
Cost per first three doses completion	High (100%)	11.08	40.41	5.8	34.22	9.16	37.69
Cost per first three doses completion	Medium (70%)	13.88	42.8	6.79	35.39	11.31	40.06
Cost per first three doses completion	Low (50%)	16.71	45.98	8.11	36.95	14.18	43.22
Cost per first three doses completion	EPI anticipated*	13.04	39.67	8.92	34.3	12.29	38.07
Cost of delivery per first three doses completion	High (100%)	7.68	9.16	2.4	2.97	5.76	6.44
Cost of delivery per first three doses completion	Medium (70%)	10.48	11.54	3.39	4.13	7.91	8.8
Cost of delivery per first three doses completion	Low (50%)	13.31	14.72	4.71	5.69	10.78	11.96
Cost of delivery per first three doses completion	EPI anticipated*	9.91	10.89	5.97	7.18	9.27	10.3
Burkina Faso							
Cost per dose administered	High (100%)	1.71	7.73	1.11	7.04	1.29	7.26
Cost per dose administered	Medium (70%)	1.9	7.96	1.26	7.21	1.48	7.48
Cost per dose administered	Low (50%)	2.16	8.24	1.47	7.44	1.73	7.77
Cost per dose administered	EPI anticipated*	1.63	7.65	1.08	7.01	1.26	7.23
Cost of delivery per dose	High (100%)	0.99	1.17	0.39	0.48	0.58	0.7
Cost of delivery per dose	Medium (70%)	1.19	1.39	0.55	0.65	0.77	0.92
Cost of delivery per dose	Low (50%)	1.44	1.68	0.75	0.88	1.02	1.21
Cost of delivery per dose	EPI anticipated*	0.91	1.08	0.37	0.45	0.54	0.66
Cost per first three doses completion	High (100%)	7.37	36.23	4.51	32.91	5.38	33.98
Cost per first three doses completion	Medium (70%)	7.96	36.98	4.92	33.46	5.96	34.73
Cost per first three doses completion	Low (50%)	8.75	37.97	5.47	34.19	6.73	35.75
Cost per first three doses completion	EPI anticipated*	7.11	36.09	4.5	33.29	5.34	34.31
Cost of delivery per first three doses completion	High (100%)	3.97	4.94	1.1	1.62	1.98	2.69
Cost of delivery per first three doses completion	Medium (70%)	4.56	5.68	1.51	2.17	2.55	3.45
Cost of delivery per first three doses completion	Low (50%)	5.34	6.68	2.06	2.9	3.32	4.46
Cost of delivery per first three doses completion	EPI anticipated*	3.68	4.58	1.05	1.55	1.89	2.57
*EPI anticipated coverage was very high for dose 1 (100% for all scenarios in Burkina Faso but lower for Mali (Mass campaign: 90%, Routine EPI: 50% Mixed delivery: 70%). Coverage values in column 'coverage' is for dose 1. For the other doses, dropout rates used in the primary analysis (given in table 1) are used. EPI, Expanded Programme on Immunisation.							

*EPI anticipated coverage was very high for dose 1 (100% for all scenarios in Burkina Faso but lower for Mali (Mass campaign: 90%, Routine EPI: 50% Mixed delivery: 70%). Coverage values in column 'coverage' is for dose 1. For the other doses, dropout rates used in the primary analysis (given in [table 1](#)) are used. EPI, Expanded Programme on Immunisation.

Cost drivers

Recurrent costs constitute the major share of the total costs across all scenarios (online supplemental appendix figure 2). Introduction/initial setup costs constitute between 9.2% and 12.8% of financial cost and 2.3% and 4.4% of economic cost, across the two countries.

Introduction cost share is relatively higher for financial cost under the EPI approach (scenario 2), which ranges between 16% and 38% of the total cost across the two countries.

The cost of vaccine procurement add-on and immunisation commodities constitutes the largest driver of

financial cost across all scenarios. Service delivery under mass campaign constitutes 27% and 32% of the total financial cost in Mali and Burkina Faso, respectively. Under the mixed delivery scenario, service delivery accounts for between 8% and 10% of total financial cost. Excluding commodity cost, service delivery is the main cost driver for mass campaign delivery accounting for 36% and 55% of financial cost in Mali and Burkina Faso, respectively. The financial cost share of service delivery ranges between 2% and 8% under routine EPI and between 12% and 23% for the mixed delivery scenario. For economic costs, service delivery is the main cost driver under mass campaign delivery, accounting for up to 57% of the cost, whereas the economic cost share for service delivery ranges between 6% and 16% under routine EPI and between 14% and 27% under mixed delivery. The distribution of resource requirements, as a proportion of total costs, for each scenario is provided in online supplemental appendix Tables 5A–C and 6A–C.

Sensitivity analysis

The analysis shows that the unit cost estimates are most sensitive to vaccine price, and its impact is most substantial on cost per first three dose completion and economic cost for all scenarios. Overall, across the two countries under different coverage and vaccine price assumptions, the financial cost per dose administered ranges between \$1.33 and \$3.99 (mass campaign), \$0.73 and \$2.89 (routine EPI) and \$0.92 and \$3.12 (mixed delivery). The economic cost per dose administered ranges between \$3.85 and \$15.14 (mass campaign), \$3.16 and \$13.84 (routine EPI) and \$3.38 and \$14.40 (mixed delivery). Across the two countries, under different coverage assumptions, the financial cost of delivery per dose ranges between \$0.91 and \$3.28 (mass campaign), \$0.37 and \$2.18 (routine EPI) and \$0.54 and \$2.41 (mixed delivery), and the economic cost of delivery per dose ranges between \$1.08 and \$3.84 (mass campaign), \$0.45 and \$2.30 (routine EPI) and \$0.66 and \$2.56 (mixed delivery). The range of cost estimates under alternative coverage and vaccine price assumptions is in [table 4](#) and online supplemental appendix table 7.

DISCUSSION

Seasonal vaccine delivery is uncommon especially in low-and middle-income countries (LMICs). The routine immunisation programme needs several adaptations to be able to accommodate seasonal vaccine delivery and achieve health impact. Necessary adaptations may include additional training activities and guidance to staff, increased human resource mobilisation in season, community mobilisation and sensitisation activities to encourage seasonal utilisation using mass vaccination campaign methodologies. These adaptations have cost consequences to the respective programmes. Several studies assessing costs of malaria vaccine delivery are available,^{5–7} yet all of these evaluate costs in the context of

routine immunisation. Seasonal vaccine delivery cost estimates are almost non-existent, especially in the LMICs. Our study fills a knowledge gap on the economic implications of seasonal vaccine planning and effective decision-making around delivery approaches and resource mobilisation.

Our findings suggest that vaccine delivery using a mass campaign approach is most costly compared with other delivery approaches. Across the two countries, the economic cost per dose administered ranges between \$7.73 and \$8.68 (mass campaign), \$7.04 and \$7.38 (routine EPI) and \$7.26 and \$7.93 (mixed delivery). The financial cost per dose administered ranges between \$1.71 and \$2.71 (mass campaign), \$1.11 and \$1.47 (routine EPI) and \$1.29 and \$2.00 (mixed delivery). Administering malaria vaccine under the routine EPI scenario is the least costly option as this approach requires the least amount of adaptation to existing immunisation programmes. Under a mass campaign approach, three targeted mass campaigns would occur each year before the transmission season, which would require significantly different levels of effort and types of activities to prepare for and complete compared with the routine EPI approach (see online supplemental appendix table 1 for detailed description of subactivities across scenarios). For example, under the mass campaign approach, service delivery, which requires human resource mobilisation necessitating direct allowances for both staff and volunteers, is one of the major cost drivers accounting for between 36% and 55% of total financial cost (excluding commodity cost). On the other hand, service delivery (excluding commodity cost) accounts for 2%–8% and 12%–23% of financial cost under the routine EPI and mixed delivery scenarios, respectively. This corroborates the finding that mass campaign delivery, in general, is more costly at a given coverage level as it requires mobilisation of a large group of human resources,¹² often diverting them away from routine health service delivery along with other resources. Mass campaigns, nonetheless, have capacity to achieve higher coverage than the routine immunisation scenario, which is not directly differentiated in this analysis.

In Mali, for the mass campaign approach, stakeholders indicated that an initial training for health workers when the vaccine is introduced, as well as annual refresher trainings before each campaign season, would be necessary activities. As a result, the financial cost for training was about 2.5 times higher under the mass campaign approach compared with the routine EPI approach in that country. Also, vaccine distribution costs during repeated campaigns added substantially to the total financial cost for mass campaigns, which was not the case for the routine EPI approach, which leverages existing vaccine distribution channels. The financial cost of vaccine distribution was between 1.5 and 2 times higher for the mixed delivery approach and between 3 and 4 times higher in the mass campaign approach, compared with the routine EPI approach. Furthermore, under the mass campaign

approach, most planning and coordination, and sensitisation and social mobilisation subactivities, are identified as necessary each year, rendering higher recurring costs for these categories under the mass campaign approach. On the other hand, most planning and social mobilisation activities were concentrated in year 1 only under the routine EPI approach, and in years 1 and 2 only in the mixed delivery approach. As a result, the total cost for planning and coordination is more than double for the mass campaign approach compared with the routine EPI approach and even higher as compared with the mixed delivery approach, particularly in Burkina Faso. In Mali, the differences in total cost were about five times higher for both the mass campaign and mixed delivery approach compared with the routine EPI scenario. The differences in cost estimates between the two countries partly reflect the differences in input prices, including staff salaries, among others.

Cost estimates are sensitive to underlying assumptions, most profoundly the vaccine price, as shown in other similar studies.⁵⁻⁷ Given malaria vaccines were not yet recommended for broader use at the time of analysis, uncertainty around various parameters is evident. Amid uncertainties in implementing modalities at the time of study conduct, potential activities for programme introduction and delivery for each alternative scenario of programme delivery were extensively discussed and identified together with in-country stakeholders to ensure the robustness of the cost estimates. However, as the malaria vaccine product was not yet recommended for broader use, these discussions with in-country stakeholders, particularly around scenarios synthesis and prioritisation of feasible delivery scenarios, were challenging, as there were uncertainties with regards to delivery approaches and difficulties in articulating activities to fit in with possible future needs. Due to this, only the core components of the strategies were discussed and included in the study. The assumptions made on delivery scenarios as well as input resources are reliant on the understanding of the discussants. The assumptions were informed by significant deliberation and discussion and draw on previous new vaccine introductions using different delivery approaches including mass campaigns.

A few studies have estimated that the economic cost of delivering RTS,S under routine EPI in Burkina Faso along with a few other sub-Saharan Africa countries. Galactionova *et al*⁶ reported the economic cost of delivery per dose (net of commodities) in Burkina Faso at \$0.72. Sicuri *et al*⁷ reported the cost per fully vaccinating a child with four-dose schedule using existing EPI platform to be \$2.58. Our results suggest that under the routine EPI delivery, the cost per first three dose completion in Burkina Faso is \$1.62. While the cost estimates are not directly comparable across these studies due to differences in underlying assumptions and cost calculations, estimates in the current analysis for Burkina Faso are broadly aligned with the reported range.

Cost estimates generated from this analysis provide useful insights into the cost drivers of alternative delivery approaches and can be applicable not just to RTS,S but also to other vaccines being considered for seasonal delivery. While the estimates are generated for two countries in the Africa Sahel region with largely similar socio-economic profile, the cross-country cost estimates provide a range that may be used by other countries, not included in the study, to estimate costs. However, we caution against making extensive comparisons cross-country, as we used a country-specific activity-based costing approach reflecting specific inputs and assumptions agreed on by each country team at the time of analysis.

Our study has some limitations. Cost projections are largely dependent on the most feasible strategy chosen for costing by country and is likely to be context specific, limiting the generalisability of the results outside of the study countries. Another potential limitation is the baseline assumption that the same level of vaccine coverage will be achieved across all delivery scenarios. This may not be true as mass campaigns, due to their targeted nature, are likely to achieve higher coverage as they bring vaccine delivery closer to the communities, provide targeted mobilisation of human resources including volunteers for vaccine administration and promote strong community mobilisation, which may not be consistent with routine EPI delivery approaches. In the mixed delivery approach, the one targeted mass campaign could likely lead to higher coverage for the subsequent annual doses as well as catch up children who missed vaccinations via routine EPI administration. Given the lack of knowledge a priori around these parameters, we look at the impact of different coverage levels on the unit cost estimates, which provides useful lower and upper bound estimates under possible coverage ranges. The analysis, however, does not account for the extra effort to increase coverage and only reflects a change in the denominator. The analysis also does not differentiate vaccine wastage rates across the scenarios, though one can expect to see variation in vaccine wastage rate by delivery scenario. Nonetheless, the non-commodity cost of vaccine delivery generated in the analysis reflects the recurring cost to the programme, unaffected by some of the key unknown parameters. The prospective cost projections in this study builds on many assumptions, while informed and validated by the EPI programmes in respective counties based on their previous new vaccine introduction experiences, would need further validation with actual costs of implementation when the RTS,S vaccine is deployed in seasonal settings.

The WHO recommends that countries consider a five-dose malaria vaccine strategy in settings of highly seasonal malaria transmission.³ The seven-dose schedule considered in this study was guided by the ongoing clinical trial in these countries, looking at RTS,S vaccination alongside administration of SMC.² While the timing of seasonal delivery of these interventions (RTS,S vaccination at or before the transmission season and SMC administration

during the transmission season) may preclude direct coadministration of these two interventions, there might be some room for efficiency in coplanning and delivery, which is not investigated in this study. The definition of a fully immunised child (FIC) in the current context is not clear, and, because of this, we did not estimate the cost per FIC, opting instead to estimate the cost per first three dose completion.

Implementation feasibility and affordability are critical input in making decisions about whether or not to adopt new vaccines and also around planning for sustainable vaccine delivery. While cost of implementation is one of the critical components to assess feasibility and affordability of any new vaccine, the effectiveness of the delivery approach in achieving the desired level of coverage is also critical. Health impact is achieved through coverage, and this study does not address potential differences in coverage by delivery strategy. Therefore, it cannot inform the relative value of competing delivery strategies based on cost alone. This remains an important area for future investigation. Despite some limitations, this study provides useful information for decision-makers on the potential cost differences associated with several seasonal malaria vaccine delivery strategies.

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Acknowledgements We acknowledge the support and inputs provided by various staff members within the Ministries of Health in Burkina Faso and Mali, who answered our questions patiently, and provided data to help with the analysis. Specifically, we would like to thank Issa Ouedraogo and Hamidou Zongpo from the National Immunization Program in Burkina Faso and Ban Diabyi and Ibrahima Diarra from the National Immunization Program in Mali. We also acknowledge the support from data collection staff in Burkina Faso and Mali. Justice Nonvignon (University of Ghana) and Colin Gilmartin (Management Sciences for Health) provided useful inputs during the planning phase of this study. We are indebted to Jayne Webster and Jane Grant from the London School of Hygiene and Tropical Medicine, who provided critical inputs throughout the conception and conduct of this study, and specifically for their insights in devising potential vaccine delivery strategies in seasonal settings.

Contributors RB (conceptualisation, methodology, formal analysis, writing, reviewing, editing, and guarantor), HD and FB (methodology, data collection, analysis, reviewing), AD and JBO (methodology, reviewing, editing), AL and WM (methodology, analysis, reviewing, editing), FK, RG, SY, ST (data collection, analysis, reviewing), CL (conceptualisation, reviewing, writing and editing), CP (conceptualisation, methodology, analysis, writing, reviewing, and editing).

Funding This work was funded by a grant from the Bill and Melinda Gates Foundation (Grant OPP1191923), Seattle, WA, USA to PATH. The funder did not have any role in the study design, data collection and analysis, decision to publish, or preparation of the manuscript. The findings and conclusions contained within are those of the authors and do not necessarily reflect positions or policies of the Bill & Melinda Gates Foundation.

Competing interests RB, CP and CL are employed by PATH while engaged in this research.

Patient and public involvement Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

Patient consent for publication Not applicable.

Ethics approval This study was received exempt determination from WCG IRB in the USA. This study was approved by Ethics Review Committees in Burkina Faso (ethics committee for health research (CERS)) and Mali (ethics committee of the University of Sciences, Techniques and Technologies of Bamako). Participants gave informed consent to participate in the study before taking part.

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement All data relevant to the study are included in the article or uploaded as supplementary information.

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Appendices

Appendix Table 1.a: List of sub-activities by cost category and activity occurrence frequency in Mali

Activities	Scenario 1: Mass campaign	Scenario 2: Routine EPI	Scenario 3: Mixed delivery
Vaccine and injection supplies procurement			
Procurement of vaccine	Each year	Each year	Each year
Procurement of supplies- 2ml syringe	Each year	Each year	Each year
Procurement of supplies- RUP syringe	Each year	Each year	Each year
Procurement of supplies- Safety boxes	Each year	Each year	Each year
Distribution			
Receive vaccine and supplies at the national store	Three times each year	Quarterly (4 times) a year, shared cost	Quarterly (4 times) a year, shared cost, plus one time for campaign starting year 2
Distribution of vaccine and supplies from national store to regional (up to district) stores	Three times each year	Quarterly (4 times) a year, shared cost	Quarterly (4 times) a year, shared cost, plus one time for campaign starting year 2
Collection of vaccine and supplies from regional store by District stores	NA	Monthly, shared cost	Monthly, shared cost
Distribution of vaccine and supplies from district store to health facilities	Three times each year	NA	One time each year
Collection of vaccine and supplies from district store by health facilities	NA	Monthly, shared cost	Monthly, shared cost
Planning and coordination			
Planning for introduction at National level	Once in year 1 only	Once in year 1 only	Once in years 1 and 2 only
Develop plans for introduction/campaign	Once in year 1 only	Once in year 1 only	Once in years 1 and 2 only
National level macroplanning for introduction/campaign	Once each year	Once in year 1 only	Once each year
Regional level microplanning for introduction/campaign	Once each year	Once in year 1 only	Once each year
District level microplanning for introduction/campaign	Once each year	Once in year 1 only	Once each year
Health facility level microplanning for introduction/campaign	Once each year	Once in year 1 only	Once each year
Training			
Develop training materials and tools and TOT at national level	Once in year 1 only	Once in year 1 only	Once in year 1 only

Activities	Scenario 1: Mass campaign	Scenario 2: Routine EPI	Scenario 3: Mixed delivery
Refresher Training of trainers for the national level staff	Once each year from year 2	NA	Once each year from year 2
Training for the regional level staff	Once in year 1 only	Once in year 1 only	Once in year 1 only
Refresher training at regional level	Once each year from year 2	NA	Once each year from year 2
Training for the district level staff	Once in year 1 only	Once in year 1 only	Once in year 1 only
Refresher training for the district level staff	Once each year from year 2	NA	Once each year from year 2
Training for the health facility staff	Once in year 1 only	Once in year 1 only	Once in year 1 only
Refresher training for the health facility staff	Once each year from year 2	NA	Once each year from year 2
Training of community health workers	Once each year	Year 1 only	Once each year
Communication (IEC)			
Production of communication materials (Sketch, spot, trailers)	Once in year 1 only	Once in year 1 only	Once in year 1 only
Broadcasting of communication material in National level (TV/Radio)	Each year	Year 1 only	Each year
Printing of IEC materials	Once in year 1 only	Once in year 1 only	Once in year 1 only
Broadcasting of communication material in local (district) level (TV/Radio)	Each year	Year 1 only	Each year
Social mobilization			
Organize press conference for introduction	Once in year 1 only	Once in year 1 only	Once in year 1 only
National level campaign launch	Once each year. Full cost for first 2 years, campaign scale halved for other years.	Once in year 1 only	Once each year. Full cost for first 2 years, campaign scale halved for other years.
Coordination and preparation of community information session by Social Development Unit	Once each year	Once in year 1 only	Once each year
Hold information sharing/launch session in district	Each year	Years 1 and 2 only	Each year
Community sensitization/mobilization by community health volunteers	Each year	Years 1 and 2 only	Each year
Monitoring and evaluation			
Post introduction/campaign evaluation	Year 1 only	Year 1 only	Year 1 only
Supervision			
Introduction supervision by a team of national, regional and district staff	Three times each year	Two times each year in years 1 and 2 only	Two times each year

Activities	Scenario 1: Mass campaign	Scenario 2: Routine EPI	Scenario 3: Mixed delivery
Introduction supervision by health facility staff	Three times each year	Two times each year in years 1 and 2 only	Two times each year
Routine quarterly supervision by a team of national, regional and district staff	NA	Quarterly (4 times) each year, shared cost	Quarterly (4 times) each year, shared cost
Routine quarterly supervision by regional level staff	NA	Quarterly (4 times) each year, shared cost	Quarterly (4 times) each year, shared cost
Routine quarterly supervision by district level staff	NA	Quarterly (4 times) each year, shared cost	Quarterly (4 times) each year, shared cost
Service delivery			
Vaccination administration through routine EPI clinic	NA	Each year	Each year
Vaccination administration through routine EPI outreach	NA	Each year	Each year
Vaccination administration during seasonal campaign	Three times each year	NA	One time each year starting year 2
Cold chain procurement			
Cold room walk in (capacity: 30 cu m) added at national level	Years 1, 3, and 5	Years 1, 3, and 5	Years 1, 3, and 5
Cold room walk in (capacity: 10 cu m) added to 11 regional levels	Years 1, and 3	Years 1, and 3	Years 1, and 3
Refrigerators (capacity: 145,000 cu cm) added to 75 district levels	Years 1, and 3	Years 1, and 3	Years 1, and 3
Cold boxes added to each health facility (5 cold boxes per health facility)	Years 1, and 3	Years 1, and 3	Years 1, and 3
Maintenance of cold chain	Each year, shared cost	Each year, shared cost	Each year, shared cost
Other capital equipment purchase			
Vehicles for national level to support implementation	8 vehicles in year 1	8 vehicles in year 1	8 vehicles in year 1
Vehicles for regional level to support implementation	2 per implementing region in year 1	2 per implementing region in year 1	2 per implementing region in year 1
Vehicles for district level to support implementation	2 per implementing district in year 1	2 per implementing district in year 1	2 per implementing district in year 1

Appendix Table 1.b: List of sub-activities by cost category and activity occurrence frequency in Burkina Faso

Activities	Scenario 1: Campaign	Scenario 2: Routine EPI	Scenario 3: Mixed delivery
Vaccine and injection supplies procurement			
Procurement of vaccine	Each year	Each year	Each year
Procurement of supplies- 2ml syringe	Each year	Each year	Each year
Procurement of supplies- RUP syringe	Each year	Each year	Each year
Procurement of supplies- Safety boxes	Each year	Each year	Each year
Distribution			
Receive vaccine and supplies at the national store	Three times each year	Quarterly (4 times) a year, shared cost	Quarterly (4 times) a year, shared cost, plus one time for campaign starting year 2
Distribution of vaccine and supplies from national store to regional stores	Three times each year	Quarterly (4 times) a year, shared cost	Quarterly (4 times) a year, shared cost, plus one time for campaign starting year 2
Collection of vaccine and supplies from regional store by District stores	Three times each year	Bi-monthly (6 times) a year, shared cost	Bi-monthly (6 times) a year, shared cost
Distribution of vaccine and supplies from district store to health facilities	Three times each year	NA	One time each year starting year 2
Collection of vaccine and supplies from district store by health facilities	NA	Bi-monthly (6 times) a year, shared cost	Bi-monthly (6 times) a year, shared cost
Planning and coordination			
Develop plans for introduction/campaign	Three events in year 1 only	Three events in year 1 only	Three events in year 1 only
Planning for introduction at national level for campaign	Once each year	NA	Once each year starting year 2
Regional level microplanning for introduction/campaign	Once each year	Once in year 1 only	Once each year
District level microplanning for introduction/campaign	Once each year	Once in year 1 only	Once each year
Health facility level microplanning for introduction/campaign	Once each year	Once in year 1 only	Once each year
Routine microplanning at national, regional, district, and health facility levels	NA	Once each year, shared cost	Once each year, shared cost
Training			
Develop training materials and tools	Once in year 1 only	Once in year 1 only	Once in year 1 only
Training of trainers at the national level	Once in year 1 only	Once in year 1 only	Once in year 1 only

Activities	Scenario 1: Campaign	Scenario 2: Routine EPI	Scenario 3: Mixed delivery
Training at the regional level	Once in year 1 only	Once in year 1 only	Once in year 1 only
Training at district levels	Once in year 1 only	Once in year 1 only	Once in year 1 only
Training at the health facility level	Once in year 1 only	Once in year 1 only	Once in year 1 only
Training of community health workers/volunteers for campaign	Once in year 1 only	NA	Once in year 1 only
Initial sensitization			
Stakeholder sensitization at national level	Once in year 1 only	Once in year 1 only	Once in year 1 and 2 only
Sensitization of media personnel at national level	Once in year 1 only	Once in year 1 only	Once in year 1 and 2 only
Stakeholder sensitization at regional level	Once in year 1 only	Once in year 1 only	Once in year 1 and 2 only
Stakeholder sensitization at district level	Once in year 1 only	Once in year 1 only	Once in year 1 and 2 only
Stakeholder sensitization at health facility level	Once in year 1 only	Once in year 1 only	Once in year 1 and 2 only
Communication			
Development and production of communication materials (Flip charts, posters)	Once in year 1 only	Once in year 1 only	Once in year 1 only
Develop radio/TV message, newspaper spots etc.	Once each year	Once in year 1 only	Once each year
Broadcasting of TV/radio messages, and new paper messages	Once each year	Once in year 1 only	Once each year
Organize media campaigns at regional level	Once each year	Once in year 1 only	Once each year
Organize media campaigns at district level	Once each year	Once in year 1 only	Once each year
Social mobilization			
Launch event at national level	Once in year 1 only	Once in year 1 only	Once in year 1 and 2 only
Launch event at regional level	Once in year 1 only	Once in year 1 only	Once in year 1 and 2 only
Organize awareness raising by town criers and mobilizing relays in the villages	Each year, integrated activity- no additional cost	Each year, integrated activity- no additional cost	Each year, integrated activity- no additional cost
Carry out educational talks in health facilities	Each year, integrated activity- no additional cost	Each year, integrated activity- no additional cost	Each year, integrated activity- no additional cost
Monitoring and evaluation			
Printing and distribution of monitoring and evaluation tools	Each year	Each year	Each year
Conduct pre and post coverage surveys	Year 2 only	Year 2 only	Year 2 only

Activities	Scenario 1: Campaign	Scenario 2: Routine EPI	Scenario 3: Mixed delivery
Supervision			
Implementation (introduction and post introduction) supervision at regional level	Three times each year	Two times in years 1 only	Two times in year 1 and one time each in other years
Implementation (introduction and post introduction) supervision at district level	Three times each year	Two times in years 1 only	Two times each year
Implementation (introduction and post introduction) supervision at health facility level	Three times each year	Two times in years 1 only	Two times each year
Routine quarterly supervision by EPI program management	NA	Four times each year, shared cost	Four times each year, shared cost
Routine semi-annual supervision of immunization program by regional level staff	NA	Two times each year, shared cost	Two times each year, shared cost
Routine semi-annual supportive supervision by district level staff	NA	Two times each year, shared cost	Two times each year, shared cost
Service delivery			
Vaccination administration through routine EPI clinic (fixed strategy)	NA	Each year	Each year
Vaccination administration through routine EPI outreach (advanced strategy)	NA	Each year	Each year
Vaccination administration during seasonal campaign	Three times each year	NA	One time each year starting year 2
Cold chain procurement			
Cold room walk in (capacity: 30 cu m) added at national level	Years 1, 3, and 5	Years 1, 3, and 5	Years 1, 3, and 5
Cold room walk in (capacity: 10 cu m) added to 11 regional levels	Years 1, and 3	Years 1, and 3	Years 1, and 3
Refrigerators (capacity: 145,000 cu cm) added to 75 district levels	Years 1, and 3	Years 1, and 3	Years 1, and 3
Cold boxes added to each health facility (5 cold boxes per health facility)	Years 1, and 3	Years 1, and 3	Years 1, and 3
Maintenance of cold chain	Each year, shared cost	Each year, shared cost	Each year, shared cost
Other capital equipment purchase			
Vehicles purchase to support implementation	NA	NA	NA

Appendix Table 2: List of unit costs used in the analysis**Mali**

Items	Units	Unit price (LCU)
Allowance and per diems¹		
Per diem for non-resident, participant, National level	Per person per day	15,000
Per diem for non-resident, facilitator National level	Per person per day	45,000
Per diem for non-resident, participant, Regional level	Per person per day	5,000
Per diem for non-resident, facilitator Regional level	Per person per day	35,000
Per diem for non-resident, participant, District level	Per person per day	5,000
Per diem for non-resident, facilitator District level	Per person per day	15,000
Allowance for community mobilization, leaders, National level	Per person per day	35,000
Allowance for community mobilization, leaders, Regional level	Per person per day	35,000
Allowance for community mobilization, leaders, District level	Per person per day	35,000
Allowance for community mobilization, participants, all level	Per person per day	5,000
Allowance for vaccine loaders	Per person per day	10,000
Transportation allowance for staff, average	Per person, both ways	5,000
Transportation allowance for staff, long distance	Per person, both ways	30,000
Transportation allowance for non-staff, average	Per person, both ways	5,000
Transportation allowance for non-staff, long distance	Per person, both ways	12,500
Community volunteers' allowance	Per person per day	3,000
Master of Ceremony for National launch event	Per person per day	150,000
Allowance for Hostesses for National launch event	Per person per day	15,000
Supplies and consumables²		
Photocopy ink	Each	80,000
Printing paper rim	Each	5,000
Report printing	Each	15,000
Pen	Each	100
Notepad	Each	1,500
Large paper rolls	Each	10,000
Markers	Each	1,000
Stationery package for training, National level	Each	2,500
Stationery package for training, Health facility level	Each	1,500
Drawing and recording materials	Per training	50,000
Drawing of sample and acquisition of SE maps	Per campaign planning event	6,000
Trailer/Spot/Sketch translation fees	Translation in different languages	20,000
Production of skit/sketch for Television	Production fees	2,000,000
Production of Spot/trailer for Television	Production fees	200,000
Production of Spot/trailer for Radio	Production fees	200,000
Broadcasting of trailer/spots in Television	Cost for one broadcast in Television	75,000
Broadcasting of skit/sketch in Television	Cost per show	200,000

Broadcasting of spots/trailer in Radio	Cost per airing	50,000
Newspaper inserts	Cost per insert	75,000
Tarpaulin banners production	Cost per banner	60,000
Printing leaflet (small)	Cost of printing one leaflet	200
Printing leaflet (large)	Cost of printing one leaflet	1,500
Printing poster	Cost of printing one poster	20,000
Invitation card for program launch and social mobilization	Cost of printing one invitation card	1,000
Printing manuals	Cost of printing	5,000
Vaccination register	Per unit	2,424
Tally register	Per unit	4,848
Monthly vaccination report	Per unit	2,424
Cotton	Per unit	4
Designer contract for developing communication material	Per unit	200,000
Coordination of community information activity	Flat cost at National level	75,000
Hold launches and information sharing session	Flat cost per district	250,000
Printing T-shirt and caps for social mobilization	Cost per unit	200
Other direct costs		
Hall/venue rental, large size, National level	Per day	1,000,000
Hall/venue rental, medium size, National level	Per day	500,000
Hall/venue rental, small size, National level	Per day	250,000
Hall/venue rental, large size, Regional level	Per day	375,000
Hall/venue rental, medium size, Regional level	Per day	200,000
Hall/venue rental, small size, Regional level	Per day	75,000
Hall/venue rental, large size, District level	Per day	150,000
Hall/venue rental, medium size, District level	Per day	75,000
Hall/venue rental, small size, District level	Per day	75,000
Refreshments (coffee, snacks)	Per person per day	1,500
Lunch	Per person per day	2,500
Dinner	Per person per day	2,500
Vehicle hire, small size (Car)	Per vehicle per day	50,000
Vehicle hire, medium size (Vans)	Per vehicle per day	75,000
Vehicle hire, large size (truck)	Per vehicle per day	200,000
Fuel cost	Per liter	660
Trampoline rental	Cost per day	20,000
Sound equipment rental	Cost per day	100,000
Animation artist service contract	Per unit	250,000
Media coverage at National level event	Cost per day	5,000
Chairs rental- metal	Cost per day	100
Chairs rental- plastic	Cost per day	200
Communication costs reimbursement	Flat cost per person	20,000
Average toll/peage	Per trip	15,750
Cold chain and equipment^{3, 4}	Capacity cm3	

Cold room, walk-in type,10 m ³	10,000,000	15,100
Cold room, walk-in type,30 m ³	30,000,000	22,500
Cold room, walk-in type,40 m ³	40,000,000	27,000
Mains Ref Sure Chill GVR50AC E003/046	46,500	1,642
Mains Ref Sure Chill GVR100AC-M1 E003/047	99,000	2,355
Cold box, RCW 12/CF,PQS E004/004	7,000	614
Mains Ref. Vestfrost VLS400A AC E003/065	145,000	1,322
Mains Ref Aucma MetafridgeCFD50 E003/079	50,000	1,400
Mains Ref Dulas VC225ILR E003/072	184,000	3,318
Mains Ref. Vestfrost VLS400A AC E003/065	145,000	1,322
Mains Ref Aucma MetafridgeCFD50 E003/079	50,000	1,400
Mains Ref SurChl GVR99Lite AC E003/082	98,500	1,200
Mains Ref SureChill GVR225AC-M1 E003/083	225,000	1,910
TCW 2000 AC	60,000	3,034
TCW 3000 AC	150,000	4,346
Cold Box, BlowKing CB/20-CF	20,000	200
TCW15SDD	16,000	4,584
VLS200A	60,000	818
VLS154	170,000	3,140
TCW4000AC	240,000	3,896
VLS400A	145,000	1,118

Sources:¹ MOH/EPI² Previous new vaccine introduction activity reports from EPI³ UNICEF Supply Catalogue (last checked Jan 2018)⁴ Assumptions informed by Kenya Malaria vaccine implementation program costs**Burkina Faso**

Items	Units	Unit price (LCU)
Allowance and per diems¹		
Per diem for resident, Directors	Per person per day	20,000
Per diem for non-resident, Directors	Per person per day	30,000
Per diem for resident, Senior/mid-level Officers	Per person per day	10,000
Per diem for non-resident, Senior/mid-level Officers	Per person per day	27,000
Per diem for resident, administrative support/Drivers	Per person per day	10,000
Per diem for non-resident, administrative support/Drivers	Per person per day	20,000
Per diem for resident, Health facility staff	Per person per day	5,000
Per diem for non-resident, Health facility staff	Per person per day	10,000
Allowance for material handlers, National level	Per person per day	5,000
Allowance for material handlers, District level	Per person per day	2,000
Per diem for resident, non-staff	Per person per day	10,000
Per diem for non-resident, non-staff	Per person per day	27,000

Transportation allowance for non-staff	Per person, both ways	5,000
Lunch allowance - District level	Per person per day	1,500
Lunch allowance - Health facility level	Per person per day	1,000
Per diem during campaign, Health facility staff	Per person per day	5,000
Supplies and consumables²		
Notebook	Per piece	1,000
Pen	Per piece	100
Ink (printer cartridge)	Per piece	65,000
Printing paper	Per piece	4,000
Folders	Per piece	1,000
Stationery package for training, Health facility level	Per unit	1,000
Stationery package for training, National level	Per unit	2,500
Printing poster/vaccine calendar	Cost per unit	3,000
Monthly reporting tools	Cost per unit	710
Purchase order form for vaccine	Cost per unit	3,600
Monitoring graphic	Cost per unit	380
Tally sheet	Cost per unit	40
Register for consumables management	Cost per unit	4,300
Register for vaccine management	Cost per unit	5,950
Vaccination card	Cost per unit	15
Plaidoyer (Advocacy) - Flat cost per region	Flat cost per region	400,000
Plaidoyer (Advocacy) - Flat cost per District	Flat cost per district	200,000
Community sensitization - Flat cost per Health Facility	Flat cost per health facility	7,500
Launch event at National level - Flat cost	Flat cost at National level	3,000,000
Launch event at Regional level - Flat cost	Flat cost at Regional level	300,000
Post introduction survey	Flat cost-no detail available	60,000,000
Development of TV spots	Cost per unit paid to media	625,000
Development of radio spots	Cost per unit paid to media	85,000
Broadcasting messages in TV	Cost per broadcast	110,000
Broadcasting messages in radio	Cost per broadcast	8,000
Media coverage - Newspaper Interview (Midi magazine)	Per unit	300,000
Media coverage - at National level	Per unit	250,000
Media coverage TV-Radio program at Regional level	Per unit	100,000
Media coverage TV-Radio program at District level	Per unit	100,000
Other direct costs²		
Hall/venue rental, large size, National level	per day	250,000
Hall/venue rental, medium size, National level	per day	150,000
Hall/venue rental, small size, National level	per day	100,000
Hall/venue rental, large size, Regional level	per day	100,000
Refreshments (coffee, snacks)- National level	Per person per day	2,500
Refreshments (coffee, snacks)- Region/District/HF	Per person per day	1,000

Lunch - National level	Per person per day	5,000
Lunch - Regional level	Per person per day	2,500
Lunch - District/HF level	Per person per day	1,500
Cocktail	Per person per day	12,500
Fuel- reimbursement at National and regional level	Reimbursement per KM	105
Fuel- reimbursement at district level to health facility	Reimbursement per KM	40
Vehicle hire, medium	Per vehicle per day	75,000
Vehicle hire, large size (truck)	Per vehicle per day	75,000
Fuel	Per liter	615
Cold chain and equipment ^{3,4}	Capacity cm3	
Cold room, walk-in type, 10 m ³	10,000,000	15,100
Cold room, walk-in type, 30 m ³	30,000,000	22,500
Cold room, walk-in type, 40 m ³	40,000,000	27,000
Mains Ref SureChill GVR50AC E003/046	46,500	1,642
Mains Ref SureChill GVR100AC-M1 E003/047	99,000	2,355
Cold box, RCW 12/CF,PQS E004/004	7,000	614
Mains Ref. Vestfrost VLS400A AC E003/065	145,000	1,322
Mains Ref Aucma MetafridgeCFD50 E003/079	50,000	1,400
Mains Ref Dulas VC225ILR E003/072	184,000	3,318
Mains Ref. Vestfrost VLS400A AC E003/065	145,000	1,322
Mains Ref Aucma MetafridgeCFD50 E003/079	50,000	1,400
Mains Ref SurChl GVR99Lite AC E003/082	98,500	1,200
Mains Ref SureChill GVR225AC-M1 E003/083	225,000	1,910
TCW 2000 AC	60,000	3,034
TCW 3000 AC	150,000	4,346
Cold Box, BlowKing CB/20-CF	20,000	200
TCW15SDD	16,000	4,584
VLS200A	60,000	818
VLS154	170,000	3,140
TCW4000AC	240,000	3,896
VLS400A	145,000	1,118

Sources:¹ MOH/EPI² Previous new vaccine introduction activity reports from EPI³ UNICEF Supply Catalogue (last checked Jan 2018)⁴ Assumptions informed by Kenya Malaria vaccine implementation program costs

Appendix Table 3.a: List of districts and facilities surveyed in Mali

	Name of the Institution/facility
National level	National Center of Immunization (NIC)
	National Malaria Control Program (NMP)
	Technical Advisory Group for Vaccine and Immunization (NITAG or GTCV)
	National Center for Information, Education of the State (CNIECS)
Regional level	Regional Health Directorate (DRS) of Koulikoro
Health district level	District Health Office, Bougouni
	District Health Office, Diema
Health facility level	Bougouni-Nord
	Bougouni-Sud
	Bougouni-Ouest
	Kaumontou
	Diema-Central
	Diancounte-Camara
	Tinkaré

Appendix Table 3.b: List of districts and facilities surveyed in Burkina Faso

	Name of the Institution/facility
National level	Direction de la Prevention par la Vaccination (DPV)
Regional level	Region Centre Ouest,
Health district level	Nanoro health district
Health facility level	Secteur 23 Tanghin
	Secteur 27 Wayalghin
	Roumtenga
	Sakoula
	Pella
	Somassi
	Siglè
	Nanoro

Appendix Table 4: Unit cost calculations

Metric	Definition	Calculations
Cost per dose administered	Total cost of the program (both introduction and recurrent), inclusive of commodity costs, divided by the total expected number of vaccinations over a given period of time.	$= \frac{\sum_{i=1}^n \text{cost of activity}_i}{\text{Number of vaccine doses administered}}$ <p>Where, i = activity groups used in costing</p>
Cost of delivery per dose	Total cost of the program (both introduction and recurrent), less the commodity related cost, divided by the total expected number of vaccinations over a given period of time.	$= \frac{\sum_{i=1}^n \text{cost of activity}_i - \text{cost of immunization commodity}}{\text{Number of vaccine doses administered}}$ <p>Where, i = activity groups used in costing Immunization commodities include vaccines, injection supplies, procurement add on charges on these commodities</p>
Cost of delivery per first 3 doses completion	Total cost of the program (both introduction and recurrent), less the commodity related cost, divided by the total expected number of children who complete the first three doses of over a given period of time.	$= \frac{\sum_{i=1}^n \text{cost of activity}_i}{\text{Number of children who receive atleast the first 3 doses of vaccine}}$ <p>Where, i = activity groups used in costing Pri</p>
Cost of delivery per first 3 doses completion	Total cost of the program (both introduction and recurrent), less the commodity related cost, divided by the total expected number of children who complete the first three doses of over a given period of time.	$= \frac{\sum_{i=1}^n \text{cost of activity}_i - \text{cost of immunization commodity}}{\text{Number of children who receive atleast the first 3 doses of vaccine}}$ <p>Where, i = activity groups used in costing Immunization commodities include vaccines, injection supplies, procurement add on charges on these commodities</p>

Appendix Table 5.a: RTS,S introduction and delivery cost drivers in Mali, scenario 1: Mass campaign

Cost categories	Financial cost			Economic cost		
	USD	%	% w/o commodities	USD	%	% w/o commodities
Vaccines and Injectable Supplies	14,403,323	26.3%	NA	132,402,606	75.6%	NA
Service Delivery	14,384,942	26.3%	35.7%	15,226,456	8.7%	35.6%
Planning and coordination	1,554,067	2.8%	3.9%	1,795,925	1.0%	4.2%
Training	5,209,902	9.5%	12.9%	5,540,074	3.2%	13.0%
Information, Education and Communication	1,076,902	2.0%	2.7%	1,135,973	0.6%	2.7%
Social Mobilization	1,875,034	3.4%	4.7%	1,881,866	1.1%	4.4%
Monitoring and Evaluation	500,012	0.9%	1.2%	500,012	0.3%	1.2%
Supervision	5,447,908	10.0%	13.5%	6,406,462	3.7%	15.0%
Distribution	1,136,620	2.1%	2.8%	1,159,810	0.7%	2.7%
Cold Chain Equipment	3,333,958	6.1%	8.3%	3,333,958	1.9%	7.8%
Other Logistical Equipment	5,743,620	10.5%	14.3%	5,743,620	3.3%	13.4%
Total cost (full cost, initial investment + recurrent)	54,666,288	100%		175,126,762	100%	
Total cost (full cost, initial investment + recurrent) without vaccines and injection supplies	40,262,966		100.0%	42,724,156		100.0%

Note: Cost drivers in Mali derived under baseline input assumptions, for mass campaign delivery modality.

Appendix Table 5.b: RTS,S introduction and delivery cost drivers in Mali, scenario 2: Routine EPI

Cost categories	Financial cost			Economic cost		
	USD	%	% w/o commodities	USD	%	% w/o commodities
Vaccines and Injectable Supplies	14,403,323	48.4%	NA	132,402,606	88.9%	NA
Service Delivery	359,339	1.2%	2.3%	1,033,941	0.7%	6.2%
Planning and coordination	327,614	1.1%	2.1%	376,712	0.3%	2.3%
Training	1,962,848	6.6%	12.8%	2,079,762	1.4%	12.6%
Information, Education and Communication	1,007,408	3.4%	6.6%	1,066,478	0.7%	6.4%
Social Mobilization	745,533	2.5%	4.9%	748,283	0.5%	4.5%
Monitoring and Evaluation	20,000	0.1%	0.1%	20,000	0.0%	0.1%
Supervision	1,528,660	5.1%	10.0%	1,794,064	1.2%	10.8%
Distribution	327,157	1.1%	2.1%	347,373	0.2%	2.1%
Cold Chain Equipment	3,333,958	11.2%	21.7%	3,333,958	2.2%	20.2%
Other Logistical Equipment	5,743,620	19.3%	37.4%	5,743,620	3.9%	34.7%
Total cost (full cost, initial investment + recurrent)	29,759,460	100%		148,946,798	100%	
Total cost (full cost, initial investment + recurrent) without vaccines and injection supplies	15,356,137		100.0%	16,544,192		100.0%

Note: Cost drivers in Mali derived under baseline input assumptions, for routine EPI delivery modality.

Appendix Table 5.c: RTS,S introduction and delivery cost drivers in Mali, scenario 3: Mixed delivery

Cost categories	Financial cost			Economic cost		
	USD	%	% w/o commodities	USD	%	% w/o commodities
Vaccines and Injectable Supplies	14,403,323	35.7%	NA	132,402,606	82.7%	NA
Service Delivery	3,164,460	7.9%	12.2%	3,872,444	2.4%	14.0%
Planning and coordination	1,554,375	3.9%	6.0%	1,796,268	1.1%	6.5%
Training	5,209,902	12.9%	20.1%	5,540,074	3.5%	20.0%
Information, Education and Communication	1,224,578	3.0%	4.7%	1,283,648	0.8%	4.6%
Social Mobilization	1,875,034	4.7%	7.2%	1,881,866	1.2%	6.8%
Monitoring and Evaluation	500,012	1.2%	1.9%	500,012	0.3%	1.8%
Supervision	2,618,242	6.5%	10.1%	3,075,357	1.9%	11.1%
Distribution	674,945	1.7%	2.6%	701,688	0.4%	2.5%
Cold Chain Equipment	3,333,958	8.3%	12.9%	3,333,958	2.1%	12.0%
Other Logistical Equipment	5,743,620	14.3%	22.2%	5,743,620	3.6%	20.7%
Total cost (full cost, initial investment + recurrent)	40,302,449	100%		160,131,541	100%	
Total cost (full cost, initial investment + recurrent) without vaccines and injection supplies	25,899,126		100.0%	27,728,935		100.0%

Note: Cost drivers in Mali derived under baseline input assumptions, for mixed delivery modality.

Appendix Table 6.a: RTS,S introduction and delivery cost drivers in Burkina Faso, scenario 1: Mass campaign

Cost categories	Financial cost			Economic cost		
	USD	%	% w/o commodities	USD	%	% w/o commodities
Vaccines and Injectable Supplies	13,647,445	41.8%	NA	125,454,195	84.8%	NA
Service Delivery	10,404,650	31.9%	54.8%	12,796,524	8.7%	57.0%
Planning and coordination	995,501	3.0%	5.2%	1,426,266	1.0%	6.4%
Training	434,792	1.3%	2.3%	547,837	0.4%	2.4%
Initial Sensitization	84,044	0.3%	0.4%	139,710	0.1%	0.6%
Communication	186,940	0.6%	1.0%	186,940	0.1%	0.8%
Social Mobilization	23,976	0.1%	0.1%	32,476	0.0%	0.1%
Monitoring and Evaluation	135,274	0.4%	0.7%	167,098	0.1%	0.7%
Supervision	1,094,491	3.4%	5.8%	1,363,940	0.9%	6.1%
Distribution	549,530	1.7%	2.9%	699,601	0.5%	3.1%
Cold Chain Equipment	5,091,141	15.6%	26.8%	5,091,141	3.4%	22.7%
Total cost (full cost, initial investment + recurrent)	32,647,782	100.0%		147,905,729	100.0%	

Total cost (full cost, initial investment + recurrent) without vaccines and injection supplies	19,000,337		100.0%	22,451,534		100.0%
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Note: Cost drivers in Burkina Faso derived under baseline input assumptions, for mass campaign delivery modality.

Appendix Table 6.b: RTS,S introduction and delivery cost drivers in Burkina Faso, scenario 2: Routine EPI

Cost categories	Financial cost			Economic cost		
	USD	%	% w/o commodities	USD	%	% w/o commodities
Vaccines and Injectable Supplies	13,647,445	64.5%	NA	125,454,195	93.2%	NA
Service Delivery	572,615	2.7%	7.6%	1,415,750	1.1%	15.5%
Planning and coordination	399,165	1.9%	5.3%	596,612	0.4%	6.5%
Training	222,374	1.1%	3.0%	316,108	0.2%	3.5%
Initial Sensitization	84,044	0.4%	1.1%	139,710	0.1%	1.5%
Communication	58,236	0.3%	0.8%	58,236	0.0%	0.6%
Social Mobilization	23,976	0.1%	0.3%	32,476	0.0%	0.4%
Monitoring and Evaluation	135,274	0.6%	1.8%	167,098	0.1%	1.8%
Supervision	733,968	3.5%	9.8%	1,117,069	0.8%	12.2%
Distribution	183,722	0.9%	2.4%	218,312	0.2%	2.4%
Cold Chain Equipment	5,091,141	24.1%	67.8%	5,091,141	3.8%	55.6%
Total cost (full cost, initial investment + recurrent)	21,151,958	100.0%		134,606,708	100.0%	
Total cost (full cost, initial investment + recurrent) without vaccines and injection supplies	7,504,513		100.0%	9,152,513		100.0%

Note: Cost drivers in Burkina Faso derived under baseline input assumptions, for routine EPI delivery modality.

Appendix Table 6.c: RTS,S introduction and delivery cost drivers in Burkina Faso, scenario 3: Mixed delivery

Cost categories	Financial cost			Economic cost		
	USD	%	% w/o commodities	USD	%	% w/o commodities
Vaccines and Injectable Supplies	13,647,445	55.3%	NA	125,454,195	90.3%	NA
Service Delivery	2,539,022	10.3%	23.1%	3,691,905	2.7%	27.4%
Planning and coordination	1,159,656	4.7%	10.5%	1,684,445	1.2%	12.5%
Training	434,792	1.8%	3.9%	547,837	0.4%	4.1%
Initial Sensitization	168,087	0.7%	1.5%	279,420	0.2%	2.1%
Communication	186,940	0.8%	1.7%	186,940	0.1%	1.4%
Social Mobilization	23,976	0.1%	0.2%	32,476	0.0%	0.2%

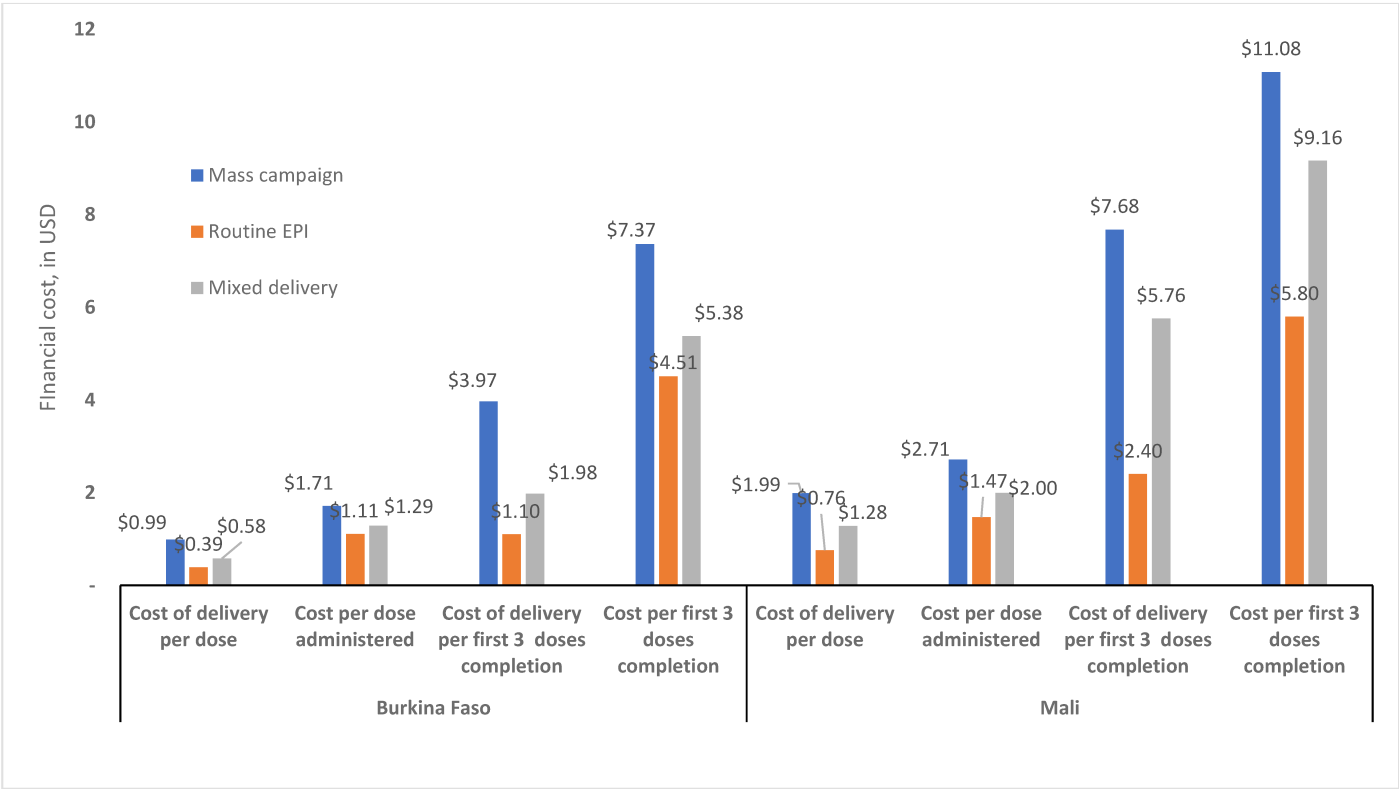
Monitoring and Evaluation	135,274	0.5%	1.2%	167,098	0.1%	1.2%
Supervision	1,025,832	4.2%	9.3%	1,480,787	1.1%	11.0%
Distribution	247,704	1.0%	2.2%	288,248	0.2%	2.1%
Cold Chain Equipment	5,091,141	20.6%	46.2%	5,091,141	3.7%	37.9%
Total cost (full cost, initial investment + recurrent)	24,659,868	100.0%		138,904,492	100.0%	
Total cost (full cost, initial investment + recurrent) without vaccines and injection supplies	11,012,423		100.0%	13,450,297		100.0%

Note: Cost drivers in Burkina Faso derived under baseline input assumptions, for mixed delivery modality.

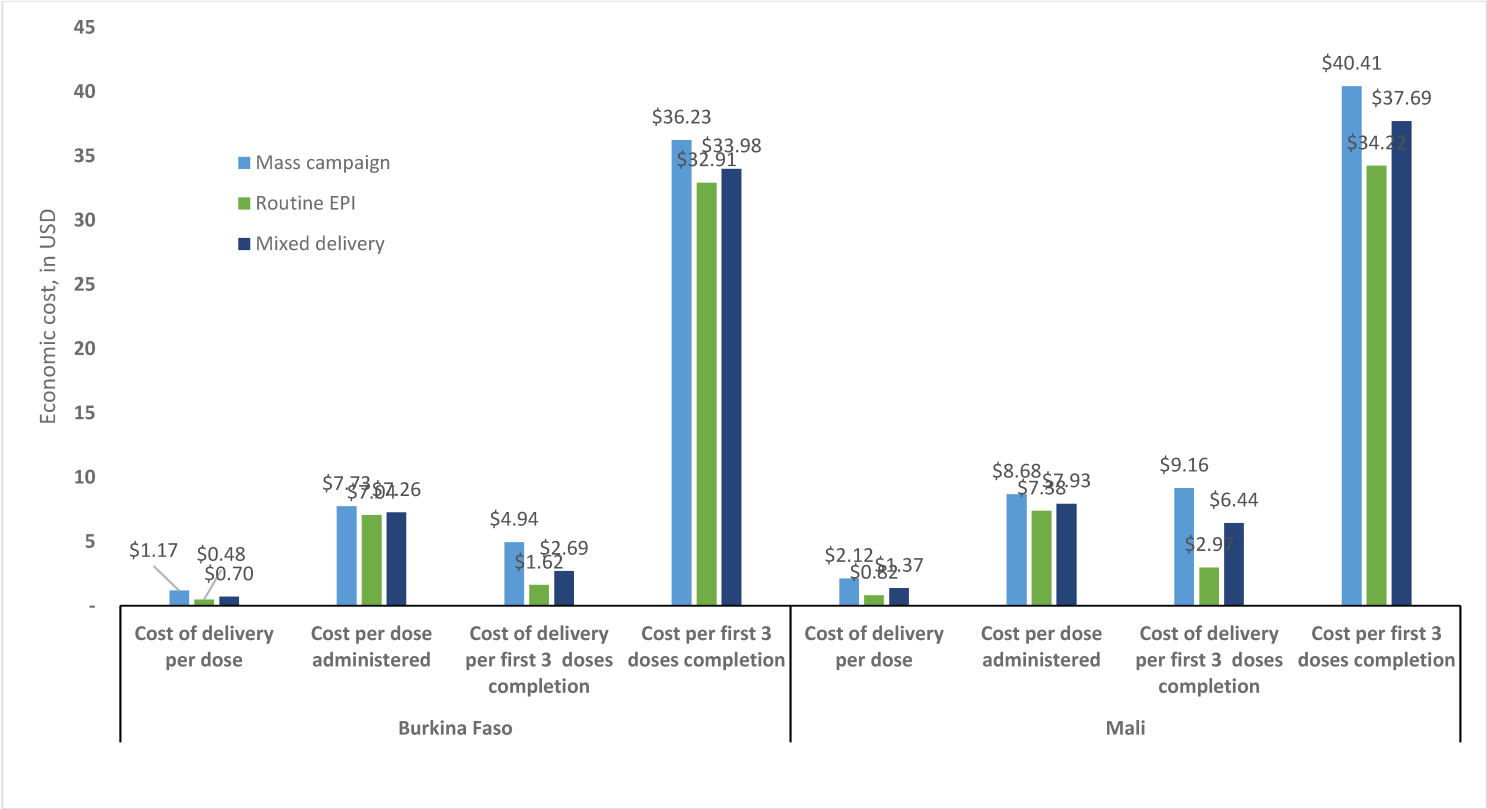
Appendix Table 7: Unit cost estimates (in USD) at various vaccine price assumptions

Metric	Vaccine price per dose	Sn1: Mass campaign		Sn2: Routine EPI		Sn3: Mixed delivery	
		Financial	Economic	Financial	Economic	Financial	Economic
Mali							
Cost per dose administered	\$2	\$2.34	\$4.80	\$1.10	\$3.50	\$1.62	\$4.05
Cost per dose administered	\$5	\$2.71	\$8.86	\$1.47	\$7.38	\$2.00	\$7.93
Cost per dose administered	\$10	\$3.33	\$15.14	\$2.09	\$13.84	\$2.62	\$14.40
Cost per first 3 doses completion	\$2	\$9.98	\$21.93	\$4.03	\$15.74	\$7.39	\$19.21
Cost per first 3 doses completion	\$5	\$11.08	\$40.41	\$5.80	\$34.22	\$9.16	\$37.69
Cost per first 3 doses completion	\$10	\$14.71	\$71.22	\$8.75	\$65.03	\$12.12	\$68.51
Burkina Faso							
Cost per dose administered	\$2	\$1.33	\$3.85	\$0.73	\$3.16	\$0.92	\$3.38
Cost per dose administered	\$5	\$1.71	\$7.73	\$1.11	\$7.04	\$1.29	\$7.26
Cost per dose administered	\$10	\$2.33	\$14.19	\$1.73	\$13.50	\$1.91	\$13.72
Cost per first 3 doses completion	\$2	\$5.60	\$17.72	\$2.73	\$14.41	\$3.61	\$15.48
Cost per first 3 doses completion	\$5	\$7.37	\$36.23	\$4.51	\$32.91	\$5.38	\$33.98
Cost per first 3 doses completion	\$10	\$10.33	\$67.07	\$7.46	\$63.76	\$8.34	\$64.82

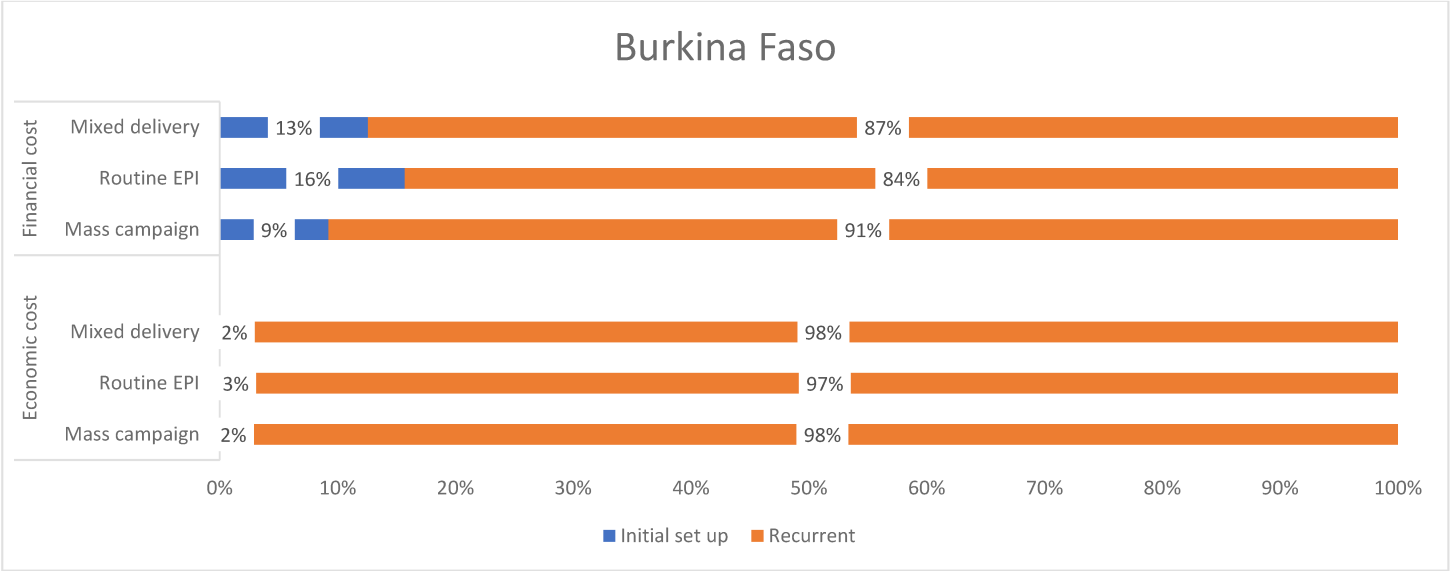
Appendix Figure 1.a: Financial unit cost estimates across different scenarios



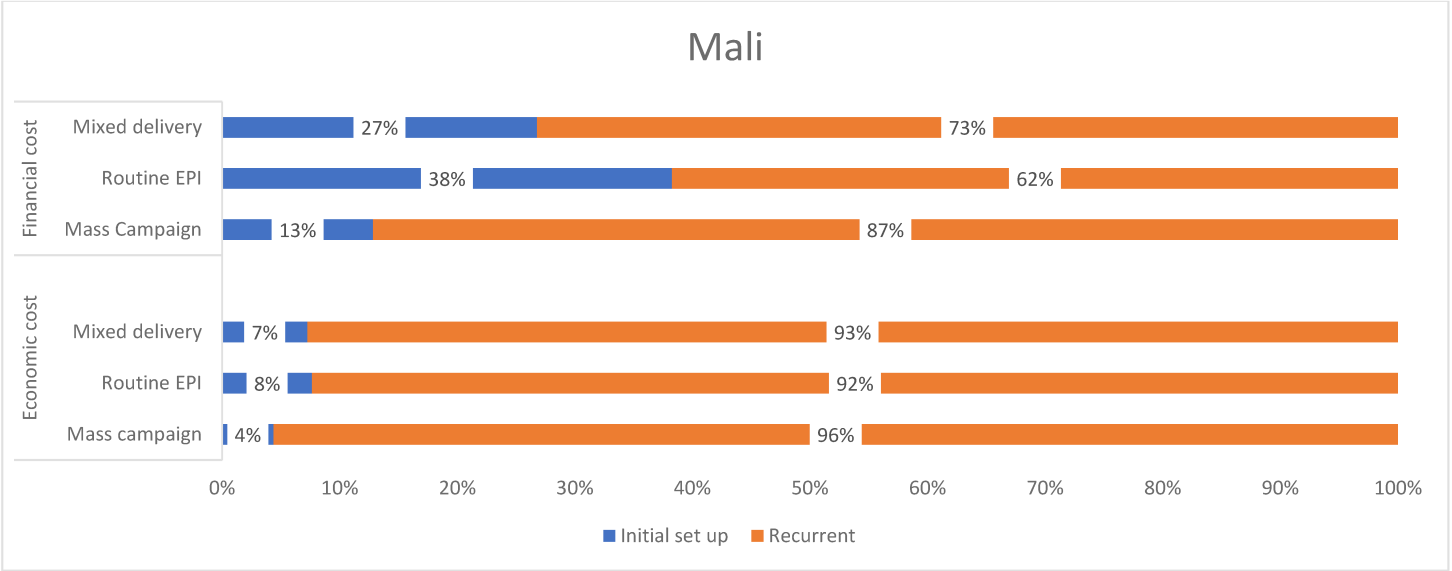
Appendix Figure 1.b: Economic unit cost estimates across different scenarios



Appendix Figure 2.a: Cost drivers across different scenarios of vaccine delivery, Burkina Faso



Appendix Figure 2.b: Cost drivers across different scenarios of vaccine delivery, Mali



Appendix S1 – Reflexivity Statement

1. How does this study address local research and policy priorities?

Malaria parasite is highly seasonal across the African Sahel sub-region including Burkina Faso and Mali. This study aimed to understand the cost of malaria vaccine delivery for different delivery modalities, Burkina Faso and Mali. As these countries consider implementation of the RTS,S vaccine into their immunization programs, the economic evidence generated in this study can be used by countries to help guide their decisions around RST,S vaccine introduction and choice of delivery modality, by evaluating the economic implications of each strategy.

2. How were local researchers involved in study design?

This study was done by an international partnership of researchers from high-income and low-income countries. The conceptualization of research was done from partners from high-income countries. The researchers from low-income countries led the data collection, engagement within country program managers and leaders to validate the data. All authors contributed to the interpretation of the data and review of the manuscript. The roles of each co-author are clearly stated in the “contributions of each person” section.

3. How has funding been used to support the local research team?

The funding for this study was supported by PATH with institutional agreement with the in-country researchers in Burkina Faso and Mali.

4. How are research staff who conducted data collection acknowledged?

Researchers leading the data collection are co-authors in this study. Research staff/data collectors are acknowledged in the acknowledgment section.

5. Do all members of the research partnership have access to study data?

All members of the partnership have access to data.

6. How was data used to develop analytical skills within the partnership?

The partners are lead health economists in their respective countries and contributed to the analysis and interpretation of the results.

7. How have research partners collaborated in interpreting study data?

The research partners collaborated in interpretation of the data via joint conference calls throughout the analysis period. Further, they led the validation meeting within each country with the in-country program managers and decision makers to interpret the data.

8. How were research partners supported to develop writing skills?

This was not specifically addressed during this study.

9. How will research products be shared to address local needs?

Validation and dissemination workshop in each country was done by in-country researchers. The workshop included in-country decision makers, program managers, malaria academic institutions in country. This paper will be published as open access.

10. How is the leadership, contribution and ownership of this work by LMIC researchers recognised within the authorship?

The study implementation was led by researchers in low-income countries. Majority of authors including the joint first co-authors in this manuscript (HD and FB) are from low-income countries reflecting the critical leadership, contribution, and ownership of this work.

11. How have early career researchers across the partnership been included within the authorship team?

We have included early career researchers (FK, RG, SY, and ST) within the authorship team.

12. How has gender balance been addressed within the authorship?

Seven authors are female (HD, FB, AL, CL, FK, RG, and RB) and six authors male (AD, JO, SY, ST, WM, and CP).

13. How has the project contributed to training of LMIC researchers?

The authorship team is primarily composed of senior researchers. All the authors based in low-income countries mostly senior researchers. Research funding leveraged as part of this project supported employment of a few junior researcher in Burkina Faso and Mali.

14. How has the project contributed to improvements in local infrastructure?

This project has not directly contributed to improvements in local infrastructure.

15. What safeguarding procedures were used to protect local study participants and researchers?

Study participants in this study included the health workers and their participation in the study pose minimal risk to interviewees. Further, all participants provided informed consent, and we have anonymized all participants.