



The Value of Vaccines to Mitigate Antimicrobial Resistance

GARP-Côte D'Ivoire Policy Brief



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LIST OF ABBREVIATIONS AND ACRONYMS

AMR	antimicrobial resistance
ARI	acute respiratory infection
BCG	Bacillus Calmette–Guérin
DALY	disability adjusted life years
DIEMP	Direction des Infrastructures, de l'Équipement, de la Maintenance et du Patrimoine (Directorate of Infrastructure, Equipment, Maintenance and Patrimony)
AIRP	Autorité Ivoirienne de Régulation Pharmaceutique (Ivorian Pharmaceutical Regulatory Authority)
DTP	diphtheria, tetanus toxoid, and pertussis
EPI	Expanded Program on Vaccination
Hib3	<i>Haemophilus influenzae</i> type b
HIV/AIDS	human immunodeficiency virus infection and acquired immune deficiency syndrome
HPV	human papillomavirus
INHP	Institut National d'Hygiène Publique (National Institute of Public Hygiene)
LMIC	low- and middle-income country
MCV1	measles-containing vaccine first dose
MCV2	measles-containing vaccine second dose
MenA	meningococcal vaccine
OOP	out-of-pocket
PCV	pneumococcal conjugate vaccine
TB	tuberculosis
UNICEF	United Nations Children's Fund
VE	vaccine efficacy
VPD	vaccine-preventable disease
VSL	value of statistical life
YLL	years of life lost



EXECUTIVE SUMMARY

Antimicrobial resistance (AMR) is a growing public health challenge that compromises the efficacy of life-saving medications and exacerbates the burden of infectious diseases. It is currently among the leading causes of death in Côte d'Ivoire, where resistance to routinely used antibiotics is driven by overuse and inappropriate use, often a consequence of poor diagnostic capabilities, unregulated sales, and inadequate access to high-quality drugs.

Vaccines are a potent yet underutilized strategy for mitigating AMR in Côte d'Ivoire. By preventing infections and reducing antibiotic use, vaccines limit the emergence and spread of drug-resistant bacteria and slow the development of AMR. The pneumococcal conjugate vaccine, the *Haemophilus influenzae* type b vaccine, the rotavirus vaccine, the typhoid conjugate vaccine, and the malaria vaccine have been shown to significantly reduce

disease incidence or antibiotic consumption, while also generating substantial economic returns.

Since its establishment in 1978, the Expanded Program on Immunization in Côte d'Ivoire has made significant strides in introducing several vaccines that have contributed to a reduction in child mortality. However, immunization rates are inconsistent across the country, with lower uptake in rural and underdeveloped areas. These gaps increase the risk of infectious diseases and AMR and exacerbate the healthcare burden at societal and individual levels.

Vaccines are not only a public health intervention but also a significant investment in the country's resilience against AMR. This policy brief summarizes key areas and priority initiatives that leverage vaccines as tools to mitigate infectious diseases and AMR in Côte d'Ivoire.

*Photo source: Koutouan Djoro

Key Recommendations

1. Maintain high coverage of all available vaccines, including rotavirus, pneumococcal conjugate, yellow fever, meningococcal, *Haemophilus influenzae* type b, and Bacillus Calmette-Guérin vaccines.
2. Integrate AMR objectives into the national immunization policy and include AMR-sensitive indicators in routine vaccine monitoring.
3. Improve vaccine uptake through maternal and caregiver engagement, and address known socioeconomic barriers regarding vaccination schedules in the country.
4. Create specific domestic funding channels for vaccines that demonstrate high impact on AMR and use evidence of cost-effectiveness to advocate for continued partner and domestic co-financing.



BACKGROUND AND CONTEXT

Côte d'Ivoire has a high burden of communicable diseases with wide-reaching impacts on public health and economic productivity. Malaria, tuberculosis (TB), human immunodeficiency virus infection and acquired immune deficiency syndrome (HIV/AIDS), acute respiratory infections (ARIs), and diarrheal diseases are the leading causes of illness and death in the country (Eze et al. 2017; World Health Organization African Region 2023). Malaria is endemic across Côte d'Ivoire, with about seven million cases reported annually, and the highest incidence among children under five years of age (Lim et al. 2012; World Health Organization African Region 2023). Second to malaria, ARIs are responsible for most hospitalizations, whereas TB disproportionately affects individuals with HIV and other at-risk populations (Climate & Clean Air Coalition 2020; Boh 2024; CDC 2024).

In 2021, Côte d'Ivoire had the 42nd-highest age-standardized death rate linked to AMR out of 204 nations (Institute for Health Metrics and Evaluation 2024). However, the AMR issue is not limited to human health. The widespread occurrence of AMR in human, animal, aquatic, and environmental settings reflects a complex One Health problem (Kacou-N'douba et al. 2012; Coulibaly et al. 2016; Gbonon-M'bengue et al. 2018; Goualié et al. 2019). Multidrug-resistant pathogens in clinical settings, food-producing animals, and aquaculture systems raise concerns about cross-sectoral transmission and the sustainability of existing antibiotic treatment options (Bakayoko et al. 2015; Koudou et al. 2020; Assoumy et al. 2021). Inappropriate prescription

and dispensing of antibiotics, poor diagnostic capacity, weak regulatory enforcement, and extensive self-medication are some of the main drivers of AMR in the country (Ayukekbong et al. 2017; Bedekelabou et al. 2022).

Paradoxically, antimicrobial overuse coexists with access issues stemming from frequent pharmaceutical shortages, unaffordability, and the spread of substandard or falsified medicines, leading to underdosing, incomplete treatment courses, or the wrong choice of antibiotics. These factors increase the risk of AMR development and place a disproportionate burden on low-income households (Abrogoua et al. 2016; World Health Organization 2018; Ecofin Agency 2024).

In this context, vaccines are important prevention tools to address both infectious diseases and AMR. By preventing infections that would otherwise require antimicrobial treatment, vaccines lower infectious disease burden and slow the emergence and spread of AMR. Therefore, strengthening and expanding vaccination programs represent practical strategies to reduce AMR, enhance population health, spare families from financial hardship, and promote the long-term resilience of the health system. Studies estimate that increased childhood immunization coverage, combined with improved water, sanitation, and infection-control measures, could avert over 750,000 AMR-associated deaths annually in low- and middle-income countries (LMICs) (Lewnard et al. 2024).



BURDEN OF INFECTIOUS DISEASE IN CÔTE D'IVOIRE

Côte d'Ivoire has a high prevalence of communicable diseases, which contributed to over one-third of deaths in 2019 (World Health Organization African Region 2023). Malaria, TB, and HIV/AIDS are reported to be the leading causes of death in the country (Eze et al. 2017).

Malaria is endemic in Côte d'Ivoire, with an estimated 7,328,427 cases in 2021 and an incidence rate of 270.8 cases per 1,000 (Lim et al. 2012; World Health Organization African Region 2023). While transmission occurs year-round, there are seasonal variations in peak

incidence across the country (U.S. President's Malaria Initiative 2022; Severe Malaria Observatory 2024). There were 6.9 million reported cases, with an incidence of 229.9 cases per 1,000 in the general population and 594 cases per 1,000 in children under 5 years in 2021. Of those cases, 14,906 deaths occurred in the general population, and 1,276 were reported in children under 5 years (World Health Organization African Region 2023).

ARIs are reported as the second leading reason for hospitalization after malaria (Boh 2024). They contributed to an estimated 34,000 premature deaths in 2016, including 8,000 in children (Climate & Clean Air Coalition 2020). Increasing air pollution in Côte d'Ivoire has been linked to lower respiratory tract illnesses such

as pneumonia and asthma, making it an increasingly important health concern in the country (World Bank 2021).

The prevalence of TB is high, with an incidence of 99.1 cases per 100,000 individuals in 2024 (N'Guessan et al. 2024; World Health Organization 2025). From 2015 to 2021, the mortality rate of all TB cases, excluding HIV coinfection, declined only marginally, from 23 to 21 cases per 100,000 people (World Health Organization African Region 2023). Vulnerable populations impacted by malnutrition, compromised immune systems, and poor healthcare access are particularly susceptible to TB, notably the leading cause of death among people living with HIV (Kuzel 2020; CDC 2024).



ANTIMICROBIAL RESISTANCE IN CÔTE D'IVOIRE

AMR refers to a microorganism's innate or acquired capacity to resist the action of an antimicrobial (World Health Organization African Region 2021). It is considered one of the greatest threats to public health and is linked to detrimental social and economic effects (Organization for Economic Co-operation and Development 2023). While AMR is a natural phenomenon, the overuse and misuse of antibiotics and other antimicrobials in humans and animals significantly accelerates the emergence and spread of AMR (World Bank 2024).

Estimates predict that by 2050, AMR infections will claim 10 million lives yearly, with economic consequences estimated at 3.8 percent of gross domestic product (GDP). This could lead to US\$1.2 trillion in additional healthcare spending annually and cause an extra 28 million people to endure extreme poverty (O'Neill 2016; World Bank 2016).

Côte d'Ivoire has high and growing resistance to commonly used antibiotics (Dosso 2021). There were 19,598 AMR-related deaths and 4,277 AMR-attributable deaths in the country in 2021 (Institute for Health Metrics and Evaluation 2024). Out of 204 nations, Côte

d'Ivoire has the 27th-highest age-standardized death rate per 100,000 people linked to AMR, surpassing the number of deaths from HIV/AIDS, gastrointestinal infections, diabetes, and kidney diseases.

Various studies have demonstrated the One Health nature of the AMR challenge in Côte d'Ivoire, detecting antibiotic-resistant pathogens in humans (Kacou-N'douba et al. 2012; Moroh et al. 2014; Kacou-N'douba 2015; Gbegbe et al. 2024), foods of animal origin (Goualié et al. 2019; Bernadette et al. 2020; Assoumy et al. 2021), water sources (Coulibaly et al. 2016; Kouadio et al. 2017; Kouassi-Agbessi et al. 2019), and the environment (Gbonon-M'bengue et al. 2018; Coulibaly et al. 2020; Koffi et al. 2022).

Multidrug resistance (MDR) is also rising at an alarming rate (Jansen and Anderson 2018). Several studies have demonstrated the isolation of MDR pathogens in isolates from humans (Bakayoko et al. 2015; N'Guessan et al. 2018; Gulumbe and Faggo 2019; Afran et al. 2023; Kangah et al. 2024), food animals (Goualié et al. 2014; Benie et al. 2017; Assoumy et al. 2021), and aquaculture (Koudou et al. 2020; Kumarage et al. 2022; Wognin et al. 2024) across the country.

As in other developing nations, factors that contribute to the spread of AMR in Côte d'Ivoire include inappropriate antibiotic prescription practices; poor patient education; a lack of diagnostic facilities;

unregulated antibiotic sales; a lack of effective drug regulatory systems; and the use of antibiotics in animals (Ayukekong et al. 2017; Ajayi et al. 2024).



ANTIMICROBIAL USE AND ACCESS

Effective antimicrobials are essential to any healthcare system, yet many patients, especially in LMICs, lack access to these medicines (Klein et al. 2021). Currently, the lack of access to antibiotics kills more people globally than drug-resistant bacterial infections (Hartwig and Kliesow 2020). In Côte d'Ivoire, the supply of medicines is frequently hampered by stockouts, inaccessibility, and low product quality, particularly in rural areas (Ecofin Agency 2024). Like overuse, lack of access to antimicrobials contributes to the development of drug-resistant infections (World Health Organization 2018). For example, patients who lack access to antibiotics may not receive treatment for their infections, which can result in both direct and indirect mortality as the infections spread (Klemperer et al. 2024). However, there are other layers to the access issue; in addition to the inability to pay for medications, many have access to inferior products such as substandard or falsified antimicrobials (Hartwig and Kliesow 2020). When patients are only able to obtain substandard antibiotics

or cannot afford a complete course of treatment, resistance may develop as ineffective medicines do not fully treat infections and promote the overuse of inappropriate antibiotics (World Health Organization 2018; Muteeb et al. 2023).

Additionally, data from Côte d'Ivoire reveal pharmacotherapeutic issues related to access and use of antibiotics. The primary issue is non-optimal dosing, followed by underdosing and an unusually short treatment period (Abrogoua et al. 2016). Moreover, people frequently self-medicate by buying antibiotics on the street or at private pharmacies. A study conducted among human and animal health professionals in Côte d'Ivoire showed that medical practitioners adopt inadequate practices regarding the use and distribution of antibiotics, as well as the use of antibiotics for preventive therapy (Bedekelabou et al. 2022). Distributors of pharmaceuticals also acknowledged that they occasionally sold antibiotics without a prescription.



THE ROLE OF VACCINES IN MITIGATING AMR AND THEIR POTENTIAL IN CÔTE D'IVOIRE

Vaccines are critical in combating infectious diseases and AMR (Hasso-Agopsowicz et al. 2024). By reducing infectious disease incidence, including viral infections treated incorrectly with antibiotics, vaccines lower the proportion of both appropriate and inappropriate antimicrobial use (Bloom et al. 2018). In addition to reducing the number of cases and deaths caused by infections from both drug-susceptible and drug-resistant microorganisms, vaccinations also lessen the financial burden of treating infections (Hasso-Agopsowicz et al. 2024). Additionally, vaccines can promote herd immunity,

protecting the unvaccinated from contracting infections, including drug-resistant ones.

An example of the impact of vaccines on AMR control is that of the pneumococcal conjugate vaccine (PCV). Five years after the introduction of PCV in the United States, invasive pneumococcal illness caused by multidrug-resistant *Streptococcus pneumoniae* in children (under the age of two) declined by 84 percent (Kyaw et al. 2006). Additionally, individuals over 65 years who did not receive the vaccine experienced a 49 percent

decrease in penicillin-resistant invasive pneumococcal infections, most likely due to reduced transmission from vaccinated children. Similarly, invasive infection caused by *Haemophilus influenzae* type b is almost completely eradicated in high-income countries, primarily due to the inclusion of *H. influenzae* type b vaccinations in immunization programs for children under five (World Health Organization 2013; Frost et al. 2023).

Illustrating how vaccines can reduce medical expenses and lessen the financial burden of drug-resistant infections, according to a 2024 global estimate, TB vaccines could avert between 71,000 to 118,000 fatalities, 2.6 million to 4.5 million disability adjusted life years (DALY), US\$ 600 million to US\$ 1.0 billion in hospital expenses, and US\$1.2 to US\$2.0 billion in lost productivity due to AMR (World Health Organization 2024a). In 2024, 5,420 estimated TB fatalities were reported in Côte d'Ivoire, and 842 people developed multidrug-resistant or rifampicin-resistant TB (World Health Organization 2025).

Côte d'Ivoire, with a promising healthcare system for disease surveillance and immunization programs, has enormous potential for infectious disease prevention (Ekaza et al. 2013). Estimates show that malaria vaccination could avert 834,000 cases annually in Côte

d'Ivoire (Unwin et al. 2021). The rotavirus vaccine was shown to lower hospitalizations for pediatric gastroenteritis, with the most significant declines found in nations with high child mortality (Burnett et al. 2017). There was a 69 percent decrease in rotavirus prevalence among children in Côte d'Ivoire during the first 2.5 years after the rotavirus vaccine was introduced in 2017, similar to the rotavirus vaccine impact in Burkina Faso, Ghana, and Togo (Mlan et al. 2023).

According to a 2022 mathematical modeling study, implementing the typhoid conjugate vaccine (TCV) could significantly reduce the incidence of drug-resistant typhoid in Côte d'Ivoire (Birger et al. 2022). Overall, 130,000 MDR typhoid fever cases and 328 deaths could be averted over 10 years with TCV for children at 9 months and a catch-up campaign up to 15 years of age (Table 1).

An estimated 25.9 out of 100 cases of ARIs in children aged 24 to 59 months in Côte d'Ivoire are treated with antibiotics. Lewnard et al. (2020) found that 79.92 percent of those cases could be prevented through PCV vaccination implementation. Among children with diarrhea (rotavirus infection), a similar pattern was reported (Table 2).

Table 1. Estimated impact of the typhoid conjugate vaccine on AMR cases and deaths in Côte d'Ivoire

Antibiotic-resistant infection	Averted AMR cases		Averted deaths		DALYs
	Number	%	Number	%	
Typhoid conjugate vaccine (10-year prediction)					
Fluoroquinolone non-susceptibility typhoid fever	148,000	65.8	448	60.4	21,000
Multi-drug resistant typhoid fever	130,000	69.9	328	68.9	16,000

Source: Birger et al. 2022

DALYs, disability-adjusted life years

Table 2. Estimated impact of the pneumococcal conjugate and rotavirus vaccines on antibiotic use in Côte d'Ivoire

Antibiotic-resistant infection	Age (Months)	All cases per 100	Antibiotic-treated cases per 100	Antibiotic-treated cases preventable by vaccine per 100
Incidence of diarrhea preventable by rotavirus vaccine	0 – 23	329.2	13.9	9.2
Incidence of ARI preventable by pneumococcal conjugate vaccine	24 – 59	279.3	25.9	20.7
	0 – 59	182.6	7.7	6.2

Source: Lewnard et al. 2020

ARI = acute respiratory infections



EXPANDED PROGRAM ON IMMUNIZATION IN CÔTE D'IVOIRE

In 1978, Côte d'Ivoire launched an ambitious Expanded Program on Vaccination (EPI) that aimed to curb morbidity and mortality from key vaccine-preventable diseases (Yenan et al. 2024). Overseen by the Institute of Hygiene, the program evolved through a series of decrees that specified, organized, and directed its operations. These decrees established an Executive Directorate to revitalize EPI efforts at the district level, elaborated detailed operational procedures, and created

a coordination directorate (DC-PEV). This body oversees six technical departments and one administrative unit, all of which are managed by dedicated research officers. The EPI's implementation is supported by multiple institutions. The National Institute of Public Hygiene (INHP) manages vaccine storage and logistics. The Ivorian Pharmaceutical Regulatory Authority (AIRP) is responsible for quality control and the certification of imported vaccines and injection

equipment. The Directorate of Infrastructure, Equipment, Maintenance and Patrimony (DIEMP) oversees the selection and maintenance of essential infrastructures and equipment.

Côte d'Ivoire has signed a memorandum of understanding with United Nations Children's Fund (UNICEF) for the provision of vaccination supplies. The EPI initiative aims to reduce vaccine-preventable disease morbidity and mortality among children under five, girls aged nine, and pregnant women, targeting diseases including tuberculosis, diphtheria, tetanus, pertussis, poliomyelitis, measles, rubella, meningitis, yellow fever, rotavirus diarrhea, viral hepatitis B, *H. influenzae* type b infections, pneumococcal infections, human papillomavirus (HPV), and maternal and neonatal tetanus. The country's socio-political instability, which began in 1999, negatively affected the EPI's performance. However, the nation has made significant progress in vaccination coverage in the last decade (Table 3).

There is variability in vaccine coverage and immunization completion within the population. A study conducted at the University Hospital Center in Bouaké found that the percentage of children up to date with their immunization schedule varied depending on where they were born. University Hospital Center in Bouaké reported an 89.4 percent rate of children with up-to-date vaccination coverage. Other hospitals included in the study had a 72.2 percent rate, secondary health institutions had an 80.8 percent rate, private clinics had a 90.5 percent rate, and children born via home birth had a 53.3 percent rate (Yenan et al. 2024). Factors associated with immunization coverage rates among children included the mother's education level, marital status, knowledge of the vaccination schedule, maternal neglect, and barriers such as transportation and financial issues in accessing vaccination centers (Sackou et al. 2012;Yenan et al. 2024).

Table 3. Côte d'Ivoire Vaccination Coverage

Vaccine		Coverage (%)							
		Year							
		2018	2019	2020	2021	2022	2023	2024	2025
Bacillus Calmette–Guérin (BCG) vaccine		93	91	84	86	85	87	88	90
Pneumococcal conjugate vaccine		82	76	68	57	58	64	57	59
<i>Haemophilus influenzae</i> type b (Hib3)		84	79	73	71	69	72	68	70
Rotavirus vaccine		68	71	71	60	62	64	57	59
Yellow fever vaccine		72	70	63	64	57	62	62	55
Measles-containing vaccine (MCV)	1 st dose	73	72	63	62	56	63	65	58
	2 nd dose	-	-	-	1	20	32	48	49
Diphtheria tetanus toxoid and pertussis (DTP)	1 st dose	96	94	87	85	83	82	81	84
	3 rd dose	84	79	73	71	69	72	68	70
Human Papillomavirus (HPV)	1 st dose	-	6	61	28	44	73	61	90
	Last dose	-	-	12	37	33	73	61	90
Poliomyelitis (inactivated polio-containing vaccine)	1 st dose	62	71	69	72	74	78	81	83
	2 nd dose	-	-	-	-	-	60	68	70
Rubella		73	72	63	62	56	63	65	58
Viral hepatitis B vaccine (HepB3)		84	79	73	71	69	72	68	70
Meningococcal vaccine (MenA)		28	70	62	58	54	55	53	51

Source: WHO/UNICEF Estimates of National Immunization Coverage 2026

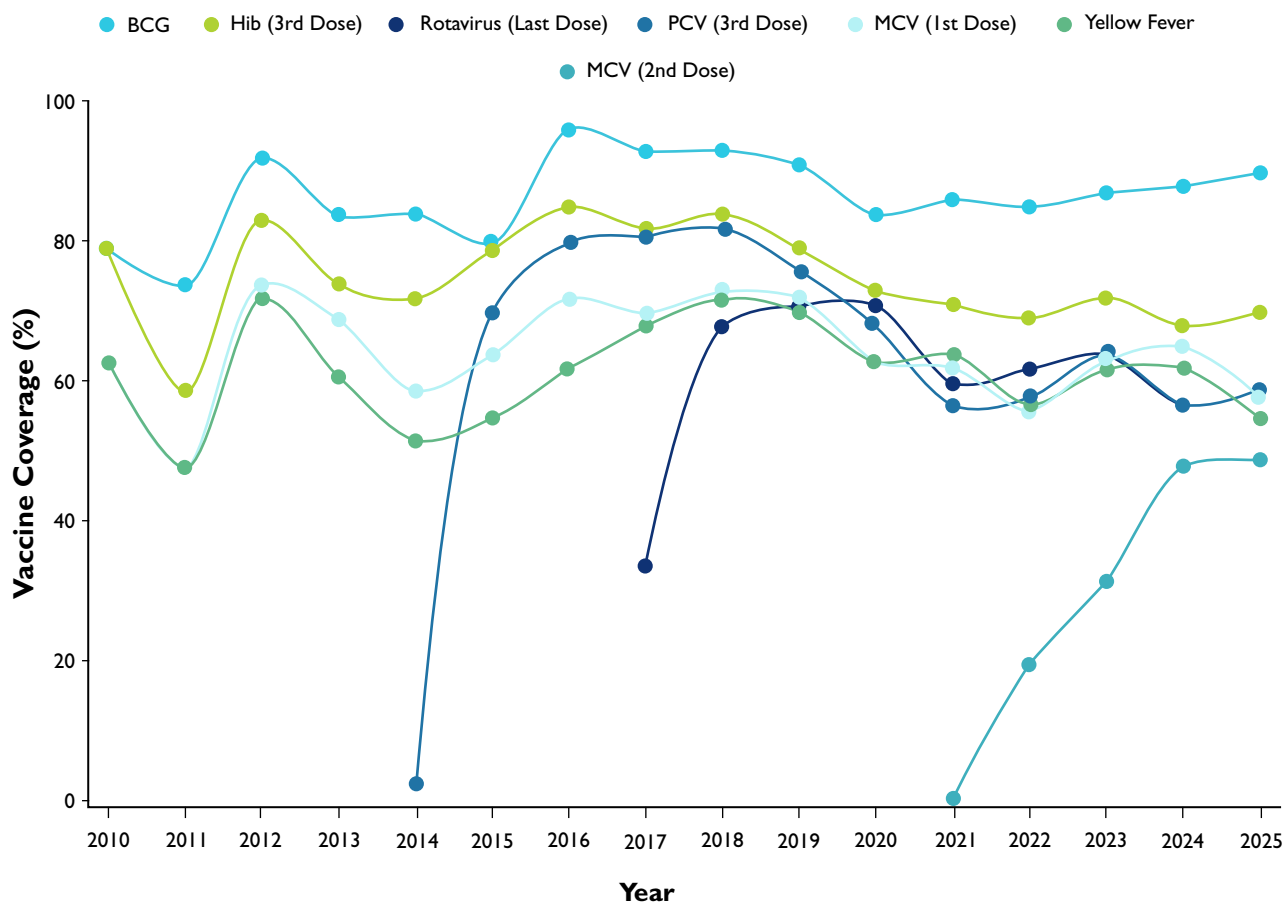


Figure 1. Coverage of Vaccines with an Impact on AMR

Source: WHO/UNICEF Estimates of National Immunization Coverage 2026



THE IMPACT OF THE MALARIA VACCINE ON ANTIMICROBIAL RESISTANCE IN CÔTE D'IVOIRE

Malaria burden in Côte d'Ivoire

Malaria represents a significant public health challenge in Côte d'Ivoire, with approximately 7,328,427 cases reported in 2021, resulting in an incidence rate of 270.8 cases per 1,000 in the general population and 594 cases per 1,000 in children under five years old, leading to 14,906 fatalities (Institute for Health Metrics and Evaluation 2024). Of the 113 districts in Côte d'Ivoire, 58 show a high level of endemicity (U.S. President's Malaria Initiative 2023). In 2023, Côte d'Ivoire was responsible for 2.8 percent of all malaria cases and deaths worldwide, 1.8 percent of all deaths globally, and 6.3 percent of all malaria cases in West Africa, making it one of the top 10 countries in the world for both cases and deaths (Severe Malaria Observatory 2024). Recent years have seen improvements in the prevention and control of malaria, as seen by the estimated 3.6 percent reduction in cases between 2022 and 2023 (from 260 cases per 1,000 population to 250 cases per 1,000) and the 12.7 percent reduction in malaria deaths, from 0.4 per 1,000 people to 0.34 (World Health Organization 2024b).

Malaria vaccine rollout in Côte d'Ivoire

As the first nation to include the R21 malaria vaccine into its regular immunization schedule, Côte d'Ivoire made history on July 15, 2024 (University of Oxford 2024). The vaccine targets children between the ages of 0 and 23 months, with the first dose administered at 6 months (Samaké-Roman 2024). In July 2024, children between the ages of 6 and 23 months started receiving the vaccine, which would be given in 4 doses at 6, 8, 9, and 15 months.

Methodology

Building on a pre-existing model (Hamilton et al. 2023) projecting the impact of vaccines on malaria cases and deaths, we estimate the economic benefits – monetized DALYs, societal costs, and catastrophic expenditures – from the number of averted cases and deaths among children under one year in Côte d'Ivoire. We assume different malaria vaccine efficacy (VE) levels ranging from 0 percent to 80 percent (Table 4) and a 3-dose immunization schedule for children aged 0 to 12 months. We estimate malaria vaccine impact under a scenario where resistance levels remain constant.

Table 4. Malaria Vaccine Efficacy Rates for Different Scenarios Across 10 Years

Year	Coverage (%)			
	Baseline	Scenario 1	Scenario 2	Scenario 3
1	0	40	80	40
2	0	40	60	40
3	0	40	40	40
4	0	40	20	40
5	0	40	0	40
10	0	0	0	40

Additionally, we estimate catastrophic healthcare expenditures, which occur when out-of-pocket (OOP) healthcare costs exceed the household's ability to pay without causing financial hardship. In our estimates, catastrophic healthcare expenditure is defined as a sum greater than 10 percent of daily household income. We used the Monte Carlo simulation method to

estimate DALYs and the value of statistical life (VSL) averted. We converted all monetary values to US dollars (US\$) (2021) for consistency and applied a 3 percent discounting factor to future expenditures and years of life lost (YLL). We generated estimates across 3-, 5-, and 10-year time horizons to visualize variation in each vaccine scenario for a given time.

Results

The introduction of malaria vaccines in Côte d'Ivoire is projected to have substantial health and economic benefits across a range of efficacy scenarios. Within 3 years of implementation, the vaccination program could avert between US\$9.9 million and US\$15 million in DALY-associated costs (Figure 2). This benefit is expected to increase over time, with estimated averted costs reaching between US\$11.2 million and US\$15.9 million in 5 years. Likewise, the initiative may prevent between US\$11.6 million and US\$18 million in monetized DALYs 10 years after it is implemented, which would help increase productivity over time by enabling infants to grow up healthy, complete their education, and join the workforce.

The program's estimated societal cost savings over 3 years range from US\$78.6 million to US\$118.8 million (Figure 2). When the period is extended to 5 years, the anticipated avoided expenses range from US\$92.4 million to US\$129.7 million. The program's long-term economic value is highlighted by the estimated US\$135.6 million in societal costs it is expected to save

over 10 years, even with the assumption of relatively low vaccine efficacy.

The malaria vaccine is also anticipated to drastically lower catastrophic medical expenses. The vaccination could prevent at least 2,414 cases of catastrophic spending in 3 years and at least 2,934 cases over 5 years (Figure 2). Assuming 10 years post-implementation, the program could avert between 3,412 and 5,558 cases of catastrophic health expenditures, protecting disadvantaged families from financial difficulty.

With the rising threat of malaria drug resistance, our estimates indicate that introducing malaria vaccination in Côte d'Ivoire could generate significant cost savings for both the government and households. In the first 3 years, vaccination could help the government save between US\$142,363 and US\$215,216 in treatment costs for drug-resistant malaria (Figure 2). These savings are projected to increase over time, reaching between US\$167,448 and US\$234,993 over 5 years, and at least US\$183,255 by the tenth year.

For families, malaria vaccination could reduce OOP spending on drug-resistant malaria by US\$67,820 to US\$102,526 within the first 3 years. Over 5 years, these savings could grow to at least US\$79,770, and by 10 years, households could avoid OOP expenses ranging from US\$87,300 to US\$138,807.

We also estimate the broader economic benefits of malaria vaccination by modeling productivity losses that

could be prevented. Avoiding drug-resistant malaria could avert productivity losses valued between US\$226,159 and US\$340,241 in the first 3 years. Over 5 years, potential savings from preserved productivity could increase in a range of US\$274,874 and US\$383,394, and by the tenth year, these gains could reach as high as US\$520,719.

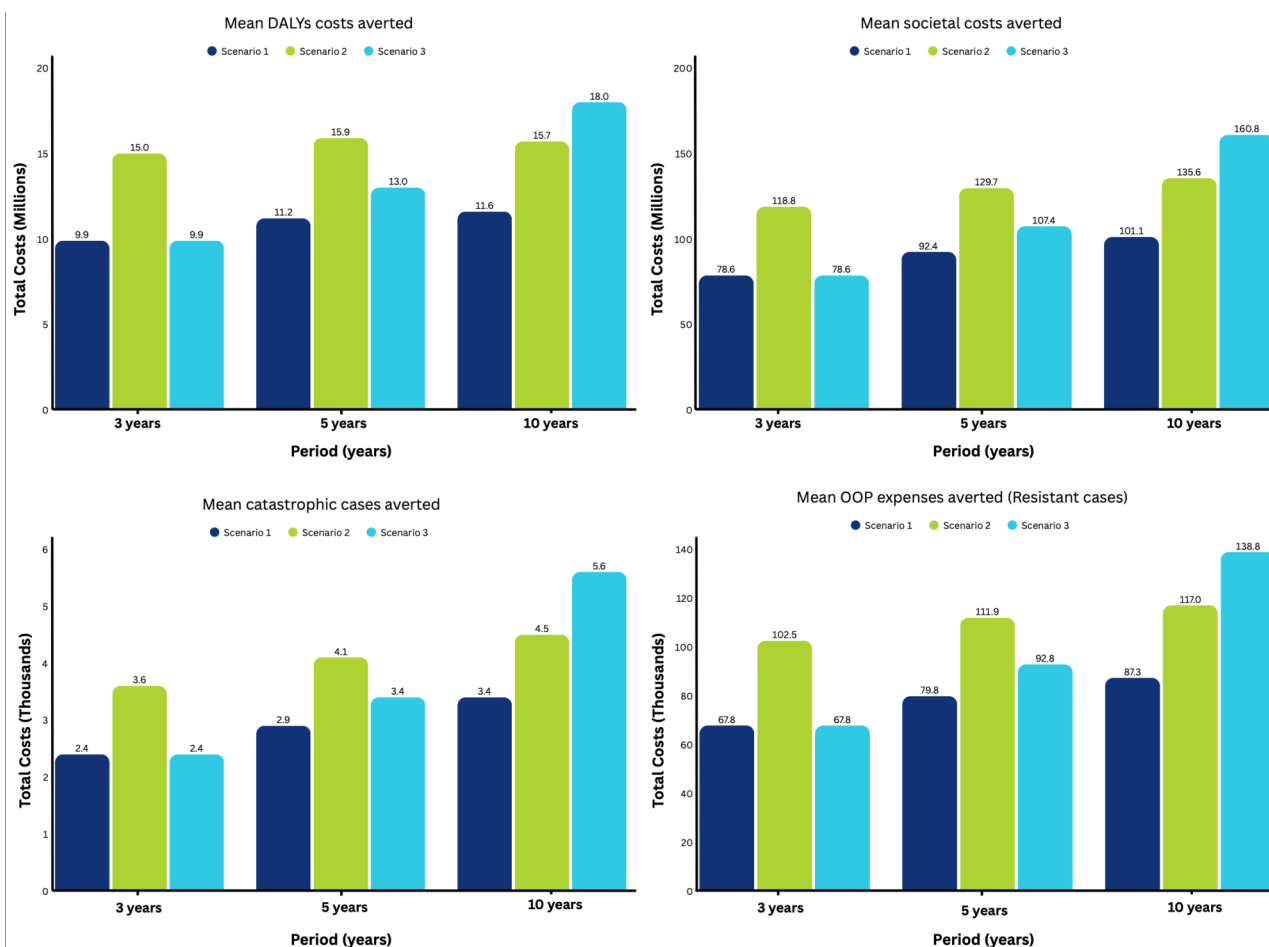


Figure 2. The Economic Impact of the Malaria Vaccine in Côte d'Ivoire

DALYs = disability-adjusted life years

OOP = out of pocket expenses



RECOMMENDATIONS

1. Strengthen routine immunization coverage.

Increase coverage of vaccines in the routine immunization program, including those with a high impact on AMR and antibiotic use: Bacillus Calmette–Guérin; Haemophilus influenzae type b, pneumococcal conjugate, rotavirus, malaria, and measles-containing vaccines. Address coverage disparities by focusing on low-income households, under-immunized communities, and rural areas, where incomplete vaccination increases the demand for antibiotics.

2. Integrate AMR objectives into the national immunization policy. Recognize the role of vaccines in reducing antibiotic use and AMR in the NAP on AMR and the EPI. Incorporate AMR-sensitive indicators into routine vaccine monitoring.

3. Prioritize malaria vaccination to reduce resistant infections. Scale up malaria vaccine introduction, focusing on high-endemic districts, to avert both drug-sensitive and drug-resistant malaria cases. Monitor antimalarial use patterns alongside vaccination roll-out to track changes in prescribing behavior and resistance trends.

4. Support TB vaccine research and preparedness. With high multidrug-resistant TB prevalence, prepare for the introduction of new TB vaccines by establishing systems for rapid uptake, once

they are WHO prequalified. Use vaccine deployment to reduce long-term dependence on second-line antimicrobials.

5. Improve vaccine uptake through maternal and caregiver engagement. Expand targeted communication on vaccine–AMR linkages to increase demand. Address known socioeconomic barriers regarding vaccination schedules.

6. Institutionalize vaccine impact assessments on AMR. Ensure that vaccine studies also measure their impact on AMR. Include AMR endpoints in vaccine effectiveness studies. Collaborate with universities and surveillance laboratories to track both disease incidence and resistance outcomes.

7. Adopt a One Health vaccine strategy for AMR mitigation. Integrate human and animal vaccination efforts. Link with Côte d'Ivoire's multisectoral AMR plan to reduce cross-species resistance transmission.

8. Strengthen financing and sustainability. Establish dedicated domestic financing lines for vaccines with high AMR impact. Use cost-effectiveness and economic impact evidence to advocate for continued Gavi and domestic co-financing.

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Initiated in 2008, the Global Antibiotic Resistance Partnership (GARP) has played a critical role in advancing country-led national strategies and policies to address antimicrobial resistance (AMR) in several countries in Africa and Asia.

GARP's current focus is generating cross-disciplinary evidence highlighting the impact of vaccines on AMR in country-specific contexts.

This policy brief lays out the situation in Cote d'Ivoire and recommends policy measures to use vaccines as tools to control AMR in the country.

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