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Cost and Return on Investment of the Mandla Malaria Elimination Demonstration Project: Health and Economic Modelling for the National Malaria Elimination Goal

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Abstract

Background: Malaria elimination is among the most cost-effective public health strategies, with strong evidence for economic and societal benefits. India has achieved an ~80% reduction in malaria cases between 2015 and 2023. At this time, 37 districts continue to report an Annual Parasite Incidence (API) greater than one and remain high-priority for intensified interventions. Subnational analyses are needed to guide resource allocation and sustain progress.

Methods: The Malaria Elimination Demonstration Project (MEDP) was implemented in Mandla, a high-endemic tribal district in Madhya Pradesh, through a public–private partnership. Intensified surveillance, case management, vector control, and community engagement were deployed. A difference-in-difference regression model using data from 2001 to 2023 compared Mandla with four control districts. An economic evaluation used a cost-of-illness framework to estimate avoided household costs, productivity losses, the value of lives saved, personal protection expenditures, and reduced health system costs. Sensitivity analyses were conducted using Monte Carlo simulations.

Results: MEDP reduced malaria incidence to near zero, averting ~998 cases annually. The intervention prevented household and health system costs totalling INR 73.6 million (US$0.87 million) annually, with a cost–benefit ratio of 1.64 and an ROI of 64%. Benefits extend beyond health, with tourism in the Kanha Tiger Reserve increasing faster than the national average following the MEDP.

Conclusion: Mandla's experience demonstrates that elimination is feasible and economically advantageous. Scaling this model to India's high-priority districts with an API greater than one could accelerate national elimination goals while delivering broad developmental benefits. The project was supported through a public–private partnership involving the Indian Council of Medical Research, the Government of Madhya Pradesh, and the Foundation for Disease Elimination and Control of India.

INTRODUCTION

Malaria elimination is widely regarded as one of the most cost-effective public health strategies, delivering significant returns on investment. Malaria slows development by undermining education, tourism, agriculture, and industry, and disproportionately affects poor and remote communities, reinforcing cycles of poverty (1). In 2024, an estimated 282 million malaria cases occurred worldwide. The Asia-Pacific region, including countries from the WHO South-East Asia, Western Pacific, and Eastern Mediterranean regions, accounted for approximately 7.8 million cases, with Pakistan alone contributing over 2 million. The WHO South-East Asia Region, which includes India, reported 2.7 million cases. This highlights the substantial and concentrated malaria burden that continues to challenge regional elimination goals (2).

Regional analyses highlight the potential economic gains of investing in malaria elimination. A 2019 study across 22 Asia-Pacific countries estimated that malaria elimination between 2017 and 2030 would generate US$87.73 billion in benefits, avert 123 million cases, and save 386,167 lives, yielding a US$6 return for every US$1 invested (3).

The WHO Global Technical Strategy for Malaria 2016–2030, Asia Pacific Leaders Malaria Elimination Roadmap, and Action and Investment to defeat Malaria 2016–2030, reinforce elimination as a high-value investment, projecting that accelerated action could avert billions of cases and generate trillions of dollars in economic impact (4–6). Experiences from Sri Lanka and China demonstrate that sustained investments can deliver both health security and economic growth; however, forested and cross-border regions remain vulnerable to resurgence (7,8).

India has achieved substantial progress towards malaria elimination goals. Between 2015 and 2023, malaria cases declined by approximately 80% (from ~ 1.17 million to ~ 227,000), and deaths decreased from 384 to 83 (9). By 2023, 122 districts reported zero indigenous cases, and several states advanced to lower transmission categories (9,10). Surveillance has strengthened, as reflected in improved Annual Blood Examination Rates (ABER) (9). Out of 780 (approx.) districts in India, around 37 districts report an API of more than one, which are spread across 8 to 9 states and are considered high-priority districts (11).

At present, sustaining gains in tribal, high-burden, and hard-to-reach areas remains challenging. Subnational economic evaluations are limited, leaving policymakers without evidence on the cost-effectiveness of district-level elimination models. As external support declines and domestic financing becomes central, localized analyses are essential to guide India's elimination strategy.

Against this backdrop, the Malaria Elimination Demonstration Project (MEDP) in Mandla district, Madhya Pradesh, was undertaken to assess the feasibility of eliminating indigenous malaria transmission using existing case management and vector control tools (12–14). This study evaluates MEDP's impact to estimate the cost–benefit ratio (CBR) and return on investment (ROI). By situating Mandla's experience within national frameworks, the goal of malaria elimination in India is within reach, and the investment yields measurable returns.

MATERIALS AND METHODS

Study Design and Setting

The MEDP was implemented in a high-endemic, tribal dominated, hilly-forested district, Mandla, Madhya Pradesh, through a Public–Private Partnership (PPP) between the Indian Council of Medical Research (ICMR), the Government of Madhya Pradesh (GoMP), and the Foundation for Disease Elimination and Control of India (FDEC India). Covering a population of 1.2 million, the project aimed to eliminate indigenous malaria through intensified surveillance, case management, vector control, community engagement, and capacity building. Implementation adhered to national guidelines while introducing innovations in monitoring, evaluation, and data reporting (14).

Epidemiological Analysis

Mandla served as the MEDP intervention district, while three bordering districts (Balaghat, Dindori, and Kawardha) and one ecologically comparable district (Gadchiroli) were selected as controls. These districts were broadly homogeneous in terms of demography, terrain, geoclimatic conditions, and malaria endemicity (Table 1). Routine anti-malaria activities implemented by the national programme were identical across all selected districts. The pre-intervention period was defined as 2001–2016, and the intervention and post-intervention periods as 2017–2023 (with sub-centre-level data available only until 2023). Temporal trend of malaria cases in the control and MEDP (intervention) group during pre- and post-intervention periods was analysed using the Poisson Joinpoint regression model. To assess the impact of MEDP, a difference-in-difference (DiD) regression model was applied to interrupted time-series data from 2001 to 2023. The model estimated malaria cases under a counterfactual scenario in the absence of MEDP.

The regression equation was specified as:

$$Y_{it} = \beta_0 + \beta_1 Post_t + \beta_2 Treatment_i + \beta_3 (Post_t \, x \, Treatment_i) + e_{it}$$

Where, Y_{it} is malaria incidence in district *i* at time *t*; $Post_t$ is a binary dummy variable equal to 1 for the post-treatment period, zero for pre-treatment; $Treatment_i$ is a binary dummy variable equal to 1 if the unit is in the treatment group (MEDP), zero otherwise (Control); $Post_t \, x \, Treatment_i$ is the interaction term (DiD estimator); β_3 is the DiD estimator — the estimate of the treatment effect ; e_{it} is the error term.

Economic analysis

The economic impact of MEDP was estimated using the cost-of-illness (COI) method to quantify savings from reduced malaria burden in the district. This included direct treatment costs (medical and non-medical), productivity losses from lost workdays, the economic value of lives lost to malaria-attributable premature deaths, and expenditures on personal protection (such as mosquito repellents, window mesh screens, bed nets, smoke, etc.) incurred by the at-risk population. All costs were calculated in Indian Rupees and converted to US dollars using a constant exchange rate of INR 85 per US$.

Cost of Illness (COI) Framework

The Total Economic Burden of malaria can be expressed as

Whe

re each component represents: *DC (Direct Cost)* as the out-of-pocket expenses for treatment, including both medical (consultations, medicines, diagnostics, hospitalization) and non-medical (transport, food, lodging) costs; *IDC (Indirect Cost)* as the income lost due to workdays missed by patients and/or caregivers. This includes waiting time to obtain initial treatment, travel time to health facilities, time spent with healthcare providers, and the number of days of full or partial productivity loss; *VLL (Value of Lives Lost)* as the economic value of premature deaths attributable to malaria; *OCE (Other Contingent*

Expenditure) as the household spending on disease prevention, such as personal protection measures to avoid mosquito bites; and *ITC (Intangible Cost)* as the non-monetary burden of pain, grief, suffering, loss of leisure time, and broader societal impacts such as lost opportunities for development, trade, and tourism. Although critical, these costs are difficult to quantify in monetary terms (15,16).

Assumptions Considered

The economic evaluation was based on several key assumptions. Direct medical treatment costs, non-medical expenses, and earnings foregone were derived from the most recent round of the National Sample Survey (17), stratified by treatment source, and then adjusted to 2023 values using the GDP deflator from the official GDP series (18). The VLL for the intervention and post-intervention periods (2017–2023) was estimated using a three-year moving average applied to pre-intervention mortality data (2001–2016). This counterfactual was then monetized as the product of potential productive years of life lost (age-stratified) (19) and per capita annual income (18). Household expenditure on personal protection measures, such as mosquito repellents, insecticides, smoke, and window mesh screens, was estimated assuming that approximately one-third of the district population resided in high-risk malaria areas and was willing to invest in some form of preventive measure (20). Finally, reductions in direct public health system costs for case management and vector control were incorporated, reflecting the district's transition to zero indigenous malaria cases.

Cost-Benefit and ROI Estimation

The Cost–Benefit Ratio (CBR) was calculated as the ratio of annualised economic and health system savings to the additional annual investment under MEDP, while the return on investment (ROI) was computed as [(Savings – Cost)/Cost] × 100.

Sensitivity analysis

To account for uncertainty, a probabilistic sensitivity analysis (PSA) was performed using Monte Carlo simulations with 10,000 iterations. Triangular distributions were assigned to key variables, including treatment costs, productivity losses, and mortality assumptions, to reflect variability in epidemiological and economic parameters.

RESULTS

Across the pre-intervention period, both the Control and MEDP groups initially exhibited substantial declines in malaria burden, followed by marked reversals. In the Control group, malaria cases decreased sharply before the 2008 breakpoint (Annual Percent Change (APC) = −11.5%; 95% CI: −11.6 to −11.4), but the trend shifted thereafter to a statistically significant annual increase of 12.6% (95% CI: 12.4 to 12.7), yielding a small but significant overall rise in cases across the whole period (Average Annual Percent Change (AAPC) = 1.1%; 95% CI: 1.0 to 1.2). A similar pattern was observed in the MEDP group before the

intervention, with a significant annual decline through 2012 (APC = −9.1%; 95% CI: −9.4 to −8.9), followed by an annual increase of 11% (95% CI: 10 to 12).

However, due to the more decisive influence of the earlier downward trend, the overall pre-intervention trajectory in MEDP remained significantly negative (AAPC = −6.1%; 95% CI: −6.2 to −5.9). In contrast, the post-intervention period showed divergent patterns between the two study arms. In the Control group, malaria cases declined sharply through 2019 (APC = −26.5%; 95% CI: −27.4 to −25.5), but this improvement was not sustained, as cases increased sharply thereafter (APC = 19.0%; 95% CI: 18.3 to 19.8). Consequently, the overall post-intervention trend in the Control group represented a significant net increase in malaria burden (AAPC = 3.7%; 95% CI: 3.3 to 4.1). In contrast, the MEDP group showed a consistently substantial, statistically significant decline throughout the post-intervention period. Malaria cases decreased by 37.5% per year (95% CI: −40.8 to −34.2) up to the 2020 breakpoint and continued to decline even more rapidly thereafter (APC = −45.1%; 95% CI: −51.0 to −38.6). This resulted in a large and highly significant overall reduction in malaria burden during the post-intervention period (AAPC = −39.7%; 95% CI: −41.8 to −37.6). Collectively, these findings indicate that while both groups experienced temporary improvements, the MEDP intervention was associated with sustained, substantially greater declines in malaria cases during the post-intervention period than in the Control group (Fig. 1).

The DiD model predicted that, in the absence of MEDP, Mandla would have reported an average of 998 malaria cases annually during the post-intervention period (2017–2023) (Fig. 2; Table 2A). Following implementation of the elimination plan in the district, malaria incidence reduced to nearly zero, indicating that MEDP reduced malaria cases by 998 per year at an additional cost of INR 37 per capita annually (US$ 0.44) during 2017–2020 (Table 2B), with these gains sustained over the subsequent three years (2021–2023) (Fig 3). This epidemiological impact translated into significant economic benefits.

The annual household-level total cost of illness (direct and indirect costs) avoided due to MEDP was estimated at INR 1.55 million (US$0.018 million) (Table 3A). At the same time, the value of lives saved, based on the assumption of three deaths averted stratified by age and YPPLL and per capita Net National Income (NNI) at current price for the year 2023 of INR 172276, amounted to INR 12.09 million (US$0.14 million) annually (Table 3B). Additionally, personal protection costs avoided, assuming one third of the 1.2 million population at high risk of malaria and willingness-to-pay of US$0.58 per person (Mills et al., 2008) adjusted with a 2.82 inflation rate at current price for the year 2023, totalled INR 55.05 million (US$0.65 million) annually (Table 3C).

At the health system level, savings were estimated using the National Strategic Plan (NSP) 2023–2027 budget projections, which indicated a 41% reduction in intervention costs between 2023 and 2027 as districts transitioned to the elimination phase. The per capita cost to achieve the malaria elimination goal was estimated at INR 10.05 in the year 2023 (Table 4) (21). Applying this proportion to Mandla, where the estimated annual health system expenditure for malaria elimination was INR 12.06 million (approximately US$0.14 million), the projected annual savings were INR 4.94 million (approximately US$0.06 million).

Overall, the combined economic savings - including reductions in household costs of illness, value of lives saved, personal protection costs, and health system expenditures - amounted to INR 73.63 million (US$0.87 million) annually, compared with an average annual investment in MEDP of INR 45 million (US$0.53 million) during 2017–2020. This yielded a cost–benefit ratio of 1.64, indicating that every rupee invested in MEDP generated INR 1.64 in economic savings. The annual ROI was 64%, and probabilistic sensitivity analysis confirmed the robustness of this estimate (mean ROI: 64%, 95% CI: 42–88%).

Beyond quantifiable economic returns, the intervention would have yielded intangible benefits, including reduced school absenteeism, thereby positively impacting human resource development, trade stability, and tourism. Notably, Kanha Tiger Reserve - a key tourist attraction in Mandla, recorded a rise in tourist arrivals from an annual average of 0.15 million in 2010–2015 to 0.18 million in 2021–2024, reflecting a 20.6% yearly growth rate in the post-MEDP and post-COVID period, substantially higher than the national tourism growth rate of 7.1% (22) With tourism contributing 1.77% to India's GDP and 12.57% to employment, the sustained malaria-free status of Mandla has likely supported accelerated regional economic development.

DISCUSSION

Analyses of temporal trends in malaria burden showed clear differences between the intervention (MEDP) and control districts across the pre- and post-intervention periods. In the control districts, malaria incidence remained relatively stable, with a modest APC during both periods (pre and post) and no evidence of a significant inflection in trend.

In contrast, the MEDP district demonstrated a pronounced decline in malaria cases following implementation of the intervention. While the pre-intervention trend showed little year-to-year change, the post-intervention period was characterized by a substantially steeper downward trajectory. The Poisson Joinpoint regression model confirmed this pattern, identifying a slope shift consistent with accelerated reductions following the initiation of MEDP interventions. The estimated AAPC in the MEDP district was substantially larger than in the control district, indicating that the intervention was associated with a significantly faster decline in malaria incidence over time. These findings support the effectiveness of MEDP interventions in intensifying malaria reduction beyond background trends observed in the non-intervention comparison districts.

The findings from Mandla district demonstrate that malaria elimination is both epidemiologically achievable and economically advantageous when interventions are implemented rigorously, with adequate resources, through systematic collaboration among the government, research institutions, civil society partners, and management and technical controls, and with independent reviews. MEDP achieved a rapid and sustained decline to zero indigenous cases in less than 4 years, enabled by adherence to national strategies and innovations, including enhanced monitoring, electronic reporting, and structured stakeholder engagement.

The DiD analysis confirmed that MEDP prevented nearly 1,000 cases annually at a modest per capita cost. These epidemiological gains translated into economic benefits across multiple domains, including reduced treatment expenditures, avoided productivity losses, fewer premature deaths, and lower household spending on personal protection. Health system savings further underscored the value of shifting from control to elimination phases. A cost–benefit ratio of 1.64 and an ROI of 64% indicate that elimination yields strong financial returns on additional investment.

Comparable analyses across Asia-Pacific reinforce these findings. Thailand's comprehensive cost–benefit study demonstrated returns of US$2–15 per US$1 invested (23). In the Philippines, a 2017 analysis estimated a 13:1 ROI, likely higher because the study considered indirect benefits such as educational outcomes and tourism (24). Sri Lanka offers a cautionary perspective, suggesting that resurgence would cost 13 times as much as prevention (25). These data highlight both the dividends of elimination and the steep costs of inaction.

Global evidence echoes this economic rationale. The Lancet Commission on Malaria Eradication (2019) argued that the Asia-Pacific is the proving ground for eradication, with success here essential to achieving global goals. Eliminating malaria permanently reduces the need for intensive, costly surveillance systems, yielding lasting economic dividends (26). Other reports, including the WHO's World Malaria Reports and regional investment case reports, consistently reaffirm elimination as one of the most compelling global health investments (2,27).

Mandla's experience also highlights broader development spillovers. The growth of tourism around Kanha Tiger Reserve illustrates how malaria-free status can enhance destination appeal, stimulate local economies, and support employment. Although causality is multifactorial, malaria elimination likely contributed to creating a safer and more attractive environment.

The 37 high-priority districts identified by the National Programme, spread across nine states, constitute a combined population of 33.5 million. Despite comprising only 2.36% of the national population, these districts account for 70% of malaria cases (9). Therefore, intensified surveillance, case management, and vector control efforts in this smaller population, with requisite funding, have become an urgent priority towards eliminating malaria.

At a programmatic level, five lessons stand out: (i) combining national guidelines with innovation in delivery and accountability accelerates progress; (ii) integration of surveillance, vector control, and community engagement under strong political and administrative oversight ensures sustainability; (iii) structured PPPs can effectively leverage private resources and technical expertise within a public health framework, (iv) utilisation of time-tested operational, management, and technical controls throughout the project activities, and (v) the returns on investment (ROI) for optimal funding to eliminate malaria would be significant.

Looking ahead, sustaining the gains in elimination will require appropriate financing with built-in accountability frameworks, stronger domestic resource mobilisation, and streamlined partnerships.

Without such measures, hard-won gains risk reversal. At the same time, the lessons learned can also be utilised to eliminate other vector-borne diseases.

In summary, the evidence from Mandla, reinforced by regional and global analyses, presents a compelling case: malaria elimination yields extraordinary health and economic benefits, protects the most vulnerable populations, and catalyses sustainable development. Yet realizing these benefits requires not just technical excellence but also durable financing and governance structures capable of safeguarding progress against emerging threats.

CONCLUSION

The AAPC estimates indicate a sustained impact of MEDP interventions relative to control districts. These findings demonstrate that with adequate investment, rigorous implementation, and multisectoral collaboration, malaria elimination is achievable within a relatively short timeframe and can generate substantial epidemiological, economic, and societal benefits. By preventing nearly 1,000 cases annually, saving households and the health system close to INR 74 million (USD 0.87 million) each year, and yielding a cost–benefit ratio of 1.64 with a return on investment exceeding 60%, MEDP not only validated the technical feasibility of malaria elimination but also demonstrated its economic rationale.

Importantly, the findings have direct implications for the 37 high-priority districts identified by the Government of India, which have an API greater than one. These districts, which continue to bear a disproportionate share of the country's malaria burden, can particularly benefit from Mandla's model of integrated surveillance, strong community engagement, and evidence-based vector control. Scaling and adapting the Mandla approach in such high-risk settings could accelerate progress toward national malaria elimination targets while simultaneously reducing health system costs and generating economic returns for households and local economies. The lessons from Mandla underscore that malaria elimination should be regarded not solely as a health objective but as a strategic investment in national development, capable of delivering long-term dividends for health systems, households, and the broader economy.

Abbreviations

AAPC – Average Annual Percent Change

ABER – Annual Blood Examination Rate

ACT – Artemisinin-based Combination Therapy

API – Annual Parasite Incidence

APC – Annual Percent Change

APLMA – Asia Pacific Leaders Malaria Alliance

BSTS – Bayesian Structural Time Series

CBR – Cost–Benefit Ratio

CI – Confidence Interval

COI – Cost of Illness

COVID – Coronavirus Disease

DC – Direct Cost

DiD – Difference-in-Difference

FDEC – Foundation for Disease Elimination and Control

GDP – Gross Domestic Product

GIS – Geographic Information System

GoMP – Government of Madhya Pradesh

ICMR – Indian Council of Medical Research

IDC – Indirect Cost

INR – Indian Rupee

ITC – Intangible Cost

LLIN – Long-Lasting Insecticidal Net

MEDP – Malaria Elimination Demonstration Project

MoSPI – Ministry of Statistics and Programme Implementation

NNI – Net National Income

NGO – Non-Governmental Organization

NSP – National Strategic Plan

NSS – National Sample Survey

NSSO – National Sample Survey Office

OCE – Other Contingent Expenditure

PPP – Public–Private Partnership

PSA – Probabilistic Sensitivity Analysis

ROI – Return on Investment

SOP – Standard Operating Procedure

USD – United States Dollar

VLL – Value of Lives Lost

WHO – World Health Organization

XGBoost – Extreme Gradient Boosting

YPPLL – Years of Potential Productive Life Lost

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Tables

Table 1 – Background characteristics of the control and intervention districts

Variable	Control (average)	Intervention
Population (census 2011) (000)	1075	1055
Schedule Tribe Population (%)	37	58
Literacy (%)	59	57
Average Family Size	4.3	4.2
Average Annual Per Capita Income (000)*	57	45
Average Rainfall (mm)	1383	1425
Average Temperature	26.84	24.73
Forest Cover (% of Total Geographic Area)**	49.57	48.88

Source: * http://data.icrisat.org/dld/src/gdp.html

** https://www.data.gov.in/catalog/district-wise-forest-cover?page=1

Table 2A – Diff-in-diff model statistics of pre-intervention and post-intervention periods across MEDP district vs. control districts.

Group	Pre-Intervention (2008-2016)	Post-Intervention (2017-2023)	Difference
MEDP district	2303.64	192.85	2110.79
Control districts	6322.70	3214.37	3108.33
Difference	4019.06	3021.52	997.54

Table 2B – Additional investment of MEDP during the four-year intervention period towards malaria elimination in Mandla district along with calculation of per capita and per annum additional expenditures.

Target population	Additional Expenditure during 4-year MEDP period	Per capita Additional Expenditure (INR)	Yearly Per Capita Additional Expenditure (INR)	Predicted Annual Cases in absence of MEDP
(A)	(B)	(C) = (B/A)	D = (C/4)	(diff-in-diff)
1.2 million	INR 180 million (USD 2.17 million)	150	37.5	998

Table 3A: Direct Cost (Treatment Cost: medical+non-medical) and Indirect Cost (Earning Forgone) of the counterfactual malaria cases (988) in Mandla

*Source of Treatment Sought	*Percent	*Unit Cost	Number of Cases (N=988)	COI (unit cost x number of cases) with Inflation @1.32**	COI (million INR)
Govt/Public Health Facilities	29.35	334.5	290	128046.6	0.13
Pvt Hospitals	24.05	1060	238	333009.6	0.33
Charitable/NGO Health Facilities	1.1	744	11	10802.88	0.01
Pvt Doctor Clinics	42.85	640	423	357350.4	0.36
Informal Health Providers	2.65	761	26	26117.52	0.03
Total Medical Cost				**855327**	0.86
Non-Medical Cost		**83**	**988**	**108245.28**	0.11
Total Treatment Cost (Direct cost)				**963572.28**	0.96
***Earning Foregone (Indirect cost)**		**455**	**988**	**593392.8**	0.59
Total COI (Direct + Indirect cost)					1.55

*Source: 75th NSS, 2018; **GDP deflator from GDP series available at mospi.gov.in was used to arrive at expenditure figures for 2023; ***The average work days lost was assumed 10 days as per 75th National Sample Survey (NSS), 2018. Work day loss in case of children illness was considered for caregivers; COI: Cost of Illness

Table 3B: Value of lives loss

Age Group of Deaths	*Percentage	Estimated Number of Deaths (N=3)	YPPLL	VLL	VLL (million INR)
Adults	58	1.74	15	4496403.6	4.50
5-15 Years	27	0.81	35	4884024.6	4.88
<5 years	15	0.45	35	2713347	2.71
Total VLL				**12093775.2**	12.09

*Source: Dhingra et al. 2010; YPPLL: Estimated Year of Potential Productive Lives Lost; VLL: Value of Lives Loss (Estimated Number of Deaths x YPPLL x Per capita Net National Income at current price for year 2023: INR 172276); An average of 15 years of YPPLL for adults was assumed at assuming 45 years of average age at malarial death among adults, an average age of work potency of 60 years or age of retirement from active work, and an average of 35 years of YPPLL was assumed for children death cases. ** mospi.gov.in

Table 3C: Personal protection cost

District Population	Estimated Population at high risk (@33% of the total district population)	*Unit cost	Personal Protection Cost (PPC)	PPC (million INR)
1.2 million	396000	139.026	55054296	55.05

*Source: Mills et al. 2008 (USD 0.58 x Inflation 2.82 at current price) x 85 (US$ to INR Conversion rate)

Table 4 - Component wise cost (INR million) estimates for malaria elimination in India as per the National Strategic Plan for Malaria Elimination 2023-2027

Types of Expenditure	2023-2024 (2023)	2024-2025 (2024)	2025-2026 (2025)	2026-2027 (2026)	2027-2028 (2027)	% Difference between 2023 and 2027
Intervention costs	10,063.5	8,364.3	5,468.7	6,392.7	5,971.0	-40.67
Program costs	3,846.9	6,231.3	5,126.6	5,315.6	5,373.7	39.69
Governance and others	40.7	105.7	105.8	55.8	35.9	-11.79
Total costs	**13,951.1**	**14,701.3**	**10,701.1**	**11,764.1**	**11,380.6**	**-18.43**
*India: Projected population (million)	1388.16	1400.74	1413.32	1425.91	1436.48	
Per capita cost for malaria elimination (INR)	10.05					
Mandla: Projected population (million)	1.20					
Mandla: Estimated cost for malaria elimination (million INR)	12.06					
Estimated saving @41% for early achieving elimination goal (million INR)	4.94					

Source: National Strategic Plan for Malaria Elimination 2023-2027; * Census of India: Projected population of India

Figures

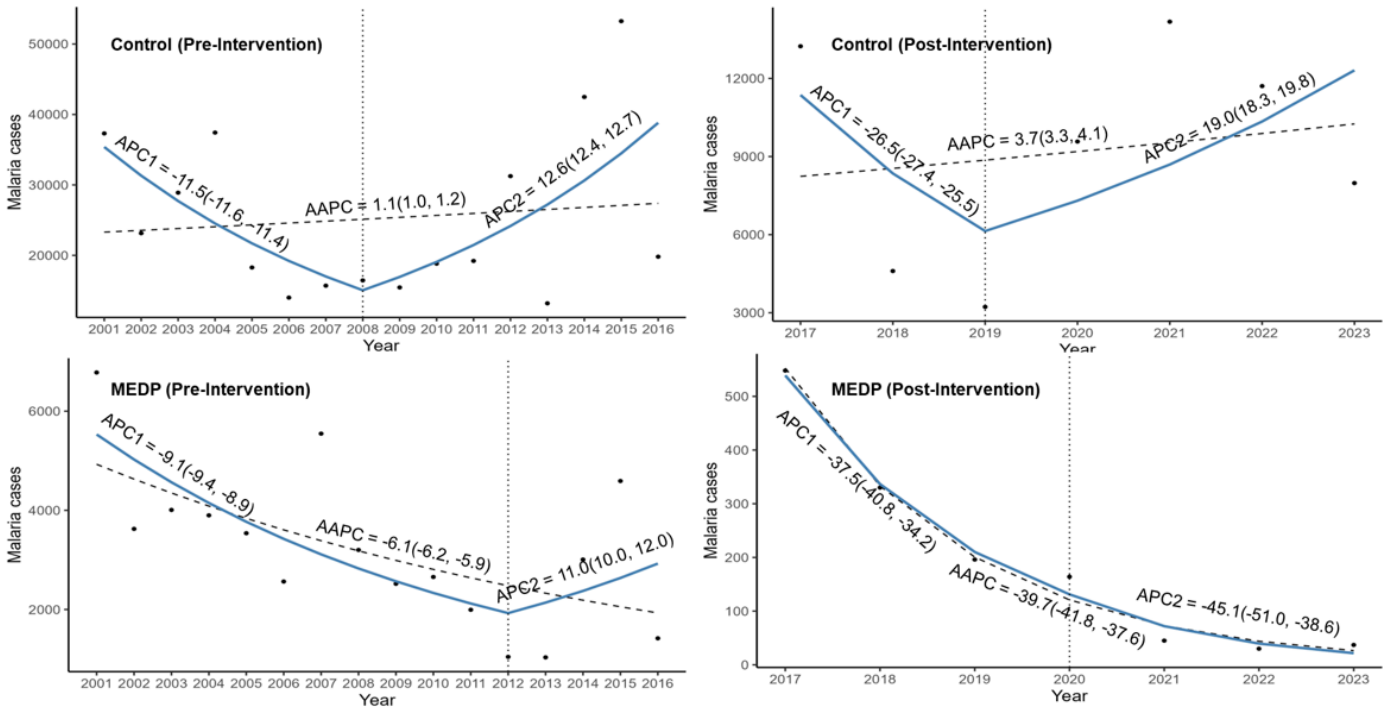


Figure 1

Analyses of temporal trends of malaria cases in control and MEDP district during pre and post intervention period using Poisson Joinpoint regression model

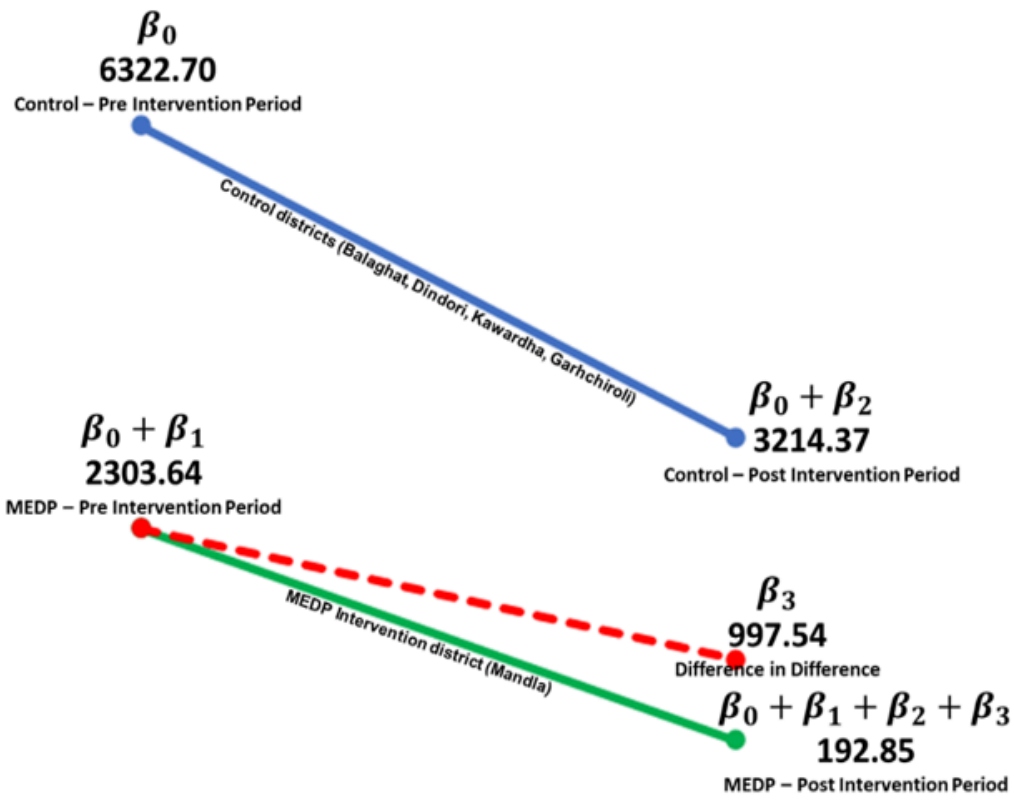
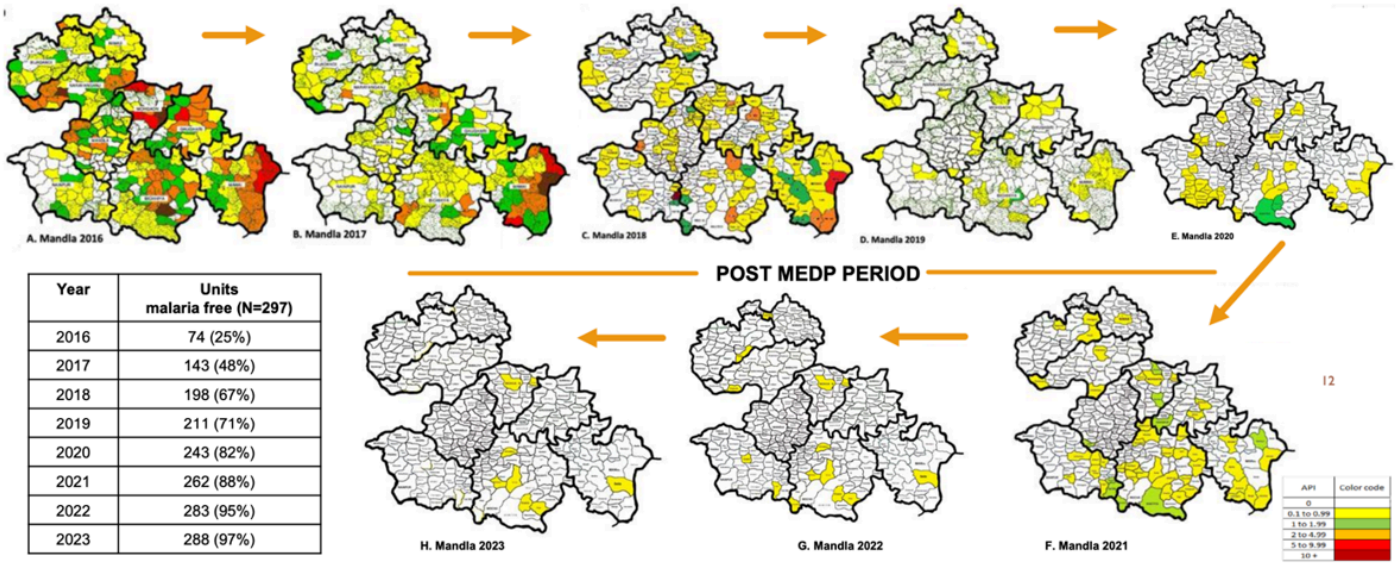


Figure 2: Difference-in-difference regression model in time series malaria data during 2008 – 2023 of district Mandla (intervention group) and districts Balaghat, Dindori, Kawardha and Gadchiroli (control group).

β_0 : Average number of malaria cases in the control districts before MEDP period (2008 – 2016); β_1 : Difference of malaria cases between control and MEDP districts before MEDP period (2008 – 2016); β_2 : Difference between average malaria cases in control districts before (2008 – 2016) and after (2017 – 2023) MEDP period; β_3 : Difference in difference estimator showing impact of MEDP intervention

Figure 2

See image above for figure legend



Year	Units malaria free (N=297)
2016	74 (25%)
2017	143 (48%)
2018	198 (67%)
2019	211 (71%)
2020	243 (82%)
2021	262 (88%)
2022	283 (95%)
2023	288 (97%)

Figure 3

Progression of malaria-free units in Mandla district from 2016 (baseline), 2017 to March 2021 (intervention), and 2022 to 2023 (post-MEDP).