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Burden of Vector-Borne Diseases in Chhattisgarh: A Comprehensive Review of Dengue, Malaria, and Chikungunya

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Abstract

Mosquito-borne diseases remain a major public health concern in India, with malaria declining nationally while dengue and chikungunya show upward trends in urban areas. Chhattisgarh, despite comprising only ~2% of the population, has historically contributed 12–14% of India's malaria cases, driven by extensive forests, tribal communities, and high Plasmodium falciparum transmission in southern divisions (Bastar, Surguja). Under NCVBDC guidance, intensified interventions—including mass distribution of long-lasting insecticidal nets (LLINs), indoor residual spraying, rapid diagnostic testing, and real-time surveillance via IHIP—have driven substantial progress. State positivity rate fell to ~0.51%, with Annual Parasite Incidence markedly reduced in most areas. Dengue control achieved a dramatic >90% case reduction in 2025 (336 cases up to late December vs. 3,523 in 2024) and zero dengue deaths, reflecting improved early detection and case management. Persistent challenges include elevated malaria burden in southern forested pockets, climate-driven vector proliferation, and gaps in community awareness of Aedes breeding sites. Sustained success requires region-tailored strategies, stronger grassroots engagement in source reduction, and adaptive surveillance to reach malaria elimination and contain arboviral resurgence.

Keywords: Mosquito-borne diseases; Dengue; Malaria; Chikungunya; Chhattisgarh; Disease patterns; Public health interventions

Introduction

Worldwide and Indian Context of Mosquito-Borne Illnesses Diseases transmitted by vectors like mosquitoes, ticks, and flies represent a persistent worldwide health issue, responsible for a large portion of infectious disease cases and deaths [1]. The World Health Organization

(WHO) estimates that these illnesses make up over 17% of all infections globally, leading to more than 700,000 fatalities each year [2]. Key examples include malaria, dengue, chikungunya, Zika, Japanese encephalitis, which thrive in tropical and subtropical climates that support vector survival and spread. Low- and middle-income countries bear the heaviest impact due to limited health systems, inadequate vector control programs, and barriers to quick diagnosis and care [3-4]. Frequent outbreaks in these areas overload medical resources, reduce economic output through lost workdays, and increase treatment expenses, hindering overall development [1-3]. In India, these infections create a substantial public health strain, with millions of cases occurring each year. Malaria and dengue stand out as the most common, often sparking seasonal surges that result in considerable illness and deaths. Additional diseases like chikungunya, Japanese encephalitis, and kala-azar further add to the challenge, particularly in rural and marginalized communities. India's national strategy prioritizes control or elimination through ongoing monitoring, vector reduction, public participation, and enhanced medical services [1-3, 7]. While notable improvements have reduced rates in some areas, recurring epidemics signal the importance of continued alertness and locally adapted innovative methods [7-8]. The transmission of vector-borne diseases (VBDs) is shaped by a complex mix of environmental, climatic, and human-related elements [3]. Factors like temperature, precipitation, and humidity play key roles in vector reproduction, longevity, and feeding patterns, which in turn drive infection rates [9]. For instance, higher temperatures and abundant rainfall often create favourable conditions for mosquito development, resulting in periodic surges of illnesses like dengue and malaria. Land-use changes—such as forest clearance, city growth, and farming intensification—disrupt ecosystems, generate additional vector habitats, and heighten interactions between people and vectors [3, 4]. Social and demographic aspects, including high population density, economic disadvantage, and partial healthcare access, exacerbate vulnerability. Dense settlements with poor water infrastructure promote breeding sites, while remote or underserved groups often lack preventive tools like bed nets or prompt treatment [9-10]. Population movement and travel can also spread vectors and pathogens to new regions, posing challenges for containment [2-3]. This review synthesizes evidence on the patterns, environmental drivers, and broader health consequences of VBDs in Chhattisgarh, emphasizing malaria, dengue, chikungunya including preventive measures and challenges.

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Geographic, Climatic, and Demographic Profile of Chhattisgarh

Chhattisgarh's vector-borne disease (VBD) landscape is defined by its tropical monsoon climate and 44% forest cover, which sustain high humidity and stagnant water ideal for *Anopheles* and *Aedes* breeding [3]. While the forested, tribal-dominated regions (31% of the population) face persistent malaria due to ecological proximity and inadequate healthcare admission, rapid urbanization in hubs like Raipur and Bilaspur has spiked dengue and chikungunya cases through poor waste management and improper water storage [41, 43].These environmental drivers are intensified by socioeconomic vulnerabilities, including seasonal labor migration and low health literacy (Fig 1), which facilitate pathogen spread and complicate surveillance efforts. Effectively combating VBDs in the state requires a dual approach: stabilizing rural malaria through forest-based interventions and managing urban outbreaks by improving sanitation and housing infrastructure [26-29]. Geographic and climatic conditions of Chhattisgarh, combined with its demographic profile and socio-economic vulnerabilities, play a critical role in shaping the transmission and burden of vector-borne diseases in the state (Table 1&2).

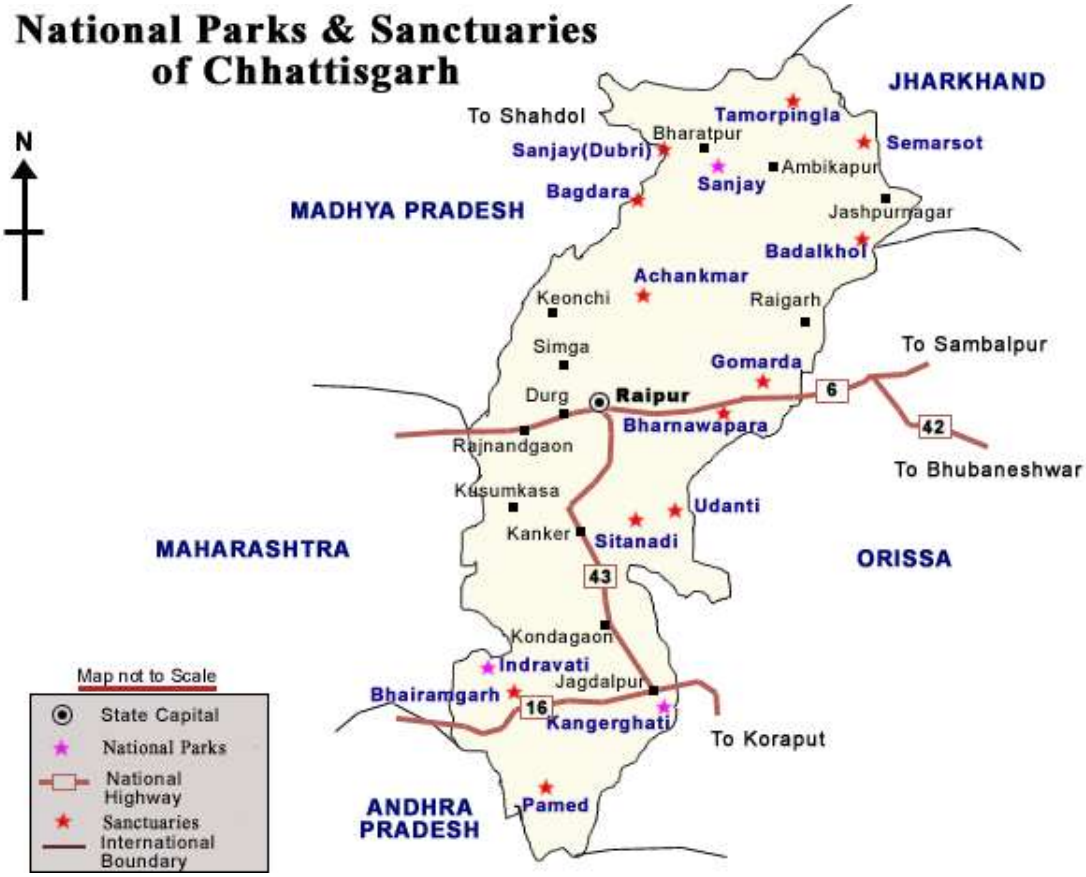

Figure 1: Chhattisgarh wildlife and forest map — highlighting the extensive forest cover (around 44%) that creates ideal humid conditions for Anopheles mosquito breeding in rural and tribal areas. https://www.mapsofindia.com/maps/wildlife/wildlife-chattisgarh.htm

Table 1: Key Geographic and Climatic Features of Chhattisgarh Relevant to VBDs

Parameter	Description
Geographic location	Central India
Climate type	Tropical monsoon
Annual rainfall	~1,200–1,600 mm
Monsoon period	June–September
Forest cover	~40–44% of total area
Temperature range	Hot summers, mild winters

Table 2: Demographic and Socio-Economic Factors Influencing VBDs

Factor	Influence on Vector-Borne Diseases
High tribal population	Increased malaria risk due to forest proximity
Urbanization	Rise in dengue and chikungunya
Seasonal migration	Spread of infections, surveillance gaps
Housing and sanitation	Favourable breeding conditions
Limited healthcare access	Delayed diagnosis and treatment

Importance of Chhattisgarh as an Endemic and High-Risk State

Chhattisgarh stands out as a prominent example of a high-burden, endemic area for VBDs in central India, where these interconnected factors converge strongly [11]. The state's varied landscape—featuring extensive forests, hilly terrain, and cultivated lowlands—supports diverse mosquito populations. Monsoon-driven heavy rains lead to widespread water pooling, especially in rural and semi-urban zones with insufficient drainage, boosting breeding opportunities [6]. This contributes to persistent cases of malaria, dengue, chikungunya, and Japanese encephalitis, frequently showing marked seasonal increases [12]. Socioeconomic hurdles, particularly in tribal and isolated communities, include restricted healthcare reach, which intensifies risks and delays interventions [13]. Official surveillance data reveal repeated outbreaks across multiple districts, confirming Chhattisgarh's classification as a

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priority high-risk zone [7]. Beyond direct health effects, these diseases impose substantial economic and community burdens, emphasizing the urgency of focused prevention and response measures [5,6].

Overview of Vector-Borne Disease Surveillance in Chhattisgarh

In Chhattisgarh, monitoring of vector-borne diseases relies on a combination of national and state-level mechanisms, chiefly the National Vector Borne Disease Control Programme (NVBDCP) and the Integrated Disease Surveillance Programme (IDSP). These frameworks facilitate ongoing data collection, prompt identification of potential outbreaks, and rapid implementation of control measures [8, 39]. Key laboratories in public health facilities and medical colleges contribute significantly by conducting confirmatory tests, including molecular and serological analyses, while also offering expert guidance to support surveillance operations [9]. Uniform reporting protocols enable consistent transmission of information from grassroots health units through district and state tiers up to the national level [4, 9]. This structured flow helps generate reliable evidence for guiding interventions, resource allocation, and strategic planning in disease management (Fig 2).

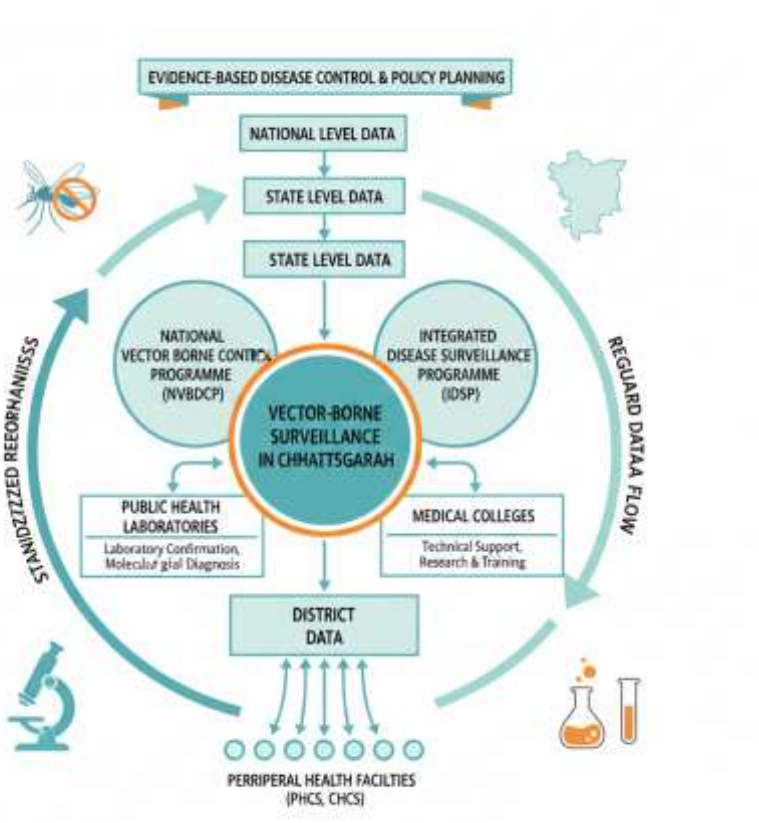

Figure 2: The figure illustrates the structured flow of information and collaboration within the vector-borne disease surveillance ecosystem in Chhattisgarh. Here is a breakdown of its

core components. 1. The Core Infrastructure: At the centre of the system are the two primary programs: the NVBDCP (National Vector Borne Disease Control Programme) and the IDSP (Integrated Disease Surveillance Programme). These work in tandem to oversee surveillance in the state. 2. The Data Pipeline**:** The figure shows a bottom-up data flow:

- **Peripheral Level:** Data collection begins at the ground level (Community Health Volunteer (Mitanin), AAM-Sub-Health Centre (Ayushman Arogya Mandir-AAM), AAM-PHCs and CHCs).
- **District & State Level:** Information is aggregated and standardized as it moves upward.
- **National Level:** Final data is reported to the national level to inform Evidence-Based Policy Planning [13-14].

Technical Support Pillars: Public Health Laboratories: Provide the "gold standard" for the system through molecular and serological diagnosis to confirm outbreaks.

- **Medical Colleges:** Act as centres for technical support, training, and specialized research.

The Feedback Loop

The circular arrows represent Standardized Reporting Mechanisms. This ensures that data isn't just sent up, but creates a continuous cycle of regular data flow, allowing for early outbreak detection and timely public health responses [11,15].

Burden of Dengue in Chhattisgarh

Dengue has become a significant public health issue in Chhattisgarh, showing regular seasonal patterns with the highest transmission occurring in the post-monsoon period (typically August to November) [16]. During this time, favorable weather supports Aedes mosquito breeding and activity. Recent surveillance records indicate repeated outbreaks accompanied by increasing numbers of reported cases, likely due to broader vector presence in new areas combined with improved detection and notification systems [1, 12-13,17]. Major urban and semi-urban hubs—including Raipur, Durg, Bilaspur, and Korba—regularly experience elevated case numbers. This pattern stems from high population density, common household water storage habits, and other conditions that encourage Aedes proliferation [18]. Although rural regions historically reported fewer incidents, they now face noticeable seasonal increases, particularly in communities lacking effective water drainage and management infrastructure [13,17]. The varying urban-rural pattern highlights the importance

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of customized approaches to vector suppression and public involvement suited to different environments. Table 1 showing the VBD case summary in Chhattisgarh.

Table 1: VBD Case Summary — Chhattisgarh (2024-2025)

Vector-Borne Disease	Cases (Annual)	Deaths (Annual)	Trend (Last 5 Years)
Malaria	~25,000 – 35,000	<10	↓ **Significant Decline** (Over 80% reduction)
Dengue	~2,800 – 3,500	~5 – 12	↑ **Emerging in urban centers** (Raipur/Durg)
Chikungunya	~100 – 250	0	↔ **Stable** (Low endemicity)
Japanese Encephalitis	~75 – 100	~5	↑ **Focal expansion** (Recent alerts in Surguja)

Key Data Insights

Malaria Success: Annual cases dropped from ~220,000 (pre-2015) to ~30,000 (2024) thanks to the *Malaria Mukt Bastar* campaign. The state is now transitioning from high burden toward elimination.

Dengue Urbanization: Cases are rising in urban hubs like Raipur, Bhilai, and Bilaspur, primarily peaking during the post-monsoon months (August–November).

JE Alert: While human cases remain low due to vaccination, Surguja district remains a high-risk focal point after positive virus detections in local pig populations in late 2025.

Clinical Manifestations and Complications

Dengue typically presents as an acute febrile condition, featuring symptoms such as elevated body temperature, intense headache (often behind the eyes), muscle and joint pains, nausea, vomiting, and skin rashes. Many infections remain mild or moderate and resolve without serious issues [12,35,36]. However, a smaller group advances to severe forms, involving plasma leakage leading to fluid accumulation, bleeding tendencies, and damage to organs like the liver or kidneys [12, 15, 36, 38]. In Chhattisgarh, hospital data during peak periods reveal that severe presentations—more common among children and younger adults—drive substantial demand for inpatient beds [14]. Fatality remains uncommon when patients receive

prompt care, though isolated deaths occur, frequently associated with delayed presentation to medical services or pre-existing health conditions. Rapid identification of danger signals (such as persistent vomiting, severe abdominal pain, bleeding, or lethargy) and appropriate clinical handling are essential to minimize illness severity and prevent loss of life [38].

Diagnosis and Prevention Approaches

Prompt and reliable diagnosis forms the foundation of effective dengue handling and ongoing monitoring. In the state, initial testing often uses rapid diagnostic kits detecting NS1 antigen or IgM/IgG antibodies for quick results [15-16, 17, 35]. More detailed confirmation, including ELISA-based serology, occurs at higher-level facilities. In specialized or investigative contexts, RT-PCR enables virus identification and determination of specific serotypes, aiding in better understanding of outbreaks and guiding responses. Prevention combines mosquito control with broader community and health system actions [36]. Core efforts focus on removing potential breeding sources by clearing stagnant water, organizing regular cleanliness drives, and improving overall environmental hygiene [18]. Targeted interventions include applying larvicides to water bodies and, where appropriate, indoor residual spraying in priority locations. Health education campaigns promote individual protection—such as using mosquito repellents, installing screens on windows—and encourage seeking care at the first signs of illness [35, 43]. The state's health system, working alongside the NVBDCP and IDSP, maintains weekly data reporting and deploys rapid intervention teams during high-transmission phases [19]. Strong partnerships among health authorities, local governments, and community groups are vital for maintaining consistent prevention work and lowering the overall impact of dengue throughout Chhattisgarh.

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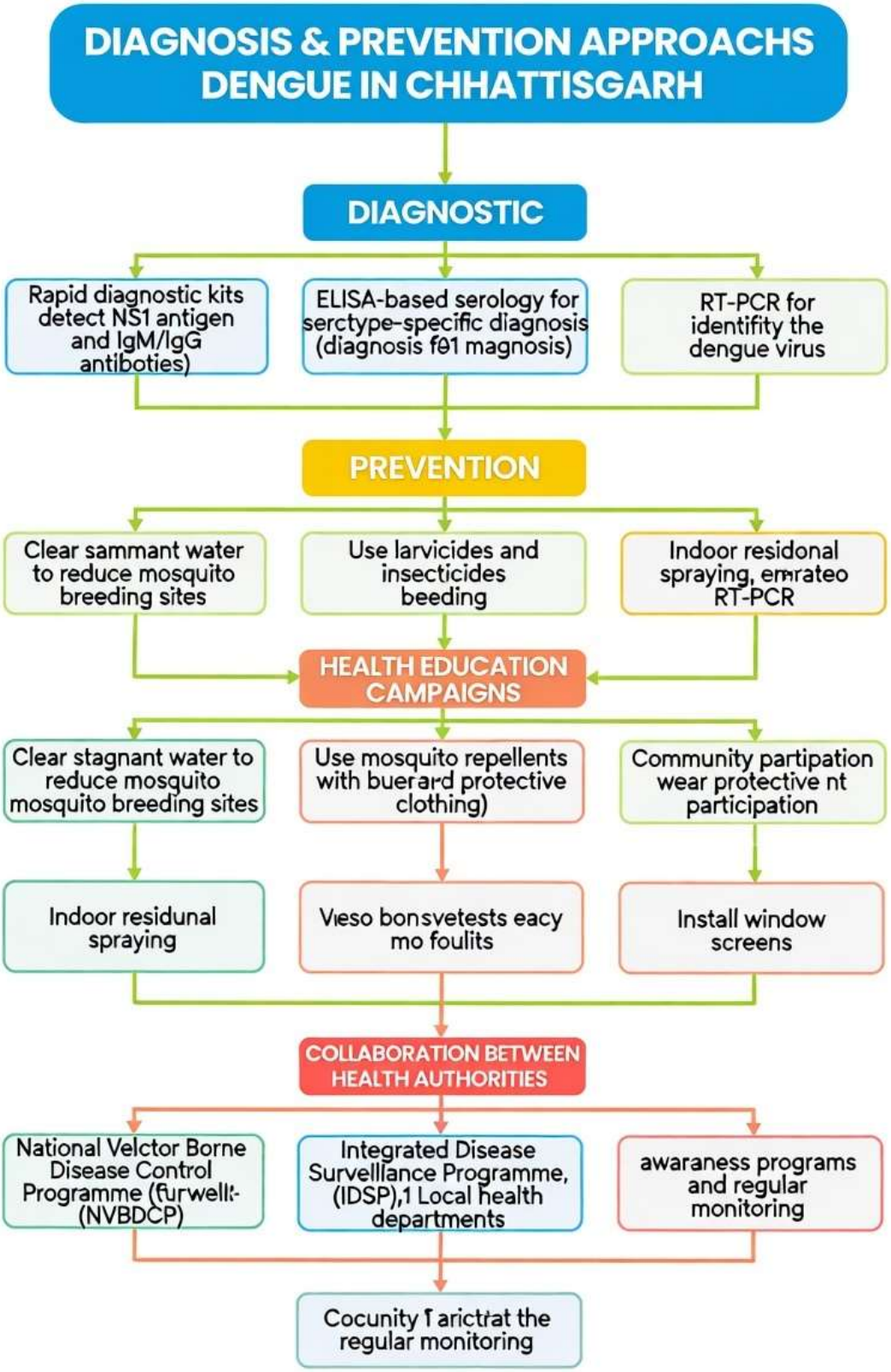

Figure 3: Diagnosis and prevention approaches of Dengue in Chhattisgarh. reference: https://ncvbdc.mohfw.gov.in/index1.php?lang=1&level=1&lid=3690&sublid=5776&referrer=grok.com ; https://ncvbdc.mohfw.gov.in/index1.php?lang=1&level=1&lid=3686&sublinkid=5899&referrer=grok.com

Burden of Malaria in Chhattisgarh: The southern tribal and forested districts of Chhattisgarh, specifically within the Bastar division including Sukma, Bijapur, Narayanpur, and Kondagaon, consistently record the state's highest malaria incidence [20]. This high burden is deeply tied to the vulnerability of tribal populations who reside in remote, difficult-to-access terrain where healthcare infrastructure remains limited [21]. These "forest-fringe" areas facilitate persistent transmission and present significant hurdles for routine monitoring. Epidemiologically, the state experiences a bimodal seasonality where cases surge during the primary monsoon peak in July and August, followed by a secondary post-monsoon peak in November as receding waters create new breeding sites. Despite these environmental challenges, the Malaria Mukt Bastar campaign, launched in 2020, has fundamentally altered the state's profile [22-23]. By deploying "Test, Treat, and Track" strategies—including mass screening of asymptomatic individuals who often act as hidden reservoirs—the program achieved a nearly 65% to 80% reduction in cases within high-endemic zones [24]. This success has transitioned Chhattisgarh from a region defined by high perennial burden to one making measurable progress toward the national goal of malaria elimination by 2030 [21, 39].

Trends in *Plasmodium falciparum* and *P. vivax*

In Chhattisgarh Plasmodium falciparum dominates malaria cases (80–85%), especially in forested high-transmission zones, while P. vivax persists due to relapses [22, 32]. From 2015 to 2025, the state achieved a major decline: Annual Parasite Incidence (API) fell from 5.21 to ~1.17 per 1,000 population—a ~78% reduction—largely thanks to the Malaria Mukt Bastar campaign, which slashed positivity rates in southern districts from 4.6% to under 0.5% by late 2025. Despite this progress, focal spikes remain in deep forests, necessitating sustained surveillance to meet the 2027–2030 elimination target [37, 39, 41].

Risk Factors and Challenges

Chhattisgarh's malaria challenge is rooted in its forest ecology, where shaded vegetation and perennial water bodies sustain entrenched vector populations [22]. These ecological drivers are compounded by geographic barriers and seasonal human migration, which facilitate

parasite spread while complicating consistent healthcare delivery in remote tribal zones [15,18]. From a clinical perspective, asymptomatic reservoirs and treatment complexities remain significant threats. While the shift to Artemisinin-based Combination Therapies (ACTs**)** addressed historical chloroquine resistance in *P. falciparum*, the radical cure of *P. vivax* requires strict 14-day adherence to primaquine, often leading to treatment gaps in rural settings. Furthermore, subclinical carriers—who harbour parasites without showing symptoms—serve as hidden sources of infection that can only be neutralized through active, high-frequency surveillance [15,20].

Malaria Elimination Initiatives

State-level and National Programs

- **Malaria-Mukt Bastar Abhiyan (Malaria-Free Bastar Campaign):** Targeted intervention in the high-burden Bastar division includes mass blood surveys, vector control (LLIN distribution), indoor residual spraying, and intensified case-finding (fig 4).
- **Distribution of LLINs and vector control:** Large-scale distribution of long-lasting insecticide-treated nets (LLINs) across districts has been a core preventive tool.
- **Active surveillance initiatives:** House-to-house screening and community health worker engagement aim to detect and treat infections early, including asymptomatic cases.
- **Integration with national strategies:** Chhattisgarh's surveillance and control efforts align with India's National Framework for Malaria Elimination (NFME) 2016-2030, emphasizing data-driven responses and universal access to diagnosis and treatment.

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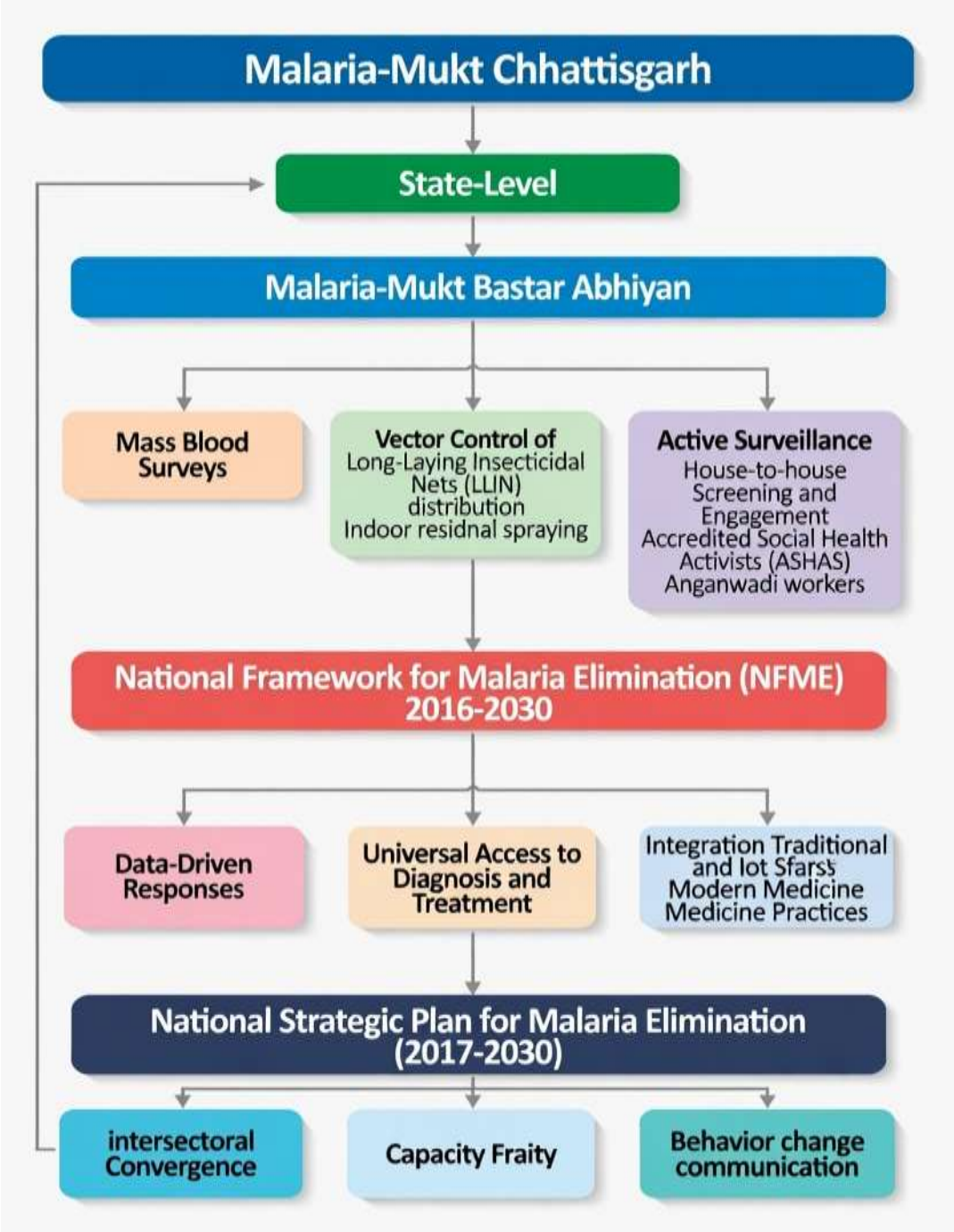

Figure 4: Malaria Mukt Chhattisgarh

Achievements and Remaining Challenges

- **Reduction in disease burden:** Recent government data show dramatic declines in malaria positivity rates and API in the Bastar division and across the state over the past decade, with reports of up to ~72% drop in cases in some areas compared with earlier years.

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- **Sustained commitment:** Continued political support, community involvement (e.g., ASHAs/mitanins), (fig 5) and strengthened health services have been pivotal in gains achieved to date.
- **Remaining gaps:** Challenges include covering hard-to-reach populations, maintaining high quality surveillance, addressing drug resistance, and eliminating residual transmission pockets. Environmental and socioeconomic factors still contribute to persistence in certain endemic belts [15,17,32,35].

Figure 5: Community health outreach in remote, forested tribal areas of Chhattisgarh — depicting the challenges of limited healthcare access in malaria-endemic tribal regions. Ref: https://www.who.int/news-room/photo-story/detail/reaching-people-at-risk-of-malaria-in-remote-areas-of-Chhattisgarh-india

Chhattisgarh has a high malaria burden, especially in forested and tribal areas due to favorable mosquito breeding conditions. Socio-economic vulnerabilities and restricted healthcare admission increase transmission risk. *Plasmodium falciparum* is the predominant species. Control measures include active surveillance, rapid diagnostics, and ACT-based treatment. Integrated vector management and targeted interventions remain crucial for control (Table 4).

Table 4: Malaria Burden, Risk Factors, and Control Measures in Chhattisgarh

Component	Category	Key Details
Geographic burden	High-endemic regions	Bastar division (Bastar, Dantewada, Sukma, Bijapur, Narayanpur, Kondagaon); pockets in

Component	Category	Key Details
		Surguja and Jashpur
	Population at risk	Predominantly tribal communities in forest and forest-fringe areas
Epidemiology	Predominant species	*Plasmodium falciparum* (70–80% of cases)
	Other species	*P. vivax* (20–30%); mixed infections <5%
	Seasonality	Peak transmission during monsoon and post-monsoon months
Risk factors	Environmental	Dense forest cover, perennial vector breeding sites
	Socio-economic	Migration, poverty, occupational forest exposure
	Health system	Poor accessibility, delayed diagnosis and treatment
Programmatic challenges	Therapeutic issues	Past chloroquine resistance; adherence gaps in *P. vivax* radical cure
	Surveillance	Asymptomatic infections, hard-to-reach populations
Control & elimination initiatives	State programs	Malaria-Mukt Bastar Abhiyan
	National alignment	National Framework for Malaria Elimination (2016–2030)
	Key interventions	LLIN distribution, indoor residual spraying, active case surveillance
Outcomes & gaps	Achievements	Significant decline in malaria cases and API in high-burden districts
	Remaining challenges	Residual transmission pockets, risk of resurgence

Burden of Chikungunya in Chhattisgarh

Chikungunya has emerged as a notable arboviral threat in Chhattisgarh, often co-circulating with dengue in urban and semi-urban areas like Raipur, Bilaspur, Durg (including Bhilai), and Korba [33,34]. Transmitted by shared Aedes aegypti and Aedes albopictus vectors, cases peak during monsoon and post-monsoon months (July–November) due to stagnant water, high humidity, and favorable temperatures [35]. Urban centers report the highest incidence, while rural and tribal districts show gradual increases from migration, peri-urban growth, and land-use changes expanding vector habitats [3,12,17,38].

Clinical Complications; diagnosis and challenges

Clinically, it presents with sudden high fever, severe joint pain (polyarthralgia), muscle aches, headache, fatigue, and maculopapular rash [39]. Fatalities are rare, but chronic arthritis causes prolonged stiffness, reduced mobility, functional impairment, lost productivity, and repeated healthcare needs, impacting quality of life [29,34, 35]. Public health challenges include added outpatient burden during peaks, economic losses from absenteeism, and diagnostic confusion with overlapping dengue symptoms (fever, headache, body aches, low platelets). Mixed infections (dengue-chikungunya predominant in urban zones; malaria co-infections in forested areas) lead to severe/prolonged illness and complex management. Symptom overlap hinders clinical differentiation in resource-limited settings [40,42]. Integrated approaches are essential: unified surveillance, combined vector control, serological/molecular diagnostics (e.g., ELISA for IgM/IgG, RT-PCR), standardized protocols, lab upgrades, and healthcare training for early detection and care. Community education on prevention remains key to mitigate this growing burden [3,12,16,17].

Key Public Health Obstacles and Deficiencies in VBD Management:

Vector-borne disease management in Chhattisgarh faces critical hurdles due to surveillance gaps in isolated tribal zones, diagnostic deficits in remote health posts, and high-risk behavioral patterns within forested communities [22,25,28]. Overcoming these challenges requires a unified strategy that upgrades laboratory infrastructure with molecular tools while integrating real-time reporting systems to catch outbreaks early [12]. By combining environmental modifications with the distribution of insecticide-treated nets and targeted indoor spraying (Fig 5), the state can implement a sustainable Integrated Vector Management approach. Success depends on cross-departmental policy support, the use of GIS mapping to identify transmission hotspots, and the empowerment of local self-help groups to lead culturally sensitive outreach [28,31,38]. This comprehensive alignment of technology, policy,

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and community action is essential to reducing the disease burden and achieving regional elimination targets [41].

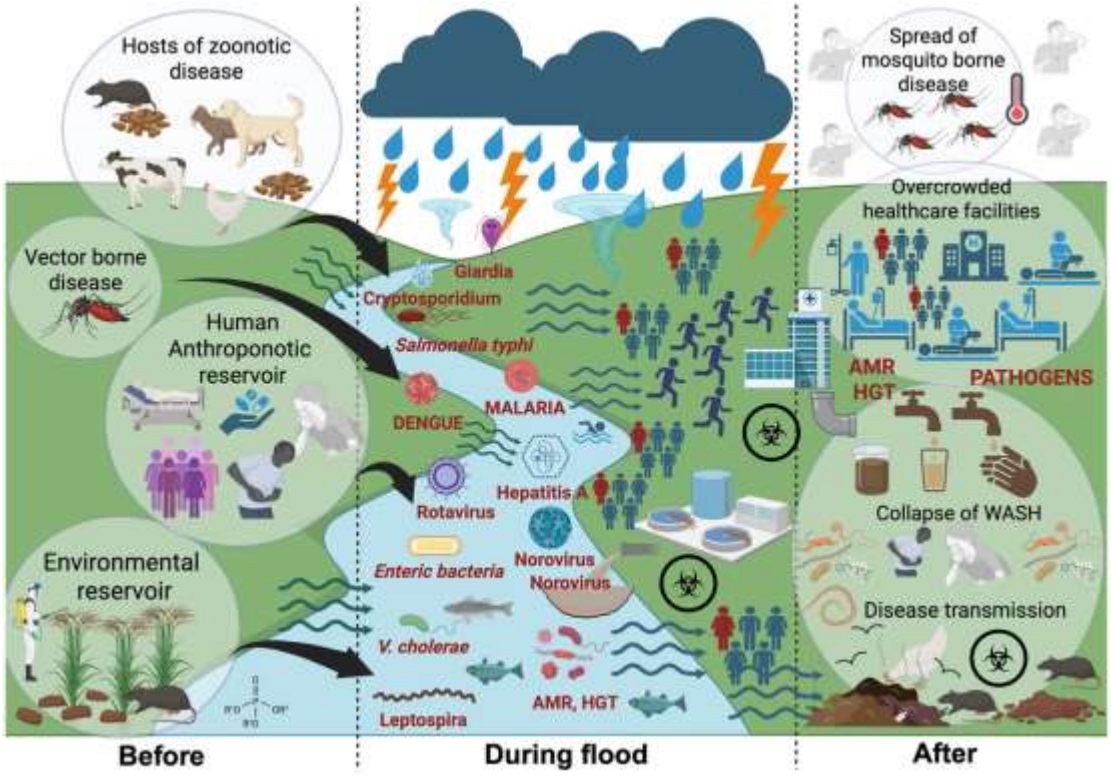

Figure 5: Urban flooding and poor drainage: illustrating how monsoon-related waterlogging in growing cities exacerbates VBD transmission through inadequate sanitation and infrastructure. These visuals capture the dual rural (forest/tribal malaria) and urban (dengue/chikungunya from poor waste/water management) nature of Chhattisgarh's VBD challenges, along with socioeconomic and ecological drivers. https://images-provider.frontiersin.org/api/ipx/w=1200&f=png/https://www.frontiersin.org/files/Articles/1694246/fmicb-16-1694246-HTML/image_m/fmicb-16-1694246-g001.jpg

Future Directions and Strategic Recommendations: To effectively lessen the impact of vector-borne diseases (VBDs) in Chhattisgarh, key actions stand out as priorities.

- **Strengthen Surveillance:** Expand real-time reporting and diagnostic access in remote areas to detect cases and co-infections early.
- **Integrated Vector Management (IVM):** Combine environmental cleanup, insecticide-treated nets (ITNs), and targeted indoor spraying with biological controls like larvivorous fish.
- **Policy & Collaboration:** Secure sustained funding and foster inter-departmental cooperation (Health, Urban Development, and Forestry) to address root causes.

- **Research & Tech:** Monitor insecticide resistance and use **GIS mapping** and predictive modeling to target hotspots.
- **Community Engagement:** Mobilize local leaders and self-help groups to promote protective behaviors and early treatment-seeking.

Conclusion

Vector-borne diseases like malaria, dengue, and chikungunya pose significant health and economic challenges in Chhattisgarh, especially for tribal and urban populations. Driven by climate variability and healthcare gaps, these illnesses require a multi-layered response. Success depends on integrating robust surveillance, advanced diagnostics, and proactive vector suppression with strong community mobilization. By aligning district and state efforts through adaptive, evidence-based strategies, Chhattisgarh can drastically reduce transmission. Ultimately, focusing on this regional elimination targets will alleviate pressure on healthcare systems, boost economic productivity, and ensure a healthier future for the state's diverse communities.

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DATA AVAILABILITY: All datasets generated or analyzed during this study are included in the manuscript.

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