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Chapter 11: Vector Control Challenges in Forest-Rural Settings: A Case Study from Gariyaband District, India

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Abstract: Background: Vector-borne diseases such as malaria, dengue, and chikungunya continue to pose major public health challenges in forest-rural regions of India. Gariyaband district in Chhattisgarh, with its dense forests, scattered tribal settlements, and seasonal water bodies, remains a high-risk zone despite ongoing vector control efforts. This study evaluates the implementation and effectiveness of core vector control interventions—Indoor Residual Spraying (IRS), Insecticide-Treated Nets (ITNs), and Larval Source Management (LSM)—in the district.

Methods: A cross-sectional mixed-methods study was conducted between August 2022 and March 2023 across six administrative blocks of Gariyaband. Quantitative data were collected from 600 households across 30 villages using structured surveys. Qualitative insights were obtained through 24 key informant interviews with health officials, ASHAs, and community representatives. Secondary data from NVBDCP reports (2019–2023) and entomological records were reviewed. Intervention effectiveness was assessed in terms of coverage, usage, compliance, and community knowledge.

Results: IRS was planned in 78% of households but executed in only 53%, with refusals and logistical issues cited as primary barriers. Although 68% of households received ITNs, regular usage was limited to 42%, mainly due to discomfort, net damage, and low perceived risk. LSM activities were visible in only 38% of areas, while larval habitats persisted in 57% of surveyed villages. Community awareness regarding disease transmission and breeding site prevention was suboptimal, especially in tribal regions.

Conclusion: Current vector control interventions in Gariyaband are constrained by operational inefficiencies and behavioural barriers. To enhance disease prevention outcomes, region-specific

strategies involving stronger community engagement, integrated vector management, and improved inter-sectoral coordination are recommended.

Keywords: Vector-borne diseases, Indoor Residual Spraying (IRS), Insecticide-Treated Nets (ITNs) and Larval Source Management (LSM).

1 Introduction

Mosquito-borne diseases remain a persistent public health challenge across India, particularly in regions with complex ecological and socio-economic landscapes. Among these, forest-fringe districts such as Gariyaband in Chhattisgarh experience heightened vulnerability due to their unique environmental conditions, including dense deciduous forests, scattered tribal settlements, seasonal water bodies, and an agrarian economy that supports vector proliferation throughout the year (District Administration Gariyaband, 2021; Srivastava et al., 2012). Despite ongoing efforts under the National Vector Borne Disease Control Programme (NVBDCP), vector-borne diseases such as malaria, dengue, chikungunya, and Japanese encephalitis continue to show seasonal surges in Gariyaband district, with malaria remaining the most prevalent (NVBDCP Annual Report, 2023). Data accessed from IDSP and district health office (2023–2024) revealed that the forested and hard to reach blocks-main in fact, Devbhog and Chhura contributed around 68% of the total malaria cases in the present study. Vector control in the area is based primarily on three main interventions: Indoor Residual Spraying (IRS) with synthetic pyrethroids distribution and use of Insecticide-Treated Nets (ITNs) and targeted Larval Source Management (LSM) using both chemical and biological methods. However, the effectiveness of these interventions has not been adequately assessed at the district level—particularly in forested and hard-to-reach areas like Gariyaband, where implementation challenges include inconsistent coverage, insecticide resistance, and community reluctance (Patel et al., 2020; Singh et al., 2022).

In response, this study was conducted during 2023–2024 to evaluate the on-ground impact of current vector control measures in Gariyaband. The objective is to generate context-specific insights that can guide the development of more adaptive, community-engaged, and sustainable vector control strategies suited to the forest-rural interface.

2 Methods

2.1 Study Area

The study was conducted in Gariyaband district, south-eastern part of Chhattisgarh, India. This constitutes a tribal-dominated area of undulating country, seasonal streams and tanks, and a forest-rural ecotone that provides favorable ecological conditions for

breeding by mosquitoes. In case of NVBDCP (2019–2022) statistics, the district has a consistently high rate of occurrence of diseases based on mosquitoes, predominantly malaria and dengue. Of the six administrative blocks (Gariyaband, Chhura, Rajim, Devbhog, Mainpur, and Bindranawagarh), based on vector density, disease trend pattern, and geographical vulnerability, six blocks have thus been purposively selected for detailed investigation.

These localities included a spectrum of ecological zones, from heavily forested tribal regions to semi-urban plains, and collectively mirror the socio-environmental diversity of the district. Decision was also informed by consultation with district vector-borne disease officers and field epidemiological reports.

2.2 Study Design

A cross-sectional mixed-methods approach was adopted to comprehensively assess the implementation and effectiveness of existing vector control interventions in the selected blocks. The study was conducted from August 2022 to March 2023, covering both monsoon and post-monsoon periods, which are typically associated with peak vector activity in the region.

The quantitative component involved structured household surveys to collect data on the coverage, usage, and perceptions of key vector control strategies. The qualitative component included key informant interviews (KIIs) with frontline health workers and community stakeholders to gather insights into operational challenges and behavioral factors influencing intervention uptake.

2.3 Data Collection

Household Survey

A total of 600 households (100 per block) were selected through stratified random sampling across 30 villages (5 per block). The selection ensured representation from forest-fringe, plain, and remote settlements. A semi-structured, pre-tested questionnaire was administered to adult household members to capture:

- Awareness and practices related to mosquito prevention
- Receipt and use of insecticide-treated nets (ITNs)
- Experience with indoor residual spraying (IRS)
- Observation of stagnant water and local source reduction efforts

Key Informant Interviews (KIIs)

A total of 24 in-depth interviews were conducted with:

Health officials (malaria inspectors, block program managers)

Accredited Social Health Activists (ASHAs)

Panchayat representatives and local community leaders

These interviews focused on implementation mechanisms, community response, logistical barriers, and sustainability concerns associated with IRS, ITNs, and larval source management (LSM).

Secondary Data Review

Published and unpublished data from the National Vector Borne Disease Control Programme (NVBDCP), district health department reports, and entomological surveillance records from 2019 to 2023 were reviewed to triangulate findings and assess trends in intervention deployment and disease burden.

2.4 Evaluation Parameters

The effectiveness of vector control interventions was assessed using the following parameters:

- IRS Coverage and Compliance: Proportion of households targeted versus actually sprayed; community response to spraying; follow-up adherence to standard protocols.
- ITN Distribution and Usage: Household-level access to ITNs; usage patterns during peak vector activity seasons; perceived benefits and challenges of ITN use.
- LSM Coverage and Environmental Status: Implementation of larval source management activities (e.g., oiling, biological larviciding, environmental cleanup); community participation; presence of active breeding sites at the time of field visits.
- Community Knowledge and Practices: Understanding of mosquito breeding sources, disease transmission, and preventive behaviors; involvement in community-led initiatives such as source reduction drives or fogging coordination.

3 Result

This section presents the findings from both quantitative household surveys and qualitative interviews conducted across six blocks of Gariyaband district. Data reflects the coverage, compliance, and community response to three key vector control interventions: Indoor Residual Spraying (IRS), Insecticide-Treated Nets (ITNs), and Larval Source Management (LSM).

3.1 Indoor Residual Spraying (IRS)

Out of the 600 households surveyed, IRS was planned for 468 households (78%) as per district health officials. However, only 318 households (53%) reported that IRS was actually carried out in their homes during the last spray cycle.

Table1: Indoor Residual Spraying (IRS): Planned vs. Actual Implementation Status (n = 600 households)

Indicator	**Value (n = 600)**
IRS planned (per records)	468 households (78%)
IRS actually conducted	318 households (53%)
Households refusing IRS	139 households (23.2%)
IRS skipped due to logistic gaps	143 households (23.8%)

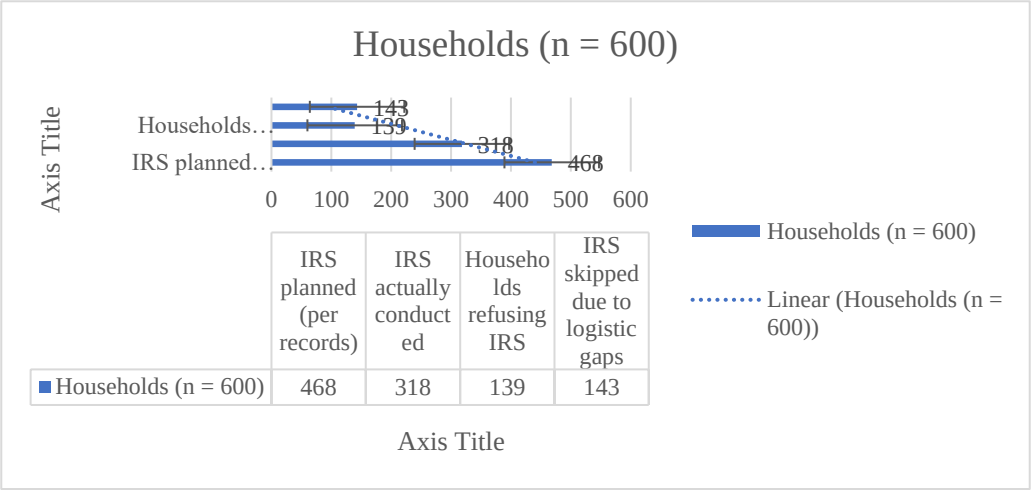

Fig.- 2 IRS Coverage vs. Execution in Surveyed Households (Gariyaband District)

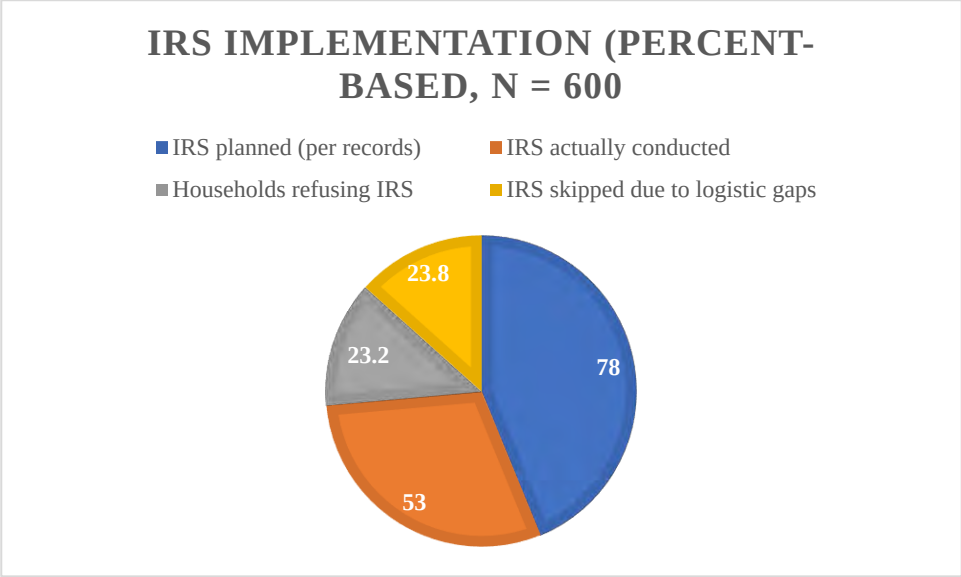

Fig.- 3 ITN Receipt and Usage Patterns Among Surveyed Households (n = 600)

Key reasons for non-implementation:

- Community refusal (23.2%): due to fear of chemical side-effects, odor, or belief that "spraying is ineffective".
- Operational lapses (23.8%): including unavailability of trained manpower, broken spray pumps, and supply shortages.

Qualitative feedback from ASHA workers and health supervisors indicated that households located in forest peripheries and undulating terrain were more likely to be missed by spray teams.

3.2 Insecticide-Treated Nets (ITNs)

Of the surveyed households, **408 (68%)** reported receiving at least one ITN through government distribution in the past two years. However, **only 252 households (42%)** reported **regular usage** (defined as ≥5 nights/week) during peak mosquito season.

Table- 2 Household Access and Utilization of Insecticide-Treated Nets (ITNs) in Gariyaband District

Indicator	**Value (n = 600)**
Received ITNs (any time since 2021)	408 households (68%)

Regular usage (≥5 nights/week)	252 households (42%)
Reasons for irregular use	
– Excess heat/discomfort	145 (57.5%)
– Torn or damaged nets	74 (29.4%)
– Low perceived risk of disease	56 (22.2%)

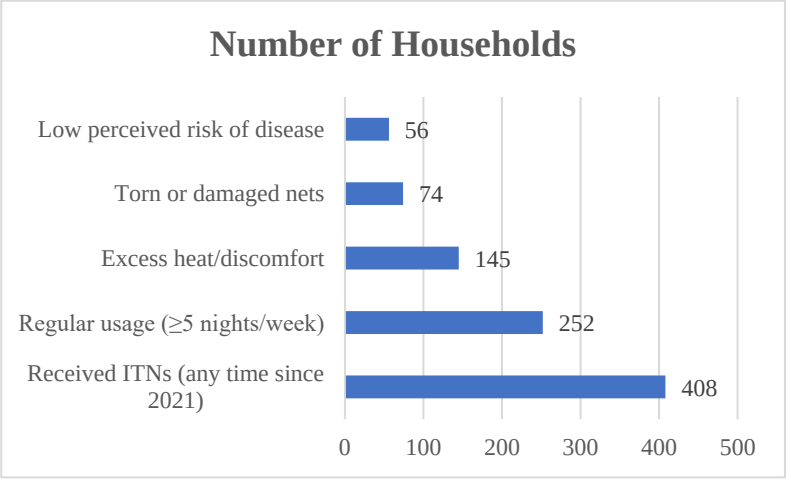

Fig.- 4 Key Reasons for Irregular Use of ITNs Among Respondents

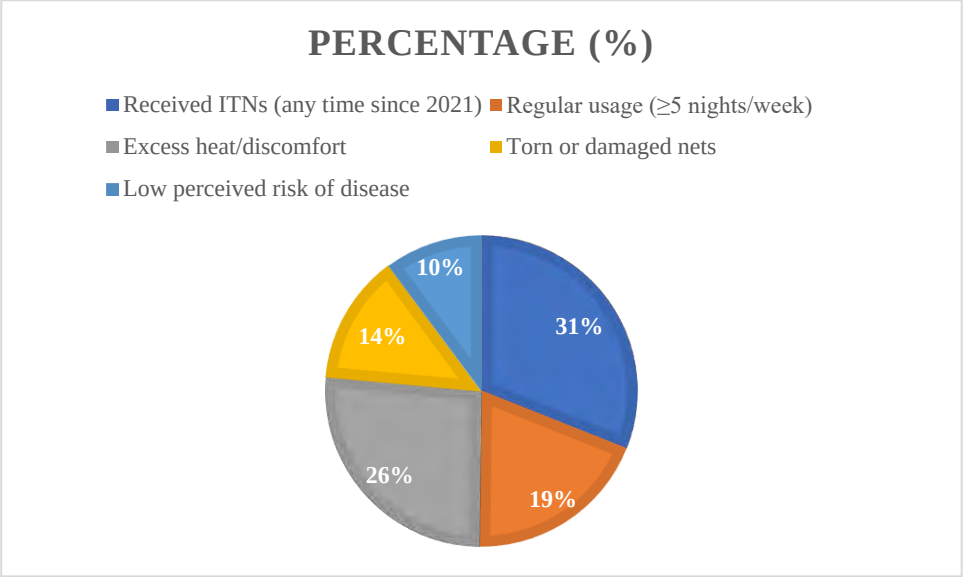

Fig. -5 Visibility and Geographic Coverage of Larval Source Management (LSM) Activities

In tribal-dominated villages in Devbhog and Mainpur blocks, net-sharing between 3–4 family members was common, and 18% of users reported that the nets were more than 3 years old with no retreatment done.

Observation note: In 7 out of 30 villages, no household reported any awareness about the difference between normal nets and insecticide-treated nets.

3.3 Larval Source Management (LSM)

LSM activities, including environmental cleaning, larvicidal oiling, and biological control, were officially reported in all six blocks. However, only 228 households (38%) reported observing any such activity in or around their locality in the past 3 months.

Table -3 Larval Source Management (LSM) Activities and Observed Breeding Sites in Surveyed Villages (n = 30)

Indicator	**Value (n = 600)**
Households reporting LSM activity	228 households (38%)
Villages with visible larval habitats	17 of 30 villages (56.7%)

Villages with fogging response only after outbreak	12 of 30 (40%)

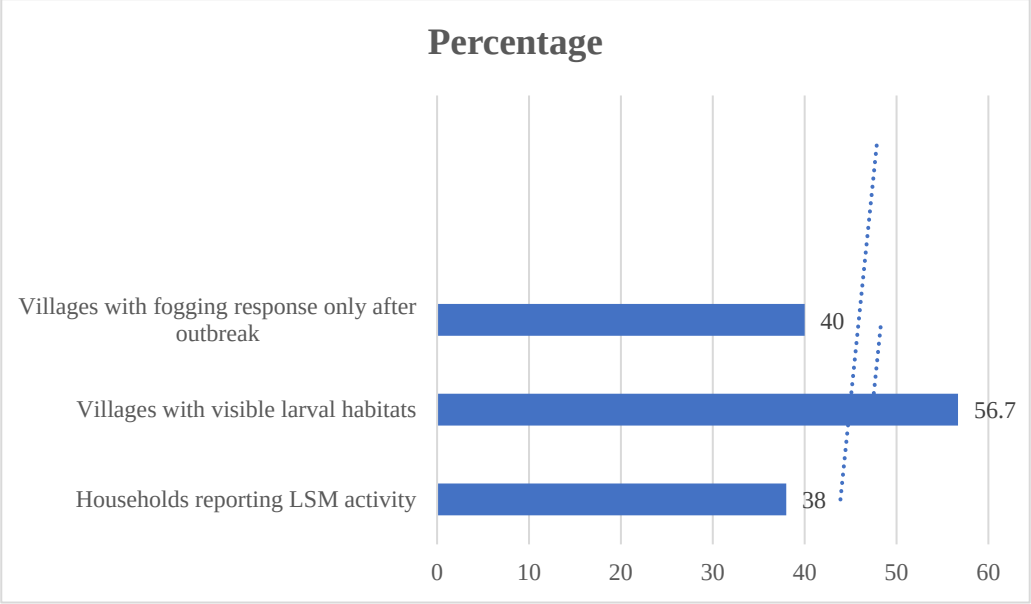

Fig.- 6 Community Awareness and Misconceptions About Vector-Borne Diseases

4 Discussion

This study provides a district-level evaluation of the effectiveness of vector control interventions—specifically Indoor Residual Spraying (IRS), Insecticide-Treated Nets (ITNs), and Larval Source Management (LSM)—in the ecologically complex setting of Gariyaband district, Chhattisgarh. The findings underscore the partial success and persistent challenges in achieving adequate coverage, compliance, and community acceptance of these interventions in a forest-rural interface.

4.1 Effectiveness and Gaps in IRS Implementation

Although IRS was officially planned in 78% of surveyed households, only 53% reported actual spraying, highlighting critical gaps in operational delivery and community compliance. These findings are consistent with studies from other tribal regions in

central India, where refusal due to perceived side-effects and spray fatigue have reduced IRS uptake (Sharma et al., 2021; Sahu et al., 2020).

The non-reach in forest-fringe habitations further indicates challenges in terrain-based microplanning, a known barrier in tribal blocks (Nanda et al., 2019). Without addressing logistical inefficiencies, IRS cannot achieve the desired indoor vector control effect, particularly in remote, high-risk areas.

4.2 Low Utilization of ITNs Despite Distribution

The study found a 68% coverage rate for ITNs but a significantly lower regular usage rate (42%), pointing to a behavioral gap rather than a supply-side deficiency. Heat discomfort, damage to nets, and low perceived risk during certain months were the main deterrents.

Similar challenges have been reported in rural Jharkhand and Odisha, where ITNs were repurposed for agricultural or domestic use (Singh et al., 2022). Suggests a need for targeted behavior change communication (BCC) interventions, with seasonal messaging emphasizing consistent use during transmission peaks.

4.3 Larval Source Management: Weak Execution, Limited Impact

LSM was reported in only 38% of surveyed areas, and larval habitats were observed in 56.7% of villages, especially near community buildings and irrigation sites. These findings reflect a disconnect between planned activities and on-ground implementation. Similar issues of weak LSM accountability have been observed in forest areas of Bastar and Gadchiroli, where larval surveillance is either irregular or absent (Patel et al., 2020; Bhatt et al., 2018).

Community involvement in LSM remains minimal, as seen in this study where only 35% of respondents participated in source reduction. Village Health Sanitation and Nutrition Committees (VHSNCs), though mandated under NRHM, appear to be non-functional in several blocks, limiting sustained community-led efforts.

4.4 Inadequate Awareness and Risk Perception

While awareness of malaria was high (85%), only 44% understood its mosquito-borne etiology. The situation was worse for dengue and chikungunya, where knowledge levels were below 50%. This demonstrates that IEC/BCC campaigns have limited penetration, especially in remote or tribal belts.

Furthermore, persistent misconceptions—such as "malaria spreads via dirty food"—highlight the urgent need for contextual, vernacular, and school-based health education models. Involving local cultural influencers (like community elders, priests, or teachers) in messaging can improve community receptivity.

4.5 Comparison with Existing Literature and NVBDCP Goals

The NVBDCP targets malaria elimination by 2030 in India. However, the current findings suggest that without addressing community-level behavior, field-level capacity gaps, and ecological complexities, such timelines may not be feasible in forested districts like Gariyaband.

Previous evaluations in tribal areas (Das et al., 2019; Dhiman et al., 2021) echo similar themes of intervention underutilization, vector resistance, and lack of sustainable engagement models. Our study strengthens the argument for a shift from purely chemical-based control to Integrated Vector Management (IVM) that combines IRS/ITNs with environmental management and community participation.

Conclusions

This study presents a comprehensive evaluation of vector control strategies implemented in the forest-rural interface of Gariyaband district, Chhattisgarh, an ecologically sensitive and epidemiologically vulnerable region. Despite the continued deployment of core interventions—Indoor Residual Spraying (IRS), Insecticide-Treated Nets (ITNs), and Larval Source Management (LSM)—the findings reveal significant implementation gaps, inconsistent usage patterns, and low community engagement, limiting the overall effectiveness of these strategies.

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