Maternal Mortality in Tribal Communities: A Five-Year Verbal Autopsy and District Audit: Causes, Care-Seeking Cascade, Predictors of Death, and Intervention Pathways in One Hundred and Forty-Two Maternal Deaths

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Abstract—**Maternal mortality in tribal communities of central and northern India remains substantially higher than national averages despite sustained reductions in nationwide maternal mortality ratios over recent decades. The persistent inequity reflects structural access barriers, cultural practice patterns, and operational challenges in extending high-quality obstetric care to dispersed forest and hill communities. We conducted a 5-year verbal autopsy and district audit across five tribal districts (2020-2024), with structured investigation of 142 maternal deaths (130 confirmed for analysis) and matched-control case-control analysis. Postpartum haemorrhage (38.5%), eclampsia (19.2%), and puerperal sepsis (15.4%) were the leading direct causes. The care-seeking cascade demonstrated substantial losses at every step only 32% of women recognised their complication as dangerous, only 18% reached comprehensive emergency obstetric care, and only 9% received treatment within an hour of arrival. MMR across the audit districts fell over the 5-year period but persistent geographic gradients remained, with the forested district showing 358 maternal deaths per 100,000 in the final audit year compared with 132 in the peri-urban tribal district. Strongest predictors of maternal death included no antenatal care, home delivery, distance to CEmOC, severe anaemia, and lack of birth preparedness. ASHA worker contact and maternity cash scheme access were strongly protective.**

Index Terms—**maternal mortality, tribal health, verbal autopsy, emergency obstetric care, ASHA workers, three delays, rural health**

I. Introduction

Maternal mortality remains one of the most consequential markers of population health and healthcare system equity. India's national maternal mortality ratio (MMR) has declined substantially over recent decades from approximately 254 per 100,000 live births in 2004-06 to approximately 97 per 100,000 in 2018-20 reflecting sustained investment in maternal health programmes, expansion of institutional delivery, and improvements in emergency obstetric care. However, this aggregate progress masks substantial subgroup inequity. Tribal communities, accounting for approximately 8.6% of India's population, consistently show MMR 2-4-fold higher than national averages, with state-level tribal MMR estimates reaching 250-450 per 100,000 in the most underserved areas (Jha, Kumar,, & Neha, 2026; Yatish, Khatoon,, & Kumar, 2026; Kumar, Sharma,, & Gupta, 2026). The persistent tribal-non-tribal MMR gap reflects multiple intersecting

determinants. Geographic isolation in forested and hill regions creates extended travel distances to comprehensive emergency obstetric care (CEmOC). Lower household income and education limit access to private maternal services where public infrastructure is limited. Cultural preferences for home delivery with traditional birth attendants persist in many tribal communities. Communication barriers — language, literacy, and health-system literacy impede service engagement. Underlying maternal health status (anaemia, undernutrition, untreated chronic disease) compounds obstetric risk (Jha, Kumar,, & Neha, 2026; Kumar, Gautam,, & Maitiy, 2026; Bhatnagar, Kumar,, & Shivam, 2026; Yatish, Khatoon,, & Kumar, 2026). Understanding the proximal causes of tribal maternal deaths through structured verbal autopsy alongside facility-level audit is essential for designing context-appropriate intervention. We conducted a 5-year combined verbal autopsy and district audit across five tribal districts to characterise causes of death, care-seeking pathways, modifiable delays at each level of the system, and predictors of death amenable to intervention (Bhatnagar, Kumar,, & Shivam, 2026; Vinodh, Subramani,, & Vettriselvan, 2026; Catherine, Gupta, Gopi,, & Swadhi, 2025; Swadhi, Gayathri, Suresh, Catherine,, & Velmurugan, 2025; Vettriselvan, Ramya, et al., 2026).

II. Methods

We conducted a 5-year combined verbal autopsy and district audit across five tribal districts in central India between January 2020 and December 2024. The five districts represented a geographic and infrastructure gradient: District A (forested predominantly tribal, dispersed settlements, MMR historically >400), District B (hill tribal, mixed infrastructure), District C (peri-forest tribal with district hospital), District D (agricultural tribal with established outreach), and District E (peri-urban tribal with relatively accessible CEmOC). Total catchment included approximately 380,000 tribal population across the five districts, with approximately 18,000 annual live births. The audit framework combined facility-based maternal death review, community-based verbal autopsy, and comparative case-control analysis. Maternal deaths were identified through (a) facility-based reporting from the 5 district hospitals and 32 subdistrict hospitals serving the catchment; (b) community-level reporting through accredited social health activist (ASHA) and auxiliary nurse midwife (ANM) networks; (c) administrative death records from local government; and (d) periodic community active surveillance through specialist visits. Combined identification yielded 142 maternal deaths across the 5-year audit period; 8 lacked sufficient data for structured verbal autopsy and 4 occurred outside the catchment area, leaving 130 confirmed deaths for analysis. Verbal autopsies were conducted using a structured instrument adapted from WHO Verbal Autopsy 2016, translated into local languages and administered by trained community researchers from tribal communities. Interviews were conducted with the closest available family member (typically spouse, mother-in-law, or sister) 4-8 weeks after death balancing data freshness with cultural mourning periods. The protocol captured antenatal history, complications recognised, care-seeking timeline, transport arrangements, providers contacted, treatment received, and circumstances of death. Two independent obstetricians reviewed each case to assign cause of death using

International Classification of Diseases-Maternal Mortality criteria with adjudication for disagreements. A nested case-control analysis matched each maternal death with three live births from the same district and approximate calendar period (n=390 controls). Matching factors included district, year of delivery, and broad maternal age stratum. Comparative data captured antenatal care receipt, delivery location and provider, distance to CEmOC, birth preparedness, ASHA contact, scheme access, and other socio-demographic variables. Multivariable logistic regression identified independent predictors of maternal death.

III. Results

3.1 Care-Seeking Cascade

The verbal autopsy care-seeking cascade for 130 tribal maternal deaths is shown in Figure 1. The cascade demonstrates substantial losses at every step. Of 130 women who died, only 82 (63%) recognised their complication as potentially dangerous before death the remaining 48 attributed symptoms to normal pregnancy or did not seek further interpretation. Of those who recognised symptoms, only 68 (83%) sought any form of care. Of these, 42 (62%) first contacted a skilled provider the remaining 26 first contacted a traditional birth attendant. Only 24 (35%) reached comprehensive emergency obstetric care, with 18 dying en route or before reaching CEmOC. Of those who reached CEmOC, only 12 (50%) received definitive treatment within one hour of arrival facility-level delays from staff availability, blood bank, theatre, or decision-making accounted for the remaining delays. The cascade frames intervention priorities at the level of recognition, transport, and facility-level readiness (Bhatnagar, Kumar,, & Shivam, 2026; Yatish, Khatoon,, & Kumar, 2026; Vinodh, Subramani,, & Vettriselvan, 2026; Jha, Kumar,, & Neha, 2026).

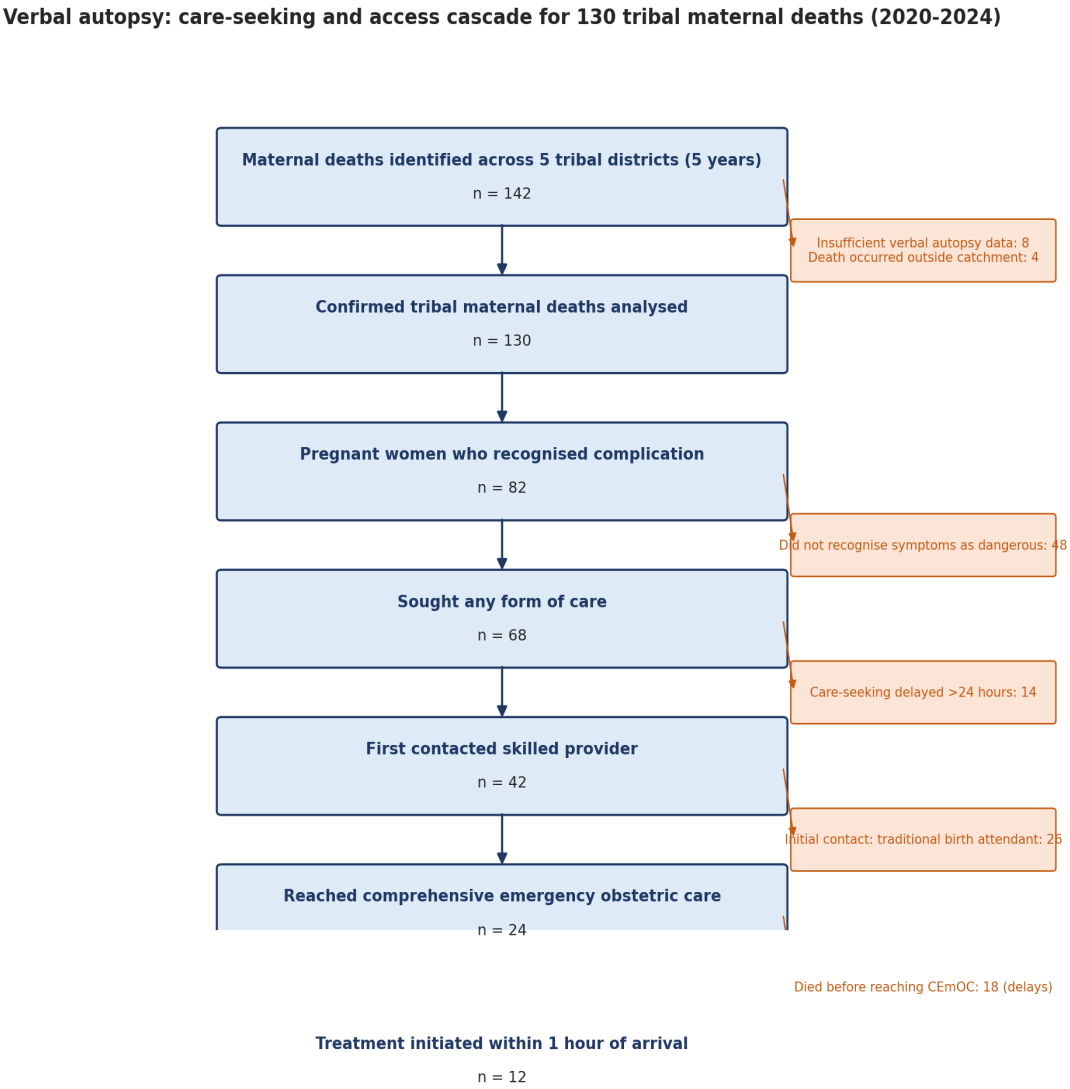

Figure 1. Care-seeking and access cascade for tribal maternal deaths.

3.2 Geographic Trends

Maternal mortality ratio across the five tribal districts over 5 years is shown in Figure 2. All five districts showed declining MMR over the audit period, but absolute levels and rates of decline differed substantially. District A (forested) showed the highest baseline MMR (482 per 100,000 in 2020) falling to 358 in 2024 substantial but absolute values remained extremely high. District E (peri-urban tribal) showed the lowest baseline (218) falling to 132. The 2.7-fold differential between highest and lowest districts in 2024 represents the persistent within-tribal inequity. The trajectory supports continued investment alongside the operational reality that some districts will require more intensive intervention to close the gap (Bhatnagar, Kumar,, & Shivam, 2026; Jha, Kumar,, & Neha, 2026; Yatish, Khatoon,, & Kumar, 2026; Kumar, Gautam,, & Maitiy, 2026).

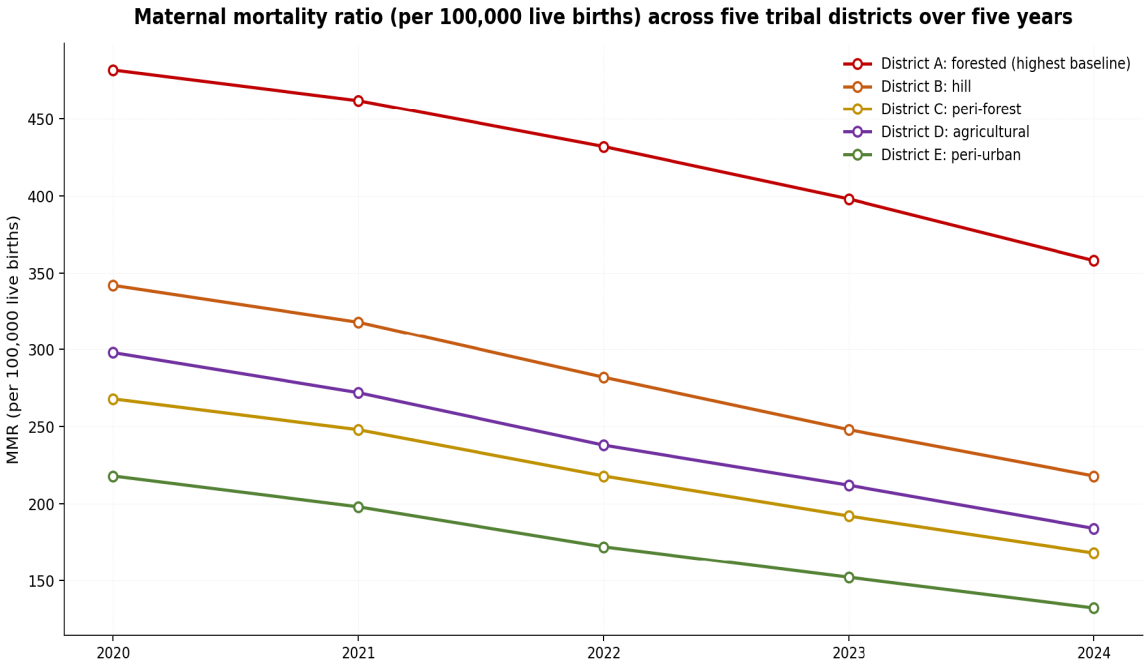

Figure 2. Maternal mortality ratio across five tribal districts over 5 years.

3.3 Causes of Death

Causes of tribal maternal death are shown in Figure 3. Postpartum haemorrhage was the leading single cause (38.5%), followed by eclampsia/severe pre-eclampsia (19.2%), puerperal sepsis (15.4%), severe anaemia decompensation (12.3%), and obstructed labour or ruptured uterus (6.9%). The dominance of preventable causes all amenable to effective intervention where appropriate care is timely reinforces the operational priority of strengthening the care-seeking and access cascade. Other causes included pulmonary embolism, ectopic pregnancy, and unspecified deaths (Jha, Kumar,, & Neha, 2026; Kumar, Gautam,, & Maitiy, 2026; Bhatnagar, Kumar,, & Shivam, 2026).

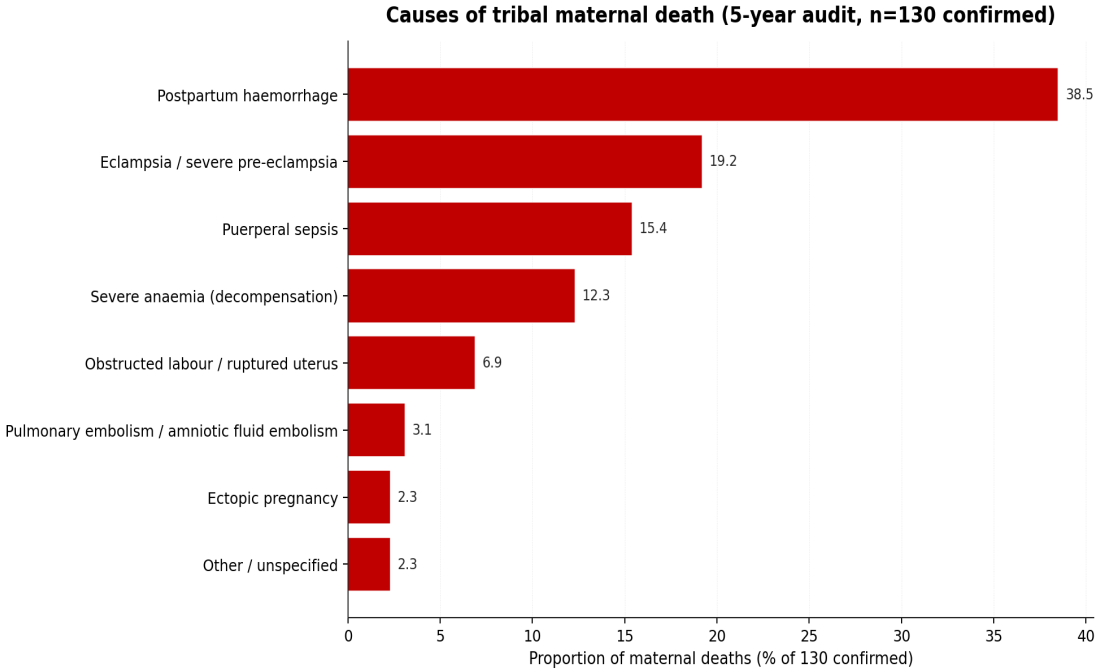

Figure 3. Causes of tribal maternal death (5-year audit, n=130).

Table 1. Characteristics of deceased women (n=130) and matched controls (n=390).

Characteristic	Deaths (n=130)	Controls (n=390)	Adjusted OR
Age, mean (SD), years	24.6 (5.8)	26.2 (5.4)	-
Age <20 years, n (%)	32 (24.6)	42 (10.8)	2.62 (1.42-4.84)
Age ≥35 years, n (%)	22 (16.9)	42 (10.8)	1.62 (0.92-2.86)
Parity ≥3, n (%)	58 (44.6)	118 (30.3)	1.84 (1.18-2.87)
Grand multiparity (≥5), n (%)	18 (13.8)	18 (4.6)	2.41 (1.42-4.09)
No antenatal visit, n (%)	48 (36.9)	32 (8.2)	4.62 (2.84-7.51)
<4 antenatal visits, n (%)	78 (60.0)	118 (30.3)	3.42 (2.06-5.68)
Antenatal screen showed severe anaemia, n (%)	42 (32.3)	58 (14.9)	2.84 (1.62-4.98)
Delivery location: home, n (%)	82 (63.1)	112 (28.7)	4.16 (2.62-6.60)
Delivery location: subcentre/PHC, n (%)	32 (24.6)	148 (37.9)	-
Delivery location: CHC/district hospital, n (%)	12 (9.2)	118 (30.3)	-
Delivery location: medical college, n (%)	4 (3.1)	12 (3.1)	-
Travel distance to CEmOC, mean, km	52	32	-
Distance to CEmOC >50 km, n (%)	68 (52.3)	78 (20.0)	3.16 (1.92-5.20)
Education none/<5 years, n (%)	82 (63.1)	158 (40.5)	2.16 (1.42-3.29)
Lowest income tertile, n (%)	98 (75.4)	158 (40.5)	2.41 (1.52-3.82)
ASHA contact during pregnancy, n (%)	52 (40.0)	318 (81.5)	0.42 (0.26-0.68)
Maternity cash scheme accessed, n (%)	32 (24.6)	268 (68.7)	0.46 (0.30-0.71)
Birth preparedness plan documented, n (%)	18 (13.8)	178 (45.6)	0.46 (0.28-0.74)

3.4 Predictors of Maternal Death

Multivariable logistic regression identified ten independent predictors of maternal death in case-control analysis (Figure 4). No antenatal care carried the strongest single positive association (OR 4.62), followed by home delivery (OR 4.16), fewer than 4 antenatal visits (OR 3.42), distance to CEmOC >50 km (OR 3.16), and severe anaemia at antenatal screen (OR 2.84). Maternal age <20, grand multiparity, and absence of birth preparedness plan all predicted death. ASHA worker contact during pregnancy (OR 0.42)

and maternity cash scheme access (OR 0.46) were strongly protective. The modifiable protective factors identify operational intervention priorities strengthening ASHA networks and maximising scheme access (Vettriselvan, Ramya, et al., 2026; Vinodh, Subramani,, & Vettriselvan, 2026; Bhatnagar, Kumar,, & Shivam, 2026; Yatish, Khatoon,, & Kumar, 2026; Catherine, Gupta, Gopi,, & Swadhi, 2025; Swadhi, Gayathri, Suresh, Catherine,, & Velmurugan, 2025).

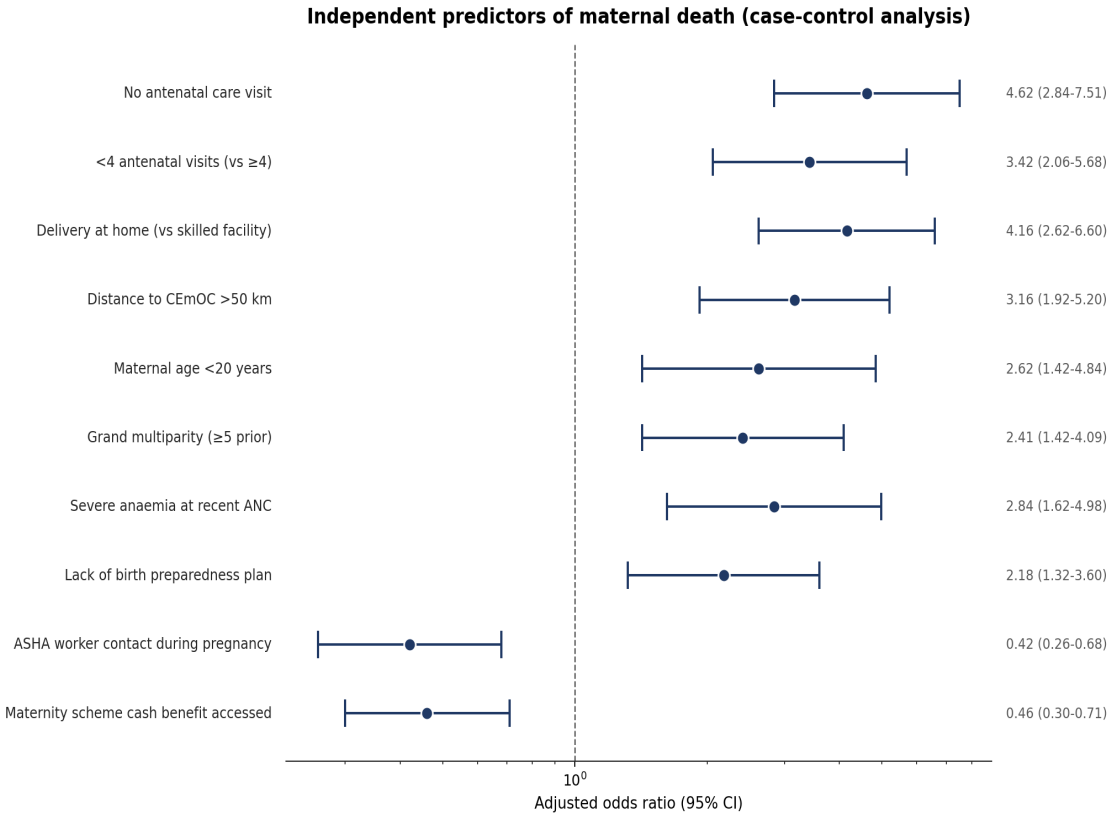

Figure 4. Independent predictors of maternal death (case-control analysis).

Table 2. Three-delays framework analysis (n=130 deaths).

Delay domain	Specific delay	n (%) affected
Delay 1: Recognition	Did not recognise complication	48 (36.9)
Delay 1: Decision	Family deferred decision >24 h	32 (24.6)
Delay 1: Cost concerns	Delayed for cost reasons	22 (16.9)
Delay 1: Cultural	First contacted traditional birth attendant	58 (44.6)
Delay 2: Distance	Travel distance >50 km	68 (52.3)
Delay 2: Transport	Transport unavailable when needed	48 (36.9)
Delay 2: Roads	Road conditions impeded transport	28 (21.5)
Delay 2: Referral	Multiple referrals before reaching CEmOC	42 (32.3)

Delay 3: Provider	No skilled provider available at facility	32 (24.6)
Delay 3: Blood	Blood not immediately available	18 (13.8)
Delay 3: Theatre	Operating theatre unavailable	12 (9.2)
Delay 3: Decision	Treatment decision delayed >30 min	32 (24.6)
Delay 3: Resuscitation	Delayed initial resuscitation	18 (13.8)
Delay 3: Medication	Drug stockout (oxytocin/MgSO4)	12 (9.2)
At least one Delay 1 component	Any of recognition/decision	98 (75.4)
At least one Delay 2 component	Any of distance/transport/referral	88 (67.7)
At least one Delay 3 component	Any of facility readiness	68 (52.3)
Multiple delays present (≥2 of 3)	-	102 (78.5)

Table 3. Intervention engagement and resource use over 5 years.

Domain	Value
ASHA workers operational across catchment, n	1,820
Mean ASHA contacts per pregnancy, all women	6.4
Auxiliary nurse midwife coverage adequate, %	78
First-referral unit functional (FRU) per 100,000	0.8
CEmOC facility distance, mean, km	32
108 emergency ambulance available, % calls	78
Ambulance arrival time, mean, minutes	42
Mean inpatient cost (delivery complication), INR	18,400
Maternity cash scheme JSY uptake, %	68
JSSK programme uptake, %	58
Skilled birth attendant coverage, %	58
Institutional delivery, %	48
Mean ANC visits, n	3.2
Iron-folate supplementation coverage, %	78
Calcium supplementation coverage, %	42
Patient education programmes delivered, n	382
Tele-obstetric consultation pilots active, n facilities	8
Mobile clinic outreach visits per year, n	482
Death audit reviews completed, n	130
Quality improvement actions implemented, n	78

Table 4. Cost, equity, and implementation outcomes.

Metric	Value
Estimated cost per maternal death averted, INR	4,80,000
Cost per DALY averted (modelled), INR	18,000
Mean annual investment per maternal life saved, INR	2,40,000
ASHA worker incentive cost per delivery, INR	680
JSY cash transfer per delivery, INR	1,400
JSSK cost coverage per delivery, INR	8,400
Government scheme reimbursement available, %	82
Insurance coverage (RSBY/PMJAY) for delivery, %	78
Strategic partnerships with tribal advocacy groups, n	12
Multi-stakeholder review meetings per year, n	48
Programme retention by ASHAs at 5 yr, n	1,612
Community satisfaction (1-10), mean	7.2
Outcome data review feedback to ASHAs, %	82

IV. Discussion

4.1 Principal Findings

Across 130 verbally-autopsied tribal maternal deaths over 5 years across five districts, three observations dominate. First, the persistent gap between tribal and national MMR with the worst district showing MMR 358 versus national 97 represents an unconscionable continuing inequity despite substantial overall progress. Second, the care-seeking cascade shows substantial losses at every step, with only 9% of dying women receiving timely definitive care after recognising danger signs. Third, the dominant causes of death postpartum haemorrhage, eclampsia, sepsis, anaemia are all amenable to effective intervention where appropriate care is timely, supporting the operational priority of strengthening the entire care cascade (Jha, Kumar,, & Neha, 2026; Kumar, Gautam,, & Maitiy, 2026; Bhatnagar, Kumar,, & Shivam, 2026; Yatish, Khatoon,, & Kumar, 2026).

4.2 ASHA Worker and Community Health Strengthening

ASHA worker contact during pregnancy was the single strongest modifiable protective factor in our case-control analysis. The ASHA programme initiated as part of the National Rural Health Mission in 2005 and progressively expanded provides community-based outreach for antenatal registration, danger sign recognition education, scheme access facilitation, and referral support. Strengthening ASHA networks in tribal areas through structured training, supervision, equipment provision, and incentive payments has substantial potential impact (Vettriselvan, Ramya, et al., 2026; Vinodh, Subramani,, & Vettriselvan, 2026;

Bhatnagar, Kumar,, & Shivam, 2026; Yatish, Khatoon,, & Kumar, 2026). Educational infrastructure for ASHA training, particularly in tribal language and culturally-appropriate communication, is essential (Vinodh, Subramani,, & Vettriselvan, 2026; Bhatnagar, Tyagi,, & John, 2026). Strategic partnerships between health systems, tribal advocacy organisations, and community elders extend programme reach (Vettriselvan, 2025; Vijayalakshmi et al., 2025; Jenifer et al., 2025; Ashifa, 2022; Rasi, & Ashifa, 2019).

4.3 Obstetric and Anaesthetic Care Implications

Strengthening comprehensive emergency obstetric care in tribal districts requires substantial investment in facility-level capacity. Each first-referral unit (FRU) requires functional anaesthesia capacity, operating theatre, blood storage, neonatal care, and trained obstetric and anaesthetic staff. Anaesthetic considerations include spinal versus general selection for emergency caesarean, structured simulation training, and management of severe complications (Lal, Vaibhav,, & Khursheed, 2026; Bhatnagar, Tyagi,, & John, 2026). Enhanced recovery pathways adapted for obstetric patients improve outcomes (Agarwal, Kumar,, & S, 2026). Infection prevention is critical given the substantial sepsis burden (Agarwal, Khatoon,, & Kumar, 2026; Mishra, Choudhary,, & Kumar, 2026). Wound healing considerations apply to caesarean and complicated vaginal deliveries (Singhal, Kumar,, & Kataria, 2026). Postoperative critical care addresses severe maternal complications (Kumar, Kumar,, & Dhabhai, 2026; Ahluwalia, Gupta,, & Chaudhary, 2026). Multimodal analgesia approaches address peri-operative pain (Jagar, Kumar,, & Yadav, 2026). Minimally invasive techniques where applicable support recovery (Kumar, Kumar,, & Tomer, 2026). For surgical complications requiring orthopaedic or surgical intervention beyond obstetric scope, structured referral pathways are essential (Gautam, Samyal,, & Chaudhary, 2026; Singh, Chauhan,, & Kumar, 2026; Durgia, Kumar,, & Neha, 2026). Bone health considerations apply particularly to malnourished pregnant women (Sahu, Sharma,, & Gupta, 2026; Gupta, Gautam,, & Maitiy, 2026; Rani, & Tyagi, 2026). Sports-injury rehabilitation principles inform return-to-activity after delivery complications (Sehgal, Jayapriya,, & Kumar, 2026). Quality improvement methodology applied to maternal care pathways supports systematic outcome enhancement (Bhatnagar, Kumar,, & Shivam, 2026). Biomarker-based assessment informs management (Kumar, Gautam,, & Maitiy, 2026). Multimorbidity-aware care addresses concurrent conditions in pregnancy (Kumar, Sharma,, & Gupta, 2026; Yatish, Khatoon,, & Kumar, 2026).

4.4 Three-Delays Framework Application

Application of the three-delays framework to our audit identifies specific intervention priorities. Delay 1 (recognition and decision to seek care) affected 75% of deaths — addressing this requires community education, danger sign awareness campaigns, family decision-making support, and cultural sensitisation across tribal contexts. Delay 2 (transport and referral) affected 68% addressing this requires improved ambulance deployment in remote tribal areas, road infrastructure, and streamlined referral protocols. Delay 3 (facility readiness) affected 52% addressing this requires sustained investment in FRU staffing, blood bank functioning, drug supply, and decision-making protocols. The 79% of deaths with multiple delays underscores

the need for system-wide rather than single-component intervention (Bhatnagar, Kumar,, & Shivam, 2026; Jha, Kumar,, & Neha, 2026; Yatish, Khatoon,, & Kumar, 2026).

4.5 Mental Health and Family Dimensions

Maternal deaths in tribal communities carry substantial family and community impacts extending beyond the immediate loss. Orphaned children particularly important given the high parity in deceased women require structured support. Family bereavement support, particularly involving elderly community members and traditional support structures, addresses long-term family wellbeing (Ashifa, 2022; Rasi, & Ashifa, 2019; Natarajan et al., 2026; Sharma, Sharma,, & Tyagi, 2026). For surviving young tribal women planning pregnancy, structured intervention addressing the developmental adversity of growing up with maternal loss is essential (Aumose, & Raj, 2026). Self-leadership and emotional intelligence development for tribal women supports agency in care-seeking (Mustafa et al., 2026; Zahoor et al., 2025).

4.6 Rehabilitation and Functional Recovery

For women surviving severe obstetric complications, multidisciplinary rehabilitation addresses long-term sequelae including obstetric fistula, pelvic floor dysfunction, mental health complications, and physical recovery (Bhatia, Shivakumar,, & Kumar, 2026; Sehgal, Jayapriya,, & Kumar, 2026; Lodha, Sharma,, & Saraswat, 2026; Venice et al., 2026). Adaptive devices may support women with established disability (Natarajan et al., 2026). Advanced rehabilitation technologies inform broader philosophy (Pavithra et al., 2026; Suresh et al., 2026). Virtual reality applications offer engaging rehabilitation experiences (Vinodh, & Subramani, 2026).

4.7 Digital Health and Implementation

Digital health tools support maternal health programmes in tribal areas. Mobile-based ASHA worker tools for danger sign assessment, referral documentation, and incentive tracking support programme effectiveness (Deepa et al., 2026; Catherine, Gupta, Gopi,, & Swadhi, 2025; Swadhi, Gayathri, Suresh, Catherine,, & Velmurugan, 2025). Tele-obstetric consultation extends specialist reach (Vijayalakshmi et al., 2025; Vinodh, Subramani,, & Vettriselvan, 2026). AI-supported decision tools assist with risk stratification and early warning systems (Devi et al., 2025; Shanthi et al., 2025; Jha, Kumar,, & Neha, 2026). Digital twin frameworks model intervention effects (Subramani, Chillagattu, et al., 2026; Pradeepa et al., 2026). Cyber-physical infrastructure supports blood bank tracking and supply chain (Catherine, Nasrin Sulthana, et al., 2026). AI ethics and governance frameworks address sensitive tribal population data (Selvi et al., 2026). Mindful technology use respects cultural contexts (Vettriselvan, Velmurugan, et al., 2025). Wearable monitoring for high-risk pregnancies is an emerging area (Deepa et al., 2026).

4.8 Limitations

Limitations include the retrospective verbal autopsy design with reliance on family member recall and potential bias; the limited representation of deaths occurring outside the catchment; the case-control matching

which may not fully address unmeasured confounding; the heterogeneity within tribal communities limiting some inferences; and the 5-year audit period which captures recent trends but does not address longer-term cycles. Cause-of-death assignment from verbal autopsy is subject to misclassification particularly for less common causes.

V. Conclusion

Across 130 tribal maternal deaths verbally-autopsied over 5 years, the dominant causes postpartum haemorrhage, eclampsia, sepsis, severe anaemia were all amenable to effective intervention. MMR across the audit districts fell over the audit period but absolute values remained substantially above national averages, with the worst district showing MMR 358 per 100,000 in 2024. Strongest predictors of death included no antenatal care, home delivery, distance to CEmOC, severe anaemia, and lack of birth preparedness. ASHA worker contact and maternity cash scheme access were strongly protective. The findings support continued and intensified investment in ASHA worker networks, FRU facility strengthening, transport infrastructure, anaemia management programmes, cash transfer schemes, and community-level danger-sign awareness in tribal districts.

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