Context Informed Rationality, SHG Platforms, and Health Behavior: Evidence from a Peer-Counselling Field Experiment

Vivek Pandey[*], Jayashree Bhusare[*], and Shantanu Kumar[§]

[*] Institute of Rural Management Anand

[§] World Bank

Abstract

This paper examines persistent underutilization of life-saving maternal and child health services (MCH) in rural India, despite its widespread availability at minimal or no cost. Culturally embedded beliefs and spiritual practices such as fear of the "evil eye" shape the context-informed rational behavior of pregnant women and their families who weigh not only monetary costs but also social and psychic costs of MCH uptake. Consequently, timely pregnancy disclosure and healthcare utilization are significantly constrained, resulting in high rates of preterm births, low birth weight, and mortality. Compounding these constraints, frontline health workers (ASHAs) face significant search cost in identifying and reaching culturally reticent households. We conducted a two-year field experiment in 160 villages across 8 districts of Jharkhand to test whether culturally sensitive, Self-Help Group-led peer-counselling can increase the uptake of antenatal services, supplementation, and entitlements, including the Janani Suraksha Yojana, and promote engagement with health workers. The intervention leveraged weekly SHG meetings for early pregnancy detection and group-to-peer health discussions, facilitating timely awareness and substantially reducing the search cost for health workers through information subsidies. Experimental results show that the intervention (JASHN) increased first trimester pregnancy registration by almost 20-percentage-points (to 81%), exceeded benchmarks for completion of four or more antenatal visits, and significantly improved micronutrient supplementation, hemoglobin, and anemia rates. Uptake of cash entitlements more than doubled in the intervention area. While, the intervention did not influence low birth weights, it eliminated almost all very-LBW cases and reduced child wasting by 24-percentage-points. The Causal Forest approach to treatment heterogeneity shows that there is no evidence of elite capture- the intervention's peer-led model and health system integration effectively reached marginalized groups, with stronger impacts in economically disadvantaged, remote, low-health-access areas, and among less-educated and SC and ST women. Analysis of potential mechanisms show that women in treatment villages disclosed pregnancies earlier to SHG peers, accessed first antenatal care 0.6 months sooner, received greater family support, and heightened ASHA outreach and counselling intensity. These findings demonstrate the importance of integrating culturally sensitive peer-counselling into public health systems to reduce utilization gaps and improve intervention targeting.

1. Introduction

Why do life-saving perinatal services remain chronically underutilized in many developing countries, despite being ostensibly free and widely promoted? Timely and adequate maternal and child healthcare (MCH) services are proven to prevent birth defects, pregnancy complications, and mortality (WHO, 2016; Wenling et al., 2024)[1]. Yet, South Asia and sub-Saharan Africa account for a quarter of a million maternal deaths and nine million preterm births (Ohuma et al., 2023; WHO, 2025). India illustrates the puzzle where, despite near-universal pregnancy registration and free or incentivized antenatal services (Tripathi, Pathak, and Lahariya, 2023), significant gaps persist in both timing and adequacy of care: more than 40% of women miss the minimum four antenatal care (ANC) visits, and only one in five meet the WHO standard of eight[2]. Micronutrient coverage mirrors this shortfall, with only 44% consuming at least 100 iron-folic acid tablets during pregnancy[3]. These coverage gaps have contributed to persistently high adverse outcomes: preterm birth rates around 13%, representing one-fifth of the global burden (Khursheed et al., 2025), alongside NFHS-5 indicators of 18% low-birth-weight prevalence and 52% maternal anemia (Tripathi, Pathak, and Lahariya, 2023). Despite universal access, the persistence of such outcomes frames our central question: how to design perinatal care interventions that close these utilization gaps in India and comparable settings.

We organize the design problem through three theoretical lenses offered in the literature explaining stubborn underutilization and corresponding policy levers. First, in the Becker-Grossman tradition, medical care is an input in the family's health production function and is demanded only if it's perceived marginal benefit exceed shadow price (Becker, 1965; Grossman, 1972; Mwabu, 2009). This explanation has informed the use of cash transfers (for example, Janani Suraksha Yojana (JSY) in India, Prospera in Mexico), transport vouchers, removal of user fees, and in-kind nutrition support to reduce barriers and improve coverage (Barham, 2011; Bellows, Bellows, and Warren, 2011; Lagarde , Barroy, and Palmet, 2012; Ekirapa-Kiracho et al., 2014). The second lens, drawing on the extensions of the Health Belief model and behavioral economics, focusses on non-monetary obstacles to care-seeking such as symbolic costs, cultural norms, and psychological barriers (Rosenstock, 1974; Janz & Becker, 1984; Dupas, 2011). For example, fear of supernatural harm ("evil eye") to mother and child often leads households to

[1] The neural tube closes by the 28th day of gestation. Therefore, consuming folic acid during this short window of early pregnancy can dramatically reduce neural tube defect from up to 85% (Czeizel, 2013; Bibbins-Domingo et al., 2017; Qu et al., 2019, da Fonseca, Raskin, and Zugaib, 2013). Consequently, WHO has recommended folic consumption prior to conception till the 12th week of gestation. A meta-analysis of almost 70,000 births in Africa shows that even one antenatal care (ANC) visit reduced the odds of LBW by almost half (Engdaw et al., 2023), while close to full compliance to ANC recommendations reduced pre-term birth by more than 15 times and reduced LWB by 40% in 50,000 births recorded in China (Wenling et al., 2024).

[2] The proportion of ANC utilization in S. Asia is about 67% and 86% institutional deliveries, with Bangladesh among the lowest with 47% ANC and 50% facility delivery.

[3] Comparable shortfalls are evident across much of sub-Saharan Africa, where recommended ANC coverage is 58% and fall below 20% in several rural districts (Lateef at al., 2024).

avoid early ANC visits and IFA supplementation (Rao and Waltson, 2004; Douglas, 1992).[4] Policy responses include group information sessions such as Ekjut in Jharkhand and mobile-based messaging MIRA in Nepal (Prost et al., 2014; Tripathy et al., 2010; Manandhar et al., 2004; Fatema & Lariscy, 2020). The third theoretical explanation models MCH delivery as a principal-agent problem. Weak supervision, modest incentives, and administrative burden raise frontline health workers' effective search costs and reduce outreach efforts to underserved households (Kruk et al., 2018). Recent interventions such as Nigeria's PBF and Tanzania's RBF have used incentive-alignment levers via performance-based financing contracts for village health workers that lowers the marginal cost of reaching households (Sato and Belel, 2021; Lamba, Friedman, and Kandpal, 2025).

Although MCH initiatives have targeted monetary, psychosocial, and provider-effort barriers, these strategies have not substantially altered the adoption incentives of households (Khan et al., 2021; Vidler et al., 2016). Persistent underutilization, therefore, indicates that while each of the three dominant frameworks explains a part of the adoption puzzle, none sufficiently accounts for why pregnant women and their families under-invest in maternal care when out-of-pocket costs are negligible. This gap suggests that more fundamental information and cultural constraints may shape health-seeking decisions within the healthcare ecosystem.

In this study, we revisit and integrate an information economics perspective, rooted in the Downsian tradition (Downs, 1957) with MCH program design. Specifically, we draw on the concepts of context informed rationality and rational ignorance to inform the design of a perinatal intervention- Joint Action for Sustainable Health and Nutrition (JASHN) in Jharkhand, India. A randomized field experiment was implemented in eight districts and 160 villages and we use the findings to assess the impact of contextually salient, time-sensitive information channels on women's health-seeking behavior, private action, and the effectiveness of frontline health workers in rural settings with poor access to information and resources.

Local systems of knowledge and practices shape perinatal beliefs and behaviors (Lukenheimer et al., 2021). For instance, in rural Jharkhand and similar settings, a significant proportion of households believe that disclosing woman's pregnancy exposes her to malevolent influences, such as the "evil eye", with potentially harmful consequences for pregnancy outcomes (USAID, 2009; Khan et al., 2021)[5]. Many pregnant women are not allowed to consume supplements like IFA and calcium because of the belief that these will make the baby "too big" for natural birth (Sedlander et al., 2020). Foods seen as "hot" such as eggs and lentils are also often avoided as they are believed to increase the risk of miscarriage (Prabhu, 2016). Consequently, families often refrain from informing health workers about pregnancies and delay or entirely forego care, even when these services are freely available. Such behavior while

[4] A significant 63% of women from rural Jharkhand in India believe that revealing one's pregnancy in early stages attracts evil eye (Ganguly, 2012)

[5] Similar beliefs have been reported in the communities inhabiting rural Maharashtra (Khan et al., 2021) and several regions in Bangladesh (Rahman et al., 2012).

appearing irrational to biomedical and technocratic perspectives can be best understood through the frameworks of context-informed rationality and non-pecuniary utility (Douglas, 1992). Here cultural norms and perceived social risks and not universal cost-benefit calculus, shape household preferences and constraints (Rao and Walton, 2004; Vlaev, 2018). When social and ethnic beliefs assign a high risk to disclosure, the non-disclosure becomes a strategic choice to maximize household welfare even if it means forgoing state-supported healthcare[6].

On the supply side, village health-workers such as ASHAs are expected to detect early pregnancies and facilitate care. Yet, administrative burdens such as data entry and compliance requirements absorb much of their limited time and institutional energy (Bhattacharyya et al., 2015). Consequently, ASHAs rationally prioritize paperwork over the difficult task of identifying hidden pregnancies among culturally reticent households. In Downsian terms, such limited outreach is not mere effort aversion, but a calculated response to incentive structures and high search costs, exemplifying rational ignorance when the expected benefit of searching falls below its cost (Acquisti and Grossklags, 2004; Nordström et al., 2023).

These frameworks and not global optimization justify seemingly suboptimal choices such as households withholding information, healthcare providers offering minimal search effort, to be strategic and informed responses to context. Integrating the concepts of context-informed rationality and rational ignorance, therefore, produces a more realistic, agent-sensitive understanding of persistent underutilization of public services, even where access is universal and incentivized. We suggest that MCH interventions should account for local culture, and opportunity costs, incentivize disclosure, minimize non-pecuniary risk, and reduce search costs, because such initiatives are more likely to succeed in raising healthcare utilization (Rao and Walton, 2004; Gigerenzer and Todd, 1999)[7].

We test this approach through a randomized field experiment that combines group-to-peer counselling with pregnancy mapping. The intervention leveraged existing shelf-help groups (SHGs) networks created under the National Rural Livelihoods Mission (NRLM) to identify pregnancies early and conduct counselling sessions with pregnant women and their families. Weekly SHG meetings provide intimate knowledge of members' lives, including menstrual patterns and early signs of pregnancy (Saggurti et al., 2018; Hazra et al., 2020). Through friendly probing and health guidance within a peer network, SHG members reframed social norms and

[6] This behavior reflects what scholars such as Rao and Walton (2004) call culturally embedded rationality. Here, the individual's utility function includes non-pecuniary costs, such as spiritual safety, social reputation, or preserving household autonomy. The standard economic models, which assume individuals, will opt for health services simply because they are subsidized or incentivized, do not sufficiently account for these embedded logics. In this context, even a substantial monetary incentive like the JSY transfer would not necessarily outweigh the culturally perceived costs of pregnancy disclosure.

[7] The recognition that cultural beliefs are not obstacles but capabilities of individuals and groups can enable redesigning incentives and engagement strategies based on what matters to the target population including trust, cultural beliefs, and autonomy (Rao and Walton, 2004). Doing so will render policy design more effective in addressing underutilization of MCH services.

reduced social and psychological costs facing expecting women. The program's emphasis on placing peer counselling sessions in the homes of pregnant women reduced social cost of service uptake and created a supportive and trustworthy environment that improved the credibility of health practices within the local context (Dasgupta and Bear, 2007)[8]. The intervention created an incentive-compatible loop: women felt comfortable disclosing pregnancies to peers rather than state agents, while the SHG "tip-offs" equipped ASHAs with timely information, thereby lowering their search cost for identifying hidden pregnancies. SHGs thus operated as local information aggregators, reducing information asymmetries and increasing accountability at the community level (Mansuri and Rao, 2013). The approach assisted the delivery of health services in ways that were culturally appropriate and aligned with the needs of rural women.

The results from the two-year JASHN field experiment demonstrate substantial and policy-relevant improvements in utilization of maternal and child health services, nutritional practices, and postnatal care, with effect sizes that in many cases exceed the national trends and are comparable to some of the most successful interventions documented in the literature. We report three main set of results.

First, the intervention improved early pregnancy registration in the first trimester by nearly 20-percentage-point, reaching 81%, substantially above the 70% reported in NFHS-5. The effect of the intervention on likelihood of completing four recommended antenatal care visits is positive and well exceeds the typical digital and community based health programs ((Endehabtu et al., 2023; Sharma et al., 2018). These gains translated into meaningful improvements in adherence to micronutrient supplementation, leading to increase in maternal hemoglobin levels and significant reduction in anemia. Beyond, antenatal care the program also improved entitlements access: uptake of JSY more than doubled from 12.5% in control areas.

Second, newborn care visits increased by 20.7-percentage-point, a 63% increase over control levels that compares favorably against national coverage gaps and experimental evidence that dedicated workers outperform multi-tasked frontline staff (Rasaily et al., 2020). While the program did not significantly shift LBW prevalence or child stunting, it eliminated almost all very LBW cases and reduced wasting among children under two by 24-percentage-point, an effect of critical magnitude given the persistence of acute malnutrition in Jharkhand.

Third, we identify private action by women and families and intensified outreach by frontline health workers as key mechanisms driving these outcomes. Pregnant women in intervention villages were substantially more likely to disclose their pregnancy to SHG members. They accessed their first ANC 0.6 months earlier, within the critical first trimester. Family support measured as a standardized index of participation and adherence, increased by 0.31 sd. ASHA workers in treatment villages are 23.5 pp more likely to approach pregnant women and conduct more counselling sessions (0.48 standard deviations more). Family attendance in these

[8] The program encouraged holding one SHG meeting each month in the homes of pregnant women which instead was utilized to provide peer counselling sessions in the presence of household members and important stakeholders.

counselling sessions is 26 pp higher in JASHN villages, reflecting significant improvement in outreach activities of the frontline health workers. Taken together, these findings underscore that integrating culturally embedded peer-counselling through SHG networks with formal health institutions can meaningfully reduce utilization gaps in critical services, entitlement uptake and nutritional outcomes. The estimates effect sizes exceed most contemporaneous national trends and comparable interventions, thereby highlighting the potential of scaling the JASHN intervention model in similar contexts.

Our study makes several contributions to the literature on MCH service utilization in low-resource settings. First, we develop and empirically test an information cost model that incorporates cultural norms as constraints in household decision-making. We recognize that non-monetary costs such as psychic costs are rooted in socio-cultural practices such as "evil eye", can delay the initiation of early care in rural communities (Mondal et al., 2023). We, therefore, integrated dual information subsidies into the household health-production framework. The findings show that reducing these non-pecuniary barriers resulted in higher optimal demand for MCH services. Notably, the intervention reduced the time to first antenatal care by 0.6 months, with treated women typically accessing care within the first trimester. This improvement is critical as early antenatal care facilitates screening and prevention (Mondal et al., 2023), yet this indicator remains insufficiently studied in the literature. This also aligns with the broader evidence that information gaps and cultural barriers are major impediments to accessing care in developmental settings (Saha, Annear, and Pathak, 2013).

Second, while prior interventions target either supply-side improvements such as upgrading health facilities and training of frontline workers, or strengthen agency via cash incentives, community mobilization and information initiatives (Mangham-Jefferies et al., 2014), our approach uniquely addresses both simultaneously. We emphasize that even when clinics and cash incentives are available (Lim et al., 2010), women and their families may not increase their utilization of MCH services without culturally embedded information channels or if ASHAs face high search cost (Sharma, Webster, and Bhattacharya, 2014). Our approach is to provide targeted information to women through group-to-peer counselling and to village health workers through timely pregnancy alerts, thereby improving access and easing identification and outreach. Notably, the intervention reduced the time to first antenatal care by 0.6 months, with treated women typically accessing care within the first trimester. This improvement is critical as early antenatal care facilitates screening and prevention (Mondal et al., 2023), yet this indicator remains insufficiently studied in the literature.

Third, we contribute to literature on peer-counselling initiatives that have emerged as a low-cost, scalable strategy for improving health behaviors such as breastfeeding and infant care (Chola et al., 2015; Lewycka et al., 2013; Kushwaha et al., 2014; Haque et al., 2023). While traditional peer-counselling emphasizes shared experience and trust (Simmons et al., 2023; Lessard et al., 2024), its effectiveness has often been limited by role ambiguity and variable support for counselors (Gaiser et al., 2021; Topping, 2022). Our contribution lies in developing a structured, group-based implementation model that integrates SHGs and an information economics perspective. The model explicitly identifies the dual role of information: reducing psychic costs (fear, stigma) and lowering search costs for frontline health workers, thus facilitating outreach. A key innovation is relocating SHG meetings to pregnant women's homes to encourage participation of influential family members, thereby reframing individual counselling as community-supported dialogue. This collective approach distributes psychic costs and mobilizes family support to access care.

Finally, this study builds upon Down's (1957) influential reframing of voter behavior, which shifted scholarly inquiry from the paradox of why people do not vote to why do vote (Riker and Ordeshook, 1970). We extend the Down's rational calculus to reposition the challenge of MCH service utilization in resource and information constrained settings from the conventional question- why don't women seek care, to an inquiry into why some women do access these services despite significant socio-cultural barriers. This shift aligns with Downsian theoretical reasoning that emphasizes motivation for participation rather than abstention. Building on this perspective, we conceptualize pregnant women's decisions to exhibit context-informed rationality, that is, their decision to access health services are shaped by cultural norms, psychic costs, and available social information. The intervention leverages this insight by integrating culturally sensitive peer-counselling and friendly probing within SHG framework. Concurrently, we engage with the street-level bureaucracy literature (Lipsky, 1980) to interpret the behavior of frontline health workers. For instance, ASHAs choose to exert sub-optimal level of effort in identifying pregnant women given convex search costs. The SLB literature interprets this behavior of health workers to be opportunistic. We, instead, invoke the Downsian notion of rational ignorance to suggest that when search cost is high then under weak supervision, modest incentives, and high administrative burden, ASHA's decision to reduce outreach efforts is strategic and not necessarily opportunistic.

2. Experimental Design and Intervention

2.1 Institutional Background

India's policy framework for maternal and child health is anchored by the National Health Mission (NHM) and Integrated Child Development Services (ICDS). The NHM, launched in 2005 targets accessible, affordable healthcare with an emphasis on vulnerable households (Ministry of Health and Family Welfare, 2020). At the community level, Accreditated Social Health Activities (ASHAs) are locally recruited female healthworkers per 1000 individuals, who serve as the primary interface between the households and the public health system for delivering core services in MCH, immunization, nutrition counselling, and contraception. ASHAs collaborate with Anganwadi workers (AWWs) under ICDS, particularly during Village Health and Sanitation Days (VHSNDs) to provide preventive and promotive care. Despite this infrastructure, Jharkhand continues to report among India's lowest levels of MCH service utilization and on several MCH indicators its performance is comparable to sub-Saharan areas.

While pregnancy registration in Jharkhand is nearly complete (90.2%), timely uptake of prenatal care lags- one-third of pregnant women do not access first ANC in their first trimester indicating reluctance to disclose pregnancy, and just 36% complete four ANC visits which is well below the rural Indian average. IFA supplementation remains limited with high prevalence of anemia. Institutional delivery rates despite financial incentives under Janani Suraksha Yojana. This shortfall leaves many births unattended by skilled personnel which is a high risk factor for early neonatal mortality (Verma and Cleland, 2022; Dixit et al., 2023). Postnatal care and breastfeeding support are also insufficient, indicated by low rates of early initiation of breastfeeding (21.3% vs. 40.7% nationally). See Appendix 1 to compare Jharkhand viz-a-vis national trends.

Furthermore, Jharkhand's demographic composition, characterized by substantial Schedule Tribe population constituting 26.2% of its 33 million residents who live predominantly in villages, creates a unique cultural context that shapes maternal health behaviors and service utilization. Traditional beliefs and practices deeply inform pregnancy and childbirth care decisions. Studies show that early pregnancy disclosure is often delayed due to fears of black magic and evil spells (Khan et al., 2021), while other local customs tied to celestial events and animals restrict the movement of women outside their household during early phases of pregnancy (Legare et al., 2020). In addition, strong preferences for traditional birth attendants, home deliveries, and practices like delayed newborn care and early bathing increase health risks for infants (Iyengar et al., 2008). Such ingrained norms and spiritual cost of accessing care contribute to households' downward revision of the perceived value of MCH services in rural areas and helps explain Jharkhand's persistent lag in maternal and child health outcomes despite extensive health infrastructure and widespread pregnancy registration. Concurrently ASHAs face heavy workloads and time pressures, especially as their responsibilities expand with population coverage (Kawade et al., 2021; Manjunath et al., 2022). The incentive structure further incentivizes activities that are financially rewarded and are measurable - such as institutional deliveries and ANC registrations. While more labor-intensive, trust-based counselling is neglected (Saprii et al., 2015). These challenges constrain the ability of village health workers to foster sustained and trust-based engagement necessary to shift MCH behaviors in rural Jharkhand.

Persistent MCH challenges highlight barriers beyond conventional health infrastructure. Addressing such gaps requires leveraging community-based platforms capable of endogenizing cultural context and promoting behavior change and utilization of MCH services. In this context, the National Rural Livelihood Mission (NRLM), launched in 2011, has emerged as a critical institutional innovation by organizing over 100 million rural women of similar socio-economic histories into self-help groups (SHGs). These groups not only provide financial inclusion and collective economic support but also offer promising avenues for integrating health and nutrition interventions. SHGs in Jharkhand reach predominantly marginalized communities, including a majority from SC/ST backgrounds. Empirical evidence links SHG presence to improved health behaviors including greater institutional delivery, and awareness of ANC services (Saha et al., 2013; Sethi et al., 2017; Irani et al., 2021). Recognizing this potential, NRLM's "Dasa Sutra" now integrates Food, Nutrition, Health, and WASH (FNHW) interventions. Through regular meetings and collaboration with frontline workers, SHGs are attempting to promote behavior change and facilitate access to entitlements, especially during the first 1000 days window. However, SHG involvements in health services remains inconsistent due to limited connect with the health staff and technical training. Building on these foundations, there remains a need for systematic interventions that can bridge the disconnect between NRLM's community mobilization strength and NHM's technical health expertise, while addressing the capacity constraints faced by overburdened ASHAs and moving beyond the ad-hoc engagement that has characterized previous SHG health initiatives.

2.2 Intervention Design

The Joint Action for Sustainable Health and Nutrition (JASHN) is a state-led convergence intervention designed to leverage the social capital of women's SHGs to improve maternal and child health outcomes in rural Jharkhand. Launched in 2022, JASHN is implemented across 31 blocks in 14 districts, targeting approximately 320,000 households at an average cost ₹243 (≈USD 3) per household. Intervention sites were selected based on high prevalence of under-nutrition, anaemia, and adverse health indicators. This study evaluates JASHN through a randomized field experiment in 16 blocks spanning 8 districts covering 160 villages. The results are intended to inform programmatic scale-up, both within Jharkhand and in comparable contexts.

The intervention introduces three primary innovations. First, it operationalizes friendly probing as a group-to-peer counselling strategy, shifting beyond standardized health messaging by promoting reflective engagement and discussion of health services in SHGs. Second, it establishes a dedicated cadre, the "Setu Didi", tasked with providing technical support and serving as a liaison between the NRLM and NHM platforms. Finally, by holding counselling sessions cum regular SHG meeting, monthly in the courtyard of focal women, the intervention ensures the direct participation of key household decision-makers in health discussions, including spouses, and parents-in-law as they influence women's care-seeking behavior.

The intervention leverages weekly SHG meetings as a platform for early pregnancy detection and health counselling. Therefore, SHG members naturally become aware of changes in peer's health status- such as missed periods or early pregnancy symptoms. SHG members are embedded within community networks. The social proximity enables them to proactively encourage timely pregnancy registration at village healthcare centres, and antenatal care uptake, thereby increasing the likelihood of compliance with health advisories in the perinatal phase. Central to JASHN's structure is the 'Setu Didi' cadre, drawn from local SHG ranks. Each Setu Didi is responsible for 6-8 villages and receives intensive training, including a six-day residential program and quarterly refreshers, covering technical material on maternal and child health, nutrition, and WASH. Equipped with behavior change communication (BCC) tools such as flip charts, pictorial aids, and digital resources like PICO projectors, Setu Didis provide technical support and facilitate community-level counselling.

Setu Didis serve multiple critical functions as a primary organizing agent and community trainer. Their initial task is to initiate participatory community action through the Triggering Plan for Community Action (TPCA). TPCA engages Village Organizations (VOs), SHGs, and key local influencers, including PRI members, teachers, religious leaders, and frontline health workers, to collectively assess the extant status of health, nutrition, and WASH services within their villages. This participatory mapping identifies vulnerable households and local challenges to service uptake (TPCA maps are presented in Appendix 2). By encouraging communities to articulate their own constraints and priorities, the process generates demand for maternal and child health services while enhancing accountability. Setu Didis have access to the ANM's pregnancy register and shares data with SHGs to ensure all pregnancies are tracked for service delivery. She holds regular meetings with ASHA, ANM, and Anganwadi workers to identify service gaps and absenteeism during VHSND and resolve them collaboratively. Quarterly review meetings at cluster and district levels, involving VO leaders, PRI members, frontline health workers, and Setu Didis serve the dual purpose of accountability and peer-learning.

Following TPCA initiation and finalization, Setu Didis train SHGs on ANC adherence, breastfeeding practices, dietary diversity, kitchen gardens, and available healthcare entitlements and services. Each month, Setu Didis visit 20–30 households to ensure adherence to ANC schedules and service delivery. Upon identifying a pregnant woman, SHG members conduct group-to-peer counselling sessions at woman's home, ensuring that husband, mother-in-law, and other household decision-makers are present. These sessions are initially co-facilitated by Setu Didis to model effective counselling practices. Later trained SHG members lead discussions independently, while Setu Didi continues to provide periodic mentorship and quality oversight to support sustained community engagement and uptake of health services.

During group-to-peer counselling sessions, SHG members combine friendly probing with trust-building strategies, notably, cultural humility, to facilitate open, reflective dialogue, and learning (Gille, Daniore, and Zavattaro, 2024; Correia, 2024). Gentle probing approach induces SHG members to ask non-threatening questions, culturally sensitive questions, steering clear of prescriptive advice. This approach allows focal women and families to reflect on missed opportunities for care, such as delayed ANC check-ups or pregnancy registration during previous pregnancy in the household. Friendly probing in a friendly setting often helps surface underlying barriers, including misconceptions about routine care or transportation constraints. Through reassurance and practical assistance, the counselling process motivates proactive engagement frontline health workers and uptake of essential health services and entitlements.

Peer-counselling for women and information tip-off to ASHAs concerning pregnant women in the village facilitates timely access to care and reduces ASHA's search cost and effort in identifying and assisting pregnant women, who might otherwise be overlooked. SHG members also monitor Mother-and-Child Protection (MCP) cards to ensure receipt of entitlements- JSY, PMVY, and JSSK. Ultimately, group-to-peer counselling subtly shifts household attitudes from hesitation to active engagement with frontline services and government health platforms.

2.3 Conceptual Framework

JASHN leverages the social capital of women's SHGs and dedicated community facilitators (Setu Didi) to promote early identification of pregnancy, improve health knowledge and encourage reflective engagement with maternal health services. Through culturally sensitive group-to-peer counselling sessions and direct involvement of key household decision-makers and regular peer monitoring, the intervention encourages timely uptake of health services and access to entitlements. The information subsidy to frontline health workers reduces their search cost which further improves utilization of perinatal services. This theory of change underpins the conceptual framework that explains the alignment of institutional mechanisms with household decision-making.

We formalize the uptake of perinatal services (via an example of ANC care) as the household's optimal response to perceived benefits and costs of compliance with health advisories, incorporating cultural beliefs and coordination between community health workers and households. A representative woman's household chooses the intensity of ANC utilization $x \geq 0$ to maximize household utility, with preferences over consumption of composite goods (c) and health (h), and facing cultural (fear) costs (ϕ) of seeking care:

$$U(c, h, x; T_v) = \frac{1-\sigma}{1-\alpha} c^{1-\alpha} + \frac{\sigma}{1-\alpha} h^{1-\alpha} - \phi T_v x \quad (1)$$

where $\sigma \in (0,1)$ is the weight on health versus other goods; $\alpha \in (0,1)$ is the constant relative risk-aversion (CRRA) parameter; T_v is the treatment indicators (1 if exposed to JASHN; 0 otherwise); and ϕT_v is the per visit (non-pecuniary) costs owing to local beliefs such as "evil eye" taboos. The household faces a budget constraint $c = y - p_v x$ and produces health via: $h(x;\ T_v) = \left(h_0 + \theta_{T_v} x^{\eta}\right),\ \ 0 < \eta < 1$; where h_0 is baseline health with zero intensity of ANC; η exhibits the diminishing returns to ANC, and θ_{T_v} is the perceived effectiveness care in JASHN villages, which the intervention is designed to increase.

The woman's optimal ANC usage is:

$$x^*_{T_v} = \left[\frac{\sigma \eta \theta_{T_v}}{\phi T_v + (1-\sigma) p_v y^{-\alpha}}\right]^{\frac{1}{1-\eta(1+\alpha)}} \quad (2)$$

ANC use is thus increasing in household's health valuation and the perceived effectiveness of care (σ, θ_{T_v}), and decreasing in cost-related parameters (ϕ, p_v). The local beliefs and information frictions can dampen the perceived benefit of ANC (θ) and inflate the cultural cost (ϕ). The intervention operates by lowering down the cultural fear costs (for example, by reframing the evil-eye concerns) and raising θ via group-based peer-counselling information sessions.

Service access also depends on whether health workers including ASHAs discover pregnant women in the community. The discovery probability is:

$q(e;\, \kappa) = 1 - e^{-\,\kappa(e+\delta)}\,, \quad 0 < q < 1 \qquad (3)$

where e is effort of health worker, κ is search efficiency, $\delta > 0$ is an information boost from SHG "tip-off" (for $T_v = 1$). Hence δ is zero in non-JASHN villages. The health worker chooses effort to maximize their returns minus effort (search) cost, with optimal effort e^*. With intervention, both the probability of discovery and the household's perceived return to perinatal care improve, thereby jointly amplifying ANC uptake:

$$x^*_{T_v} = \left[\frac{\sigma\eta\theta_0 q^*_{T_v}}{\phi T_v + (1-\sigma)p_v y^{-\alpha}}\right]^{\frac{1}{1-\eta(1+\alpha)}} \qquad (4)$$

Where the equilibrium probability of discovery ($q^*_{T_v}$) is increasing function of information subsidy δ and a decreasing function of search cost γ. The conceptual framework suggests that health worker's search cost will be higher in control areas resulting in lower probability of pregnancy discovery q^*_0. Consequently the effective benefit value ($\theta_0 q^*_0$) will be lower in non-intervention areas. Thus, households will rationally choose a lower utilization level of ANC services (x^*_0 is low). Conversely, reduction in search cost will incentivize health workers in the JASHN villages to improve q^*. When we combine demand-side shifts ($\theta \uparrow, \phi \downarrow$) with the supply-side mechanisms ($q^* \uparrow$ through $\delta \uparrow$ and $\gamma \downarrow$), the ANC utilization in JASHN villages will be strictly greater compared to control group villages: $x^*_{JASHN} > x^*_{Control}$. In the randomized field experiment setting, the average difference $\Delta x^* = x^*_1 - x^*_0$ is the structural effect of JASHN on ANC uptake. Please see Appendix 3 for a complete presentation of the model.

2.4 Sample, Randomization, and Take-Up

2.4.1 Study Sample and Power

The JASHN intervention was rolled out in 2022 across 14 districts of Jharkhand, while the field experiment was conducted in 160 villages from 8 districts[9]. The endline survey was conducted in early 2024 (refer to Figure 1 for surveys and intervention timeline). The intervention geography is predominantly rural and represents tribal-dominated regions of Jharkhand that exhibit low levels of economic development. Within the sampled villages, we conducted a census of all currently pregnant women and lactating mothers (defined as women with at least one child aged two years or younger). The final sample was comprised of 806 pregnant women and 2,674 lactating mothers. Eligible women were asked questions related to their current or recent

[9] The districts are: Chatra, Koderma, Giridih, Godda, Palamu, Dumka, West Singhbhum, and Saraikela-Kharsawa

pregnancy, antenatal practices, and postnatal practices. Anthropometric information was gathered for 2,874 children aged two years or younger.

[Insert Figure 1]

We computed ex-ante minimum detectable effects (MDEs) for primary outcomes at 5% significance level and 80% power, adjusting for village-level clustering and varying cluster sizes. The study is powered to detect small effects of 0.25-0.39 standard deviations across key indicators including antenatal care visits, ANC services received institutional delivery rates, Anganwadi service awareness, and pregnancy-related health worker visits. These MDEs confirm that the sample size and clustering structure can reliably identify relevant differences between treatment and control groups.

[Insert Figure 2]

2.4.2 Block Randomization

We conducted a block random assignment, where 160 villages were randomly assigned to either treatment or control group within each of the experimental blocks. The blocks were defined by: (i) district affiliation (eight districts), and (ii) quartiles based on principal component scores calculated from baseline village characteristics (four quartiles). Village-level indicators for the principal component included village population, proportion of households below the poverty line, SHG count, and health worker density- representing social infrastructure, economic constraints, and institutional capacity expected to influence JASHN implementation and outcomes. SHG density, for example shapes the scalability of group based counselling, while baseline frontline health worker capacity can affect the effectiveness of service delivery targeting pregnant and lactating women. Cross-classifying districts and PCA-based quartiles initially yielded 32 blocks (8 × 4). However, not all combinations were represented, as two districts lacked villages in the first quartile and one district had none in the fourth, resulting in 29 final strata.

[Insert Figure 3]

2.4.3 Sample Balance and Descriptive Results

Table 1 provides balance checks on a set of village-level baseline variables. It also provides the context for the type of villages, citizens, and their relationship with the health system. The sample is well balanced across treatment and control groups for nearly all demographic, infrastructural, and geographic variables, including drought-prone status, population size, sex ratio, and caste composition. Indicators of infrastructure also show similar distributions, such as household access to functional toilets, electricity, and other basic amenities. Health facilitiy availability is comparable across groups, including health sub-centers, private clinics, medical shops, health worker density, and related amenities. The remoteness index- constructed from distances and travel times to nearest facilities, is balanced between groups. ASHA worker characteristics (age, education, health sector experience, and SHG membership) as well as patterns of service delivery and engagement in health activities show no notable differences between JASHN and non-intervention villages. Utilization of maternal health services and related awareness measures, such as pregnancy registration, institutional delivery rates, Anganwadi services, and consumption patterns, are likewise balanced. Pre-treatment outcomes, including perinatal service utilization and child anthropometry do not differe across groups. A few exceptions remain: treatment villages are more likely to have a primary healthcare center (15% vs. 3%; *p*- value = 0.005). SHG participation is higher in the control group (32% vs. 24%; *p*-value = 0.085). These unbalanced variables are controlled in all main analysis. Overall, we fail to reject the joint orthogonality of baseline characteristics (*p*-value = 0.28), confirming joint covariate balance between the groups.

[Insert Table 1]

The average woman in our sample is 24 years old with seven years of schooling; 24% received no formal education and 90% identify as housewives. Women have an average of 1.8 children: 37% per woman. First-time mothers constitute 37% of the sample and the average number of completed pregnancy months was 5.5 at the time of the survey. Average child age is 11 months and 47% are female.

The baseline reflects the resource and information scarcity typical of rural India. Only 17% of villages had health sub-centers, fewer than 10% had primary health centers, and over two-thirds lacked any formal health facility. Human resources are similarly limited: there are fewer than one health worker per 100 people. ASHA workers are the primary health resource that are present in 94% of villages; Anganwadi workers (91%) and ANM (61%) workers are less common, and trained doctors serve only 43%. Notably, 32% of women received no NHM health worker visits during pregnancy. Information gaps compounded these deficits as 43% of women are unaware of government health schemes at baseline. While 72% knew of IFA and calcium supplements, awareness drops below 40% for services like hemoglobin testing, blood pressure monitoring, or abdominal exams. Women are aware of only 5 of 9 Anganwadi services. Despite national focus on institutional delivery, 25% of births occur outside health facilities. Only 57% received the full quota of IFA tablets, while ANC counselling is also suboptimal as only 59% received advice about danger signs or appropriate care-seeking. Health service utilization shows moderate engagement as women completed an average of 3.4 ANC visits (conditioned on at least one ANC visit). The baseline findings underscore the resource and information barriers facing perinatal health interventions in rural India and therefore, it justifies the JASHN intervention's focus on testing whether context-driven group-to-peer counselling via SHG-ASHA networks can address lack of adoption of perinatal services in resource- and culturally- challenging settings.

3. Measuring Impacts

3.1 Data and Survey

Following the two-year JASHN intervention, an endline census survey was conducted in March-April 2024, covering all currently pregnant women and lactating mothers (defined as women with at least one child aged two years or younger) in the study villages. The survey collected detailed information on household characteristics, pregnancy, childbirth experiences, and prenatal care pregnant and lactating women, and post-natal experiences from lactating mothers. Anthropometric measurements were collected for all children aged two years or younger within eligible households to assess child nutritional status. The census surveyed 3,443 women from 3,359 households, including 796 pregnant and 2,647 lactating women, with anthropometric data collected for 2,874 children from the same households.

3.2 Measurement of Main Outcomes

3.2.1 Women level outcomes:

A number of women level outcome indicators capturing maternal health and healthcare utilization were measured in this study. Consumption of iron-folic acid and calcium tablets was recorded using six categorical groups (0-30, 30-60, 60-90, 90-120, 120-150, and more than 150), showing total supplement intake during pregnancy. Awareness and usage of government maternity benefit schemes- Janani Suraksha Yojana (JSY) and Matritva Vandana Yojana (MVY), were measured with binary indicators reflecting both knowledge and receipt of benefits. Healthcare utilization was assessed via Antenatal Service Index, defined as the proportion of 24 recommended ANC services accessed by pregnant women. Two composite indices were constructed for broader maternal health seeking behavior assessment. The ANC Access Index was calculated as the standardized sum of variables related to timing of pregnancy registration, initiation of ANC in first-trimester, receipt of MCP card, utilization of ANC and AWC services, contact with the healthcare worker, and utilization of government schemes. Similarly, a Compliance Index was constructed as the standardized sum of nine key behaviors and services, including micronutrient supplementation adherence, institutional delivery, health worker interactions, pregnancy registration, and completion of mandatory number of ANC visits.

3.2.2 Child level outcomes:

Child-level outcomes included anthropometric indicators- weight-for-age (WAZ), height-for-age (HAZ), and weight-for-height (WHZ) z-scores, calculated according to World Health Organization (WHO) standardized formulas that adjust for child age and gender. These z-scores are used to classify nutrition status with standard cutoffs: underweight (WAZ < -2 SD), stunting (HAZ < -2 SD), and wasting (WHZ < -2 SD). For full detail on all covariates, outcome variables, and variables used in machine learning specification, please see Appendix 5.

3.3 Estimating Impacts

We estimate the intention-to-treat effect of being offered the JASHN treatment through the following specification for woman i in village v during the end-line survey:

$$Y_{i,v} = \beta_0 + \beta_1 Treat_v + \pi Y_{v,baseline} + \sum_{k=1}^{K} \gamma_k X_{kv} + \sum_{s=1}^{4} \theta_s 1(i \epsilon s) + u_{iv} \quad (5)$$

where $Y_{i,v}$ is the outcome variable of interest measured at endline; $Treat_v$ is an indicator variable that takes the value 1 if village v is randomly assigned to the JASHN treatment; $Y_{v,baseline}$ represents the village-level baseline value of the outcome variable (where available); X_{kv} is the vector of observables that were unbalanced post randomization and include proportion of households that are SHG members, ASHA's experience in years, and whether the village has a primary healthcare center. $1(i \epsilon s)$ represents experimental strata dummies; and u_i is the error term.

4. Results

We first report first stage results on treatment receipt and then we present findings on the uptake of prenatal and postnatal care, followed by robustness checks and heterogeneous effects. Finally, we explore two sets of potential mechanisms.

4.1 Treatment Receipt

Policymakers have expanded the mandate of SHGs under NRLM's 'Dasa Sutra' startegy to include food, nutrition, health and WASH interventions, integrating behavior change communication and entitlement access into SHG activities (World Bank, 2020). However, implementation gaps remain due to SHG members' limited technical knowledge and weak linkages with frontline health workers. The JASHN intervention is designed to bridge NRLM's community mobilization capacity with NHM's technical expertise. Given SHG's pre-existing roles in health behaviors, the first question is: did the intervention lead to greater SHG support for households?

The regression results are in Table 2. Col. 2 indicates a 22.9-percentage-point increase in the likelihood that a household in the treatment village received some form of SHG support compared to a control group mean of 30.3% (a relative increase of 76.3%). The coefficients are not sensitive to inclusion of covariates (Col. 1). Col. 3 reports findings for the SHG support index which indicates the receipt of the proportion of SHG services (out of 8) by the household. The coefficient suggests that compared to control group mean of 12%, there is a 14.5-percentage-point increase in SHG index in the intervention arms (a relative increase of 121%). All the results are statistically significant.

[Insert Table 2 here]

In Appendix 4, we report findings from the individual components of the SHG support, for example, help in approaching ASHA worker, SHGs encouraged me to take medications and good quality food during pregnancy, help with potential places of delivery, etc. These results establish that the SHG support to households is significantly higher in JASHN villages, next we examine the impact of the intervention on utilization of perinatal services and health and nutrition status of mother and the child.

4.2 Intervention Effect on Uptake of Prenatal Health Services

Results from the two-year long JASHN intervention provide evidence on its effectiveness across several indicators of uptake of MCH services. The estimates show that the intervention improved both early engagements with health services as well as adherence to recommended protocols among the women in treated villages. Four sets of findings emerge from Table 3:

First, the probability of registering a pregnancy increased by 5.3-percentage-point, however, this effect is statistically insignificant given near-universal coverage in the non-JASHN areas (Col. 1). More significantly, the registration in the first trimester, a critical indicator of timely care, is 19.8-percentage-point higher in the intervention villages (Col. 2; p-value < 0.001). The 32.4% improvement over the first trimester registration of 61% in the control areas is particularly noteworthy when benchmarked against national trends: the first trimester registrations increased nationally from 59% during NHFS-4 to 70% during NFHS-5 (Tripathi, Pathak, and Lahariya, 2023). Therefore, the intervention achieved 81% registrations in the first trimester, which substantially exceeded the national average of 70%. These findings suggest that the intervention not only expanded the overall coverage but also encouraged earlier interaction with the health system during the most crucial phase of pregnancy which is particularly challenging to influence (Nihal and Shekhar, 2024).

[Insert Table 3 here]

Second, the intervention enhanced both the adequacy and frequency of antenatal care. Among the group of later stage pregnant women (more than seven months) and newly lactating mothers (less than three months), the average count of ANC visits increased by 0.68 sd (Col. 3), and the likelihood of meeting the mandatory ANC visit threshold of four improved by 37.6-percentage-point (Col. 4). Given the control group means of 3.89 ANC visits and 52% likelihood of meeting the mandatory ANC visits, the intervention effect corresponds to 43.5% increase in the number of ANC visits and 72.31% increase in the likelihood of meeting the mandatory ANC visit recommendation. For context, most digital health interventions reported 15-30% increase in ANC attendance (Endehabtu et al., 2023), while community-based interventions achieved 10-20% improvements. Therefore, an increase of 72.31% in the likelihood of meeting the mandatory visit threshold compares to some of the most successful interventions reported in the literature such as 70% improvement in ANC uptake in targeted community health worker programs (Sharma et al., 2018). Therefore, the intervention influenced the frequency as well as the completeness of recommended ANC check-up. See Appendix 6 for the effect on individual ANC services (24 in number).

Third, the impact of the intervention on the consumption of IFA and calcium supplements is positive. In the control group, 31-percentage-point of women consumed their full quota of IFA and calcium tablets (i.e., >100 tablets each), while the likelihood of completing the full course in the treated villages is higher by 14.1-percentage-point (*p*-value<0.05, Col. 6). The impact estimates on micronutrient supplements are similar to the effects reported in the literature which generally are in the range of 10-15-percentage-point (Tripathi, Pathak, and Lahariya, 2023). In terms of absolute consumption, the mean value of IFA supplementation in control areas is 2.56 points that corresponds to consumption in the range of 30-60 tablets. The estimates show that the intervention led to a 0.421 points increase in IFA consumption which is equivalent to 60-90 tablets and the findings are statistically significant. Similar findings emerge in the case of calcium supplementation (Appendix 7).

Fourth, there is some suggestive evidence that shows that the intervention achieved a 1.811 g/dL increase in hemoglobin levels (Appendix 7), representing an 18.3% improvement over the control mean of 9.90 g/dL[10]. The substantial gain in hemoglobin levels translated into significant reductions in moderate anemia (68.7%) and mild anemia (57.2%)[11]. We argue that the positive impact of the intervention on hemoglobin levels and anemia status of pregnant women is due to increased utilization of IFA supplements. This connection also aligns with established physiological pathways: IFA supplementation increases hemoglobin levels by addressing iron deficiency and anemia, with each additional month of IFA intake typically associated with 0.3-0.5 g/dL increase in hemoglobin (Anato and Reshid, 2025).

Finally, Setu and SHG women members in the intervention villages worked with pregnant women and village health institutions to enhance awareness of and access to entitlement schemes such as JSY and MVY. The interviewers obtained access information from the MCP card of currently pregnant women in the survey areas. The control group mean of 14.5-percentage-point suggests a particularly underserved population in the intervention area. The treatment effect reported in Col. 7 shows that the intervention improved the awareness and access to JSY by 15.2-percentage-point. The 105% increase in JSY access is particularly striking as the recent studies have reported JSY uptake ranging from 25-87% (Dangi et al., 2024). The more than doubling of the JSY uptake indicates that the intervention's effectiveness in linking women to financial entitlements is a concomitant outcome of connecting them to the village health eco-system.

[10] The impact on hemoglobin count is not causal because this information was obtained from the MCP cards shared by focal women during the survey. Given that MCP information is available only for 266 women, we cannot rule out systematic information attrition.
[11] The overall anemia prevalence is lower by 11.4%, while the estimate is not statistically significant.

These findings contribute to the growing literature on information-based interventions in health service delivery. The magnitude of the effects reported in Table 1, particularly for early pregnancy registration, utilization of ANC, and uptake of benefits, suggests that integrating cultural and informational attributes of the intervention areas with the public health service delivery system can yield substantial outcomes. The outcomes of the intervention exceeded most national trends and available evidence on effect sizes from comparable interventions while operating with existing health systems. Thus, JASHN has important implications for scaling effective MCH interventions in similar contexts.

4.2 Institutional Births and Utilization of Postnatal Services and

The strategic decision to link SHG members with village health workers as part of the two-year field experiment demonstrates substantial improvements in institutional births, newborn care (NBC) utilization, and comprehensive access to postnatal care (PNC) services, with particularly strong impacts among women who received any NBC services. Following results emerge from Table 4:

First, the intervention improved the count of institutional births by 16.1-percentage-points (Col. 1). Compared to the control group mean of 78%, it seems that 95% of the deliveries took place in institutional facilities.

Second, the control group's 32% NBC coverage is notably below national benchmarks. According to NFHS-5, 82% of newborns received postnatal check-up within two days of the delivery, compared to just 27% in NFHS-4. The control group's low coverage can be due to: (a) significant implementation gaps in rural Jharkhand compared to national protocols and (b) the national figures include facility-based NBC, while our study focused specifically on home-based NBC visits by community health workers.

[Insert Table 4 here]

Third, the intervention increased the likelihood of receiving NBC visits by 20.7-percentage-point (Col. 2), representing a 63.4% improvement over the control mean of 32%. Among the women who received any NBC visits, the intervention boosted the number of visits by 0.394 standard deviations (Col. 3), a 24% gain over the control group mean of two visits. Similarly, the impact of the intervention on number of NBC visits (unconditional) is 0.485 standard deviations, which is 85% improvement compared to the control group mean of 0.69 NBC visits (see Col. 4).

Fourth, the impact on NBC service index, measuring the proportion of recommended NBC services received (out of 6) rose by 13.6-percentage-point (Col. 6) compared to the control group mean of 32%. We also analysed the receipt of 6 NBC services at the disaggregated level (see Appendix 8). The estimates show that the exposure to the treatment has a positive impact on the access of all 6 NBC services, ranging from a 7.5-percentage-point increase in measuring the child's height to a 16-percentage-point increase in measuring chest circumference.

Fifth, the intervention significantly improved the post-delivery healthcare access index by 44.3% of a standard deviation and statistically significant (p < 0.01; Col. 7). This composite measure is based on 12 choices concerning healthcare access in the post-delivery phase. The index is prepared by standardizing the aggregates of the proportion of PNC and NBC services and advisories received and the standardized scores of NBC and PNC visits. The healthcare access index is unconditioned, and therefore, we include dummy variables to indicate whether women received at least one of such advisories and services.

Lastly, the findings concerning the utilization of postnatal services resonates with evidence from recent RCTs that suggest that dedicated workers achieve better outcomes than adding responsibilities to the existing staff, which potentially explains the intervention's success in leveraging SHG-peer networks rather than solely relying on ASHA and AWW capacity (Rasaily et al., 2020). However, the finding that even in treatment villages, only 53% of women received NBC visits (compared to 32% in control areas) highlights persistent implementation challenges that are critical in nature because NBC coverage is one of the primary factors determining neonatal health and mortality (Gogia et al., 2011).

4.3 Birth Weight and Nutrition Status

The intervention showed mixed effects on birth outcomes and child nutrition status. The treatment demonstrated directionally favourable but statistically non-significant effects on low birth weight. While the intervention did not influence the likelihood of LBW, it could almost entirely remove the probability of observing very low birth weight outcomes in the treatment villages. Compared to the control group mean likelihood of 6% for a very LBW outcome, the treatment reduced this probability by 7.9-percentage-point (p-value<0.10), an improvement of 131%. The persistence of LBW reflects on broader structural factors that are identified in the literature and include maternal anthropometric status and inadequate antenatal care (Jana, 2023).

There is ample evidence of positive links between early care of pregnant woman and nutrition status of their young children (Hamel et al., 2015; Kuhnt & Vollmer, 2017). Therefore, we expect the intervention to influence the nutrition status of children. The endline survey recorded the anthropometric details of children less than 24 months. Table 5 shows that 38 percent, 22 percent, and 37 percent of children in the control group villages are identified to be underweight, stunted, and wasted, respectively. While, the intervention has no effect on the underweight and stunting status of children, it reduced the likelihood of child wasting by 23.6-percentage-point in the intervention villages (p < 0.01). See Appendix 9 for the impact on nutrition z-scores for children.

[Insert Table 5 here]

4.4 Robustness

We conduct several robustness tests to verify the sensitivity of our results. First, applying post-double selection lasso to select controls, we continue to observe statistically significant treatment effects for treatment receipt, first trimester pregnancy registration, ANC visits, supplementation, post-natal care, and child wasting status, though estimate precision does not notably improve (Appendix 10). Second, to determine whether the intervention's effects are broad-based improvements in MCH service utilization or isolated gains, we construct three standardized composite indices. The awareness index aggregates woman's knowledge across ANC services (24 items), Anganwadi services (11 items), and government schemes (JSY, MVY). The index is computed by aggregating these dimensions and standardizing to a z-score. The ANC access index combines timing and initiation of pregnancy registration, timing and initiation of ANC visits, receipt of MCP card, completion of four ANC visits, and uptake of JSY and MVY. The overall compliance index summarizes ANC service utilization, dietary adherence, timely registration, interactions with health workers, and kitchen garden access. The intervention led to improvements of 0.48 sd in awareness, 0.3 sd in ANC access, and 0.36 sd in overall compliance (see Appendix 11). These results indicate the program shifted MCH service usage in a holistic direction, rather than conferring only fragmented gains.

4.5 Heterogeneity in Treatment Effects

We estimate treatment effect heterogeneity to ascertain whether there has been an elite capture where intervention benefits accrue to better-off households rather than reaching the most vulnerable populations. Our heterogeneity analysis of the program provides compelling evidence against such capture, revealing instead that the intervention's peer-to-peer group support model combined with institutional healthcare linkages successfully reached and benefitted marginalized communities.

For heterogeneity analysis we use Causal Forests (Wager and Athey, 2018) which adapts random forest algorithms to estimate heterogeneous treatment effects. Instead of predicting outcomes, causal forests predict individual-level treatment effects by growing trees that split the data observations (using honest splitting) to maximize the differences in treatment effects between groups. Averaging many such trees yields stable predictions of how treatment effects vary across the covariate space.

We find robust evidence that the intervention's impact on compliance with recommended pregnancy-related health practices is greater in economically disadvantaged settings (Appendix 12). Villages with lower nightlight intensity, a proxy for lower economic development, exhibit treatment effect of 0.88 sd, while more economic activity villages show no significant effect (-0.271 sd). As Appendix 13 illustrates treatment effects decline with increasing nightlight intensity, though this trend reverses for values above 3; however, the positive association in more developed villages is not statistically significant. We speculate that peer counselling is less effective in higher economic activity villages (Kumakech et al., 2009), where rigid social norms and greater household's economic resources reduce dependence on such interventions. Our second guess is that lower NRLM outreach intensity in these villages may also contribute to insignificant treatment effects. The intervention is particularly effective in areas with low medical facility density (0.691 sd) compared to better-served areas (-0.356 sd), with the difference being statistically significant (p=0.032). Compliance with MCH advisories did not differ significantly between backward caste dominant and other villages. These findings align with studies showing that, while caste-based inequities remain a persistent feature of healthcare utilization in India, targeted interventions can mitigate such gaps, especially in settings where conventional healthcare delivery systems are weakest or exclusionary.

The intervention's impact on SHG support (measured by SHG support index) is especially pronounced among schedule caste and tribe households, who experienced treatment effects of 0.735 sd compared to -0.008 sd for other castes (Appendix Table 15), yielding a significant difference of 0.743 sd (p=0.048). This indicates the program was effective in overcoming historical disadvantages in access to support systems. Additionally, villages with higher health worker density benefitted more (0.79 sd versus -0.069 sd, p=0.048), suggesting the intervention complemented existing health system rather than substituting it, and amplified support where frontline workers were present. Treatment effects are greater among less educated women, disappearing for those with 13 or more years of education (Appendix 15). This finding underscores the importance of optimal policy learning, indicating that such interventions yield largest benefits for women with lower educational attainment. Heterogeneity analysis reveals that the intervention produced substantially greater improvements in the antenatal care access in more remote villages (Appendix 16). Where remoteness (time to facilities) was higher than the median, treatment effects reached 0.54 sd versus -0.789 sd in less remote areas (difference: 1.33 sd, p-value=0.02). This pattern highlights the intervention's effectiveness in facilitating early pregnancy disclosure and institutional care-seeking via peer networks in areas that face geographic barriers to healthcare access.

No significant heterogeneity in treatment effects is observed for postnatal healthcare access (Appendix 17) or health services awareness (Appendix 18) across any of the observable characteristics. Taken together, disadvantaged groups typically experienced larger benefits, indicating that the intervention effectively reached marginalized communities and avoided elite capture often seen in development programs.

4.6. Potential Mechanisms

Next, we investigate the mechanisms underlying JASHN's impact on uptake of perinatal services and adherence to health advisories by focusing on two key design features of the intervention: (a) private action and (b) outreach by frontline health workers.

4.6.1 Private Action

First, while NRLM and NHM provide important institutional platform for linking households and frontline health workers, the sustained uptake of a continuum of care requires a positive shift in household decision to utilize health services given their perceived social and spiritual costs. SHGs in the treated areas reach out pregnant women and their families via culturally sensitive group-to-peer counselling sessions and provide assistance in availing essential health services. The subsequent discussions in SHG meetings and counselling sessions can positively influence the willingness to engage with SHG members and government functionaries. Thus in Table 6 we examine changes in women's private action. We hypothesize that having a strong connect with SHG members may cause pregnant women to reveal their status with them. Column 1 shows that women in treated areas are 13-percentage-point more likely to disclose their pregnancy to SHG members after informing their families- 93% relative increase over control group. We next examine whether pregnant women in JASHN villages would choose to access their first ANC earlier compared to their counterparts in the control villages. This is arguably the most critical of the mechanisms because majority of maternal and infant complications related to pregnancy could be avoided through early use of ANC services (Tripathy and Mishra, 2023).

[Insert Table 6 here]

In Col. 2, we find that pregnant women in JASHN villages accessed their first ANC 0.60 months prior to their counterparts in the control areas. The control mean of 3.54 months, implies that an average woman in the intervention village was successful in accessing her first ANC within the first pregnancy trimester. We also hypothesized that pregnant women would receive greater support from her family members if she were to access a continuum of services and engage with health workers. We compute a family support index which is constructed from five indicators: family participation in ANC related decisions, accompanying to health facilities, attendance during peer-counselling sessions of SHG, proportion of family members present, and adherence to advisories received during counselling. The index is calculated by summing these variables and then standardizing the final value. Col. 3 shows that women in the JASHN villages reported a significant increase of 31.5 percent of a standard deviation in family support. Additionally, the treatment increased the likelihood of consulting ASHA and ANM workers by 19.5-percentage-point (Col. 4) and raised VHSND meeting attendance over six months by 21.5% (Col. 5). These findings indicate that the intervention led to meaningful changes in mechanisms underlying women's health-seeking related actions.

4.6.2 Outreach activities of Frontline Health Workers

The theoretical framework posits that reduction in households' psychic cost (through culturally sensitive peer-counselling) and search cost (via information subsidy) can jointly improve the utilization of prenatal services. Therefore, the second potential mechanism examined is the outreach activity of ASHA workers. If the discovery cost of identifying pregnancies declines, ceteris paribus, ASHAs should experience fewer barriers to entering culturally reticent tribal households. Col. 1 in Table 7 reports that in treatment villages ASHAs are 23.5-percentage-point more likely to reach out to pregnant women for registration (control mean: 56.4% and 42% relative increase). In addition to probability of outreach, the timing of such outreach is also critical because delayed care reduces the full realization of benefits from accessing care. We find in Col. 2 that the treatment improved the first trimester pregnancy registration by 17-percentage-point (a relative gain of 22.5%). Compared to control villages, the number of counselling sessions conducted by ASHAS was 0.48 standard deviations higher in JASHN villages (Col. 3). The intervention appears to have triggered the joint effect of peer-counselling and information subsidy as in Col. 4 we find that family members of pregnant women are 26-percentage-point more likely to attend the counselling sessions conducted by ASHA workers. We conclude from these findings that lower search costs enhanced ASHA's engagement with pregnant women.

[Insert Table 7 here]

5. Conclusions

Our central research question is how best to support women and families in resource constrained settings, who weight not only monetary but also psychic and socio-cultural costs when accessing MCH services. Rather than delivering prescriptive advisories under the assumption that such households either lack awareness or are irrational, our study demonstrates that structured peer-counselling in an environment characterized by trust, empathy, and cultural humility to local practices and beliefs, is more effective. We empirically test this model through a randomized field experiment across 160 villages in Jharkhand.

Our results show that integrating culturally sensitive peer-counselling initiatives with existing village healthcare systems led to significant improvements in the timing and uptake of prenatal and postnatal services, health of pregnant women, and child nutrition. Importantly, the structured group-based model appears to impact health behavior of culturally reticent households through novel mechanisms- namely, enhanced private action of women and their families and increased frontline worker outreach. A particular strength of the JASHN intervention is its resistance to elite capture, and its capacity to effect positive health behavior change among marginalized populations, including those in economically backward areas, SC/ST households, and women with lower educational attainment. Moreover, the intervention appears to mitigate disparities between backward and upward caste-dominant villages, with both groups likely to derive similar benefits.

Nevertheless, few limitations should be considered when interpreting these results. First, information on hemoglobin count was obtained from MCP cards typically held by women, were only tracked for 20% of respondents. This could be due to interviewer or respondent effect, though the missing card is not correlated with treatment assignment. Second, ASHA interviews were obtained in only 110 of 160 surveyed villages, with the remainder either unavailable or unwilling to participate, thereby leading to potential attrition bias in the estimates of ASHA-level impacts. Third, variables including SHG membership of households, proximity to primary health center, and awareness of Anganwadi services are not identically distributed between treatment and control arms; all these factors are controlled for in all the econometric specifications.

This study contributes to the literature by providing compelling evidence that culturally anchored, peer-driven counselling models offer a scalable and equitable strategy to improve MCH service utilization in rural India, especially among those who face compounded social disadvantage.

References

Acquisti, A., & Grossklags, J. (2004). Privacy attitudes and privacy behavior. In L. J. Camp & S. Lewis (Eds.), Economics of information security (Advances in Information Security, Vol. 12). Springer. https://doi.org/10.1007/1-4020-8090-5_13

Anato, A., & Reshid, M. (2025). Effect of nutrition education and iron–folic acid supplementation on anemia among pregnant women in Ethiopia: A quasi-experimental study. Scientific Reports, 15, 3556. https://doi.org/10.1038/s41598-025-87957-x

Barham, T. (2011). A healthier start: The effect of conditional cash transfers on neonatal and infant mortality in rural Mexico. Journal of Development Economics, 94(1), 74–85. https://doi.org/10.1016/j.jdeveco.2010.01.005

Becker, G. S. (1965). A theory of the allocation of time. The Economic Journal, 75(299), 493–517. https://doi.org/10.2307/2228949

Bellows, N. M., Bellows, B. W., & Warren, C. (2011). The use of vouchers for reproductive health services in developing countries: A systematic review. Tropical Medicine & International Health, 16(1), 84–96. https://doi.org/10.1111/j.1365-3156.2010.02667.x

Bibbins-Domingo, K., et al. (2017). Folic acid supplementation for the prevention of neural tube defects: U.S. Preventive Services Task Force recommendation statement. JAMA, 317, 183–189. https://doi.org/10.1001/jama.2016.19438

Chola, L., Fadnes, L. T., Engebretsen, I. M. S., Nkonki, L., Nankabirwa, V., Sommerfelt, H., et al. (2015). Cost-effectiveness of peer counselling for the promotion of exclusive breastfeeding in Uganda. PLoS ONE, 10(11), e0142718. https://doi.org/10.1371/journal.pone.0142718

Choudhry, U. K. (1997). Traditional practices of women from India: Pregnancy, childbirth, and newborn care. Journal of Obstetric, Gynecologic, & Neonatal Nursing, 26(5), 533–539. https://doi.org/10.1111/j.1552-6909.1997.tb02156.x

Correia, T. (2024). Trust building in public health approaches: The importance of a people-centered concept in crisis response. Risk Management and Healthcare Policy, 17, 1903–1908. https://doi.org/10.2147/RMHP.S471250

Czeizel, A. E., Istvan, D., Attila, V., & Ferenc, B. (2013). Folate deficiency and folic acid supplementation: The prevention of neural-tube defects and congenital heart defects. Nutrients, 5, 4760. https://doi.org/10.3390/nu5114760

da Fonseca, B. E., Raskin, S., & Zugaib, M. (2013). Folic acid for the prevention of neural tube defects. Revista Brasileira de Ginecologia e Obstetrícia, 35(7).

Dangi, M. K., Keerti, Upadhyay, M., Prajapati, J., Choudhary, S., & Nagal, R. (2024). A study to assess the awareness and uptake of Janani Suraksha Yojana among the women attending a tertiary care hospital. International Journal of Community Medicine and Public Health, 11(12), 4869–4874. https://doi.org/10.18203/2394-6040.ijcmph20243657

Dasgupta, A., & Beard, V. (2007). Community-driven development, collective action and elite capture in Indonesia. Development and Change, 38(2), 229–249.

Dixit, P., Sundararaman, T., & Halli, S. (2023). Is the quality of public health facilities always worse compared to private health facilities? Association between birthplace and neonatal deaths in the Indian states. PLoS ONE, 18(12), e0296057.

Douglas, M. (1992). Risk and blame: Essays in cultural theory. Routledge.

Downs, A. (1957). An economic theory of democracy. Harper & Row.

Dupas, P. (2011). Health behavior in developing countries. Annual Review of Economics, 3, 425–449. https://doi.org/10.1146/annurev-economics-111809-125029

Ekirapa-Kiracho, E., Muhumuza Kananura, R., Tetui, M., Namazzi, G., Mutebi, A., et al. (2017). Effect of a participatory multisectoral maternal and newborn intervention on maternal health service utilization and newborn care practices: A quasi-experimental study in three rural Ugandan districts. Global Health Action, 10(Suppl. 4). https://doi.org/10.1080/16549716.2017.1363506

Endehabtu, B. F., Gelaye, K. A., Mengiste, S. A., & Tilahun, B. (2024). Mapping the role of digital health interventions to enhance effective coverage of antenatal care: A scoping review. Journal of Multidisciplinary Healthcare, 17, 71–82.

Engdaw, G. T., Tesfaye, A. H., Feleke, M., Negash, A., Yeshiwas, A., Addis, W., Angaw, D. A., & Engidaw, M. T. (2023). Effect of antenatal care on low birth weight: A systematic review and meta-analysis in Africa, 2022. Frontiers in Public Health, 11, 1158809. https://doi.org/10.3389/fpubh.2023.1158809

Fatema, K., & Lariscy, J. T. (2020). Mass media exposure and maternal healthcare utilization in South Asia. SSM – Population Health, 11, 100614. https://doi.org/10.1016/j.ssmph.2020.100614

Ganguly, A. (2012, August 16). Beware of 'evil eye' on common sense. The Telegraph Online.

Gigerenzer, G., & Todd, P. M. (1999). Simple heuristics that make us smart. Oxford University Press.

Gille, F., Daniore, P., & Zavattaro, F. (2024). Bringing trust building to life within health policy-making: Comment on "Placing trust at the heart of health policy and systems." International Journal of Health Policy and Management, 13, 8662. https://doi.org/10.34172/ijhpm.8662

Gilson, L. (2015). Lipsky's street-level bureaucracy. In E. Page, M. Lodge, & S. Balla (Eds.), The Oxford handbook of classics in public policy and administration. Oxford University Press.

Gogia, S., Ramji, S., Gupta, P., Gera, T., Shah, D., Mathew, J. L., Mohan, P., & Panda, R. (2011). Community-based newborn care: A systematic review and meta-analysis of evidence (UNICEF–PHFI series on newborn and child health, India). Indian Pediatrics, 48(7), 537–546. https://doi.org/10.1007/s13312-011-0096-8

Grossman, M. (1972). On the concept of health capital and the demand for health. Journal of Political Economy, 80(2), 223–255.

Hamel, C., Enne, J., Omer, K., Ayara, N., Yarima, Y., Cockcroft, A., & Andersson, N. (2015). Childhood malnutrition is associated with maternal care during pregnancy and childbirth: A cross-sectional study in Bauchi and Cross River States, Nigeria. Journal of Public Health Research, 4(1), 408. https://doi.org/10.4081/jphr.2015.408

Haque, M., et al. (2023). Peer counselling as an approach to improve complementary feeding practices: A narrative review. Journal of Health, Population and Nutrition. https://doi.org/10.1186/s41043-023-00408-z

Hazra, A., Atmavilas, Y., Hay, K., Saggurti, N., Verma, R. K., Ahmad, J., Kumar, S., Mohanan, P. S., Mavalankar, D., & Irani, L. (2020). Effects of health behaviour change intervention through women's self-help groups on maternal and newborn health practices and related inequalities in rural India: A quasi-experimental study. eClinicalMedicine, 18.

Iradukunda, F. (2020). Food taboos during pregnancy. Health Care for Women International, 41(2), 159–168. https://doi.org/10.1080/07399332.2019.1574799

Irani, L., Schooley, J., Supriya,, et al. (2021). Layering of a health, nutrition and sanitation programme onto microfinance-oriented self-help groups in rural India: Results from a process evaluation. BMC Public Health, 21, 2131. https://doi.org/10.1186/s12889-021-12049-0

Iyengar, S., Iyengar, K., & Martines, J. (2008). Childbirth practices in rural Rajasthan, India: Implications for neonatal health and survival. Journal of Perinatology, 28(Suppl. 2), S23–S30.

Jana, A. (2023). Correlates of low birth weight and preterm birth in India. PLoS ONE, 18(8), e0287919. https://doi.org/10.1371/journal.pone.0287919

Janz, N. K., & Becker, M. H. (1984). The Health Belief Model: A decade later. Health Education Quarterly, 11(1), 1–47.

Kadiyala, S., et al. (2021). Effect of nutrition-sensitive agriculture interventions with participatory videos and women's group meetings on maternal and child nutritional outcomes in rural Odisha, India (UPAVAN trial): A four-arm, observer-blind, cluster-randomised controlled trial. The Lancet Planetary Health, 5(5), e263–e276.

Kassie, M., Fisher, M., Muricho, G., & Diiro, G. (2020). Women's empowerment boosts the gains in dietary diversity from agricultural technology adoption in rural Kenya. Food Policy, 95, 101957. https://doi.org/10.1016/j.foodpol.2020.101957

Kawade, A., Gore, M., Lele, P., et al. (2021). Interplaying role of healthcare activist and homemaker: A mixed-methods exploration of the workload of community health workers (Accredited Social Health Activists) in India. Human Resources for Health, 19, 7.

Khan, S. S., Tawale, N. K., Patel, A., Dibley, M. J., & Alam, A. (2021). "My husband is my family." The culture of pregnancy disclosure and its implications on early pregnancy registration in a child nutrition intervention in rural Maharashtra, India. Midwifery, 103, 103141. https://doi.org/10.1016/j.midw.2021.103141

Khanal, V., Bista, S., & Lee, A. H. (2024). Examining the combined effect of antenatal care visits and iron–folic acid supplementation on low birth weight: A pooled analysis of two national data sets from Nepal. BMC Pregnancy and Childbirth, 24, 612.

Khursheed, R., Kanna, R., Dharwad, F. B., Dalal, A., Khan, M., & Maldar, A. (2025). Prevalence of extreme preterm, very and moderate to late preterm births and their association with risk factors in a South Indian cohort. Indian Journal of Obstetrics and Gynecology Research, 12(1), 119–128.

Kruk, M. E., Gage, A. D., Arsenault, C., Jordan, K., et al. (2018). High-quality health systems in the Sustainable Development Goals era: Time for a revolution. The Lancet Global Health, 6(11), e1196–e1252.

Kuhnt, J., & Vollmer, S. (2017). Antenatal care services and their implications for vital and health outcomes of children: Evidence from 193 surveys in 69 low-income and middle-income countries. BMJ Open, 7(11), e017122. https://doi.org/10.1136/bmjopen-2017-017122

Kumakech, E., Cantor-Graae, E., Maling, S., & Bajunirwe, F. (2009). Peer-group support intervention improves the psychosocial well-being of AIDS orphans: Cluster randomized trial. Social Science & Medicine, 68(6), 1038–1043. https://doi.org/10.1016/j.socscimed.2008.10.033

Kushwaha, K. P., Sankar, J., Sankar, M. J., Gupta, A., Dadhich, J. P., et al. (2014). Effect of peer counselling by mother support groups on infant and young child feeding practices: The Lalitpur experience. PLoS ONE, 9(11), e10918. https://doi.org/10.1371/journal.pone.0109181

Lagarde, M., Barroy, H., & Palmer, N. (2012). Assessing the effects of removing user fees in Zambia and Niger. Journal of Health Services Research & Policy, 17(1), 30–36.

Lamba, S., Friedman, J., & Kandpal, E. (2025). The effect of performance-based financing interventions on health worker motivation and job satisfaction: Experimental evidence from six national pilots. Health Policy and Planning. https://doi.org/10.1093/heapol/czaf035

Lassi, Z. S., Padhani, Z. A., Rabbani, A., Rind, F., Salam, R. A., & Bhutta, Z. A. (2021). Effects of nutritional interventions during pregnancy on birth, child health and development outcomes: A systematic review of evidence from low- and middle-income countries. Campbell Systematic Reviews, 17, 1150. https://doi.org/10.1002/cl2.1150

Lateef, M. A., Kuupiel, D., Mchunu, G. G., & Pillay, J. D. (2024). Utilization of antenatal care and skilled birth delivery services in sub-Saharan Africa: A systematic scoping review. International Journal of Environmental Research and Public Health, 21(4), 440. https://doi.org/10.3390/ijerph21040440

Legare, C. H., Akhauri, S., Chaudhuri, I., Hashmi, F. A., Johnson, T., Little, E. E., Lunkenheimer, H. G., Mandelbaum, A., Mandlik, H., Mondal, S., Mor, N., Saldanha, N., Schooley, J., Sharda, P., Subbiah, S., Swarup, S., Tikkanen, M., & Burger, O. (2020). Perinatal risk and the cultural ecology of health in Bihar, India. Philosophical Transactions of the Royal Society B, 375, 20190433.

Lessard, É., O'Brien, N., Panaite, A. C., et al. (2024). Can you be a peer if you don't share the same health or social conditions? A qualitative study on peer integration in a primary care setting. BMC Primary Care, 25, 298. https://doi.org/10.1186/s12875-024-02548-5

Lewycka, S., et al. (2013). Effect of women's groups and volunteer peer counselling on rates of mortality, morbidity, and health behaviours in mothers and children in rural Malawi (MaiMwana): A factorial, cluster-randomised controlled trial. The Lancet, 381(9879), 1721–1735.

Lim, S. S., Dandona, L., Hoisington, J. A., James, S. L., Hogan, M. C., & Gakidou, E. (2010). India's Janani Suraksha Yojana, a conditional cash transfer programme to increase births in health facilities: An impact evaluation. The Lancet, 375(9730), 2009–2023.

Lunkenheimer, H. G., Burger, O., Akhauri, S., Chaudhuri, I., Dibbell, L., Hashmi, F. A., Johnson, T., Little, E. E., Mondal, S., Mor, N., Saldanha, N., Schooley, J., & Legare, C. H. (2021). Tradition, taste and taboo: The gastroecology of maternal perinatal diet. BMJ Nutrition, Prevention & Health, 4(2), 385–396. https://doi.org/10.1136/bmjnph-2021-000252

Manandhar, D. S., Osrin, D., Shrestha, B. P., Mesko, N., Morrison, J., Tumbahangphe, K. M., Tamang, S., Thapa, S., Shrestha, D., Thapa, B., Shrestha, J. R., Wade, A., Borghi, J., Standing, H., Manandhar, M., & Costello, A. M. (2004). Effect of a participatory intervention with women's groups on birth outcomes in Nepal: Cluster-randomised controlled trial. The Lancet, 364(9438), 970–979. https://doi.org/10.1016/S0140-6736(04)17021-9

Mangham-Jefferies, L., Pitt, C., Cousens, S., et al. (2014). Cost-effectiveness of strategies to improve the utilization and provision of maternal and newborn health care in low-income and lower-middle-income countries: A systematic review. BMC Pregnancy and Childbirth, 14, 243. https://doi.org/10.1186/1471-2393-14-243

Manjunath, U., Raju, S., Dharmappa, R., Deepashree, M., Chokshi, M., Mokashi, T., & Mythri, N. (2022). Assessment of workload of ASHAs: A multi-stakeholder perspective study for task-sharing and task-shifting. Journal of Health Management, 24. https://doi.org/10.1177/09720634221079084

Mansuri, G., & Rao, V. (2013). Localizing development: Does participation work? World Bank. https://doi.org/10.1596/978-0-8213-8847-1

Maria, G. G., Buche, J. L., Wayment, C. C., Schoebel, V., Smith, J. E., Chapman, S. A., & Beck, A. J. (2021). A systematic review of the roles and contributions of peer providers in the behavioral health workforce. American Journal of Preventive Medicine, 61(4), e203–e210. https://doi.org/10.1016/j.amepre.2021.03.025

Mondal, S., Anand, A., & Awasthi, N. (2023). Factors affecting pregnancy registration in India: Does the pregnancy intention matter? BMC Pregnancy and Childbirth, 23, 674. https://doi.org/10.1186/s12884-023-06002-9

Murthy, N., Chandrasekharan, S., Prakash, M. P., Ganju, A, Peter, J., Kaonga, N., & Mechael, P. (2020). Effects of an mHealth voice message service (mMitra) on maternal health knowledge and practices of low-income women in India: Findings from a pseudo-randomized controlled trial. BMC Public Health, 20(1), 820. https://doi.org/10.1186/s12889-020-08965-2

Mwabu, G. (2008). Health economics for low-income countries. In T. P. Schultz & J. A. Strauss (Eds.), Handbook of development economics (Vol. 4, pp. 3305–3374). Elsevier.

National Family Health Survey (NFHS-5), 2019–21. Ministry of Health and Family Welfare (MoHFW), Government of India.

Nihal, S., & Shekhar, C. (2024). An assessment of adequate quality antenatal care and its determinants in India. BMC Pregnancy and Childbirth, 24(1), 698. https://doi.org/10.1186/s12884-024-06806-3

Nordström, J., Thunström, L., Van ’t Veld, K., Shogren, J. F., & Ehmke, M. (2023). Strategic ignorance of health risk: Its causes and policy consequences. Behavioural Public Policy, 7(1), 83–114. https://doi.org/10.1017/bpp.2019.52

Ohuma, E. O., et al. (2023). National, regional, and global estimates of preterm birth in 2020, with trends from 2010: A systematic analysis. The Lancet, 402(10409), 1261–1271.

Olajide, B. R., van der Pligt, P., & McKay, F. H. (2024). Cultural food practices and sources of nutrition information among pregnant and postpartum migrant women from low- and middle-income countries residing in high income countries: A systematic review. PLoS ONE, 19(5), e0303185. https://doi.org/10.1371/journal.pone.0303185

Peahl, A. F., & Howell, J. D. (2021). The evolution of prenatal care delivery guidelines in the United States. American Journal of Obstetrics & Gynecology, 224, 339–347. https://doi.org/10.1016/j.ajog.2020.12.016

Prabhu, D. F. (2016). Scaling the Maternal and Neonatal Survival Initiatives (MANSI) program in low resource settings (Master’s thesis, Massachusetts Institute of Technology).

Prost, A., Colbourn, T., Seward, N., Azad, K., Coomarasamy, A., Copas, A., Houweling, T. A., Fottrell, E., Kuddus, A., Lewycka, S., MacArthur, C., Manandhar, D., Morrison, J., Mwansambo, C., Nair, N., Nambiar, B., Osrin, D., Pagel, C., Phiri, T., … Costello, A. (2013). Women’s groups practising participatory learning and action to improve maternal and newborn health in low-resource settings: A systematic review and meta-analysis. The Lancet, 381(9879), 1736–1746. https://doi.org/10.1016/S0140-6736(13)60685-6

Qu, P., Li, S., & Liu, D. (2019). A propensity-matched study of the association between optimal folic acid supplementation and birth defects in Shaanxi province, Northwestern China. Scientific Reports, 9, 5271. https://doi.org/10.1038/s41598-019-41584-5

Rahman, S. A., Kielmann, T., McPake, B., & Normand, C. (2012). Healthcare-seeking behaviour among the tribal people of Bangladesh: Can the current health system really meet their needs? Journal of Health, Population and Nutrition, 30(3), 353–365. https://doi.org/10.3329/jhpn.v30i3.12299

Rao, V., & Walton, M. (2004). Culture and public action. Stanford University Press.

Rasaily, R., Saxena, N. C., Pandey, S., Garg, B. S., Swain, S., Iyengar, S. D., Das, V., Sinha, S., Gupta, S., Sinha, A., Kumar, S., Pandey, A., Pandey, R. M., Sachdev, H. S., Sankar, M. J., Ramji, S., Paul, V. K., Bang, A. T., & ICMR-HBMYI Study Group. (2020). Effect of home-based newborn care on neonatal and infant mortality: A cluster randomised trial in India. BMJ Global Health, 5(9), e000680. https://doi.org/10.1136/bmjgh-2017-000680

Riker, W. H., & Ordeshook, P. C. (1970). A theory of the calculus of voting. American Political Science Review, 25–41.

Rosenstock, I. M. (1974). The Health Belief Model and preventive health behavior. Health Education Monographs, 2(4), 354–386. https://doi.org/10.1177/109019817400200405

Saggurti, N., Atmavilas, Y., Porwal, A., Schooley, J., Das, R., Kande, N., Irani, L., & Hay, K. (2018). Effect of health intervention integration within women's self-help groups on collectivization and healthy practices around reproductive, maternal, neonatal and child health in rural India. PLoS ONE, 13(8), e0202562. https://doi.org/10.1371/journal.pone.0202562

Saha, S., Annear, P. L., & Pathak, S. (2013). The effect of self-help groups on access to maternal health services: Evidence from rural India. International Journal for Equity in Health, 12, 36.

Saprii, L., Richards, E., & Kokho, P. (2015). Community health workers in rural India: Analysing the opportunities and challenges Accredited Social Health Activists (ASHAs) face in realising their multiple roles. Human Resources for Health, 13, 95.

Sato, R., & Belel, A. (2021). Effect of performance-based financing on health service delivery: A case study from Adamawa state, Nigeria. International Health, 13(2), 122–129. https://doi.org/10.1093/inthealth/ihaa026

Sedlander, E., Long, M. W., Mohanty, S., Munjral, A., Bingenheimer, J. B., Yilma, H., & Rimal, R. N. (2020). Moving beyond individual barriers and identifying multi-level strategies to reduce anemia in Odisha, India. BMC Public Health, 20, 457.

Sethi, V., Bhanot, A., Bhalla, S., et al. (2017). Partnering with women collectives for delivering essential women's nutrition interventions in tribal areas of eastern India: A scoping study. Journal of Health, Population and Nutrition, 36, 20.

Shah, N., Zaheer, S., Safdar, N. F., Turk, T., & Hashmi, S. (2023). Women's awareness, knowledge, attitudes, and behaviours towards nutrition and health in Pakistan: Evaluation of kitchen gardens nutrition program. PLoS ONE.

Sharma, P., Patel, R., Behera, J., Samanta, S. D., & Mehra, S. (2018). Effectiveness of a community intervention program to improve maternal healthcare services uptake among young married women in rural India. Journal of Women's Health Care, 7, 432.

Sharma, R., Webster, P., & Bhattacharyya, S. (2014). Factors affecting the performance of community health workers in India: A multi-stakeholder perspective. Global Health Action, 7(1).

Simmons, M. B., Cartner, S., MacDonald, R., Whitson, S., Bailey, A., & Brown, E. (2023). The effectiveness of peer support from a person with lived experience of mental health challenges for young people with anxiety and depression: A systematic review. BMC Psychiatry, 23(1), 194. https://doi.org/10.1186/s12888-023-04578-2

Talegawkar, S. A., Jin, Y., Sedlander, E., Ganjoo, R., Behera, S., DiPietro, L., & Rimal, R. (2021). A social norms-based intervention improves dietary diversity among women in rural India: The Reduction in Anemia through Normative Innovations (RANI) project. Nutrients, 13(8), 2822. https://doi.org/10.3390/nu13082822

Topping, K. J. (2022). Peer-led interventions in health and well-being: A review of effectiveness. Clinical Psychiatry, 8(6), Article 146. https://doi.org/10.35841/2471-9854-8.6.146

Tripathi, S., Pathak, V. K., & Lahariya, C. (2023). Key findings from NFHS-5 India report: Observing trends of health indicators between NFHS-4 and NFHS-5. Journal of Family Medicine and Primary Care, 12(9), 1759–1763. https://doi.org/10.4103/jfmpc.jfmpc_377_23

Tripathy, A., & Mishra, P. S. (2023). Inequality in time to first antenatal care visits and its predictors among pregnant women in India: Evidence from the National Family Health Survey. Scientific Reports, 13(1), 4706. https://doi.org/10.1038/s41598-023-31902-3

Tripathy, P., Nair, N., Barnett, S., Mahapatra, R., Borghi, J., Rath, S., Gope, R., Mahto, D., Sinha, R., Lakshminarayana, R., Patel, V., Pagel, C., Prost, A., & Costello, A. (2010). Effect of a participatory intervention with women's groups on birth outcomes and maternal depression in Jharkhand and Orissa, India: A cluster-randomised controlled trial. The Lancet, 375(9721), 1182–1192. https://doi.org/10.1016/S0140-6736(09)62042-0

USAID. (2009). Health issues and health seeking behaviour of tribal population in Jharkhand. Jharkhand Health Society, Ministry of Health and Family Welfare, Government of Jharkhand.

Verma, A., & Cleland, J. (2022). Is newborn survival influenced by place of delivery? A comparison of home, public sector and private sector deliveries in India. Journal of Biosocial Science, 54(2), 184–198. https://doi.org/10.1017/S0021932021000080

Vidler, M., Ramadurg, U., Charantimath, U., Katageri, G., Karadiguddi, C., Sawchuck, D., Qureshi, R., Dharamsi, S., Joshi, A., von Dadelszen, P., Derman, R., Bellad, M., Goudar, S., & Mallapur, A.; Community Level Interventions for Pre-eclampsia (CLIP) India Feasibility Working Group. (2016). Utilization of maternal health care services and their determinants in Karnataka State, India. Reproductive Health, 13(Suppl. 1), 37. https://doi.org/10.1186/s12978-016-0138-8

Vlaev, I. (2018). Local choices: Rationality and the contextuality of decision-making. Brain Sciences, 8(1), 8. https://doi.org/10.3390/brainsci8010008

Wager, S., & Athey, S. (2018). Estimation and inference of heterogeneous treatment effects using random forests. Journal of the American Statistical Association, 113(523), 1228–1242. https://doi.org/10.1080/01621459.2017.1319839

Wang, Z., Chaudhry, M., Mistry, R., Needham, B. L., Baylin, A., Mancuso, P., et al. (2022). A mixed-methods study on the dietary practices of early postpartum women during the summer rainy season in Belgaum, Karnataka, India. Ecology of Food and Nutrition, 61(6), 728–752. https://doi.org/10.1080/03670244.2022.2136171

Wenling, H., Jiangli, D., & Aiqun, H. (2024). Analysis of the relationship between the quality of antenatal care examinations and the incidence of preterm birth and low birth weight. BMC Public Health, 24, 3134.

World Health Organization. (2016). WHO recommendations on antenatal care for a positive pregnancy experience. https://iris.who.int/bitstream/handle/10665/250796/9789241549912-eng.pdf

World Health Organization. (2025). Maternal mortality [Fact sheet].

World Bank. (2020). Integration of health and nutrition into livelihood programs under DAY-NRLM. World Bank.

(https://nrlm.gov.in/MobilizationHouseholdsAction.do?methodName=showDetail&reportVar=total)

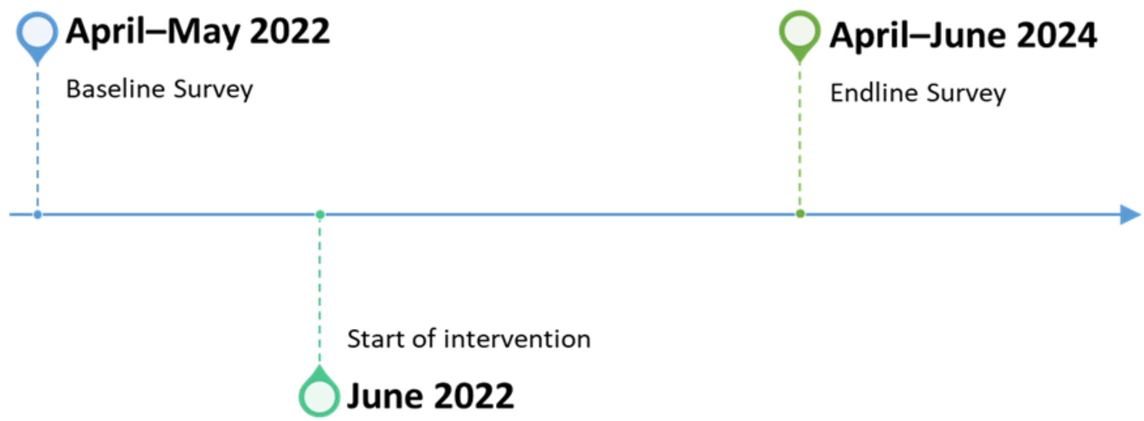


Figure 1: Intervention Timeline

Note: This figure displays the timeline of the JASHN intervention study. The baseline survey was conducted in April-May 2022, prior to implementation of intervention. The intervention began in June 2022 and continued for approximately two years. The endline survey was conducted in April-June 2024, allowing for assessment of treatment effects after nearly two years of intervention exposure.

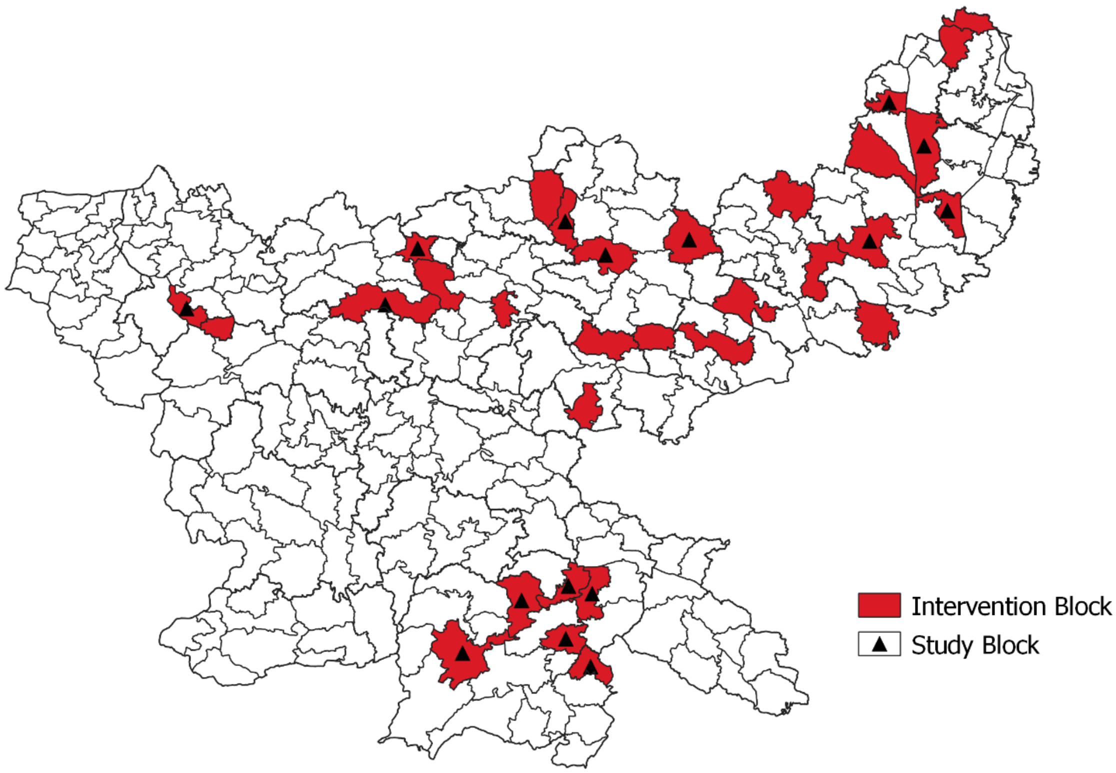


Figure 2: Intervention Map

Note: This map displays the geographic coverage of the JASHN intervention across Jharkhand state at the block level. Red-shaded areas represent the 31 blocks where the intervention was fully implemented. Black triangles indicate the 16 blocks selected for the experimental evaluation, which form a subset of the broader intervention rollout. The map demonstrates good geographic spread of both the overall intervention and the study sample across different regions of the state, including northern, central, eastern, and southern districts. This distribution ensures that the experimental findings are representative of diverse geographic and socio-economic contexts within Jharkhand, enhancing the external validity of the results. The study blocks are well-distributed across the intervention area rather than clustered in a single region, supporting the generalizability of findings for potential state-wide scale-up of the JASHN program.

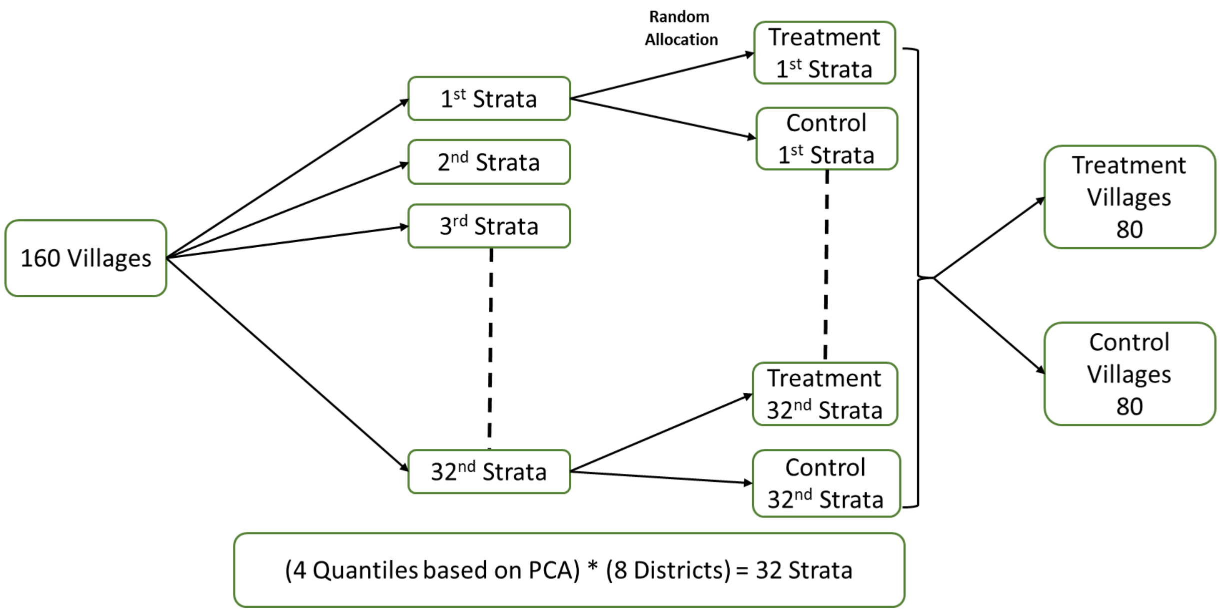


Figure 3: Block Randomization Design

Note: Figure 3 illustrates the block randomization procedure used in the JASHN evaluation. The 160 study villages were organized into 32 strata created by cross-classifying 4 socio-economic quantiles with 8 districts. Socio-economic quantiles were constructed using the principal component of baseline village-level characteristics including health workers per 100 population, village population, below poverty line ratio, and number of Self-Help Groups. Within each stratum, villages were randomly allocated to treatment or control groups, ensuring that both groups are balanced across socio-economic levels and geographic districts. This stratified approach resulted in 80 treatment villages and 80 control villages.

Table 1: Balancing Test and Summary Statistic

	Treatment	Control	*p*-value
	(1)	(2)	(3)
Panel A: Village characteristics			
Drought prone	0.61	0.48	0.112
Population	720.37	837.32	0.215
Proportion of female	0.48	0.49	0.261
Ratio of SC/ST household	0.55	0.6	0.405
Backward caste dominant	0.57	0.58	0.873
Proportion of kutcha houses	0.49	0.53	0.47
Proportion of households with functional toilet	0.61	0.63	0.788
Proportion of households with electricity	0.89	0.91	0.501
Proportion of households having Antyodaya card	0.16	0.16	0.983
Proportion of households who are part of SHG	0.24	0.32	0.085
No. of SHGs per 100 population	0.72	0.74	0.893
Health sub-centre exists	0.18	0.15	0.67
Primary health centre exists	0.15	0.03	0.005
Private clinic/hospital exists	0.15	0.22	0.307
Medical shop exists	0.18	0.2	0.687
Multi brand grocery shop exists	0.15	0.18	0.67
Public distribution system shop exists	0.39	0.38	0.871
Village is a panchayat headquarter	0.24	0.23	0.852
ATM exists	0.06	0.03	0.249
No. of medical facilities per 100 population	0.15	0.09	0.259
No. of medical shops per 100 population	0.04	0.04	0.702
No. of multi brand grocery shops per 100 population	0.04	0.07	0.208
No. of public distribution system shops per 100 population	0.07	0.06	0.402
Remoteness index using distance	0.06	-0.05	0.503
Remoteness index using time	0	0.01	0.922
No. of health workers per 100 population	0.7	0.82	0.245
Woman reserved panchayat	0.53	0.59	0.426
Panel B: Women characteristics			
Age of the woman*	24.53	24.48	0.816
Whether first time mother*	0.36	0.39	0.226
No. of months pregnant during first ANC visit*	3	2.95	0.231
AWC services woman is aware of (out of 9)*	4.87	5.09	0.053
Woman herself decided to go for ANC visit*	0.41	0.39	0.424
Institutional delivery*	0.77	0.73	0.156
Received a home visit by the health worker during pregnancy*	0.67	0.7	0.245
No. of months pregnant during first ANC visit	3.05	2.95	0.262
Proportion of women who registered their pregnancy	0.98	0.98	0.881
Proportion of women with institutional deliveries	0.76	0.75	0.866

AWC services woman is aware of (out of 9)	4.8	4.88	0.736
Proportion of women who received a home visit by the health worker during pregnancy	0.64	0.66	0.803
Panel C: Children characteristics			
Children height-for-age z-score	-1.41	-1.1	0.27
Children weight-for-age z-score	-1.23	-1.18	0.753
Children weight-for-height z-score	-0.27	-0.27	0.983
Children BMI z-score	-0.11	-0.17	0.785
Panel D: ASHA characteristics and service provision			
Age of ASHA worker	37.29	37.02	0.803
No. of completed years of education	8.71	8.87	0.737
Years of experience in health sector	13.55	13.63	0.922
Years of experience elsewhere	0.19	1.48	0.046
Whether ASHA a member of SHG?	0.84	0.84	0.913
Awareness on nutrition and sanitation	0.96	0.91	0.194
Counselled on childbirth practices	0.97	0.9	0.05
Helped women in accessing health services	0.95	0.9	0.232
Accompanied women to the health facility	0.96	0.92	0.306
Inform about birth to the health centre	0.96	0.94	0.471
Provide IFA tablets and ORS	0.97	0.95	0.408
Provide newborn care	0.94	0.92	0.756
No. of services provided by ASHA (out of 7)	6.72	6.44	0.227
Joint Orthogonality Test (*p*-value)			0.205
Sample size (Villages)	80	80	

Notes: This table presents balance test between treatment and control villages with 160 villages (80 treatment, 80 control). While the joint orthogonality test indicates overall balance, a few characteristics show significant or marginally significant differences: control villages have higher SHG participation rates, treatment villages are more likely to have primary health centres, control group women show marginally higher awareness of Anganwadi services, ASHA workers in treatment areas have less experience working elsewhere, and ASHAs from treatment villages reported higher rates of counselling on childbirth practices. * These are individual-level characteristics; all others are village-level aggregates/characteristics. Individual-level variables are excluded from the joint orthogonality test, which is conducted at the village level.

Table 2: Treatment Receipt

	Whether SHG Support?	Whether SHG Support?	SHG Support Index
VARIABLES	(1)	(2)	(3)
Treatment	0.212***	0.229***	0.145***
	[0.059]	[0.059]	[0.033]
Experimental Block FE	YES	YES	YES
Taluka FE	YES	YES	YES
Unbalanced Controls	YES	YES	YES
Household Controls	NO	YES	YES
Woman Controls	NO	YES	YES
Observations	3397	3397	3397
First-stage F	1059.44	1060.87	1060.87
Control Mean	0.30	0.30	0.12
Percentage Change	70.66	76.33	120.83

Notes: The dependent variable in columns (1) and (2) is a binary indicator equal to one if the woman received any SHG support during pregnancy. Column (3) uses the SHG Support Index, measuring the proportion of support services received out of nine possible types. SHG support services include: pregnancy disclosure and advice-seeking within the group; encouragement for medication adherence, nutrition, testing, and delivery planning; home-based SHG meetings and family counselling; mental health support; and pregnancy celebrations. Sample includes pregnant and lactating women; 45 observations are excluded due to missing data on SHG variables. Household controls include whether household has a toilet and asset index. Woman controls include age, age at marriage, and education. Robust standard errors are reported in brackets. *** p<0.01, ** p<0.05, * p<0.1.

Table 3: Accessing Health Services during Pregnancy

	Registered Pregnancy	Registered in 1st Trimester	ANC Visits (z-score)	ANC Visits (Mandatory)	ANC Services (Proportion)	IFA & Calcium	JSY
VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Treatment	0.053	0.198***	0.679**	0.376**	0.129**	0.141**	0.152***
	[0.051]	[0.076]	[0.273]	[0.158]	[0.062]	[0.057]	[0.053]
All Women Sample	YES	YES	-	-	-	YES	YES
Pregnant Women Sample	-	-	YES	YES	-	-	-
Experimental Block FE	YES	YES	YES	YES	YES	YES	YES
Taluka FE	YES	YES	YES	YES	YES	YES	YES
Unbalanced Controls	YES	YES	YES	YES	YES	YES	YES
Household Controls	YES	YES	YES	YES	YES	YES	YES
Woman Controls	YES	YES	YES	YES	YES	YES	YES
Observations	2,397	2,397	700	700	657	2889	2646
First-stage F	706.74	706.74	166.44	166.44	227.01	1005.35	810.18
Control Mean (absolute)	0.87	0.61	3.89	0.52	0.427	0.31	0.145
NFHS-5		0.70	-	0.58		0.44	0.255
Percentage Change	6.09	32.45	43.52	72.31	30.21	45.48	104.82

Notes: Columns (1) and (2) examine pregnancy registration outcomes for pregnant and lactating women with children ≤12 months old. Column (1) measures whether the pregnancy was registered; column (2) measures registration within the first trimester. Column (3) presents a z-score of ANC visits (0.679 SD = 1.7 additional visits), while column (4) indicates completion of the recommended four ANC visits. Both are conditional on receiving at least one ANC visit and include lactating women with children ≤3 months old and pregnant women ≥6 months. This sample is used to minimize recall bias, and these women have completed or nearly completed their pregnancies. Column (5) measures the proportion of ANC services received out of 24 possible services for pregnant women only. Column (6) indicates consumption of ≥90 tablets each of iron-folic acid and calcium, conditional on receiving these supplements, for pregnant and lactating women. Column (7) measures awareness and utilization of the Janani Suraksha Yojana (JSY) institutional delivery scheme among lactating women only. Household controls include whether household has a toilet and asset index. Woman controls include age, age at marriage, and education. Columns (3) and (4) include additional controls for religion, house ownership, and number of children. NFHS-5 figures provide state-level benchmarks where available. Robust standard errors are reported in brackets. *** p<0.01, ** p<0.05, * p<0.1.

Table 4: Institutional Birth and PNC Services and

	Institutional Birth	Whether received NBC Visits?	No. of NBC Visits (z-score)		NBC Services (Proportion)		Post-Delivery Healthcare Access Index
VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Treatment	0.161***	0.203***	0.392**	0.485***	0.093	0.136***	0.443***
	[0.055]	[0.067]	[0.193]	[0.140]	[0.063]	[0.041]	[0.135]
Unconditional Sample	-	-	NO	YES	NO	YES	YES
Experimental Block FE	YES	YES	YES	YES	YES	YES	YES
Taluka FE	YES	YES	YES	YES	YES	YES	YES
Unbalanced Controls	YES	YES	YES	YES	YES	YES	YES
Household Controls	YES	YES	YES	YES	YES	YES	YES
Woman Controls	YES	YES	YES	YES	YES	YES	YES
Observations	2,646	2,646	903	2646	903	2646	2646
First-stage F	810.18	810.18	427.39	810.18	427.39	810.18	810.18
Control Mean	0.78	0.32	2.00	0.69	0.43	0.14	-
Percentage Change	20.64	63.43	23.52	84.34	-	97.14	-

Notes- Column (1) measures whether delivery occurred in a health facility. Column (2) indicates whether the child received any newborn care (NBC) visits. Columns (3) and (5) are conditional on receiving NBC visits, while columns (4) and (6) include all observations (unconditional sample) with non-recipients coded as zero. Column (3) presents z-score of NBC visits; column (4) presents the same measure unconditionally. Columns (5) and (6) measure the proportion of NBC services received out of six possible services: weight, height, head circumference, abdominal circumference, chest circumference measurements, and full physical examination. Column (7) presents the Post-Delivery Healthcare Access Index, constructed as the z-score of the sum of: PNC visits (z-score), proportion of PNC services received, NBC visit receipt, NBC visits (z-score), proportion of NBC services received, and ASHA/ANM home visits for NBC. Household controls include whether household has a toilet and asset index. Mother controls include age, age at marriage, and education. Robust standard errors are reported in brackets. *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Table 5: Birth Weight and Child Nutrition Status

	Low Birth Weight (LBW)	Very LBW	Underweight	Stunted	Wasted
VARIABLES	(1)	(2)	(3)	(4)	(5)
Treatment	-0.078	-0.079*	-0.104	0.052	-0.236***
	[0.076]	[0.046]	[0.070]	[0.061]	[0.074]
Unbalanced Controls	YES	YES	YES	YES	YES
Household Controls	YES	YES	YES	YES	YES
Mother Controls	YES	YES	YES	YES	YES
Observations	1606	1606	2,799	2,772	2,674
First-stage F	475.42	475.42	844.87	829.54	795.96
Control Mean	0.187	0.060	0.38	0.22	0.37

Notes- All dependent variables are binary indicators. Column (1) measures low birth weight, defined as birth weight less than 2.5kg. Column (2) measures very low birth weight, defined as birth weight less than 1.5kg. Columns (3)-(5) examine child nutritional status based on anthropometric measurements. Column (3) indicates underweight status (weight-for-age z-score < -2 standard deviations). Column (4) indicates stunted growth (height-for-age z-score < -2 standard deviations). Column (5) indicates prevalence of wasting (weight-for-height z-score < -2 standard deviations). Z-scores are calculated using WHO growth standards that account for child age and gender. Sample sizes vary across nutritional outcomes due to exclusion of biologically implausible anthropometric measurements. Birth weight data are limited to children with recorded weights. Household controls include whether household has a toilet and asset index. Woman controls include age, age at marriage, and education. The program showed no effect on raw height, weight, and chest/head/waist circumferences, even after controlling for mother, household, and child characteristics. Robust standard errors are reported in brackets. *** p<0.01, ** p<0.05, * p<0.1.

Table 6: Potential Mechanism- Private Action

	Consulted ASHA and ANM	Months Pregnant at 1st ANC	Whether shared Pregnancy information with SHG?	Family Support Index	VHSND Visits	Awareness Index- Robustness Check table
VARIABLES	(4)	(2)	(1)	(3)	(5)	
Treatment	0.195***	-0.597**	0.13***	0.315**	0.521***	0.442***
	[0.068]	[0.270]	[0.046]	[0.123]	[0196]	[0.119]
Experimental Block FE	YES	YES	YES	YES	YES	YES
Taluka FE	YES	YES	YES	YES	YES	YES
Unbalanced Controls	YES	YES	YES	YES	YES	YES
Household Controls	YES	YES	YES	YES	YES	YES
Woman Controls	YES	YES	YES	YES	YES	YES
Observations	2,397	2,204	3397	3442	2762	3442
First-stage F	530.08	423.32	1060.87	1063.98	1096.65	1063.98
Control Mean	0.72	3.54	0.139	0.002	2.43	-0.0001
Percentage Change	27.08	16.86	93.52	-18.97	21.44	

Note - Column (1) is a binary variable indicating whether the woman consulted both ASHA and ANM during pregnancy, for pregnant women and lactating women with children ≤12 months old. Column (2) measures the month of pregnancy when the first ANC visit occurred, conditional on receiving ANC visits. Column (3) is a binary variable indicating whether the woman shared pregnancy information with SHG members; 45 observations are excluded due to missing SHG data. Column (4) presents the Family Support Index, constructed from five indicators: family participation in ANC decisions, accompaniment to health facilities, presence during SHG counselling sessions, number of family members at counselling, and implementation of counselling advice. The index is calculated by summing these variables and standardizing to a z-score. Column (5) measures the number of Village Health Sanitation and Nutrition Days (VHSNDs) attended by the woman in the last six months, conditional on attending any VHSND. Household controls include whether household has a toilet and asset index. Woman controls include age, age at marriage, and education. Robust standard errors are reported in brackets. *** p<0.01, ** p<0.05, * p<0.1.

Table 7: Potential Mechanism- Outreach by Frontline Health Workers (ASHAs)

	Registered in 1st Trimester	Woman approached ASHA	ASHA approached woman	Counselling in 1st Trimester	Number of counselling sessions	Family members present during counselling
VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)
Treatment	0.171 *	0.199 *	0.234 *	0.168*	0.608*	0.260***
	[0.099]	[0.119]	[0.121]	[0.102]	[0.365]	[0.099]
Experimental Block FE	YES	YES	YES	YES	YES	YES
Taluka FE	YES	YES	YES	YES	YES	YES
ASHA Controls	YES	YES	YES	YES	YES	YES
Village Controls	YES	YES	NO	NO	NO	NO
Observations	561	590	590	564	590	590
First-stage F	423.65	354.39	277.63	274.65	277.63	268.12
Control Mean	0.76	0.34	0.56	0.77	2.12	0.8
Percentage Change	22.5	58.52	41.78	21.81	28.67	32.5

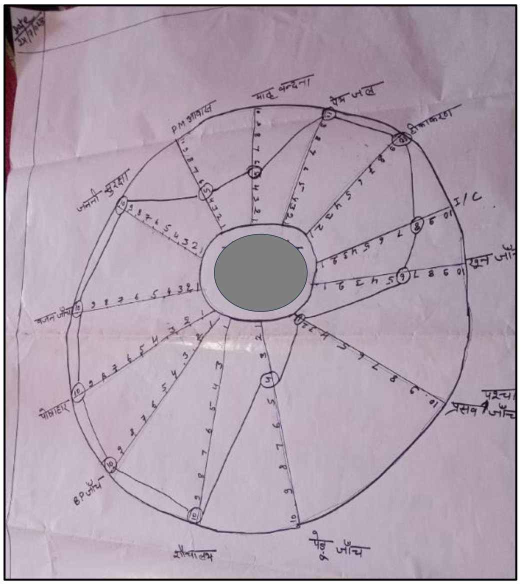
Note- All coefficients represent treatment effects using ASHA survey data. Sample includes 590 pregnant women registered with ASHAs across 110 villages; some ASHAs were unavailable due to hospital or delivery-related duties. Column (1) indicates whether pregnancy was registered in the first trimester, conditional on registration. Column (2) is a binary variable indicating whether the woman approached the ASHA to inform about her pregnancy. Column (3) indicates whether the ASHA approached the woman first upon learning of the pregnancy. Column (4) indicates whether the first counselling session occurred in the first trimester, conditional on receiving counselling. Column (5) measures the number of counselling sessions conducted by the ASHA for each woman, taking the value zero for women who have not received any counselling sessions. Column (6) indicates whether family members were present during counselling sessions. ASHA controls include age, education, motivation, whether she has other occupation, and experience. Village controls include remoteness index, medical facility availability, PHC availability, and whether it is a backward caste dominant village. Robust standard errors are reported in brackets. *** p<0.01, ** p<0.05, * p<0.1

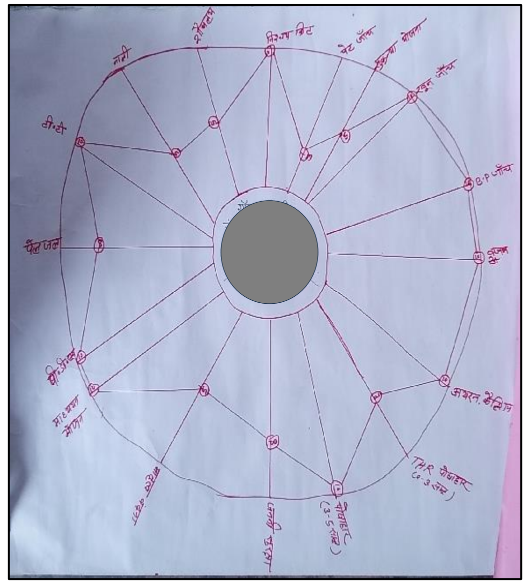
Appendix 1: Health Behavior and Outcomes (Jharkhand and India)

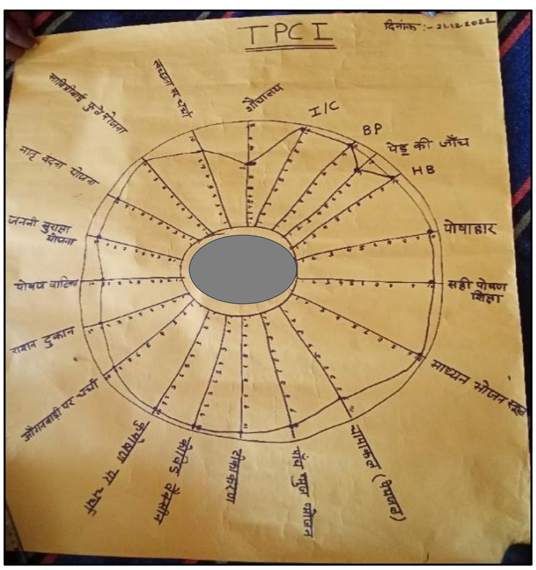
	Jharkhand (Rural)	India (Rural)
Neonatal mortality rate	30.4	27.5
Infant mortality rate	41.1	38.4
Under-five mortality rate	49.2	45.7
Mothers who had an antenatal check-up in the first trimester (%)	66.2	67.9
Mothers who had at least 4 antenatal care visits (%)	36.4	54.2
Mothers who consumed iron folic acid for 100 days or more when they were pregnant (%)	26.1	40.2
Percentage of pregnancies registered in the first trimester (%)	80.8	84.4
Mothers who received postnatal care from health personnel within 2 days of delivery (%)	66.7	75.4
Children who received postnatal care from health personnel within 2 days of delivery (%)	66.1	76.5
Institutional births (%)	73.1	86.7
Children under 5 years who are stunted (height-for-age) (%)	42.3	37.3
Children under 5 years who are wasted (weight-for-height) (%)	22.3	19.5
Children under 5 years who are underweight (weight-for-age) (%)	41.4	33.8
All women age 15-49 years who are anemic (%)	66.7	58.5

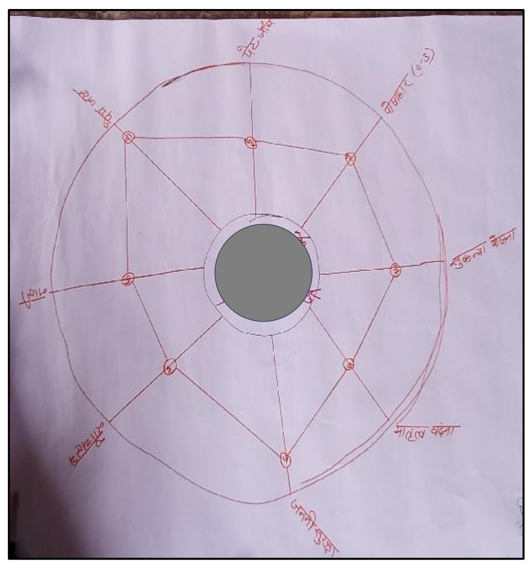
Notes: This table compares key maternal and child health indicators between rural Jharkhand and rural India using data from the National Family Health Survey-5 (2019-21), Ministry of Health and Family Welfare, Government of India. Rural Jharkhand consistently underperforms relative to the rural India across nearly all indicators, with substantial gaps in antenatal care utilization, maternal nutrition supplementation, institutional delivery rates, and child nutritional outcomes. The state also shows higher mortality rates and maternal anemia prevalence compared to the national rural average, highlighting significant disparities in maternal and child health outcomes.

Appendix 2: Triggering Plan for Community Action (TPCA) Maps









Notes: These maps demonstrate the TPCA process, with village names anonymized for confidentiality. Each service is positioned around the circle and rated on a 1-10 scale (1 = lowest availability, 10 = highest availability), with scores marked on the radial lines extending from the inner circle to the outer circle, where the highest scores are positioned closer to the outer circle and lowest scores closer to the inner circle. These participatory assessments identify service gaps, vulnerable households, and uptake barriers, forming the foundation for community-driven action planning.

Appendix 3: Context-Informed ANC Adoption Model

We model the woman's decision to consume a particular level of ANC and exhibit compliance with health advisories as a continuous-intensity ANC model. We assume an additive iso-elastic (CRRA) form of the utility function which is strictly increasing and quasi-concave. The CRRA form allows us to introduce flexibility in the marginal rate of substitution between consumption of composite goods and health instead of being a fixed share[12]:

$$U(c, h, x; T_v) = \frac{1-\sigma}{1-\alpha} c^{1-\alpha} + \frac{\sigma}{1-\alpha} h^{1-\alpha} - \phi T_v x \quad (1)$$

where c is consumption of all other goods; h is woman (and fetal) health stock; $x \geq 0$ is the quantity of ANC services consumed during pregnancy (example, number of ANC check-ups, proportion of recommended protocols (such as consumption of IFA, calcium, and nutritious food items) completed; $\sigma \in (0,1)$ is the importance that the household places on health relative to other goods; $\alpha \in (0,1)$ is the constant relative risk-aversion (CRRA) parameter; and ϕT_v is the non-pecuniary cultural (fear) cost per visit.

$U(\cdot)$ is the sum of strictly concave functions minus a linear cost, hence it is strictly quasi-concave.

Budget constraint: $c = y - p_v x \quad (2)$

Health production function: $h(x\,;\ T_v) = \left(h_0 + \theta_{T_v} x^{\eta}\right),\ 0 < \eta < 1, \qquad (3)$

where p_v is the marginal cost of ANC in village v (i.e., money, time, and psychic hassle), T_v is the treatment indicators (1, if village is exposed to JASHN intervention, 0 otherwise), h_0 is baseline health with no ANC; η exhibits the diminishing returns to additional check-ups, i.e., marginal productivity of ANC visits in terms of health stock and θ_{T_v} is the effectiveness parameter or the perceived medical productivity of following the health advisories for instance undertaking ANC visits and that might be higher in JASHN villages (i.e., $\theta_1 > \theta_0$) because

[12] CRRA form suggests that households dislike risk and the tradeoff between money and health is flexible as better-off households will give up more money to accumulate an additional unit of health compared to poorer households. Therefore, the marginal rate of substitution is not fixed across various types of households.

counseling of woman, her family members, trust in the SHG, and service quality improves the value of ANC and compliance to other advisories.

In Jharkhand, women and their households act on a locally consistent however incomplete mental model that if outsiders know that the woman is pregnant then the evil eye will harm the baby and therefore the household chooses to remain reticent about the health status of the woman. As households and their practices are embedded in the local context, the household's approach will alter two important parameters: (a) the perceived productivity of adhering to medical advisories such as completing mandatory ANC visits (θ), and (b) cultural cost (fear) per unit adherence to the medical procedures (ϕ). In fact,

$$\theta_{context} = \mu\theta_0, \quad \phi_{context} = \phi_0 + \psi \quad (3')$$

So for instance if μ =0.4, then the woman and the family values each ANC visit at only 40% of its 'true' medical value and if ψ=3, then they experience three utility-units of additional anxiety.

The household optimization problem can be expressed as:

$$\max_{x \geq 0} \frac{1-\sigma}{1-\alpha} (y - p_v x)^{1-\alpha} + \frac{\sigma}{1-\alpha} (h_0 + \theta_{T_v} x^{\eta})^{1-\alpha} - \phi T_v x \quad (4)$$

In order to derive closed-form solution we drop baseline health (h_0"θx^{η}) and assume that income is large relative to what is spent on pregnancy (y"$p_v x$). In that case, $(y - p_v x)^{-\alpha} \approx y^{-\alpha}$ is nearly constant[13]. Under these generalized development-health approximations we get:

$$-(1-\sigma)\, p_v y^{-\alpha} + \sigma\eta\theta_{T_v} x^{\eta-1-\alpha\eta} = \phi T_v \quad (5)$$

We solve for x:

$$x^*_{T_v} = \left[\frac{\sigma\eta\theta_{T_v}}{\phi_{T_v} + (1-\sigma)p_v y^{-\alpha}}\right]^{\frac{1}{1-\eta(1+\alpha)}}, \; 0 < \eta(1+\alpha) < 1 \qquad (6)$$

From (6) we can ascertain the optimal ANC visits that the woman will undertake. The numerator can be interpreted as the "benefit index" because if the parameters σ (household's preference for health viz'-a-viz other goods), η (marginal productivity of ANC visits), and θ_{T_v} (perceived

[13] Differentiate (4) w.r.t. $x = \frac{\partial U}{\partial x} = -(1-\sigma)(y - p_v x)^{-\alpha} + \sigma\eta\theta_{T_v} x^{\eta-1}\left(h_0 + \theta_{T_v} x^{\eta}\right)^{-\alpha} = \phi T_v \quad (4')$

effectiveness of ANC visits) were to improve then it will result in more number of ANC visits. On the other hand, the denominator in (6) can be considered as a "cost index" because if the parameters ϕ_{T_v} (fear premium), p_v (monetary and hassle price per ANC visits), and $y^{-\alpha}$ (down weights the cash pain for better-off households, i.e., if income increases, this term shrinks) were to increase then these will negatively influence ANC intensity.

If we were to plug the parameters influenced by context informed rationality from (3') in (6), we find that the optimal-visit expression will be updated for the scenario where no JASHN type intervention is present:

$$x^*_{context} = [\frac{\sigma\eta(\mu\theta_0)}{(\phi_0+\psi)+(1-\sigma)p_v y^{-\alpha}}]^{\frac{1}{1-\eta(1+\alpha)}} \qquad (6')$$

$x^*_{context}$ is strictly smaller than $x^*_{T_v}$ (the full-information benchmark) because the numerator shrinks and the denominator grows. Thus in the absence of the intervention, the context-informed rationality will directly reduce the intensity and likelihood of ANC utilization by shrinking perceived benefits and inflating fear costs of social traditions including '*nazar'* or evil-eye. Compared to that, the JASHN integration with SHG platform operates on the levers of information and private action to reverse such distortions. Thus, in the JASHN villages, SHG group discussions particularly the ones that take place inside the home of the pregnant woman can reframe local beliefs and normalize early check-ups (i.e., reduces the fear premium ψ). The collective nature of peer-peer counseling and the discussions held by the "Setu Didi" with the pregnant women and other group members enhances the value of early disclosure of pregnancy and medical care, thereby aligning health-seeking behavior with public-health recommendations (i.e., μ increases). Therefore, $\theta_1 > \theta_0$ and $\phi_1 > \phi_0 \Rightarrow x^*_1 > x^*_0$.

We extend the household problem to include ASHA worker's discovery problem as it allows us to position ANC access as a two-sided coordination task. The ASHA worker exerts search effort $e \geq 0$ to identify newly-pregnant women. The probability that the woman is discovered by the ASHA worker is:

$$q(e;\ \kappa) = 1 - \exp[-\kappa(e+\delta)], \quad 0 < q < 1 \qquad (7)$$

where κ is the efficiency of search efforts, and $\delta > 0$ is an information boost provided by the SHGs in JASHN villages when they inform or tip-off pregnancies. Hence δ is zero in non-JASHN villages.

Under the assumption that woman's ANC choice is dependent on either ASHA approaching her or she is encouraged by SHG to meet the ASHA worker, we update θ from (3) which is effectiveness parameter to $\theta_{eff} = \theta_0\, q(e;\ \kappa)$ (8)

We write the ASHA optimization problem assuming she is paid a fixed bonus $w > 0$ for every pregnancy she registers. Her effort cost is convex: $g(e) = \frac{\gamma}{2}e^2$ with $\gamma > 0$ and indicates ASHA's unit effort cost.

$$\max_{e \geq 0}\ \mathrm{w}q(\mathrm{e};\ \kappa) - \frac{\gamma}{2}\mathrm{e}^2 \qquad (9)$$

First-order condition (interior optimum):

$$\mathrm{w}\,\kappa \exp\left[-\kappa(\mathrm{e}+\delta)\right] - \gamma \mathrm{e} = 0 \Rightarrow \mathrm{e}^* = \frac{W[\frac{w\kappa}{\gamma}\mathrm{e}^{\kappa\gamma}]}{\kappa} \qquad (10)$$

where $W(\cdot)$ is the Lambert-W function.

From comparative statics, we can infer that if $\delta \uparrow$ or $\gamma \downarrow \Rightarrow \mathrm{e}^* \uparrow$, that is, SHG tip-offs and reduced mapping hassle of pregnant women will induce ASHA to increase her effort-level.We plug e^* from (10) into (7) in order to derive the probability of discovery of pregnant woman at optimum effort-level:

$\mathrm{q}^* = 1 - \exp[-\kappa(\mathrm{e}^* + \delta)]$ (11), with e^* from (10)

Since $\mathrm{e}^* \uparrow$ and $\delta > 0$ in JASHN villages, we expect $\mathrm{q}_1^* > \mathrm{q}_0^*$

We plug q^* from (11) in (8) and then replace θ_{T_V} in (6) with the effective value:

$$\theta_{\mathrm{eff}} = \theta_0\, \mathrm{q}^*(\mathrm{e};\ \kappa)$$

The optimal ANC usage is:

$$x^*_{T_v} = [\frac{\sigma\eta\theta_0 q^*_{T_v}}{\phi T_v + (1-\sigma)p_v y^{-\alpha}}]^{\frac{1}{1-\eta(1+\alpha)}} \quad (6'')$$

where $q^*_{T_v}$ is increasing function of δ and a decreasing function of γ.

In non-JASHN villages, the ASHA's search cost is higher (γ is high) as she almost receives no support from SHG in identifying pregnancy in early phases (δ =0). Therefore, optimal effort of ASHA, e^*_0 is modest resulting in lower probability of discovery (q^*_0 is low). As a result, the effective benefit value ($\theta_0 q^*_0$) is expected to be somewhat muted as households rationally choose fewer use of ANC services (x^*_0 is low). We expect that the ASHA workers in the JASHN villages will attempt to endogenously improve q^*. Given that the information boost functions upstream, its impact is multiplicative as rising q^* is amplified by the exponent: $\frac{1}{[1-\eta(1+\alpha)]} > 1$. Therefore, even modest search-cost savings can lead to large gains in utilization of ANC services. When we combine demand-side shifts ($\theta \uparrow, \phi \downarrow$) with the supply-side mechanisms ($q^* \uparrow$ through δ ↑ and γ ↓), the ANC utilization in JASHN villages will be strictly greater compared to control group villages: $x^*_{JASHN} > x^*_{Control}$.

Appendix 4: SHG Support

	SHG Help to reach ASHA	Encouraged for food & medicines	Potential Place of Delivery	Test and Ultrasound	SHG Meeting at home	Counseled family members	Mental Support	Pregnancy Celebrated
VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Treatment	0.204***	0.160***	0.143***	0.145***	0.141***	0.212***	0.074*	0.097***
	[0.048]	[0.048]	[0.043]	[0.050]	[0.034]	[0.042]	[0.042]	[0.036]
Unbalanced Controls	YES	YES	YES	YES	YES	YES	YES	YES
Household Controls	YES	YES	YES	YES	YES	YES	YES	YES
Mother Controls	YES	YES	YES	YES	YES	YES	YES	YES
Observations	3397	3397	3397	3397	3397	3397	3397	3397
First-stage F	1060.87	1060.87	1060.87	1060.87	1060.87	1060.87	1060.87	1060.87
Control Mean	0.153	0.161	0.114	0.172	0.067	0.103	0.104	0.078
Percentage Change	133.33	99.37	125.43	84.30	210.44	205.82	71.15	124.35

Notes: All dependent variables are binary indicators measuring different types of SHG support received during pregnancy. Sample includes pregnant and lactating women; 45 observations are excluded due to missing SHG data. These represent 8 of 9 types of SHG support (the 9th, sharing pregnancy information with SHG, is analyzed in Table 6). Column (1) indicates whether SHG helped the woman reach the ASHA. Column (2) measures whether SHG encouraged the woman to eat quality diverse food and take prescribed medicines. Column (3) indicates whether SHGs discussed potential places of delivery with the woman. Column (4) measures whether SHG encouraged the woman to get all tests and ultrasounds done. Column (5) indicates whether an SHG meeting was conducted at the pregnant woman's home during her pregnancy. Column (6) measures whether SHG counseled the woman's family members at some point during pregnancy. Column (7) indicates whether SHG members provided mental support and encouragement during pregnancy. Column (8) measures whether the pregnancy was celebrated in the SHG group. Household controls include whether household has a toilet and asset index. Mother controls include age, age at marriage, and education. Robust standard errors are reported in brackets. *** p<0.01, ** p<0.05, * p<0.1.

Appendix 5: Variable Definition

Variable Name	Descriptions
SHG Support	This variable represents the sum of 9 key supports provided by SHGs during the woman's pregnancy. Woman was asked whether she agreed with the following statements: a) I shared the news about my pregnancy in my SHG group or to one of the SHG didi after disclosing it with my family members. b) I sought their advice to approach the ASHA worker. c) The SHG didis encouraged me to regularly take my medications and good quality food during the pregnancy. d) I enquired from them about the potential places for delivery. e) They encourage me to go through all the test and ultrasound. f) During my pregnancy at least one SHG meeting was conducted at my home. g) SHG didis counselled my family members at some point in time during my pregnancy. h) SHG didis provided me mental support and encouragement when I felt low during the pregnancy phase. i) My pregnancy was celebrated in the SHG group.
Whether SHG Support	This is a binary variable that equals 1 if the woman received at least one of the 9 key SHG supports and 0 otherwise.
SHG Support Index	This is a proportion of SHG support services (described above) received, calculated by dividing the total number of supports received by 9.
Registered Pregnancy	Binary indicator equal to 1 if the woman's pregnancy was officially registered with any healthcare facility or frontline health worker, 0 otherwise.
Registered in 1st Trimester	Binary indicator equal to 1 if the woman registered her pregnancy within the first three months (first trimester) of pregnancy, 0 otherwise.
ANC Visits (z-score)	Standardized z-score of the total number of antenatal care visits received during pregnancy.
ANC Visits (Mandatory)	Binary indicator equal to 1 if the woman completed the minimum recommended four antenatal care visits during pregnancy as per government guidelines, 0 otherwise.
ANC Services (Proportion)	Continuous variable measuring the proportion of antenatal care services received out of 24 possible services, ranging from 0 to 1. The 24 services include: tetanus injection, deworming medication, 100 IFA tablets, calcium tablets, weight monitoring, blood pressure monitoring, blood test, urine test, abdominal examination, height monitoring, syphilis test, x-ray, ultrasound/sonogram, HIV test, hepatitis test, tuberculosis test, nutrition advice, advice for institutional delivery, advice on delivery date and care, danger signs of pregnancy, where to go for complications, newborn care (NBC), family planning, and rest during pregnancy
IFA+Calcium	Binary indicator equal to 1 if the woman consumed at least 90 tablets each of both iron-folic acid (IFA) and calcium supplements during pregnancy, 0 otherwise.
JSY (Janani Suraksha Yojana)	Binary indicator equal to 1 if the woman was both aware of and successfully availed benefits under the Janani Suraksha Yojana government scheme for institutional deliveries, 0 otherwise.
Institutional Birth	This is a binary indicator that equals 1 if the delivery took place in a health facility (government/private/trust hospital, clinic, health sub-centre, or Anganwadi centre) and 0 if the delivery took place at home.
Whether received NBC Visits?	This is a binary variable that equals 1 if the child received at least one newborn care visit and 0 otherwise.
Number of NBC Visits (z-score)	This variable indicates the z-score of the total number of newborn care visits the child received.
NBC Services (Proportion)	This variable indicates the number of newborn care services the child received out of 6 key services. These 6 services include: weight, height, head circumference, abdominal circumference, chest circumference measurements, and full physical examination
Postnatal Healthcare Access Index	This index is constructed by summing the following binary and continuous variables and then calculating its z-score: a) Z-score of number of PNC visits undertaken by the woman b) Proportion of PNC services the woman received out of 8

	c) Proportion of PNC advisories the woman received out of 8 d) Whether the child received any NBC visit e) Z-score of number of NBC visits received by the child f) Proportion of NBC services received out of 6 g) Proportion of NBC advisories received out of 9 h) Whether the child received a home visit from ASHA/ANM for NBC
Low Birth Weight (LBW)	This is a binary indicator that equals 1 if the child's birth weight is less than 2.5 kilograms (2,500 grams) and 0 if the birth weight is 2.5 kilograms or above. Birth weight is measured at the time of delivery.
Very Low Birth Weight	This is a binary indicator that equals 1 if the child's birth weight is less than 1.5 kilograms (1,500 grams) and 0 if the birth weight is 1.5 kilograms or above. Birth weight is measured at the time of delivery.
Underweight (WAZ < -2SD)	This is a binary indicator that equals 1 if the child's weight-for-age z-score is below -2 standard deviations and 0 if it is -2 standard deviations or above. Weight-for-age z-scores are calculated using WHO Child Growth Standards that adjust for the child's age in months and gender. This variable identifies underweight children.
Stunted (HAZ < -2SD)	This is a binary indicator that equals 1 if the child's height-for-age z-score is below -2 standard deviations and 0 if it is -2 standard deviations or above. Height-for-age z-scores are calculated using WHO Child Growth Standards that adjust for the child's age in months and gender. This variable identifies children with stunting.
Wasted (WHZ < -2SD)	This is a binary indicator that equals 1 if the child's weight-for-height z-score is below -2 standard deviations and 0 if it is -2 standard deviations or above. Weight-for-height z-scores are calculated using WHO Child Growth Standards that adjust for the child's age and gender. This variable identifies children with wasting.
Consulted ASHA and ANM	Binary indicator equal to 1 if the woman consulted with both an ASHA and an ANM during her pregnancy, 0 otherwise. This measures engagement with frontline health workers.
Months Pregnant at 1st ANC	This variable indicates the month of pregnancy (1-9) when the woman received her first antenatal care visit. Lower values indicate earlier initiation of prenatal care, with first trimester visits occurring in months 1-3.
Whether shared Pregnancy information with SHG?	Binary indicator equal to 1 if the woman shared news of her pregnancy with Self-Help Group members after first disclosing to family members, 0 otherwise.
Family Support Index	This index is constructed by summing the following binary and continuous variables and then calculating its z-score: a) Whether family members made the decision to go for an ANC visit b) Whether family members accompanied the woman to health facilities c) Whether family members were present during the counselling meetings conducted by the SHGs d) Number of family members present during the counselling meetings e) Whether the family complied with what was suggested/advised during the counselling meetings
VHSND Visits	Count variable measuring the number of VHSNDs attended by the woman in the six months prior to the survey. VHSNDs are monthly community health events where multiple services are provided by frontline workers.
Registered in 1st Trimester (as reported by ASHA)	Binary indicator equal to 1 if the woman's pregnancy was registered with healthcare authorities during the first trimester (first three months) of pregnancy, 0 otherwise. This variable is calculated using ASHA survey data.
Woman approached ASHA	Binary indicator equal to 1 if the woman herself initiated contact with the ASHA to inform her about the pregnancy, 0 if the ASHA learned about the pregnancy through other means. This variable is calculated using ASHA survey data.
ASHA approached woman	Binary indicator equal to 1 if the ASHA was the first to approach the woman after learning about her pregnancy, 0 otherwise. This variable is

	calculated using ASHA survey data.
Counselling in 1st Trimester	Binary indicator equal to 1 if the woman's first counseling session with the ASHA occurred during the first trimester of pregnancy, 0 otherwise. This variable is calculated using ASHA survey data.
Number of counselling sessions	Count variable measuring the total number of counseling sessions conducted by the ASHA for each pregnant woman. This variable is calculated using ASHA survey data, takes the value zero for women who have not received any counseling sessions, and positive integer values for those who have.
Family members present during counselling	Binary indicator equal to 1 if family members (such as husband, mother-in-law, or other relatives) were present during the ASHA's counseling sessions with the pregnant woman, 0 otherwise. This variable is calculated using ASHA survey data and measures family involvement in maternal health counseling.
SHG Help to reach ASHA	Binary indicator equal to 1 if SHG members helped/encouraged the woman to contact or reach the ASHA during pregnancy, 0 otherwise.
Encouraged for food & medicines	Binary indicator equal to 1 if SHG members encouraged the woman to regularly consume quality diverse food and take prescribed medications during pregnancy, 0 otherwise.
Potential Place of Delivery	Binary indicator equal to 1 if SHG members discussed with the woman about potential places for delivery (home vs. institutional delivery options), 0 otherwise. This measures SHG involvement in delivery planning discussions.
Test and Ultrasound	Binary indicator equal to 1 if SHG members encouraged the woman to undergo all recommended tests and ultrasounds during pregnancy, 0 otherwise.
SHG Meeting at home	Binary indicator equal to 1 if at least one SHG meeting was conducted at the pregnant woman's home during her pregnancy, 0 otherwise.
Counseled family members	Binary indicator equal to 1 if SHG members counseled the woman's family members (such as husband, mother-in-law, or other relatives) at some point during her pregnancy, 0 otherwise.
Mental Support	Binary indicator equal to 1 if SHG members provided mental support and encouragement to the woman when she felt low during pregnancy, 0 otherwise.
Pregnancy Celebrated	Binary indicator equal to 1 if the woman's pregnancy was celebrated within the SHG group, 0 otherwise.
IFA	This is a categorical variable with six categories: 0-30, 30-60, 60-90, 90-120, 120-150, and 150-180. It records the group based on the total number of IFA tablets that the woman consumed.
Calcium	This is a categorical variable with six categories: 0-30, 30-60, 60-90, 90-120, 120-150, and 150-180. It records the group based on the total number of calcium tablets that the woman consumed.
Haemoglobin	This variable captures the woman's haemoglobin level during pregnancy (gm/dl). Data were collected from the woman's MCP card, which contains health indicators recorded during pregnancy.
Anaemia	This is a binary indicator that equals 1 if the woman's haemoglobin level during pregnancy is below 11 gm/dl and 0 if the haemoglobin level is 11 gm/dl or above. This variable identifies women with any form of anaemia during pregnancy.
Mild Anaemia	This is a binary indicator that equals 1 if the woman's haemoglobin level during pregnancy is between 7 gm/dl and 9 gm/dl (inclusive) and 0 if the haemoglobin level is above 9 gm/dl. This variable identifies women with mild anaemia during pregnancy.
Moderate Anaemia	This is a binary indicator that equals 1 if the woman's haemoglobin level during pregnancy is 7-9.9 gm/dl (inclusive) and 0 otherwise. This variable identifies women with moderate anaemia during pregnancy.
Severe Anaemia	This is a binary indicator that equals 1 if the woman's haemoglobin level during pregnancy is below 7 gm/dl and 0 if the haemoglobin level is 7 gm/dl or above. This variable identifies women with severe anaemia during pregnancy.
Height-for-Age Z-score (HAZ)	This variable captures the child's height-for-age z-score calculated using WHO child growth standards, which also accounts for the child's age and gender. Biologically implausible values (below -6 or above +6 standard deviations) are replaced with missing values.
Weight-for-Age Z-score (WAZ)	This variable captures the child's weight-for-age z-score calculated using WHO child growth standards, which also accounts for the child's age and gender. Biologically implausible values (below -6 or above +5 standard deviations) are replaced with missing values.
Weight-for-Height Z-score	This variable captures the child's weight-for-height z-score calculated using WHO child growth standards, which also accounts for the child's age and

(WHZ)	gender. Biologically implausible values (below -5 or above +5 standard deviations) are replaced with missing values.
Awareness Index	This index is constructed by summing the following binary and continuous variables and then calculating its z-score: a) Whether the woman is aware of Janani Suraksha Yojana b) Whether the woman is aware of Matritva Vandana Yojana c) Proportion of services provided during ANC that the woman is aware of out of 24 d) Proportion of services provided at AWC that the woman is aware of out of 11
ANC Access Index	This index is constructed by summing the following binary and continuous variables and then calculating its z-score: a) Whether the woman registered her current/most recent pregnancy b) Whether the pregnancy was registered in the first trimester c) Whether the first ANC visit took place in the first trimester d) Whether the woman received a mother-child protection card e) Whether the woman completed at least four mandatory ANC visits f) Proportion of total ANC services received out of 24 g) Proportion of total Anganwadi services utilized out of 11 h) Whether the woman met both ASHA and ANM workers at any point during her pregnancy i) Whether the woman has utilized benefits from Janani Suraksha Yojana j) Whether the woman has utilized benefits from Matritva Vandana Yojana
Compliance Index	This index is constructed by summing the following binary and continuous variables and then calculating its z-score: a) Whether the woman consumed at least 90 tablets each of iron and calcium b) Whether the woman satisfies minimum dietary diversity (i.e., consumed at least five out of ten defined food groups in the past 24 hours) c) Number of food groups consumed out of 10 in the past 24 hours d) Whether the woman has a kitchen garden e) Whether institutional delivery took place f) Whether the woman met an ASHA worker at any point during her pregnancy g) Whether the woman met both ASHA and ANM workers at any point during her pregnancy h) Whether the woman registered her current/most recent pregnancy i) Whether the woman undertook at least four ANC visits during her pregnancy
Whether HH has a toilet	Binary indicator equal to 1 if the household has any type of toilet facility, 0 otherwise.
HH Assets Index	Standardized z-score constructed from the total number of assets owned by the household plus house ownership status. The index combines various household assets (such as television, radio, bicycle, motorcycle, tractor/car, refrigerator, etc.) with house ownership.
Age of the woman	Woman's age in completed years at the time of the survey.
Age at the time of marriage	Woman's age in completed years at the time of her marriage.
Education	Continuous variable measuring the total number of years of formal education completed by the woman at the time of the survey.

Appendix 6: ANC Services

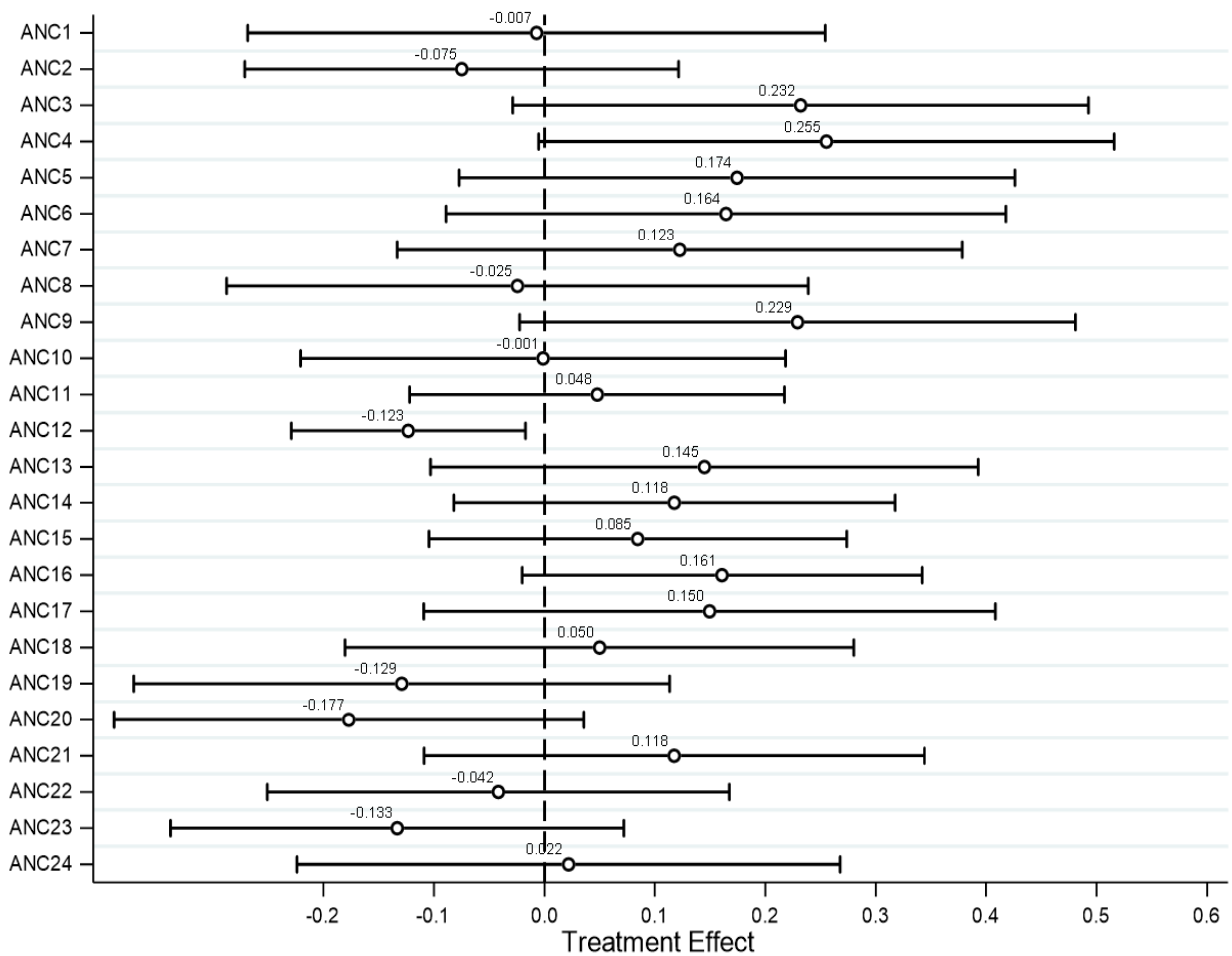


Figure A1: Treatment Effects on Individual ANC Services

Figure A1 displays coefficient estimates and 95% confidence intervals examining treatment effects on receipt of individual antenatal care services. Each point represents the treatment effect for a specific ANC service, with services ordered as follows: (ANC1) Tetanus injection, (ANC2) Deworming medication, (ANC3) 100 IFA tablets, (ANC4) Calcium tablets, (ANC5) Weight monitoring, (ANC6) Blood pressure monitoring, (ANC7) Blood test, (ANC8) Urine test, (ANC9) Abdominal examination, (ANC10) Height monitoring, (ANC11) Syphilis test, (ANC12) X-ray, (ANC13) Ultrasound/sonogram, (ANC14) HIV test, (ANC15) Hepatitis test, (ANC16) Tuberculosis test, (ANC17) Nutrition advice, (ANC18) Advice for institutional delivery, (ANC19) Advice on delivery date and care, (ANC20) Danger signs of pregnancy, (ANC21) Where to go for complications, (ANC22) Newborn care (NBC), (ANC23) Family planning, (ANC24) Rest during pregnancy. All regressions include experimental block fixed effects, taluka fixed effects, unbalanced controls, household controls, and woman controls. The services showing the highest treatment effects are calcium tablets, 100 IFA tablets, and abdominal examination, with supplementation services showing particularly strong responses to the intervention. Some counseling and advisory services also demonstrate notable positive effects, including nutrition advice, tuberculosis testing, and weight monitoring; suggesting the intervention effectively improved both clinical service delivery and health education components of antenatal care.

Appendix 7: Consumption of Supplements and Health of Pregnant Women

	IFA	Calcium	Hemoglobin	Anemia	Severe Anemia	Mild Anemia	Moderate Anemia
VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Treatment	0.421**	0.595***	1.811***	-0.114	-0.031	-0.572**	-0.687***
	[0.206]	[0.205]	[0.622]	[0.190]	[0.048]	[0.247]	[0.244]
Experimental Block FE	YES	YES	YES	YES	YES	YES	YES
Taluka FE	YES	YES	YES	YES	YES	YES	YES
Unbalanced Controls	YES	YES	YES	YES	YES	YES	YES
Household Controls	YES	YES	YES	YES	YES	YES	YES
Woman Controls	YES	YES	YES	YES	YES	YES	YES
Observations	2922	2648	266	266	266	264	264
First-stage F	1008.96	1003.23					
Control Mean	2.56	2.55	9.90	0.80	0.012	0.21	0.41
Percentage Change (%)	16.44	23.33	18.30	-	-	57.20	68.70

Notes: Columns (1) and (2) examine supplement consumption using categorical variables with six groups (0-30, 30-60, 60-90, 90-120, 120-150, and 150-180 tablets), conditional on receiving IFA and calcium tablets respectively. Hemoglobin and anemia outcomes are shown for pregnant women only, with data collected from Mother-and-Child Protection (MCP) cards representing the most recent test during pregnancy. Column (3) measures hemoglobin levels in gm/dl. Column (4) indicates any anemia (hemoglobin <11 gm/dl). Column (5) indicates severe anemia (hemoglobin <7 gm/dl). Column (6) indicates mild anemia (hemoglobin 7-9 gm/dl inclusive). Column (7) indicates moderate anemia (hemoglobin ≥7 and <10 gm/dl). Household controls include whether household has a toilet and asset index. Woman controls include age, age at marriage, and education. Robust standard errors are reported in brackets. *** p<0.01, ** p<0.05, * p<0.1.

Appendix 8: NBC Services

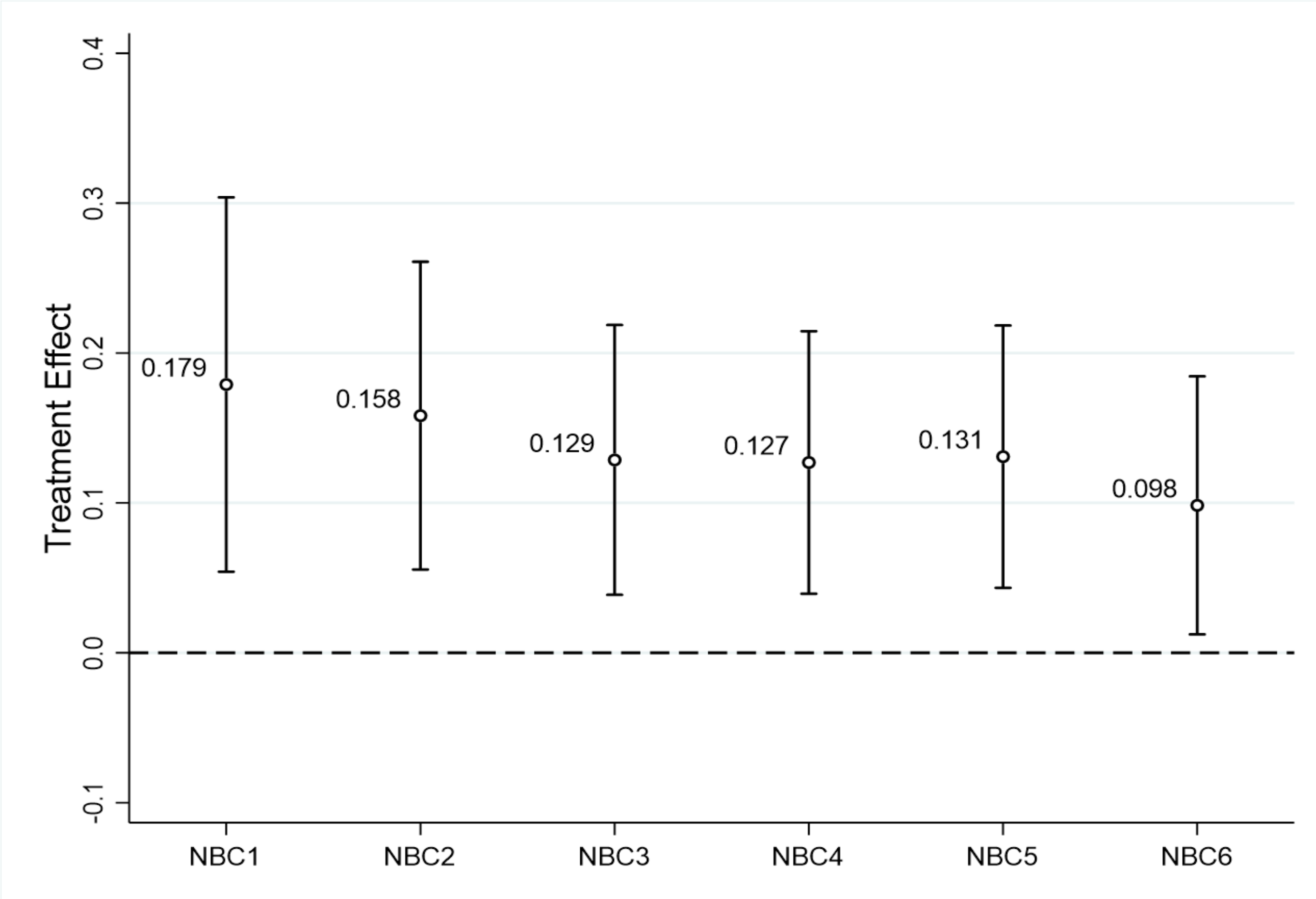


Figure A2: Treatment Effects on Individual NBC Services

Figure A2 shows coefficient estimates and 95% confidence intervals examining treatment effects on receipt of individual newborn care services. Each point represents the treatment effect for a specific NBC service, with services ordered as follows: (NBC1) Weight measured, (NBC2) Height measured, (NBC3) Head circumference measured, (NBC4) Abdominal circumference measured, (NBC5) Chest circumference measured, (NBC6) Full physical examination of the child. All regressions include experimental block fixed effects, taluka fixed effects, unbalanced controls, household controls, and woman controls. The services showing the highest treatment effects are weight measurement and height measurement, with anthropometric measurements demonstrating particularly strong responses to the intervention. All NBC services show positive treatment effects, suggesting the intervention successfully improved comprehensive newborn care practices across multiple dimensions of child health assessment.

Appendix 9: Child Nutrition Z-scores

	WAZ	HAZ	WHZ
VARIABLES	(1)	(2)	(3)
Treatment	0.303	-0.095	0.600***
	[0.196]	[0.239]	[0.232]
Experimental Block FE	YES	YES	YES
Taluka FE	YES	YES	YES
Unbalanced Controls	YES	YES	YES
Household Controls	YES	YES	YES
Woman Controls	YES	YES	YES
Observations	2,799	2,772	2,674
First-stage F	844.87	829.54	795.96

Note- All coefficients represent treatment effects examining child anthropometric outcomes. Column (1) presents weight-for-age z-scores (WAZ), column (2) presents height-for-age z-scores (HAZ), and column (3) presents weight-for-height z-scores (WHZ). All z-scores are calculated using WHO Child Growth Standards that adjust for the child's exact age in months and gender. Sample includes all children up to 24 months of age. Sample sizes vary across columns due to exclusion of biologically implausible anthropometric measurements. Household controls include whether household has a toilet and asset index. Woman controls include age, age at marriage, and education. Robust standard errors are reported in brackets. *** $p<0.01$, ** $p<0.05$, * $p<0.10$.

Appendix 10: Robustness Check 1- Lasso Specification

	Main Coefficients	PDS-LASSO Coefficient
VARIABLES	(1)	(2)
Whether SHG Support?	0.229***	0.105***
	[0.059]	[0.021]
SHG Support Index	0.145***	0.057***
	[0.033]	[0.013]
Registered Pregnancy	0.053	0.022
	[0.051]	[0.016]
Registered in 1st Trimester	0.198***	0.075***
	[0.076]	[0.022]
ANC Visits (z-score)	0.679**	0.19**
	[0.273]	[0.078]
ANC Visits (Mandatory)	0.376*	0.123***
	[0.158]	[0.039]
ANC Services (Proportion)	0.129**	0.045**
	[0.062]	[0.022]
IFA+Calcium	0.141**	0.026
	[0.057]	[0.026]
JSY	0.152***	0.037**
	[0.053]	[0.017]
Institutional Birth	0.161***	0.052*
	[0.055]	[0.030]
Whether received NBC Visits?	0.203***	0.057**
	[0.067]	[0.023]
No. of NBC Visits (z-score) Conditional	0.392**	0.191**
	[0.193]	[0.088]
No. of NBC Visits (z-score) Unconditional	0.485***	0.156***
	[0.140]	[0.054]
NBC Services (Proportion) Conditional	0.093	0.048*
	[0.063]	[0.028]
NBC Services (Proportion) Unconditional	0.136***	0.044***
	[0.041]	[0.013]
Post-Delivery Healthcare Access Index	0.443***	0.142***
	[0.135]	[0.053]
Underweight	-0.104	-0.021
	[0.070]	[0.021]
Stunted	0.052	0.017
	[0.061]	[0.019]
Wasted	-0.236***	-0.067***
	[0.074]	[.025]

Note: This table presents treatment effect estimates using LASSO. Column (1) reports main coefficients. Column (2) reports PDS-LASSO coefficients using LASSO variable selection with the full regressor set. Cluster robust errors are reported in brackets. The results demonstrate that most treatment effects remain positive and statistically significant across both estimation methods, with LASSO-based approaches generally producing smaller but consistent coefficient magnitudes compared to standard estimation. *** p<0.01, ** p<0.05, * p<0.1

Appendix 11: Robustness Check 2- Alternative Definition of Outcome Variables

	Awareness Index	ANC Access Index	Compliance Index
VARIABLES	(1)	(2)	(3)
Treatment	0.442***	0.300**	0.359***
	[0.119]	[0.123]	[0.138]
Experimental Block FE	YES	YES	YES
Taluka FE	YES	YES	YES
Unbalanced Controls	YES	YES	YES
Household Controls	YES	YES	YES
Woman Controls	YES	YES	YES
Observations	3442	3442	3397
First-stage F	1063.98	1063.98	1060.87
Control Mean	-0.0001	-0.047	0.078

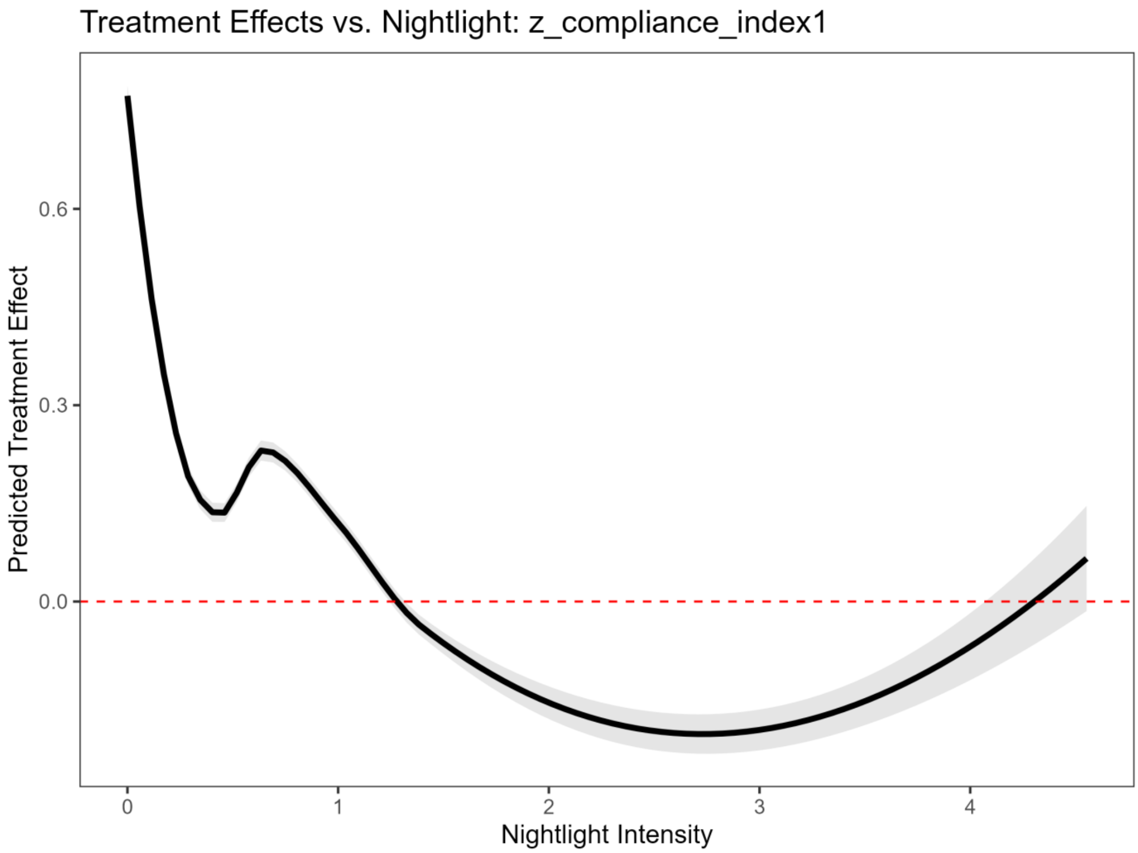
Notes: Column (1) presents the Awareness Index, constructed by summing and standardizing the following components: awareness of Janani Suraksha Yojana, awareness of Matritva Vandana Yojana, proportion of ANC services known (out of 24), and proportion of Anganwadi services known (out of 11). Column (2) presents the ANC Access Index, constructed by summing and standardizing ten indicators: pregnancy registration, first trimester registration, first trimester ANC visit, receipt of mother-child protection card, completion of four ANC visits, proportion of ANC services received (out of 24), proportion of Anganwadi services utilized (out of 11), contact with both ASHA and ANM, utilization of Janani Suraksha Yojana, and utilization of Matritva Vandana Yojana. Column (3) presents the Compliance Index, constructed by summing and standardizing nine indicators: consumption of at least 90 of both IFA and calcium tablets, minimum dietary diversity (5+ food groups), number of food groups consumed (out of 10), kitchen garden ownership, institutional delivery, ASHA contact, contact with both ASHA and ANM, pregnancy registration, and completion of four ANC visits. Household controls include whether household has a toilet and asset index. Woman controls include age, age at marriage, and education. Cluster robust standard errors are reported in brackets. *** p<0.01, ** p<0.05, * p<0.1

Appendix 12: Heterogeneity (Compliance Index)

Variable	Yes/Below Median (SE)	No/Above Median (SE)	Difference (SE)	P-value
Nightlight intensity (satellite data)	0.879**	-0.271	1.15**	
	[0.397]	[0.267]	(0.478)	0.016
Village remoteness index (distance)	-0.051	0.687***	-0.738	
	[0.42]	[0.258]	(0.493)	0.134
Vegetation index (NDVI)	0.378	0.244	0.134	
	[0.431]	[0.242]	(0.494)	0.786
Village remoteness index (time)	-0.088	0.719***	-0.808	
	[0.436]	[0.231]	(0.494)	0.102
Village population	0.217	0.41	-0.193	
	[0.204]	[0.464]	(0.506)	0.704
Health worker density	0.298	0.324	-0.025	
	[0.435]	[0.228]	(0.491)	0.959
ASHA motivation	0.53	0.038	0.492	
	[0.328]	[0.363]	(0.489)	0.314
Medical facility density	0.691**	-0.356	1.047**	
	[0.312]	[0.377]	(0.489)	0.032
Age at marriage	0.246	0.451	-0.205	
	[0.26]	[0.295]	(0.393)	0.603
Woman's current age	0.193	0.467*	-0.274	
	[0.285]	[0.278]	(0.398)	0.491
Woman's education level	0.485**	0.124	0.361	
	[0.218]	[0.353]	(0.415)	0.384
Household asset index	0.4*	0.151	0.249	
	[0.219]	[0.415]	(0.469)	0.596
Household size	0.174	0.466	-0.292	
	[0.259]	[0.305]	(0.401)	0.466
Backward caste dominant village	0.448	0.159	0.29	
	[0.403]	[0.262]	(0.481)	0.547
Number of children	0.271	0.426	-0.155	
	[0.258]	[0.322]	(0.413)	0.707

Note: This table presents heterogeneity analysis of treatment effects on the Compliance Index using causal forest methodology with machine learning algorithms. The analysis examines how treatment effects vary across different subgroups. Continuous variables are split at the median for interpretability, while binary variables use yes/no categories. The "Yes/Below Median" column shows treatment effects for observations below the median (for continuous variables) or coded as "yes" (for binary variables). The "No/Above Median" column shows treatment effects for observations above the median or coded as "no." The "Difference" column presents the difference between these subgroup effects, with standard errors in parentheses. P-values test the null hypothesis that treatment effects are equal across subgroups. Significant differences indicate heterogeneous treatment effects along that dimension. *** p<0.01, ** p<0.05, * p<0.1.

Appendix 13: Compliance Index and Nightlights Intensity

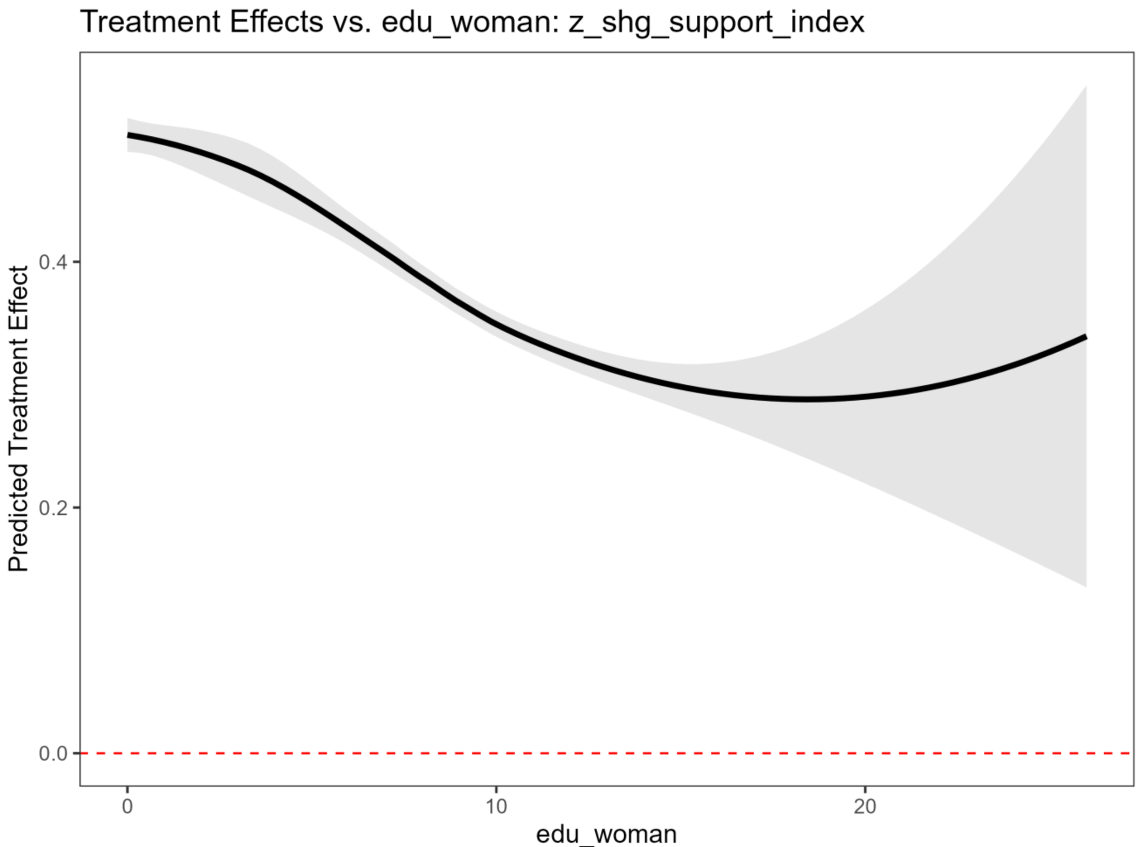


Appendix 14: Heterogeneity (SHG Support Index)

Variable	No/Below Median (SE)	Yes/Above Median (SE)	Difference (SE)	P-value
Village remoteness index (time)	0.078	0.646***	0.568	0.194
	[0.387]	[0.202]	(0.437)	
Night light intensity	0.445	0.271	-0.173	0.698
	[0.361]	[0.264]	(0.447)	
Health worker density	-0.069	0.791***	0.86**	0.048
	[0.378]	[0.215]	(0.435)	
Village population	0.406*	0.31	-0.096	0.833
	[0.211]	[0.405]	(0.456)	
ASHA motivation	0.475**	0.215	-0.26	0.577
	[0.238]	[0.401]	(0.466)	
Village remoteness index (distance)	0.283	0.437	0.154	0.73
	[0.299]	[0.329]	(0.445)	
Vegetation index (NDVI)	0.281	0.439*	0.158	0.722
	[0.358]	[0.264]	(0.445)	
Medical facility density	0.548**	0.03	-0.518	0.299
	[0.257]	[0.427]	(0.498)	
Woman's current age	0.178	0.599**	0.421	0.247
	[0.27]	[0.243]	(0.363)	
Woman's education level	0.656***	0.038	-0.617*	0.093
	[0.243]	[0.275]	(0.368)	
Whether SHG member	0.246	0.653*	0.407	0.358
	[0.215]	[0.388]	(0.443)	
Village has women reservation for panchayat	0.547**	0.234	-0.313	0.451
	[0.26]	[0.324]	(0.415)	
SC/ST caste status	-0.008	0.735***	0.743**	0.048
	[0.302]	[0.224]	(0.376)	
Household asset index	0.557***	0.002	-0.555	0.149
	[0.209]	[0.322]	(0.384)	
Age at marriage	0.369	0.341	-0.028	0.94
	[0.238]	[0.284]	(0.371)	
Backward caste dominant village	0.22	0.51**	0.29	0.507
	[0.362]	[0.244]	(0.436)	
Household size	0.483**	0.22	-0.263	0.457
	[0.216]	[0.279]	(0.353)	

Note: This table presents heterogeneity analysis of treatment effects on the SHG Support Index using causal forest methodology with machine learning algorithms. The analysis examines how treatment effects vary across different subgroups. Continuous variables are split at the median for interpretability, while binary variables use yes/no categories. The "Yes/Below Median" column shows treatment effects for observations below the median (for continuous variables) or coded as "yes" (for binary variables). The "No/Above Median" column shows treatment effects for observations above the median or coded as "no." The "Difference" column presents the difference between these subgroup effects, with standard errors in parentheses. P-values test the null hypothesis that treatment effects are equal across subgroups. Significant differences indicate heterogeneous treatment effects along that dimension. *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Appendix 15: SHG Support Index and Woman's Education



Appendix 16: Heterogeneity (ANC Health Access Index)

Variable	No/Below Median (SE)	Yes/Above Median (SE)	Difference (SE)	P-value
Village remoteness index (time)	-0.789	0.543**	1.331**	0.029
	[0.555]	[0.249]	(0.608)	
Night light intensity	0.143	-0.41	-0.553	0.402
	[0.607]	[0.259]	(0.66)	
Village population	0.157	-0.436	-0.593	0.364
	[0.221]	[0.615]	(0.653)	
Village remoteness index (distance)	-0.5	0.254	0.754	0.228
	[0.562]	[0.274]	(0.626)	
Vegetation index (NDVI)	-0.337	0.077	0.413	0.519
	[0.59]	[0.251]	(0.641)	
Health worker density	-0.371	0.117	0.488	0.44
	[0.59]	[0.23]	(0.633)	
ASHA motivation level	0.291	-0.656	-0.947	0.142
	[0.308]	[0.566]	(0.644)	
Medical facility density	0.037	-0.425	-0.462	0.428
	[0.483]	[0.325]	(0.582)	
Woman's current age	-0.292	0.084	0.376	0.443
	[0.384]	[0.304]	(0.49)	
Woman's education level	-0.012	-0.258	-0.247	0.624
	[0.388]	[0.321]	(0.503)	
Age at marriage	-0.224	0.071	0.296	0.54
	[0.373]	[0.306]	(0.482)	
Village has women reservation for panchayat	0.286	-0.412	-0.698	0.237
	[0.338]	[0.485]	(0.591)	
Household asset index	-0.053	-0.27	-0.217	0.69
	[0.287]	[0.464]	(0.545)	
Household size	-0.223	-0.026	0.196	0.691
	[0.365]	[0.331]	(0.493)	
Village has PHC	0.046	-1.062**	-1.107*	0.071
	[0.379]	[0.483]	(0.614)	

Note: This table presents heterogeneity analysis of treatment effects on the ANC Health Access Index using causal forest methodology with machine learning algorithms. The analysis examines how treatment effects vary across different subgroups. Continuous variables are split at the median for interpretability, while binary variables use yes/no categories. The "Yes/Below Median" column shows treatment effects for observations below the median (for continuous variables) or coded as "yes" (for binary variables). The "No/Above Median" column shows treatment effects for observations above the median or coded as "no." The "Difference" column presents the difference between these subgroup effects, with standard errors in parentheses. P-values test the null hypothesis that treatment effects are equal across subgroups. Significant differences indicate heterogeneous treatment effects along that dimension. *** p<0.01, ** p<0.05, * p<0.1.

Appendix 17: Heterogeneity (PNC Health Access Index)

Variable	No/Below Median (SE)	Yes/Above Median (SE)	Difference (SE)	P-value
Village population	-0.003	0.696	0.699	0.342
	[0.283]	[0.679]	(0.735)	
Village remoteness index (time)	0.009	0.67**	0.661	0.34
	[0.622]	[0.305]	(0.693)	
Vegetation index (NDVI)	0.181	0.487	0.306	0.662
	[0.533]	[0.452]	(0.699)	
Village remoteness index (distance)	-0.038	0.727*	0.765	0.266
	[0.54]	[0.425]	(0.687)	
Night light intensity	0.505	0.158	-0.347	0.625
	[0.608]	[0.367]	(0.71)	
ASHA motivation	0.573	0.027	-0.546	0.443
	[0.424]	[0.571]	(0.711)	
Health worker density	-0.067	0.748*	0.815	0.235
	[0.557]	[0.401]	(0.686)	
Medical facility density	0.334	0.329	-0.005	0.995
	[0.437]	[0.601]	(0.743)	
Village is a panchayat headquarter	0.162	0.69	0.528	0.578
	[0.313]	[0.895]	(0.948)	
Village has women reservation for panchayat	0.095	0.499	0.404	0.531
	[0.32]	[0.561]	(0.645)	
Woman's current age	0.154	0.547*	0.393	0.468
	[0.435]	[0.323]	(0.542)	
Woman's education level	0.408	0.249	-0.158	0.781
	[0.314]	[0.473]	(0.568)	
Backward caste dominant village	0.403	0.257	-0.147	0.833
	[0.614]	[0.327]	(0.696)	
Household asset index	0.429	0.149	-0.281	0.652
	[0.31]	[0.54]	(0.623)	
Age at marriage	0.145	0.75	0.606	0.319
	[0.34]	[0.504]	(0.608)	
Household size	0.434	0.212	-0.221	0.698
	[0.273]	[0.5]	(0.57)	

Note: This table presents heterogeneity analysis of treatment effects on the PNC Health Access Index using causal forest methodology with machine learning algorithms. The analysis examines how treatment effects vary across different subgroups. Continuous variables are split at the median for interpretability, while binary variables use yes/no categories. The "Yes/Below Median" column shows treatment effects for observations below the median (for continuous variables) or coded as "yes" (for binary variables). The "No/Above Median" column shows treatment effects for observations above the median or coded as "no." The "Difference" column presents the difference between these subgroup effects, with standard errors in parentheses. P-values test the null hypothesis that treatment effects are equal across subgroups. Significant differences indicate heterogeneous treatment effects along that dimension. *** p<0.01, ** p<0.05, * p<0.1.

Appendix 18: Heterogeneity (Awareness Index)

Variable	No/Below Median (SE)	Yes/Above Median (SE)	Difference (SE)	P-value
Village remoteness index (time)	-0.481	0.514*	0.994	0.175
	[0.667]	[0.306]	(0.734)	
Night light intensity	0.367	-0.353	-0.719	0.314
	[0.642]	[0.314]	(0.714)	
Village population	0.309	-0.306	-0.615	0.416
	[0.284]	[0.701]	(0.757)	
Health worker density	-0.013	0.036	0.049	0.946
	[0.656]	[0.307]	(0.725)	
Village remoteness index (distance)	0.13	-0.113	-0.242	0.736
	[0.565]	[0.443]	(0.718)	
ASHA motivation	-0.252	0.339	0.591	0.413
	[0.436]	[0.575]	(0.722)	
Vegetation index (NDVI)	-0.04	0.062	0.101	0.89
	[0.66]	[0.312]	(0.73)	
Medical facility density	0.452	-0.762	-1.214*	0.084
	[0.44]	[0.547]	(0.702)	
Woman's current age	-0.017	0.048	0.065	0.904
	[0.434]	[0.317]	(0.537)	
Village is a panchayat headquarter	0.337	-0.652	-0.989	0.338
	[0.271]	[0.997]	(1.033)	
Woman's education level	0.389	-0.394	-0.783	0.155
	[0.385]	[0.394]	(0.551)	
OBC caste status	0.462*	-0.553	-1.015	0.145
	[0.272]	[0.642]	(0.697)	
Age at marriage	0.012	0.008	-0.004	0.994
	[0.44]	[0.271]	(0.517)	
Household asset index	0.06	-0.078	-0.138	0.836
	[0.304]	[0.595]	(0.668)	
Household size	0.01	0.012	0.002	0.997
	[0.411]	[0.352]	(0.541)	
Backward caste dominant village	-0.369	0.431	0.8	0.263
	[0.645]	[0.307]	(0.715)	
Village has women reservation for panchayat	-0.224	0.169	0.393	0.583
	[0.525]	[0.487]	(0.716)	

Note: This table presents heterogeneity analysis of treatment effects on the Awareness Index using causal forest methodology with machine learning algorithms. The analysis examines how treatment effects vary across different subgroups. Continuous variables are split at the median for interpretability, while binary variables use yes/no categories. The "Yes/Below Median" column shows treatment effects for observations below the median (for continuous variables) or coded as "yes" (for binary variables). The "No/Above Median" column shows treatment effects for observations above the median or coded as "no." The "Difference" column presents the difference between these subgroup effects, with standard errors in parentheses. P-values test the null hypothesis that treatment effects are equal across subgroups. Significant differences indicate heterogeneous treatment effects along that dimension. *** p<0.01, ** p<0.05, * p<0.10