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Original Article

Effectiveness of Family Empowerment Based on *Arui Sai* Cultural Values on Prophylactic DHP Adherence and Malaria Incidence among Pregnant Women in Papua, Indonesia

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ABSTRACT

Background: Malaria during pregnancy remains a major public health concern in Papua, Indonesia, with significant maternal and neonatal consequences. Although dihydroartemisinin–piperaquine (DHP) is effective as prophylaxis, adherence remains suboptimal. Culturally grounded, family-based approaches may improve adherence. **Objective:** To evaluate the effectiveness of a family empowerment intervention based on Arui Sai cultural values on DHP adherence and malaria incidence among pregnant women. **Methods:** A quasiexperimental study with a pretest–posttest control group design was conducted in Kepulauan Yapen Regency from March to December 2025. A total of 184 pregnant women (92 in the intervention group; 92 in the control group) were analyzed. The intervention involved family empowerment through educational modules, home visits, and family engagement, whereas the control group received standard antenatal care. The outcomes included DHP adherence (≥80%) and malaria incidence during a five-month follow-up period. Data were analyzed using chi-square tests and logistic regression. **Results:** DHP adherence was significantly greater in the intervention group (95.7% vs. 63.0%; OR=12.90; 95%CI: 4.35–38.27; $p<0.001$). In the multivariable analysis, the intervention remained a significant predictor (adjusted OR=13.73; 95%CI: 4.42–42.65; $p<0.001$). The incidence of malaria was lower in the intervention group according to the results of the bivariate analysis (7.6% vs. 20.7%; RR=0.37; 95%CI: 0.16–0.83; $p=0.020$) but was not significantly different after adjustment (adjusted OR=0.42; 95%CI: 0.15–1.17; $p=0.098$). Living near vector breeding sites was an independent predictor (adjusted OR=4.09; $p=0.010$). **Conclusion:** Family empowerment based on Arui Sai cultural values significantly improves DHP adherence. Integration with environmental risk control is necessary for malaria prevention in high-endemic settings.

Keywords: Malaria during pregnancy, DHP adherence, cultural intervention, Arui Sai, prophylaxis, quasiexperimental study

INTRODUCTION

Malaria remains the infectious disease with the highest mortality burden globally. The WHO recorded 249 million cases and 608,000 deaths across 85 endemic countries in 2022, which will increase to more than 263 million cases in 2023[1]. Among all vulnerable groups, pregnant women face the greatest risk: more than 125 million pregnant women reside in areas with active *Plasmodium falciparum* and *Plasmodium vivax* transmission, and when infected, they face substantially more severe complications than nonpregnant women do because of the immunological changes that accompany pregnancy[2,3].

Malaria infection during pregnancy can damage the placenta through well-documented mechanisms. *P. falciparum* causes the accumulation of infected erythrocytes in the intervillous space, triggering proinflammatory cytokine production that impairs placental transport function[4]. Disrupted oxygen and nutrient supply to the fetus increases the risk of intrauterine growth restriction and low birthweight (LBW). *P. vivax*, the predominant species in eastern Indonesia, including Papua, causes maternal anemia that compounds this risk[5]. A case-control study in Papua revealed that compared with unexposed women, pregnant women with malaria exposure had more than twice the risk of delivering an LBW infant. Failure to use an insecticide-treated net was an independent and significant risk factor[6].

The consequences of malaria during pregnancy extend beyond the neonatal period and persist into child growth and development. Research in Papua has shown that children born to mothers with a history of malaria during pregnancy and children who themselves experienced malaria before the age of one year tended to have lower height-for-age z scores than children without such exposure did[7]. A separate case-control study from Papua used Mantel-Haenszel analysis and revealed that after stratification across eight demographic and socioeconomic variables, malaria during pregnancy remained an independent risk factor for childhood stunting[8]. These two findings support the argument that malaria prevention interventions in pregnant women have dual benefits: protecting maternal and neonatal health at birth while simultaneously reducing the long-term risk of growth failure.

Papua represents a disproportionate share of Indonesia's national malaria burden. More than 86% of all malaria cases in Indonesia in 2023 originated in Papua, with an annual parasite incidence (API) of 156.59 per thousand people, compared with the

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national average of 1.5[9]. Kepulauan Yapen Regency is among the eight districts in Papua that consistently report a high incidence; its API falls in the range of 50–100, and the most recent data recorded more than 16,000 cases in just the first five months of 2025[10,11]. This burden persists because of a combination of a year-round dry-season-free climate that supports year-round mosquito breeding, the presence of Anopheles vectors that bite actively both indoors and outdoors throughout the night[10], limited health infrastructure, and treatment-seeking behavior influenced by local beliefs[12].

Although DHP has been shown to significantly reduce maternal malaria complications in Papua[13], adherence to the regimen remains low. In Papua and other endemic regions of Indonesia, some patients choose traditional medicine as an alternative or complement to modern treatment, and many delay seeking care at health facilities for more than three days after symptoms appear[12,14]. Qualitative research in Papua and Nusa Tenggara Timur revealed that illness perception, belief in traditional medicine, and geographic barriers jointly shape the decision to seek and complete malaria treatment [15]. Similar patterns are documented in South Asia and sub-Saharan Africa, where community health knowledge is often blended with traditional beliefs such that prevention efforts based on clinical instruction alone do not reliably change behavior[16,17].

To address coverage gaps, the local government of Papua has implemented a periodic antimalarial drug distribution program through routine antenatal care, known as PEMILA-OAM. This programme emphasizes the integration of clinical services with health education, adherence monitoring, and the involvement of families and community health workers in supporting regular prophylactic drug use. Although this approach has the potential to strengthen service-based interventions, its effectiveness in improving DHP adherence and reducing malaria incidence in the local sociocultural context has not been extensively or systematically evaluated in a controlled study design.

Evidence from multiple countries indicates that approaches that account for cultural context produce better acceptance and adherence than programmes designed without community involvement do. In Gambia, a social-ecological intervention model that positioned community norms as the entry point for preventive behavior change revealed that strategies deemed "culturally compelling" achieved far broader acceptance from the target population[16]. In sub-Saharan Africa, insecticide-treated net distribution programmes that failed to account for local perceptions about net materials—including their cultural association with funeral cloth in some communities—faced unanticipated rejection[18]. In Cameroon, vector control programs in rural areas encountered resistance because of religious and customary beliefs that restricted indoor access to residual spraying[18]. In Kenya, a community review on Rusinga Island revealed that community knowledge of malaria was a blend of scientific understanding and traditional beliefs, and interventions that did not account for this interplay generated distrust of external health messages[19].

A scoping review of community engagement strategies in malaria control across multiple countries revealed that programs involving local leaders, religious figures, and communities as design partners achieved more sustainable coverage and adherence[20]. In Mozambique, the use of community radio, theatre performances, and community dialog grounded in local values was recommended as an approach that complements insecticide-treated net distribution and treatment[21]. In Indonesia, a study in Kepulauan Yapen (API 38.95%) and other Papua regions revealed that sociodemographic factors and cultural beliefs jointly determine access to and use of malaria services, and programs that neglect this dimension risk failing to reach the most vulnerable populations[22].

Arui Sai is a system of indigenous cultural values of the Yapen people who encompasses mutual care (mewai tawang wawing), solidarity, and collective responsibility within the extended family. These values position the family — rather than the individual alone — as the unit of health maintenance and are thus conceptually aligned with family empowerment principles in disease prevention. Although cultural–health partnerships have proven effective in various contexts, no intervention model has systematically operationalized Arui Sai values as the foundation of a malaria prevention program for pregnant women and tested its effectiveness in a controlled study. This evidence gap constitutes the justification for this study. This study aimed to evaluate the effectiveness of an Arui Sai-based family empowerment model on prophylactic DHP adherence and malaria incidence among pregnant women in Kepulauan Yapen Regency, Papua.

METHODS

Study Design and Setting

This study used a quasiexperimental design with a pretest–posttest control group approach. This design was selected because the unit of intervention allocation was the puskesmas catchment area, making individual-level randomization unfeasible. This represents a design limitation that may affect causal inference and was therefore taken into account in the interpretation of the findings.

This study was conducted in Kepulauan Yapen Regency, Papua Province, across two purposively selected puskesmas catchment areas from March to December 2025. Site selection was based on the comparability of malaria epidemiological profiles and demographic characteristics between the two areas to minimize potential selection bias. Puskesmas Serui Kota was designated as the intervention site, which is located in a coastal area and serves as the primary healthcare center in the regency capital. Puskesmas Warari was designated as the control site and is located in a semimountainous area with different geographic characteristics but a comparable malaria epidemiological profile.

The placement of the intervention and control groups at two geographically distant puskesmas was intended to reduce the possibility of intervention contamination between groups so that the observed differences in outcomes would more accurately reflect the effect of the intervention rather than cross-group participant interaction.

Participants

The target population included all pregnant women residing in the catchment areas of Puskesmas Serui Kota and Puskesmas Warari during the study period. The accessible population consisted of second-trimester (gestational age 14–27 weeks) and third-trimester (28–40 weeks) pregnant women registered in the antenatal cohort at each puskesmas at the start of the study period.

The minimum sample size was calculated for the comparison of two independent proportions for the primary outcome of dihydroartemisinin–piperaquine (DHP) adherence between the intervention and control groups. Adherence was selected as the basis for calculation because it is the proximal outcome most directly influenced by the Arui Sai family empowerment intervention. Assuming an adherence rate of 60% in the control group and 80% in the intervention group, a 5% two-sided significance level, 80% statistical power, and a 1:1 allocation ratio, the minimum required sample size was 82 participants per group. After adding 10% to account for incomplete follow-up data, the minimum became 91 participants per group.

All pregnant women meeting the inclusion criteria in both Puskesmas catchment areas were enrolled through a total sampling approach. On the basis of antenatal cohort registers, 243 women met the eligibility

criteria and were recruited: 122 to the intervention group and 121 to the control group. Following verification of the completeness of the outcome data, 184 participants were included in the final analysis, with 92 in each group. This analytic sample size meets the prespecified minimum.

The inclusion criteria were a second or third trimester at the start of the study period, permanent residence in the relevant puskesmas catchment area throughout the follow-up period, and willingness to participate. The exclusion criteria were planned changes in residence outside the puskesmas catchment area during the study; occurrence of abortion or stillbirth before follow-up completion; and incomplete primary outcome data.

Intervention

The intervention group received Arui Sai-based family empowerment over five months. The intervention was designed on the basis of findings from a prior qualitative exploration in phase one of the study, which identified the core Arui Sai values—Safe (*Aman*), Joyful (*Ceria*), Beautiful (*Indah*), and Healthy (*Sehat*)—as the foundation for behavior change in malaria prevention. The intervention comprised four complementary components. First, each pregnant woman and her family received an Arui Sai-based guidebook module containing malaria information in Papuan Malay and local idioms, guidance on the use of insecticide-treated nets, a daily DHP consumption checklist, an antenatal visit schedule, and an action protocol for when symptoms arose. Second, each participant was assigned a trained community health worker (kader) as a companion who conducted home visits at least twice per month to monitor DHP adherence, remind participants of antenatal appointments, and reinforce preventive behaviors through Arui Sai values.

Prior to the study, all kaders underwent a three-day structured training programme covering malaria transmission and prevention, DHP regimen counselling, home visit procedures, and adherence documentation using standardised forms; training was facilitated by the research team in collaboration with puskesmas health staff. Third, extended family education sessions were held, using the Arui Sai value of *gotong royong* (communal cooperation) to engage husbands and other family members in monitoring pregnant women's health. A total of four sessions were conducted over the five-month study period, each lasting 60 minutes, held at community venues (posyandu or community hall), facilitated by kaders in coordination with traditional and religious leaders, and delivered in Papuan Malay adapted to local communicative norms. Fourth, cross-sector socialization involved traditional leaders, religious figures, and subdistrict heads as community-level reinforcers of social norms supporting preventive behavior.

To ensure fidelity of implementation, each kader maintained a structured visit logbook recording the date, duration, topics discussed, and adherence status at each home visit. Logbooks were reviewed regularly by the malaria programme officer at each puskesmas, who served as the field supervisor responsible for verifying that all intervention components were delivered as planned.

All intervention components were implemented within the framework of routine antenatal care (ANC) that had already adopted the PEMILA-OAM malaria prevention program, in which dihydroartemisinin–piperaquine (DHP) is administered as intermittent preventive treatment for pregnant women beginning in the second trimester. In this program, DHP is given as three tablets per day for three consecutive days at each ANC visit, with each tablet containing 40 mg of dihydroartemisinin and 320 mg of piperaquine.

The control group received standard antenatal care according to national Ministry of Health guidelines, without any additional Arui Sai module or community health worker companion components; DHP prophylaxis was administered according to the national malaria programme protocol for pregnant women in high-endemic areas. Care in the control group also operated within the same PEMILA-OAM implementation framework, with an identical DHP regimen but without any Arui Sai-based family empowerment components. Participants in the control group did not receive the Arui Sai-based intervention during the study period; following completion of data collection, the educational modules and intervention materials were made available to the control group puskesmas as part of the study's community benefit commitment.

Variables

In this study, three groups of variables were measured: outcome variables, the primary independent variable, and covariates. The outcome variables included postintervention malaria incidence and adherence to DHP consumption. The incidence of malaria was defined as laboratory-confirmed *Plasmodium sp*. infection during the follow-up period and categorized as no and yes. *Plasmodium* species were classified as *P. falciparum*, *P. vivax*, mixed infection, or other species. DHP adherence was defined as the percentage of tablets consumed out of the total prescribed in one cycle (9 tablets) and categorized as adherent (≥80%) and nonadherent (<80%).

The primary independent variable was the study group, which was classified into the control or intervention group on the basis of the puskesmas where the participant was registered; the covariates included demographic characteristics, environmental factors, and preventive behavior factors. Demographic characteristics included age in years (continuous), ethnicity (Papuan and non-Papuan), parity (primigravida and multigravida), education level (low: ≤ junior secondary; high: ≥ senior secondary), employment status (employed and housewife), household income (≥ minimum regional wage [UMR] and < UMR), gestational age in weeks (continuous, also categorized as second and third trimester), and history of malaria during the current pregnancy before recruitment (no and yes).

Environmental factors included the distance from residence to the malaria vector habitat (more than 500 meters and ≤500 meters) and a history of travel to a malaria-endemic area during the past month (no and yes). Preventive behavior factors included nightly use of insecticide-treated nets (no or yes), outdoor activity at night (no or yes), use of mosquito repellent or lotion (no or yes), and use of protective clothing when outdoors at night (no or yes).

Data collection

Data were collected using three primary instruments: a structured questionnaire, a pill count form, and a malaria surveillance form. A structured questionnaire was used to obtain information on demographic characteristics, malaria history, environmental factors, and preventive behaviors through direct interviews by trained enumerators. This instrument was adapted from the WHO (2017) questionnaire and modified for the local context of Kepulauan Yapen. The pill count form was used to assess DHP adherence on the basis of the number of tablets remaining at each follow-up visit, combined with daily consumption self-reports. A malaria surveillance form was used to record clinical events and laboratory results, including the date of the event, symptoms, rapid diagnostic test (RDT) results, and microscopy confirmation.

Data collection was conducted through two approaches: survey and longitudinal monitoring. Baseline and endline surveys were conducted at the beginning and end of the study period to collect data on demographic characteristics, environmental factors, and preventive behaviors. Monitoring during the five-month follow-up period was conducted to assess DHP adherence and detect malaria events. Malaria

event assessment uses both active and passive approaches. RDT with microscopy confirmation was performed at each routine ANC visit. Pregnant women who reported clinical symptoms of malaria between ANC visits were referred for laboratory examination. Malaria cases were confirmed on the basis of reactive RDT results and/or microscopy, confirming the presence of *Plasmodium* parasites.

Statistical Analysis

Data analysis was conducted in stages covering descriptive, comparative, and multivariable analyses. Descriptive analysis revealed the baseline characteristics of the participants in both groups. Continuous variables are presented as the mean ± standard deviation or median and interquartile range; categorical variables are presented as frequencies and percentages.

A comparative analysis was performed to assess the effectiveness of the intervention on adherence to DHP consumption and malaria incidence. DHP adherence was compared using the Mann–Whitney U test for the distribution of percentage consumption and the chi-square test for adherence proportions, with odds ratios (ORs) and 95% confidence intervals (CIs) estimated. Malaria incidence was compared using the chi-square test, and the risk ratio (RR), OR, absolute risk reduction (ARR), and number needed to treat (NNT) were estimated.

Multivariate analysis was conducted using logistic regression to identify factors associated with each outcome. Variables were selected for inclusion in the multivariable models based on two criteria: statistical significance at $p<0.25$ in the bivariate analysis and theoretical relevance based on prior literature on malaria in pregnancy. All eligible variables were entered simultaneously using the enter method. The DHP adherence model included study group and demographic covariates, while the malaria incidence model additionally included these covariates, along with environmental factors. Multicollinearity among covariates was assessed using the variance inflation factor (VIF); all VIF values ranged from 1.03 to 1.85 in the adherence model and from 1.06 to 1.17 in the malaria incidence model, indicating no problematic collinearity in either model. The results are presented as crude and adjusted ORs with 95% CIs. Model performance was evaluated using Nagelkerke R^2 and the Akaike information criterion (AIC). An interaction term between study group and proximity to vector breeding sites was tested in both outcome models to evaluate whether the intervention effect differed by environmental exposure level.

Research Ethics

Ethical approval was obtained from the Health Research Ethics Committee of the Faculty of Public Health, Universitas Hasanuddin, reference number 369/UN4.14.1/TP.01.02/2025. The study was conducted in accordance with applicable research ethics principles, including respect for participant autonomy, confidentiality of data, and the principles of beneficence and nonmaleficence. All participants were given a full explanation of the study's purpose, procedures, benefits, and potential risks before data collection and provided consent through signed informed consent forms. Participant identities were protected by using unique codes, and data were used solely for research purposes. Participants received transportation reimbursement and a small incentive for each study-related antenatal visit, provided in accordance with the approved ethics protocol.

RESULTS

Baseline Characteristics

A total of 184 pregnant women were analyzed, with 92 in each group (intervention and control). In general, the distributions of baseline characteristics across groups were relatively similar. The majority of participants were in the higher education category, with a greater proportion in the control group (89.1%) than in the intervention group (77.2%). The prevalence of Papuan ethnicity was also greater in the control group (65.2%) than in the intervention group (52.2%).

The most prominent difference concerned gestational age at recruitment. The intervention group was predominantly in the second trimester (58.7%), whereas the control group was more commonly in the third trimester (57.6%). Moreover, the proportions of homemakers, below-minimum-wage households, and those with a history of prior malaria before the intervention were broadly comparable between the two groups (Table 1).

Intervention Effectiveness on DHP Adherence

All participants received the same regimen of 9-DHP tablets. Adherence levels differed significantly between the two groups. Compared with the control group, the intervention group demonstrated higher consumption rates (mean 97.9% vs. 77.3%; $p<0.001$) (Table 2). This difference was consistent across the adherence categories. The proportion of adherent participants (≥80%) in the intervention group reached 95.7%, whereas it was 63.0% in the control group. Conversely, the proportion of nonadherent participants was greater in the control group (37.0%) than in the intervention group (4.3%) (Table 3). The distribution of consumption revealed that nearly all participants in the intervention group were in the ≥80% adherence category. In contrast, in the control group, a proportion remained across the low-to-moderate consumption categories, as shown in Figure 1.

Further analysis revealed that the intervention was significantly associated with improved adherence. Pregnant women in the intervention group had a substantially greater probability of adhering to DHP consumption than did those in the control group did (OR=12.90; 95%CI: 4.35–38.27; $p<0.001$).

Factors associated with DHP adherence

The results of the bivariate analysis and multivariable logistic regression are presented in Table 4. According to the results of the bivariate analysis, only the study group was significantly associated with DHP adherence (Crude OR=12.90; 95%CI: 4.35–38.27; $p<0.001$). After controlling for covariates in the multivariable model, the study group remained the only significant predictor (adjusted OR=13.73; 95%CI: 4.42–42.65; $p<0.001$). The relatively consistent magnitude of effect between the bivariate and multivariable analyses indicates that the association between the intervention and adherence is not substantially influenced by the covariates included in the model.

Low household income showed a borderline tendency toward an association with adherence after adjustment (adjusted OR=0.28; 95%CI: 0.08–1.00; $p=0.050$), although this was at the threshold of statistical significance. Other variables, including age, ethnicity, parity, gestational age, and malaria history, were not significantly associated with adherence in either the bivariate or multivariable analysis.

Postintervention Malaria Incidence

Malaria incidence was monitored in all 184 participants over five months of follow-up. Diagnosis was established through RDT and/or peripheral blood smear microscopy. The incidence of malaria in the intervention group (7.6%) was significantly lower than that in the control group (20.7%) ($\chi^2=5.420$; $p=0.020$). The intervention group had a 63% lower risk of malaria (RR=0.37; 95% CI: 0.16–0.83), with an NNT of 7.7 (Table 5).

P. falciparum was the dominant species in both groups (57.1% vs. 42.1%). The distribution of *Plasmodium* species did not differ significantly between groups (Table 6), indicating that the difference in incidence was not attributable to differences in species exposure.

Table 1. Baseline Characteristics of Pregnant Women by Study Group

Variable	Intervention n=92	Control n=92
Age (years) Mean ± SD	28.7 ± 6.7	28.1 ± 6.8
Gestational age (weeks) Mean ± SD	25.2 ± 7.2	27.9 ± 5.8
Second trimester	54 (58.7%)	39 (42.4%)
Third trimester	38 (41.3%)	53 (57.6%)
Parity Mean ± SD	2.8 ± 1.6	2.6 ± 1.6
Ethnicity		
Papuan	48 (52.2%)	60 (65.2%)
Non-Papuan	44 (47.8%)	32 (34.8%)
Education		
Low (≤ junior secondary)	21 (22.8%)	10 (10.9%)
High (≥ senior secondary)	71 (77.2%)	82 (89.1%)
Occupation		
Housewife	72 (78.3%)	78 (84.8%)
Employed	20 (21.7%)	14 (15.2%)
Household income		
Below minimum wage	71 (77.2%)	75 (81.5%)
At or above minimum wage	21 (22.8%)	17 (18.5%)
Prior malaria during current pregnancy		
Present	6 (6.5%)	3 (3.3%)
Absent	86 (93.5%)	89 (96.7%)

Table 2. Comparison of DHP Adherence Between Intervention and Control Groups

Variable	Intervention n=92	Control n=92	p value
DHP tablets consumed (%)			
Mean ± SD	97.9 ± 10.4	77.3 ± 32.1	<0.001*[a]
Min – Max	22.2 – 100.0	0.0 – 100.0	
Adherence category			
Adherent (≥80%)	88 (95.7%)	58 (63.0%)	<0.001*[b]
Nonadherent (<80%)	4 (4.3%)	34 (37.0%)	
Odds Ratio for adherence			
Intervention vs. Control	12.90	(4.35–38.27)	<0.001*[b]

*Statistically significant. [a] Mann–Whitney U test (U=5,641; Z=5.032; p<0.001). [b] Pearson chi-square (χ^2=27.892; df=1; p<0.001). Nonnormal distribution (Shapiro–Wilk; p<0.001); nonparametric test was applied.

Table 3. Distribution of DHP Tablet Consumption by Percentage Category and Group

% DHP Tablets Consumed	Intervention group	%	Control group	%	Total n (%)
<20%	0	0.0	4	4.3	4 (2.2%)
20–39%	1	1.1	13	14.1	14 (7.6%)
40–59%	1	1.1	13	14.1	14 (7.6%)
60–79%	2	2.2	4	4.3	6 (3.3%)
≥80% (Adherent)	88	95.7	58	63.0	146 (79.3%)
Total	92	100.0	92	100.0	184 (100%)

Consumption percentage = (tablets consumed/9) × 100%. Adherence threshold ≥80% per the WHO standard.

Table 4. Factors associated with DHP adherence: Crude and adjusted odds ratios

Variable	Crude OR (95% CI)	p value	B (SE)	Adjusted OR (95% CI)	p value
Study group (Intervention vs. Control)	12.90 (4.35–38.27)	<0.001**	2.620 (0.578)	13.73 (4.42–42.65)	<0.001**
Age (years)	1.13 (0.55–2.33)	0.873	-0.053 (0.042)	0.95 (0.87–1.03)	0.207
Papuan ethnicity (yes vs. no)	0.79 (0.38–1.65)	0.658	0.174 (0.454)	1.19 (0.49–2.90)	0.701
Parity (pregnancy order)	1.62 (0.78–3.38)	0.265	0.317 (0.195)	1.37 (0.94–2.01)	0.104
Low household income (<minimum wage)	0.39 (0.13–1.17)	0.114	-1.280 (0.653)	0.28 (0.08–1.00)	0.050*
Gestational age (weeks)	0.75 (0.36–1.53)	0.534	0.012 (0.034)	1.01 (0.95–1.08)	0.721
Prior malaria history	0.91 (0.18–4.55)	1.000	-0.485 (1.001)	0.62 (0.09–4.38)	0.628

Crude OR = bivariate logistic regression odds ratio. Adjusted OR = multivariable logistic regression odds ratio (enter method). For continuous variables (age, parity, and gestational age), crude ORs were calculated using median dichotomization, and adjusted ORs were calculated using continuous values. Reference categories: Control group; non-Papuan ethnicity; household income ≥ minimum wage. Goodness-of-fit: χ^2=39.783 (df=7); p<0.001 | AIC=163.6 | Nagelkerke R^2=0.195 | n=183. * p<0.05; ** p<0.001.

Table 5. Postintervention Malaria Incidence in the Intervention and Control Groups

Variable	Intervention n=92	Control n=92	p value
Malaria incidence			
Yes	7 (7.6%)	19 (20.7%)	0.020*
No	85 (92.4%)	73 (79.3%)	
Risk Ratio (RR)	0.37	(0.16–0.83)	0.020*
Odds Ratio (OR)	0.32	(0.13–0.80)	0.020*
Absolute Risk Reduction (ARR)	13.1%		
Number Needed to Treat (NNT)	7.7		

* $p<0.05$. $\chi^2=5.420$; df=1. RR = risk ratio; CI = confidence interval; ARR = absolute risk reduction; NNT = number needed to treat.

Table 6. Distribution of Plasmodium Species among Postintervention Malaria Cases

Plasmodium species	Intervention (n=7) n (%)	Control (n=19) n (%)	Total (N=26) n (%)
P. falciparum	4 (57.1%)	8 (42.1%)	12 (46.2%)
P. vivax	2 (28.6%)	7 (36.8%)	9 (34.6%)
Mixed (P. falciparum + P. vivax)	1 (14.3%)	3 (15.8%)	4 (15.4%)
P. malariae	0 (0.0%)	1 (5.3%)	1 (3.8%)
Total	7 (100%)	19 (100%)	26 (100%)

Diagnosis by RDT and/or peripheral blood smear microscopy. Mixed = coinfection with P. falciparum and P. vivax.

Table 7. Factors Associated with Malaria Incidence—Crude and Adjusted Odds Ratios

Variable	Crude OR (95% CI)	p value	Adjusted OR (95% CI)	p value
Study group (Intervention vs. Control)	0.32 (0.13–0.80)	0.020*	0.42 (0.15–1.17)	0.098
Papuan ethnicity	0.95 (0.41–2.21)	1.000	0.49 (0.18–1.29)	0.148
Parity	0.83 (0.36–1.93)	0.828	0.86 (0.63–1.17)	0.328
Low household income	3.54 (0.80–15.71)	0.114	3.31 (0.68–16.09)	0.139
Gestational age (weeks)	1.47 (0.64–3.40)	0.487	1.02 (0.95–1.09)	0.660
Prior malaria history	1.80 (0.35–9.17)	0.617	2.67 (0.41–17.25)	0.303
Living near a swamp/forest (≤500 m)	3.98 (1.52–10.45)	0.006*	4.09 (1.40–11.96)	0.010*
Travel to the endemic area (past month)	3.27 (1.39–7.67)	0.010*	2.05 (0.80–5.27)	0.138

* $p<0.05$. Crude OR = bivariate analysis. Adjusted OR = multivariable logistic regression (n=183; AIC=144.7; Nagelkerke $R^2=0.119$). Reference categories: Control group; non-Papuan ethnicity; household income ≥ minimum wage.

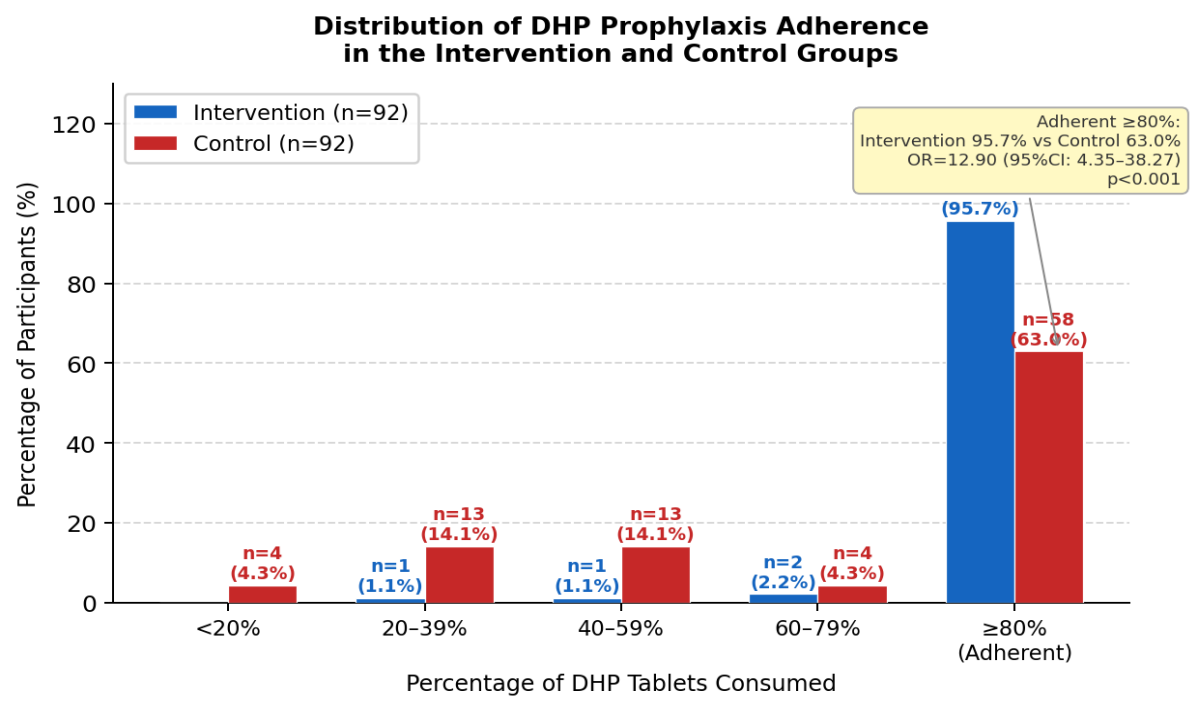

Figure 1. Distribution of prophylactic DHP tablet consumption in the intervention and control groups

Factors Associated with Malaria Incidence

Bivariate analysis and multivariable logistic regression (study group + 6 demographic covariates + 2 environmental factors; enter method) were performed (Table 7). On bivariate analysis, three variables were significant: study group (Crude OR=0.32; p=0.020), living near a swamp/forest (OR=3.98; p=0.006), and travel to an endemic area (OR=3.27; p=0.010). After controlling for covariates in the multivariable model, proximity to swamps or forests remained independently significant (adjusted OR=4.09; 95%CI: 1.40–11.96; p=0.010). The adjusted OR for the intervention group of 0.42 (95% CI: 0.15–1.17; p=0.098) indicates a consistently protective effect. The interaction term between study group and proximity to vector breeding sites was not statistically significant in either the malaria incidence model (OR=1.17; 95%CI: 0.13–10.22; p=0.886) or the adherence model (OR=1.82; 95%CI: 0.18–18.27; p=0.610), indicating that the effect of the intervention was consistent regardless of participants' proximity to vector habitats

DISCUSSION

Pregnant women in the intervention group demonstrated substantially higher DHP adherence than those in the control group did, with the intervention group as the sole significant predictor in the multivariable model after controlling for the demographic covariates analyzed. This pattern indicates that the association between the intervention and adherence is not substantially influenced by the variables included in the model. The presence of community health worker companions conducting regular home visits enabled monitoring of tablet use outside health facility visits. The engagement of husbands and extended family members through Arui Sai values created a social environment that supported day-to-day adherence. Accordingly, the intervention not only increased access to information but also changed the social context in which medication consumption decisions are made. Programmes relying solely on directly observed dosing at health facilities have limited reach; data from IPTp-DHP implementation in Mimika showed that only a portion of pregnant women received the intervention as per the protocol through routine ANC services[23], underscoring the importance of community-based approaches.

The low adherence in the control group is consistent with patterns previously reported in Papua. Decisions to continue or discontinue antimalarial therapy are influenced by symptom perception, healthcare access barriers, and the parallel presence of traditional medicine practices[12]. For *P. vivax*, adherence to extended regimens such as 14-day primaquine is known to be low because therapy is often stopped once symptoms subside[14]. Similar barriers have been reported in other endemic contexts, particularly regarding combinations of cognitive, cultural, and social support factors[12,15]. In this context, the Arui Sai intervention appears to work not by reinforcing clinical instruction alone but by embedding medication consumption as part of a collective family responsibility that carries cultural meaning.

These findings are consistent with evidence from multiple countries that decisions about prophylactic medication consumption among pregnant women are rarely individual; the social network within the household shapes them[24]. Programmes that actively involve families and communities show more stable adherence rates[24]. Arui Sai frames the pregnant woman's health within a framework of collective responsibility, thereby creating the social conditions that sustain behavior change over time.

On bivariate analysis, the incidence of malaria was lower in the intervention group than in the control group. However, in the multivariable model, the protective effect of the intervention no longer reached statistical significance after controlling for environmental factors. This finding indicates that the difference in malaria incidence cannot be fully attributed to the intervention and is also influenced by variation in environmental exposure between the two areas. Distance of residence from swamps or forests emerged as the sole independent predictor, reinforcing the role of environmental determinants in malaria transmission.

The distribution of risk factors revealed that the control group had a greater proportion of participants living near vector habitats and who had a history of mobility to endemic areas, both of which biologically increase exposure risk. In addition, the intervention group showed a greater proportion of preventive behaviors, including insecticide-treated net use, mosquito repellent use, and protective clothing use. These differences likely contributed to the reduction in malaria incidence, although the specific causal relationship between each behavioral component and the outcome cannot be formally determined in this analysis.

Strong evidence supports the effectiveness of insecticide-treated nets for malaria prevention during pregnancy[25]. However, coverage in Papua remains low because of the factors of comfort, risk perception, and distribution barriers[25]. In this intervention, net use was framed within the Arui Sai social value of mutual care so that the practice was no longer merely a response to medical instruction but was part of responsibility toward family members. This approach likely improved both acceptance and behavioral consistency.

Outdoor exposure at night remains an important risk given the exophagic character of local vectors[10]. Commodity-based interventions do not fully address exposure in this context. The family-based approach within Arui Sai enables more context-specific discussion of activity patterns and associated risks, ensuring that the resulting behavior change is better suited to the local situation.

These findings are consistent with the social-ecological model that emphasizes the importance of cultural fit in behavior change[16]. Programmes that position communities as active partners demonstrate greater acceptance and sustainability [20,21,26]. Meta-analyses have also shown that compared with general education approaches, theory-based behavioral interventions produce greater effects[18]. Arui Sai employs similar principles but with indigenous cultural values as the source of intrinsic motivation rather than external health theory.

In the Papua context, this approach is particularly relevant given the documented distrust of health messages perceived as externally derived or not aligned with local understanding[15]. The perception of malaria as a normal part of daily life can reduce the motivation for consistent preventive behavior. The integration of Arui Sai values provides a more widely accepted framework for meaning, making health messages more contextually grounded and easier to adopt.

Several limitations warrant consideration. The quasiexperimental design with area-based allocation allows for unmeasured confounding arising from area characteristics. Baseline differences in gestational age and education reflect the inherent characteristics of coastal versus semimountainous populations and represent residual confounding that was controlled for in the model but cannot be fully eliminated. In addition, the possibility of cross-area contamination cannot be ruled out entirely. The relatively short follow-up period also limits the evaluation of long-term outcomes, such as birthweight and child growth.

CONCLUSION

Arui Sai-based family empowerment is associated with improved prophylactic DHP adherence among pregnant women in Kepulauan Yapen Regency. The incidence of malaria was lower in the intervention group according to the results of the bivariate analysis. However, after controlling for environmental factors, the intervention effect was no longer statistically significant, indicating the important

role of environmental determinants in malaria transmission. These findings support the integration of culturally grounded, family-based approaches into malaria prevention programs during pregnancy while recognizing environmental factors as key components of intervention design in high-endemic areas.

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