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# Impact of eight or more antenatal care visits on intermittent preventive treatment of malaria uptake during pregnancy and facility-based delivery in Ghana: a propensity score matched analysis

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## Abstract

**Introduction** Maternal and malaria-related morbidity remain major public health challenges in sub-Saharan Africa, particularly in Ghana. The World Health Organization (WHO) recommends eight or more antenatal care (ANC8+) contacts to enhance maternal and child health, but its effect on malaria prevention and delivery outcomes is not well established. This study examined the impact of ANC8 + visits on facility-based delivery and optimal uptake of intermittent preventive treatment for malaria during pregnancy (IPTp-SP).

**Methods** Data were drawn from the 2022 Ghana Demographic and Health Survey, including women aged 15–49 years who had given birth within the three years preceding the survey. Propensity score matching was applied to estimate the effect of ANC8 + visits on facility-based delivery and uptake of at least three IPTp-SP doses.

**Results** Only 38.7% of women met the ANC8 + threshold. Among all respondents, 85.4% delivered in a health facility, and 66.5% received three or more IPTp-SP doses. After matching, ANC8 + attendance increased the likelihood of facility delivery by 8.2% points (ATT = 8.2, 95% CI: 4.6–11.9) and optimal IPTp-SP uptake by 11.1% points (ATT = 11.1, 95% CI: 6.8–15.4).

**Conclusion** Adherence to WHO's ANC8 + recommendation significantly improves facility-based delivery and malaria prevention during pregnancy. Strengthening policies that enhance ANC attendance, particularly among socioeconomically and geographically disadvantaged groups, is essential for advancing maternal and child health in Ghana.

**Keywords** Maternal health, Antenatal care, Sub-Saharan Africa, maternal mortality

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## Introduction

Maternal and neonatal mortality and morbidity remain pressing public health challenges in sub-Saharan Africa, including Ghana. With a maternal mortality ratio of 234 per 100,000 live births, Ghana still far exceeds the Sustainable Development Goal target of fewer than 70 by 2030 [1]. A major contributor to these adverse outcomes is Malaria in Pregnancy (MiP), which causes severe maternal anemia and placental malaria, leading to Intrauterine Growth Restriction (IUGR) and low birth weight [2]. West Africa alone reported 6.06 million affected pregnancies in 2023 [3], and in Ghana, about 11 in every 100 pregnant women present with malaria [4]. Progress in reducing these burdens remains slow, largely due to the limited uptake of crucial preventive interventions like intermittent preventive treatment (IPTp-SP) and inadequate access to skilled delivery services, both essential for safeguarding maternal and newborn health.

To combat these risks, the 2016 World Health Organization (WHO) recommendation of at least eight antenatal care (ANC8+) visit**s** presents a vital strategy [5]. These frequent visits offer multiple critical opportunities: to administer intermittent preventive treatment (IPTp-SP), distribute insecticide-treated nets, and deliver vital education to prevent MiP, as well as counsel for facility-based delivery [6]. In Ghana, the self-reported prevalence of at least one episode of malaria among pregnant women was 76.7% in the Ashanti Region [7]. Strengthening ANC attendance could increase both the uptake of preventive treatment and the likelihood of delivering in a health facility, directly addressing key barriers to maternal and neonatal health. However, despite the promise of this policy, the causal impact of achieving ANC8 + on these critical outcomes, such as IPTp-SP uptake and facility-based delivery remains insufficiently examined using rigorous causal methods. This study aims to fill this important evidence gap.

Despite its clear benefits, implementing the ANC8 + recommendation in Ghana faces significant challenges, particularly in rural areas. While a high percentage (93.2%) of women access ANC, far fewer (21.2%) utilize all recommended maternal healthcare services [8]. Additionally, many women initiate care late, with 71.3% starting their first ANC attendance *after* the eighth week of pregnancy, diminishing the protective window for early interventions [9]. Several interrelated factors contribute to this delay and limited attendance. Financial barriers, such as the cost of transportation and out-of-pocket expenses, often deter early booking. Cultural influences and limited health awareness further reduce motivation to attend regularly, while logistical challenges, including long distances to clinics and inadequate transport infrastructure, make consistent visits difficult [9, 10]. These constraints collectively diminish the delivery of malaria preventive treatment and reduce the likelihood of facility-based delivery, sustaining high risks for both maternal and newborn health. Evaluating how increased ANC attendance causally influences these outcomes is therefore essential to fully understand its potential to improve maternal and neonatal health indicators.

Critically, existing observational research [11–15], while identifying strong associations between ANC attendance and maternal health outcomes, has largely failed to establish a true causal link. This is because many previous studies have not adequately controlled for crucial confounding variables such as a woman's socioeconomic status, education, or baseline health-seeking behavior which may influence both her decision to attend ANC8 + and her likelihood of achieving positive outcomes. For instance, one study [15], effectively identified factors *influencing* ANC8 + but did not establish the causal impact of ANC8 + on subsequent protective behaviors like facility-based delivery or IPTp-SP uptake. To address this gap, the present study employs Propensity Score Matching (PSM), a robust quasi-experimental method [16, 17]. This approach allows us to statistically balance numerous confounding variables and mimic the randomization of a controlled trial, thereby enhancing the internal validity of our findings and providing a more accurate estimation of the causal effect.

This study, therefore, aims to provide evidence on the causal impact of ANC8 + visits on IPTp-SP uptake and facility-based delivery that can directly inform maternal health policy in Ghana, strengthen malaria prevention strategies, and promote delivery in health facilities. The findings will support national efforts to reduce maternal and neonatal mortality and morbidity, contributing significantly to achieving Sustainable Development Goal 3, which focuses on ensuring healthy lives and promoting well-being for all by 2030 [9].

## Materials and methods

### Study design and setting

This study used secondary data from the 2022 Ghana Demographic and Health Survey (GDHS). The GDHS is a nationally representative household survey conducted by the Ghana Statistical Service (GSS), Ghana Health Service (GHS), and ICF International [10]. It collects standardized information on fertility, family planning, maternal and child health, nutrition, and malaria prevention using harmonized sampling methods and questionnaires, allowing comparability across time and subgroups. The 2022 GDHS followed a two-stage stratified sampling design. In the first stage, enumeration areas (EAs) were selected from all 16 regions in Ghana based on probability proportional to size. In the second stage, a systematic random sample of households was drawn from each EA. The study population was all women aged

15–49 years, but only women who had given birth within the three years preceding the survey were included in this study. A sample of 5,135 was used to estimate the impact of ANC8 + on facility-based delivery. After dropping missing values in IPTp-SP, a sample of 4680 women were left and included in the analysis of impact of 8 + ANCs on IPTp-SP uptake. A complete cases analysis on the impact of 8 + ANC visits on IPTp-SP uptake was used because it's a common methods used in DHS-based studies, its transparent, reproducible and only 7.8% was missing.

### Definition of variables

#### *Outcome variables*

The study examined two key outcome variables: health facility-based delivery and uptake of intermittent preventive treatment (defined as having taken 3 or more doses of IPTp) for malaria during pregnancy with sulfadoxine-pyrimethamine (IPTp-SP).

- Health facility-based delivery was a binary variable coded as 1 if the respondent delivered her most recent child in a public, private, or non-governmental health facility, and 0 if the delivery occurred at home or elsewhere.
- Optimal IPTp-SP uptake was also a binary variable, coded as 1 if the woman received at least three doses of sulfadoxine-pyrimethamine (SP) during her most recent pregnancy, and 0 if she received fewer than three doses, consistent with 2016 WHO recommendations for malaria prevention in pregnancy.

#### *Treatment variable*

The treatment variable was based on the number of antenatal care (ANC) contacts a woman received during her most recent pregnancy that ended in a live birth. It was categorized into two groups: women who attended eight or more ANC visits (coded as 1) formed the exposed or treated group and those who had fewer than eight visits (coded as 0) formed the unexposed or untreated group in line with the 2016 WHO guideline recommending a minimum of eight ANC contacts for improved maternal and perinatal outcomes. Ghana adopted the focused antenatal care package in the early 2000s [11] and later reinforced maternal health policies, including the Free Maternal Health Care Policy of 2008 [12, 13], which supports access to 8 or more ANC visits in the country, situating this study within the local policy context.

#### *Covariates*

Matching covariates were selected based on previous literature [14–17] demonstrating their relevance to both ANC attendance and maternal health outcomes. The covariates were categorized as follows: *maternal age* was grouped into five-year intervals (15–24, 25–29, 30–34, 35–49 years); *education level* (no education, primary, secondary, and higher); *birth order* (1–2, 3–4, 5 or more), *preceding birth interval* (< 24 months, 24–59 months, > 59 months), *contraceptive use* (Non user/never used, current user), *covered by insurance* (No, Yes), *household wealth status* (poorest, poorer, middle, richer, and richest), *media exposure* was defined as exposure to at least one form of mass media, including radio, television, or newspapers or magazines (yes (if have been exposed at least once a week or less to one of the media platforms) or no (otherwise)), *type of place of residence* (urban or rural) and *geographic region* included all sixteen administrative regions of Ghana. These variables were included in the propensity score model to adjust for potential confounding between women who attended eight or more ANC visits and those who attended fewer, thereby improving the accuracy of the estimated treatment effects.

### Data analysis

Descriptive statistics were used to summarize the characteristics of the study population, stratified by antenatal care (ANC) attendance status. Proportions and their 95% confidence intervals were estimated for both background characteristics and outcome variables. Cross-tabulations were performed to explore the associations between ANC attendance and key sociodemographic covariates, and Pearson's chi-square test was used to determine statistical significance at a 5% level. Analyses were conducted using Stata version 14.0, with adjustments for the complex survey design using DHS sampling weights, clustering, and stratification, on descriptive statistics, associations and propensity score model estimation, up on which matching was done.

#### *Propensity score-matched analysis (PSMA)*

To estimate the causal impact of attending ANC8 + on facility-based delivery and optimal uptake of IPTp-SP, we applied propensity score matching (PSM). PSM is a quasi-experimental technique used to minimize selection bias by balancing observed covariates between treatment (ANC8+) and control groups (< 8 ANC visits), thereby approximating randomization in observational data [18, 19]. The propensity score, denoted by *e(X)*, was defined as the conditional probability of a woman attending eight or more ANC visits given a set of observed baseline covariates:

$$e(X) = \Pr(Z_i = 1 | \boldsymbol{X}_i) \quad (1)$$

In Eq. 1, $Z_i$ represents the treatment indicator (Z = 1 if ANC8+, Z = 0 otherwise), and $X_i$ denotes the vector of covariates used in the propensity score model while $e(X)$ is the probability of receiving treatment as a function of the observed covariates $X_i$ [18, 20]. The

propensity scores were estimated using a logistic regression model that included variables such as maternal age, education, wealth index, birth order, insurance coverage, contraceptive use, residence type, region, media exposure, and preceding birth interval. Before estimating the propensity score, we assessed multicollinearity among covariates using the Variance Inflation Factor (VIF). All VIF values were below 5, with mean VIF of 2.10, indicating no substantial multicollinearity and supporting model stability. The propensity score model was tested for goodness-of-fit using Hosmer-Lameshow test, and was found to be a good fit with $p = 0.682$.

We applied 1:1 nearest neighbour matching without replacement, with a caliper width of 0.001 to ensure quality matches. The 1:1 nearest neighbor matching without replacement was used to maximize covariate balance while preserving interpretability and yields highly comparable matches [21, 22]. A caliper of 0.001 was applied to ensure high precision in matches and minimize residual bias. Other matching algorithms were not checked since this approach provided better quality matches. Balance diagnostics were assessed by comparing mean bias, median bias, and pseudo-R-squared values in matched and unmatched samples. The standardized percentage bias of less than 10% was considered adequate for good covariate balance. In addition, standardized difference of propensity scores (less than 0.25) and variance ratio of propensity scores (between 0.5 and 2.0) was examined for quality matching [23]. Observations falling outside the region of common support were excluded from the matched sample to reduce bias and improve estimate stability.

The Average Treatment Effect on the Treated (ATT) was estimated as:

$$\mathrm{ATT} = \mathrm{E}[\,\mathrm{Y_i}\,(1) - \,\mathrm{Y_i}\,(0)\,\mid \mathrm{Z_i} = 1] \qquad (2)$$

In Eq. 2, $\mathrm{Y_i}\,(1)$ is the observed outcome (facility-based delivery or IPTp-SP uptake) for a treated woman, and $\mathrm{Y_i}\,(0)$ is the counterfactual outcome had that woman not received eight or more ANC visits. To obtain robust standard error estimates and confidence intervals, we applied bootstrapping with 150 replications to account for uncertainty in the matching process. These replications are sufficient for stable variance estimation in large samples [18, 24]. This analytical approach allows for robust estimation of the effect of ANC8 + attendance on key maternal outcomes, in a setting where randomised trials would be impractical or unethical [25].

## Results

In this section, we first present the prevalence of eight or more antenatal care (ANC) visits among women in Ghana, along with descriptive statistics of background characteristics by ANC attendance status. We use proportions with 95% confidence intervals and associated p-values to examine associations between covariates and ANC visit frequency. Next, we estimate the effects of attending eight or more ANC visits on facility-based delivery and optimal uptake of intermittent preventive treatment during pregnancy with sulfadoxine-pyrimethamine (IPTp-SP) using propensity score matching. Results for covariate balance and overlap between exposed and unexposed groups are shown in Figs. 1 and 2. Average treatment effects on the treated (ATT), with 95% confidence intervals, and the quality of the matching procedure are presented in Tables 2 and 3.

### Prevalence of eight or more ANC visits and background characteristics of the sample

The prevalence of attending eight or more antenatal care (ANC) visits among women in Ghana was 38.7% (95% CI: 36.6, 41.0). Facility-based delivery was reported by 85.4% (95% CI: 83.3, 87.3) of women, with those attending eight or more ANC visits exhibiting a significantly higher rate by 13.9% points (93.9% vs. 80.1%). Uptake of three or more doses of intermittent preventive treatment with sulfadoxine-pyrimethamine (IPTp-SP) was 66.5% (95% CI: 64.4, 68.6), with a 12.5% point higher uptake among women with eight or more ANC visits. Maternal characteristics associated with attending eight or more ANC visits included being aged 30–34 years (26.4%) or 35–49 years (26.7%), and having secondary (57.9%) or higher education (14.2%). Most women in this group were married or cohabiting (85.0%) with 1–2 children (52.9%), and practiced optimal birth spacing of 24–59 months (62.1%).

In terms of socioeconomic status, women who attended eight or more ANC visits were more likely to have health insurance coverage (97.1%), be currently employed (85.2%), reside in urban areas (57.3%), and belong to the richer (22.5%) or richest (26.6%) wealth quintiles. Additionally, they were more frequently exposed to mass media (89.6%) and less likely to consider distance to a health facility a major barrier (19.7%). Regional distribution showed higher percentages of attendance in Ashanti (18.9%), Greater Accra (15.3%), and Eastern (8.7%) regions. These patterns point to disparities influenced by regional, socioeconomic, and demographic factors. Results are shown in Table 1.

### Effect of eight or more ANC visits on facility-based delivery and optimal IPTp-SP uptake

The propensity score graphs were utilised to assess the matching quality and area of common support between women who attended eight or more antenatal care (ANC) visits (exposed) and those who attended fewer than eight visits (unexposed) with respect to two outcomes: facility-based delivery and optimal uptake of IPTp-SP. The

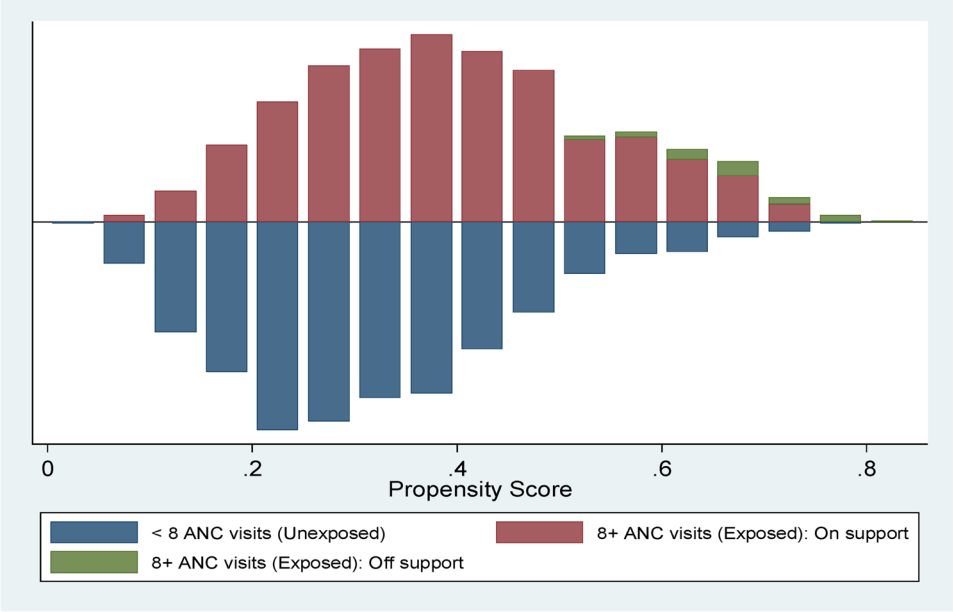


**Fig. 1** Propensity score graph for exposure to 8 or more ANC Visits (1 = Exposed, 0 = Unexposed) on Facility-Based Delivery [Common Support (ANC visits on Place of Delivery)]

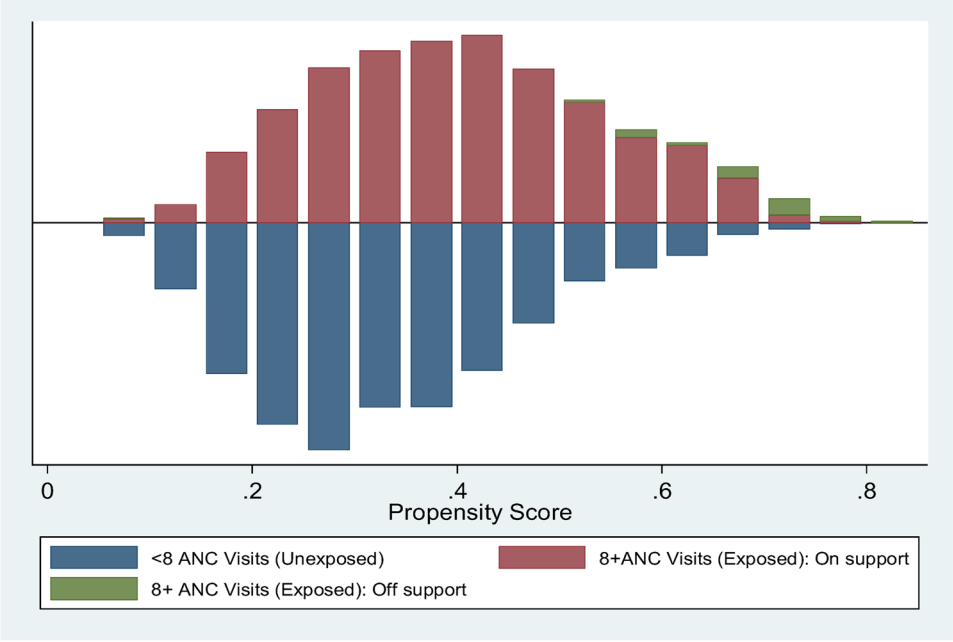


**Fig. 2** Propensity score graph for exposure to 8 or more ANC Visits (1 = Exposed, 0 = Unexposed) on Optimal IPTp – SP Uptake [Common Support (ANC visits on IPTp)]

distributions of propensity scores for both outcomes indicate substantial overlap between the exposed and unexposed groups within the region of common support (Figs. 1 and 2), suggesting that the groups were comparable after matching. A total of 44 women were excluded from the analysis of facility-based delivery, and 41 from the IPTp-SP analysis due to being outside this region of common support.

After matching, we estimated the average treatment effect on the treated (ATT) for facility-based delivery and optimal IPTp-SP uptake among women in Ghana. The unmatched difference in facility-based delivery was 0.160, and for optimal IPTp-SP uptake, it was 0.140 (Table 2), highlighting initial disparities. Post-matching, the ATT for facility-based delivery was (0.082, SE = 0.017, *t-stat* = 4.82), and for optimal IPTp-SP uptake,

**Table 1** Distribution of women sample on selected characteristics

| | | Number of ANC Visits | | *p*-value |
|---|---|---|---|---|
| | **Overall** | **< 8 visits** | **>= 8 visits** | |
| **Covariates** | **% [95% CI]** | **% (95% CI)** | **% (95% CI)** | |
| | | **61.3 (59.0, 63.5)** | **38.7 (36.6, 41.0)** | |
| Outcomes | | | | |
| Place of delivery | | | | |
| Home or other | 14.6 (12.7, 16.7) | 19.9 (17.2, 22.9) | 6.1 (4.9, 7.6) | < 0.001 |
| Health facility | 85.4 (83.3, 87.3) | 80.1 (77.1, 82.8) | 93.9 (92.4, 95.1) | |
| Optimal IPTp-SP | | | | |
| < 3 doses | 33.5 (31.4, 35.6) | 38.3 (35.7, 41.1) | 25.8 (22.7, 29.0) | < 0.001 |
| 3 or more doses | 66.5 (64.4, 68.6) | 61.7 (58.9, 64.3) | 74.2 (71.0, 77.3) | |
| Individual/Mother Level Factors | | | | |
| Age of the mother | | | | |
| 15–24 | 26.3 (24.7, 28.0) | 28.4 (26.4, 30.5) | 22.3 (19.8, 25.0) | 0.002 |
| 25–29 | 24.2 (22.6, 25.8) | 23.8 (21.8, 25.9) | 24.6 (22.3, 27.1) | |
| 30–34 | 23.5 (22.0, 25.1) | 22.1 (20.4, 23.9) | 26.4 (23.8, 29.1) | |
| 35–49 | 26.0 (24.5, 27.6) | 25.7 (23.7, 27.9) | 26.7 (23.9, 29.8) | |
| Highest education level | | | | |
| No education | 21.7 (19.9, 23.6) | 25.9 (23.7, 28.3) | 15.8 (13.1, 18.9) | < 0.001 |
| Primary | 15.3 (13.9, 16.9) | 17.4 (15.7, 19.3) | 12.1 (10.2, 14.3) | |
| Secondary | 53.7 (51.4, 55.9) | 50.6 (48.1, 53.2) | 57.9 (54.4, 61.3) | |
| Higher | 9.3 (8.1, 10.6) | 6.1 (4.9, 7.5) | 14.2 (12.1, 16.6) | |
| Current marital status | | | | |
| Married or living with partner | 82.7 (81.0, 84.3) | 81.7 (79.6, 83.7) | 85.0 (82.4, 87.3) | 0.042 |
| Single/widowed/separated, etc. | 17.3 (15.7, 19.0) | 18.3 (16.2, 20.4) | 15.0 (12.8, 17.6) | |
| Birth Order Number | | | | |
| 1–2 children | 49.2 (47.3, 51.0) | 46.0 (43.6, 48.4) | 52.9 (49.7, 56.1) | < 0.001 |
| 3–4 children | 29.3 (27.6, 31.0) | 29.0 (26.8, 31.2) | 30.4 (27.6, 33.3) | |
| 5 or more | 21.6 (19.9, 23.4) | 25.1 (22.9, 27.5) | 16.8 (14.4, 19.5) | |
| Preceding Birth interval | | | | |
| < 24 months (Short) | 11.8 (10.5, 13.2) | 13.2 (11.5, 15.1) | 9.6 (7.5, 12.3) | 0.002 |
| 24–59 months (Optimal) | 63.6 (61.5, 65.7) | 64.7 (62.1, 67.2) | 62.1 (58.8, 65.4) | |
| > 59 months (Long) | 24.6 (22.8, 26.5) | 22.1 (20.0, 24.4) | 28.3 (25.5, 31.3) | |
| Contraceptive Use | | | | |
| Non user/never used | 61.3 (59.3, 63.3) | 64.3 (61.9, 66.6) | 56.5 (53.3, 59.6) | < 0.001 |
| Current User | 38.7 (36.7, 40.7) | 35.7 (33.4, 38.1) | 43.5 (40.4, 46.7) | |
| Covered by Insurance | | | | |
| No | 4.9 (4.0, 6.1) | 6.3 (5.0, 8.0) | 2.9 (2.0, 4.2) | < 0.001 |
| Yes | 95.1 (93.9, 96.0) | 93.7 (92.0, 95.0) | 97.1 (95.8, 98.0) | |
| Woman's working status | | | | |
| Not working | 17.5 (15.9, 19.2) | 19.4 (17.4, 21.6) | 14.8 (12.7, 17.1) | < 0.001 |
| Working | 82.5 (80.8, 84.1) | 80.6 (78.4, 82.6) | 85.2 (82.9, 87.3) | |
| Distance to health facility | | | | |
| Big problem | 25.0 (22.4, 27.8) | 28.3 (25.3, 31.6) | 19.7 (16.8, 23.0) | < 0.001 |
| Not a big problem | 75.0 (72.2, 77.6) | 71.7 (68.4, 74.7) | 80.3 (77.0, 83.2) | |
| Exposure to mass media | | | | |
| Not exposed | 17.0 (15.1, 19.1) | 21.6 (19.1, 24.4) | 10.4 (8.6, 12.4) | < 0.001 |
| Exposed | 83.0 (80.9, 84.9) | 78.4 (75.6, 80.9) | 89.6 (87.6, 91.4) | |
| Household Factors | | | | |
| Number of household members | | | | |
| 1–3 members | 22.5 (20.8, 24.3) | 20.7 (18.7, 22.8) | 24.4 (21.8, 27.2) | 0.001 |
| 4–6 members | 49.2 (47.3, 51.1) | 48.4 (46.1, 50.7) | 51.3 (48.2, 54.4) | |
| 7 or more members | 28.3 (26.3, 30.4) | 30.9 (28.4, 33.6) | 24.3 (21.4, 27.4) | |
| Sex of Household head | | | | |

**Table 1** (continued)

| | | Number of ANC Visits | | *p*-value |
|---|---|---|---|---|
| | **Overall** | **< 8 visits** | **>= 8 visits** | |
| **Covariates** | **% [95% CI]** | **% (95% CI)** | **% (95% CI)** | |
| Male | 69.3 (67.2, 71.4) | 70.1 (67.5, 72.5) | 68.7 (65.4, 71.7) | 0.458 |
| Female | 30.7 (28.6, 32.8) | 29.9 (27.5, 32.5) | 31.4 (28.3, 34.6) | |
| Wealth Index | | | | |
| Poorest | 23.1 (20.3, 26.1) | 29.3 (25.9, 33.0) | 14.2 (11.7, 17.2) | < 0.001 |
| Poorer | 21.1 (19.0, 23.2) | 22.7 (20.1, 25.4) | 18.9 (16.2, 21.9) | |
| Middle | 19.9 (18.0, 21.9) | 21.0 (18.7, 23.6) | 17.7 (15.5, 20.2) | |
| Richest | 18.8 (17.0, 20.8) | 15.8 (14.0, 17.9) | 22.5 (19.8, 25.5) | |
| Richest | 17.1 (15.1, 19.3) | 11.2 (9.2, 13.5) | 26.6 (23.4, 30.1) | |
| Religion | | | | |
| Christian | 70.1 (67.2, 72.9) | 66.9 (63.5, 70.1) | 74.6 (70.7, 78.3) | < 0.001 |
| Others | 29.9 (27.1, 32.8) | 33.1 (29.9, 36.5) | 25.4 (21.8, 29.3) | |
| Community Level Factors | | | | |
| Type of place of residence | | | | |
| Urban | 48.2 (45.8, 50.5) | 41.7 (38.8, 44.5) | 57.3 (53.6, 61.0) | < 0.001 |
| Rural | 51.9 (49.5, 54.2) | 58.4 (55.5, 61.2) | 42.7 (39.0, 46.4) | |
| Region | | | | |
| Western | 6.08 (5.2, 7.1) | 5.2 (4.1, 6.5) | 7.7 (6.5, 9.2) | < 0.001 |
| Central | 10.0 (8.9, 11.1) | 9.3 (7.8, 11.2) | 10.5 (8.9, 12.4) | |
| Greater | 12.4 (10.8, 14.3) | 10.2 (8.4, 12.2) | 15.3 (12.5, 18.6) | |
| Volta | 3.8 (3.2, 4.5) | 3.7 (3.0, 4.4) | 4.1 (3.0, 5.4) | |
| Eastern | 7.2 (6.2, 8.3) | 6.1 (4.9, 7.6) | 8.7 (6.9, 10.8) | |
| Ashanti | 17.9 (15.7, 20.3) | 17.0 (14.5, 19.9) | 18.9 15.6, 22.6) | |
| Western | 2.6 (2.3, 3.1) | 3.1 (2.5, 3.7) | 2.0 (1.5, 2.6) | |
| Ahafo | 2.2 (1.9, 2.6) | 2.1 (1.8, 2.6) | 2.4 (1.8, 3.2) | |
| Bono | 3.3 (2.8, 4.0) | 3.3 (2.7, 4.0) | 3.4 (2.5, 4.7) | |
| Bono East | 5.3 (4.5, 6.3) | 5.8 (4.6, 7.2) | 4.8 (4.0, 5.8) | |
| Oti | 3.4 (2.7, 4.3) | 4.3 (3.1, 5.8) | 2.1 (1.7, 2.7) | |
| Northern | 11.2 (9.8, 12.9) | 13.8 (11.6, 16.3) | 7.7 (5.4, 11.0) | |
| Savannah | 3.0 (2.4, 3.8) | 3.9 (3.0, 4.4) | 1.7 (1.3, 2.3) | |
| North East | 3.2 (2.7, 3.9) | 3.8 (3.4, 4.4) | 2.4 (1.6, 3.7) | |
| Upper East | 5.1 (4.0, 6.6) | 5.1 (4.0, 6.4) | 5.6 (4.1, 7.7) | |
| Upper West | 3.1 (2.7, 3.5) | 3.4 (2.9, 4.1) | 2.6 (2.1, 3.4) | |

**Table 2** Estimation of average treatment effects on the treated (ATT) of Exposure to 8 + ANC visits on facility-based delivery and optimal IPTp-SP uptake

| **Intervention** | **Sample** | **8 + ANC visits** | **< 8 ANC visits** | **Difference** | **SE** | **t-stat** |
|---|---|---|---|---|---|---|
| Place of Delivery (Facility-Based Delivery) | | | | | | |
| Had 8 or more ANC visits | Unmatched | 0.925 | 0.765 | 0.160 | 0.013 | 12.36 |
| | ATT | 0.923 | 0.841 | 0.082 | 0.017 | 4.82 |
| Optimal IPTp-SP uptake | | | | | | |
| Had 8 or more ANC visits | Unmatched | 0.760 | 0.621 | 0.140 | 0.017 | 8.33 |
| | ATT | 0.762 | 0.652 | 0.111 | 0.024 | 4.65 |

*SE* Standard Errors, *ANC* Antenatal Care

it was (0.111, SE = 0.024, *t-stat* = 4.65) among women who attended eight or more ANC visits compared to similar women with fewer visits. Beyond these direct ATT calculations, we estimated standard errors using bootstrapping with 150 repetitions to derive the 95% confidence intervals. Results are shown in Table 2.

The results revealed that women who attended eight or more ANC visits were 8.2% more likely to deliver in a health facility (ATT = 8.2%, 95% CI: 4.6%, 11.9%) compared to what the same women would have, had they have attended fewer visits (Table 3). This indicates a statistically significant increase in facility-based delivery

**Table 3** Quality of matching and average treatment effects on the treated (ATT) of Exposure to 8 + ANC visits on facility-based delivery and optimal IPTp-SP uptake

| | | Model Diagnostics | | | | | ATT [95% CI] |
|---|---|---|---|---|---|---|---|
| | | Pseudo R2 | LR Chi2 | *p*> Chi2 | Mean Bias | Median Bias | |
| Facility-Based Delivery | | | | | | | |
| Had 8 or more ANC visits | Unmatched | 0.068 | 328.5 | 0.000 | 11.8 | 10.1 | |
| | CC (0.001) | 0.009 | 30.5 | 0.591 | 3.0 | 2.3 | 8.2% (4.6%, 11.9%) [a] |
| Optimal IPTp-SP uptake | | | | | | | |
| Had 8 or more ANC visits | Unmatched | 0.060 | 266.8 | 0.000 | 11.0 | 10.1 | |
| | CC (0.001) | 0.011 | 36.9 | 0.295 | 3.1 | 2.7 | 11.1% (6.8%, 15.4%) [a] |

*LR* Likelihood Ratio, *CI* Confidence Interval, *CC* Common Caliper, *ANC* Antenatal Care

[a] $p = 0.000$

attributed to attending eight or more ANC visits. Similarly, women who attended eight or more ANC visits were 11.1% more likely to receive the recommended number of IPTp-SP doses during pregnancy (ATT = 11.1%, 95% CI: 6.8%, 15.4%) compared to the counterfactual scenario of fewer visits. This implies that attending eight or more ANC visits significantly increases the uptake of IPTp-SP during pregnancy by up to 11.1%. Results are shown in Table 3. A sensitivity analysis using Rosenbaum bounds indicated no evidence of hidden bias or unmeasured confounding, further supporting the robustness of these results.

## Discussion

This study evaluates the impact of eight or more antenatal care (ANC) visits on facility-based delivery and optimal uptake of intermittent preventive treatment of malaria during pregnancy (IPTp-SP) among women of reproductive age in Ghana. Utilizing propensity score matching (PSM) with data from the 2022 Ghana Demographic and Health Survey (DHS), the study robustly balanced exposed (women with ANC8+) and unexposed (women with fewer than 8 ANC visits) groups based on observable variables including age, education, wealth, birth order number, preceding birth order number, contraceptive use, health insurance coverage, media exposure, residence, and region. This PSM approach enabled a robust estimation of the causal effect of ANC attendance on these critical maternal health outcomes.

The national prevalence of eight or more antenatal care visits (ANC8+) in Ghana is 38.7%, indicating a significant gap in achieving the World Health Organization's (WHO) recommendations for optimal maternal care. Concurrently, 85.4% of women delivered in health facilities, and 66.5% achieved optimal uptake of intermittent preventive treatment of malaria in pregnancy (IPTp-SP). Our findings on ANC8 + prevalence align largely with prior Ghanaian studies, such as [26], which reported a 41.9% ANC8 + prevalence using 2019 Ghana Malaria Indicator Survey (GMIS) data, and [27], who noted at least 37.6% had 8 + ANC contacts before delivery in northern Ghana. Similarly, our results on optimum IPTp-SP uptake are consistent with recent studies, including that of [28], who reported 61.6% in the 2019 GMIS, and [29], who found 61.3% at Ayeduase Health Centre. However, lower uptake was reported by [30] in 2023 with 42.4% in northern Ghana, and [31] in 2024 with 59.8% in the Volta Region. For facility-based delivery, our estimate of 85.4% is higher than the 75.3% reported by [6] using 2014 DHS data and the 70% reported by [32] among young mothers. However, it is lower than the 91.6% skilled delivery service utilization observed by [33] in Wa Municipality.

These comparisons reveal regional disparities in maternal health indicators, likely influenced by differences in health system capacity, socio-cultural norms, and economic constraints [34]. For instance, rural and northern regions often face limited availability of skilled health personnel, longer distances to health facilities, and lower household income levels, which may restrict access to regular antenatal care and facility-based delivery. Ghana also has notable regional and socioeconomic variation, which may influence ANC attendance and IPTp-SP uptake in ways not fully captured in national estimates. This within-country diversity should be considered when interpreting the generalizability of our findings. In contrast, urban areas tend to benefit from better health infrastructure, targeted maternal health programs, and higher educational attainment, facilitating improved uptake of ANC8 + and IPTp-SP services. Moreover, cultural perceptions surrounding pregnancy and childbirth, including reliance on traditional birth attendants and gender-related decision-making dynamics, may further account for observed regional variations. Notably, our findings demonstrate that women with eight or more ANC visits had significantly higher rates of facility-based delivery (93.9%) and IPTp-SP uptake (74.2%), underscoring the role of consistent ANC attendance in promoting safer delivery practices and malaria prevention. This observed impact directly supports Ghana's broader maternal health goals of reducing preventable maternal and neonatal deaths, as outlined in the National Health Policy [35] and aligned with Sustainable Development

Goal 3 (SDG 3) [36]. Strengthening interventions that enhance ANC engagement, particularly among disadvantaged populations, can thus serve as a catalyst for achieving equitable and sustained improvements in maternal health outcomes across the country.

A broader comparison with other sub-Saharan African contexts reveals marked variations in the uptake of eight or more antenatal care (ANC8+) contacts, facility-based delivery, and optimal intermittent preventive treatment of malaria in pregnancy (IPTp-SP). These cross-country variations underscore persistent programmatic and systemic gaps, from which valuable lessons can be drawn for enhancing maternal health outcomes in malaria-endemic settings. Ghana demonstrates relative strength compared to some regional peers: our observed ANC8 + prevalence of 38.7% is notably higher than Nigeria's 17.62%, Benin's 8.57%, and Liberia's 30.88% [37]. Similarly, our facility-based delivery rate of 85.4% surpasses Nigeria's 59% [37] and aligns with nations such as Benin and Namibia, though it remains slightly below rates exceeding 90% reported in Gabon and Malawi [37]. However, Ghana's performance still lags behind high-performing contexts globally, such as Jordan (74.0%) [38] and Indonesia (60.97%) [37] for ANC8 + coverage. Regarding IPTp-SP uptake, Ghana's coverage of 66.5%, though encouraging, remains lower than the 79.6% reported in Western Kenya [39], even while exceeding coverage in Uganda (45.3%) and Tanzania (31%) [39, 40]. These comparisons of both success and shortfalls highlight specific areas where Ghana can adopt best practices from higher-performing nations to boost coverage. Continued focused efforts leveraging policy implementation, strengthening community outreach, health system capacity, and targeted removal of rural and socioeconomic barriers as observed in higher-performing countries, could aid Ghana in closing these gaps and improving maternal and neonatal health outcomes.

Our findings that attending eight or more ANC visits was associated with an 8.2% higher probability of facility-based delivery and an 11.1% higher probability of optimal IPTp-SP uptake, compared to the counterfactual scenario for the same women attending fewer visits, provide compelling evidence that increased ANC attendance directly improves utilization of essential maternal health services. These findings align with evidence showing that Ghana's National Health Insurance Scheme (NHIS) and the Free Maternal Health Care Policy (FMHCP) of 2008 significantly improved maternal service uptake, including facility delivery rates and ANC utilization [12, 13]. Specifically, the FMHCP has been associated with a substantial increase in facility-based deliveries and other maternal health service utilization since its inception [12, 41]. Moreover, studies on supply chain innovations and community health interventions demonstrate positive downstream effects on ANC attendance and facility deliveries [42]. Furthermore, our analysis revealed distinct characteristics among women with higher ANC attendance; they were more likely to have higher educational attainment, reside in urban areas, and have health insurance coverage. These factors likely facilitate enhanced access to and engagement with maternal health services, thereby creating pathways to higher ANC utilization. This indicates persistent equity gaps in maternal health service access, and underscores the importance of targeted interventions to support rural and less educated women, including community outreach, tailored health education, and strengthening rural health infrastructure. These estimated effects also have meaningful practical implications. An increase of 8–11% points in facility-based delivery and IPTp-SP uptake means more women receive skilled care during childbirth and receive essential malaria prevention during pregnancy. In a malaria-endemic setting like Ghana, such improvements may contribute to lower risks of severe malaria, maternal complications, preventable infections, and neonatal mortality. Therefore, beyond statistical significance, these findings highlight the potential for ANC8 + attendance to translate into measurable gains in maternal and newborn health outcomes. The existing literature consistently demonstrates a positive association between ANC attendance and both facility-based delivery [43–46] and IPTp-SP [33, 47–49]. However, these studies rely on conventional regression models to report these associations. These models, while useful, often fall short of establishing causality due to potential confounding and do not account for causal effects as robustly as PSM. In contrast, studies employing PSM, though fewer in number, provide stronger causal evidence. For instance, a 2023 study in low- and middle-income countries by [50] found that women who attended ANC8 + visits had a 14% increase in facility-based delivery. Mwebesa et al., [51] in their study found an 11.8% increase in facility-based delivery with ANC4 + in Uganda [51]. These PSM-based studies, including this study, suggest that ANC provides critical maternal education and referrals that promote facility-based delivery and adherence to malaria prevention protocols, offering stronger causal evidence than associational studies. The robustness of our ATT estimates, supported by sensitivity analysis using Rosenbaum bounds, suggests minimal hidden bias, enhancing the credibility of our causal inferences. These findings collectively highlight the profound importance of ANC as a multifaceted platform for health education, early identification of risks, timely referrals, and the delivery of crucial preventive interventions. For Ghana, a malaria-endemic setting, maximizing ANC attendance to eight or more visits represents a potent strategy for significantly improving maternal and neonatal outcomes and reducing morbidity.

Despite the strong evidence provided by PSM, it is imperative to acknowledge the inherent limitations of drawing causal inferences from observational data. Additionally, it is important to acknowledge the possibility of confounding by indication. Women experiencing pregnancy complications are often advised to attend ANC more frequently, which means higher ANC attendance may sometimes reflect underlying high-risk pregnancies rather than improved care-seeking behaviour. In such cases, ANC8 + may function as a marker of pregnancy risk rather than the cause of improved outcomes. Although PSM reduces bias from observed characteristics, it cannot fully account for this type of reverse causality, and some residual confounding may remain. While PSM effectively controls for observed confounders, the potential influence of unobserved factors such as individual health beliefs, cultural practices, and differences in provider quality or attitudes cannot be entirely ruled out. These unmeasured variables may still introduce bias and lead to over- or underestimation of the true effects. Additionally, the study relies on self-reported measures of ANC attendance and malaria preventive treatment, which may be subject to recall bias or social desirability bias, potentially affecting data accuracy. The quality and timing of ANC visits were also not captured in sufficient detail, yet these factors can critically influence both the uptake of IPTp-SP and facility-based delivery. Despite these limitations, in contexts where randomized controlled trials are impractical or ethically challenging, PSM provides a robust and methodologically sound approach for assessing the impact of public health interventions. By ensuring covariate balance between treatment and control groups based on observable characteristics, PSM produces the most unbiased estimates feasible from observational data, contributing valuable insights for policy and practice. Additionally, because women with missing IPTp-SP values were excluded and not compared with those retained in the analysis, we cannot determine whether systematic differences existed, and some degree of missing-data bias cannot be completely ruled out. Future studies should consider longitudinal designs to establish temporal relationships between determinants and ANC utilization. Qualitative inquiries could provide deeper insights into cultural norms, beliefs, and health system factors influencing maternal healthcare use. In addition, health systems research focusing on the quality, timing, and accessibility of ANC services would help identify structural barriers to care. Policy evaluation approaches such as stepped-wedge or cluster-randomized designs may also strengthen causal inference and inform evidence-based interventions aimed at improving the continuum of maternal healthcare. While matching quality was strong; in the IPTp results one category of the wealth index still showed a standardized bias greater than 10%. The potential effect of this remaining imbalance were not addressed in the study. Future studies could examine the impact of such imbalance in similar contexts.

## Conclusions and implications

This study demonstrates that completing eight or more antenatal care (ANC) visits significantly strengthens maternal health service utilization in Ghana, particularly improving facility-based delivery and the uptake of malaria prevention during pregnancy through intermittent preventive treatment with sulfadoxine-pyrimethamine (IPTp-SP). Using propensity score matching on nationally representative data, we found that women who completed the recommended ANC visits were more likely to access skilled delivery care and receive appropriate malaria prevention compared to those who attended fewer visits.

Despite these benefits, many women still do not achieve the recommended eight contacts, revealing persistent inequities in healthcare access and continuity. The strong associations between ANC attendance and social determinants such as education level, household wealth, place of residence, and exposure to health information highlight the need for context-sensitive and equity-focused policy actions. Concrete strategies should include subsidizing transportation costs for rural women, expanding the National Health Insurance Scheme to cover indirect ANC expenses, and enhancing community health worker outreach to encourage early and consistent attendance. These strategies should be implemented collaboratively by the Ministry of Health, district health management teams, and community health workers, who play central roles in expanding ANC access, strengthening service delivery, and improving IPTp-SP uptake at the community level. In addition, targeted awareness campaigns using local media, faith-based organizations, and mobile health platforms can help increase awareness of the benefits of ANC8 + and facility-based delivery. Improving the quality and timeliness of care across all eight contacts through health worker training, supervision, and patient-centered communication is equally essential to build community trust and sustain utilization. While this study applied rigorous methods to minimize bias, limitations such as self-reported data and potential unobserved confounding should be acknowledged. Nevertheless, the findings provide actionable evidence for improving maternal health outcomes in Ghana. Future research should investigate the quality and timing of ANC visits, explore provider-level barriers, and employ longitudinal or policy evaluation designs such as stepped-wedge trials to strengthen causal inference on the broader impacts of ANC on maternal and neonatal health.

**Abbreviations**

| | |
|---|---|
| ANC | Antenatal Care |
| IUGR | Intrauterine Growth Restriction |
| ATT | Average Treatment Effect on the Treated |
| CI | Confidence Interval |
| DHS | Demographic and Health Survey |
| EA | Enumeration Area |
| GHS | Ghana Health Service |
| GMIS | Ghana Malaria Indicator Survey |
| GSS | Ghana Statistical Service |
| ICF | Inner City Fund (ICF International) |
| IPTp | SP–Intermittent Preventive Treatment of malaria during pregnancy with Sulfadoxine–Pyrimethamine |
| ITN | Insecticide–Treated Net |
| SDG | Sustainable Development Goal |
| WHO | World Health Organization |
| ATT | Average Treatment Effect of the Treated |
| PSM | Propensity Score Matching |
| CC | Common Calliper |
| CI | Confidence Interval |
| LR | Likelihood Ratio |
| PSMA | Propensity Score–Matched Analysis |
| SE | Standard Error |

## Supplementary Information

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Supplementary Material 1.

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**Authors' contributions**

DMA and EM conceptualized the research idea, obtained and analyzed the data, and wrote the first draft of the manuscript. AIJ contributed to writing the manuscript. SVK and GKK supervised the writing and provided thorough edits. All authors read and approved the final manuscript.

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**Data availability**

No datasets were generated or analysed during the current study.

## Declarations

**Ethics approval and consent to participate**

This study analyzed data obtained from DHS Program, which had no identifiable participants data; as such, ethical approval was not needed.

**Consent for publication**

Not applicable.

**Competing interests**

The authors declare no competing interests.

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