AFRICAN JOURNAL OF PARASITOLOGY, MYCOLOGY AND ENTOMOLOGY
Official journal of the African Society of Parasitology

Increase in Adherence and Efficacy of Intermittent Preventive Treatment (IPT) with Sulfadoxine–Pyrimethamine Among Pregnant Women in Bouna from 2021 to 2024

Akoua Valérie Bédia-Tanoh [1,2,*], Abibatou Konaté-Touré [1,2], Abo Henriette Vanga-Bosson [1], Assohoun Jean Sebastien Miezan [1], Estelle Gnanyo Massafoma Koné [1], Fulgence Kondo Kassi [1], Pulchérie M. Christiane Kiki-Barro [1], Etienne Kpongbo Angora [1], Vincent Djohan [1], Hervé El Menan [1] and William Yavo [1,2]

[1] Department of Parasitology-Mycology-Animal Biology-Zoology UFR Pharmaceutical and Biological Sciences, Félix Houphouët-Boigny University, Abidjan BPV 34, Côte d'Ivoire; abykonate@yahoo.fr (A.K.-T.); vangahenriette@yahoo.fr (A.H.V.-B.); sebastienmiezan@yahoo.fr (A.J.S.M.); dignanyo@yahoo.fr (E.G.M.K.); kasful2000@yahoo.fr (F.K.K.); kikipcm@yahoo.fr (P.M.C.K.-B.); angorakpongbo2005@yahoo.fr (E.K.A.); vincentdjohan1@yahoo.fr (V.D.); rvmenan@yahoo.fr (H.E.M.); yavowilliam@yahoo.fr (W.Y.)

[2] Malaria Research and Control Center, National Institute of Public Health, Abidjan PBV 47, Côte d'Ivoire

* Corresponding author: akouaval@yahoo.fr; Tel.: +225-0779222112

Submitted: 30 September 2025, accepted: 22 June 2026, published: 10 September 2026

Abstract: Introduction: There are limited scientific data on the effectiveness of malaria control strategies among pregnant women in Bouna. This study was initiated to evaluate the efficacy of Intermittent Preventive Treatment with Sulfadoxine–Pyrimethamine (IPT-SP) among pregnant women in Bouna from 2021 to 2024. Methods: This study compiled data from two cross-sectional studies assessing the effectiveness of IPT-SP. These studies involved parturients received at the maternity ward of Bouna General Hospital in 2021 and 2024. Data were collected using a structured questionnaire, and plasmodial infestation was detected through optical microscopy. Results: The adherence rate for the third dose of SP (SP3) was 59.6% (143/240) in 2021 compared with 62.1% (149/240) in 2024. Plasmodial indices in 2021 were 13.8%, 11.7%, 8.3%, and 11.3% in venous blood, placental blood, cord blood, and placental smear, respectively, compared to 6.7%, 5.8%, 2.1%, and 6.3% in 2024. Data analysis revealed that attending fewer than four antenatal care (ANC) visits was associated with a low adherence rate to IPT-SP (2021: OR = 6.07; CI: [3.05–12.08]; p = 0.0001; 2024: OR = 43.66; CI: [20.29–93.98]; p = 0.0001). Factors such as maternal age (2021: p = 0.034; 2024: p = 0.030), parity (p = 0.001), gravidity (2021: p = 0.0001; 2024: p = 0.009), IPT-SP intake (2021: p = 0.032; 2024: p = 0.031), presence of anomalies (p = 0.003), and plasmodial infestation were associated with the occurrence of low birth weight. Conclusion: This study confirms the efficacy of IPT-SP. However, regular monitoring of its effectiveness and the exploration of new strategies for malaria control among pregnant women are recommended.

Keywords: plasmodial infestation; pregnant women; Sulfadoxine–Pyrimethamine; Côte d'Ivoire

How to cite: Bédia-Tanoh, A.V.; Konaté-Touré, A.; Vanga-Bosson, A.H.; Miezan, A.J.S.; Koné, E.G.M.; Kassi, F.K.; Kiki-Barro, P.M.C.; Angora, E.K.; Djohan, V.; Menan, H.E.I.; et al. Increase in Adherence and Efficacy of Intermittent Preventive Treatment (IPT) with Sulfadoxine–Pyrimethamine Among Pregnant Women in Bouna from 2021 to 2024. *Afr. J. Parasitol. Mycol. Entomol.*, 2026, 4(2): 3; doi:10.35995/ajpme04020003.

© 2026 Copyright by Authors. Licensed as an open access article using a CC BY 4.0 license.



1. Introduction

Malaria control has been disrupted in recent years by several factors, including the emergence of *Plasmodium* resistance to antimalarial drugs, female *Anopheles* resistance to insecticides, the COVID-19 pandemic, and climate change. According to the World Health Organization (WHO), approximately 263 million people were affected by malaria across 83 malaria-endemic countries in 2023, an increase of 11 million cases compared to 2022 [1]. The WHO African Region is the most severely impacted, accounting for about 94% of malaria cases, or approximately 247 million cases [1]. While all individuals are at risk, the majority of victims are children under five years old and pregnant women. Every year, over 36 million women become pregnant, 12.4 million of whom (34%) contract malaria [1]. Moreover, around one-quarter of pregnant women in endemic regions, particularly primigravidae, present with placental infection [2]. Malaria has devastating effects on maternal and fetal health, as well as on newborns and pregnancy outcomes [1–4]. For the fetus, sequestration of infected red blood cells in the placenta leads to placental damage, reduced oxygen and nutrient transport, and, consequently, low birth weight, with reductions of up to 170 grams on average [5].

Additionally, malaria significantly increases the risk of maternal and fetal anemia, miscarriage, intrauterine growth restriction, preterm delivery, and maternal and neonatal mortality [3,4]. In Africa, 5.7% of maternal deaths are attributed to placental malaria infection [6,7]. In Côte d'Ivoire, malaria is endemic and remains a major public health issue. In 2020, approximately 469,943 cases of gestational malaria were reported [8].

To effectively combat this disease, particularly among pregnant women, the WHO recommends several promising strategies through the National Malaria Control Programs (NMCPs), especially in areas of high and moderate endemicity: (i) the use of long-lasting insecticide-treated nets (LLINs); (ii) monthly administration of a dose of Sulfadoxine–Pyrimethamine (SP) as an Intermittent Preventive Treatment (IPTp-SP) starting from the second trimester during antenatal visits; and (iii) rapid, adequate, and effective management of malaria cases [3]. IPTp-SP is a crucial component in combating malaria among pregnant women. One of the NMCP's key objectives for malaria prevention in Côte d'Ivoire is to ensure that at least 80% of pregnant women receive at least three doses of IPTp-SP during antenatal care (ANC) [9]. Studies have shown that administering at least three doses of IPTp-SP significantly reduces the number of infants born with low birth weight and mitigates the adverse effects of malaria during pregnancy [1,2,10]. However, the emergence and spread of *Plasmodium* parasites resistant to Sulfadoxine–Pyrimethamine threaten the effectiveness of IPTp-SP during pregnancy [11]. Limited published data exist on the efficacy of IPTp-SP among pregnant women in Bouna, a recently designated sentinel site for antimalarial drug surveillance by

the NMCP. Therefore, several years after the adoption of these guidelines, it is critical to assess the coverage and effectiveness of IPTp-SP among pregnant women in Bouna from 2021 to 2024. Enhanced and regular monitoring will enable the adaptation of guidelines to ensure sustained malaria control.

2. Methods

2.1. Study Type, Period and Site

This research comprised two cross-sectional studies conducted to evaluate the efficacy of Intermittent Preventive Treatment with Sulfadoxine–Pyrimethamine (IPTp-SP) among pregnant women in 2021 and 2024. The studies involved a cohort of pregnant women (parturients) who delivered at the maternity ward of Bouna General Hospital.

Bouna is the administrative capital of the Bounkani region in northeastern Côte d'Ivoire. It is one of the 12 sentinel sites designated by the National Malaria Control Program for monitoring the effectiveness of antimalarial drugs. Geographically, Bouna borders Ghana to the east and Burkina Faso to the north, covering an area of 15,280 km^2 (coordinates: 9°16′ North, 3°00′ West) with a population density of 3.8 inhabitants per km^2. Bouna has a sub-Sudanese climate characterized by four seasons: two rainy seasons (March–June and September–October) and two dry seasons (November–February and July–August). Annual rainfall ranges from 1100 to 1200 mm, and the average temperature is approximately 28 °C. Malaria in Bouna is of moderate endemicity, with an annual incidence ranging between 300 and 399 cases per 1000 inhabitants [9]. Malaria transmission is stable throughout the year but intensifies during the rainy seasons. *Plasmodium falciparum* is the predominant malaria parasite. Entomological studies conducted in 2019 reported high endophagic behavior (65%) of *Anopheles gambiae* in rural areas of the Bouna region [9].

2.2. Study Population

The participants included in these studies were parturients who provided informed consent, with no selection criteria based on their use of an Intermittent Preventive Treatment (IPT). Women were excluded from the study if they met any of the following criteria: (i) poor understanding of the survey questions, potentially compromising the validity of their responses; (ii) inability to perform placental sampling or measure the newborn's birth weight, or unavailable records of previous IPTp-SP treatment; and (iii) evident pregnancy complications, such as hypertension, diabetes, eclampsia, twin pregnancies, or confirmed HIV seropositivity. This limited confounding factors and guaranteed participant safety.

The minimum required sample size was 235 participants. Accordingly, 240 parturients were included in the studies conducted in both 2021 and 2024.

2.3. Data Collection

Each woman meeting the inclusion criteria was enrolled in the study after providing informed consent. Participants were interviewed using a structured questionnaire designed to collect information on maternal and neonatal data.

Additional data were gathered from maternal–child health booklets and delivery registers to verify and complement the information collected during the interviews.

2.4. Sample Collection and Examination

For each enrolled woman, blood samples were collected from venous, placental, and umbilical cord blood, as well as placental imprints. The blood samples were drawn as follows:

- Venous blood: Collected from the antecubital vein using EDTA tubes.
- Placental and cord blood: Collected within hours after placental delivery.

Placental blood was obtained by creating a lesion on the maternal-facing surface of the placenta. Using a Pasteur pipette, blood was drawn directly from the lesion. Additionally, tissue sections approximately 2 cm × 2 cm in length and width and 1 cm in depth were excised from the maternal side of the placenta. These sections were used to prepare thin smears for placental imprints [10]. Cord blood was collected immediately after delivery from the umbilical vein of the clamped cord using a sterile syringe or directly into an EDTA tube.

2.5. Laboratory Analysis of Blood Samples

The collected blood samples were used to prepare thick and thin smears (mixed smears) stained with Giemsa. Thick smears were used for the biological diagnosis of *Plasmodium* infection and to determine parasite density, and thin smears were used to identify *Plasmodium* species.

Microscopic examination of the blood smears was performed using an optical microscope with an X100 oil-immersion objective. Each slide was independently reviewed by two experienced laboratory technicians. In cases of discordance, a third reading was conducted by a senior, more experienced technician.

- Parasite Density Determination

To calculate parasite density, the thick smear was examined by counting asexual forms of *Plasmodium* (trophozoites and schizonts) alongside leukocytes.

- Hemoglobin Measurement

The maternal hemoglobin level was determined using venous blood samples using the HemoCue Hb 555 analyzer (HemoCue AB, Ängelholm, Sweden) according to the manufacturer's instructions.

All laboratory analyses were conducted at the laboratory of the General Hospital of Bouna.

2.6. Ethical Approval and Informed Consent

These studies received approval from the National Committee for Ethics in Life and Health Sciences of Côte d'Ivoire prior to their implementation. The approval reference numbers for the studies conducted in 2020 and 2023 are N/reference: 081-20/MSHP/CNESVS-kp and N/reference: 114-23/MSHP-CMU/CNESVS-km, respectively. All participants were informed about the study objectives and procedures. For each participant, written informed consent was obtained, and they were free to withdraw their consent at any time during the study without it affecting their access to healthcare services. The survey forms were anonymous, and confidentiality of the data was strictly maintained.

2.7. Statistical Analysis and Outcome Measures

The treatment with Sulfadoxine–Pyrimethamine (SP) was considered effective in the absence of *Plasmodium* species on placental examination [12]. A woman was considered to have adhered to the treatment regimen if she received at least three doses of Sulfadoxine–Pyrimethamine starting

from the second trimester of pregnancy. A newborn was considered to have low birth weight if their birth weight was less than 2500 g.

Data were summarized using descriptive statistics, including frequencies, percentages, means, standard deviations, medians, and ranges. Data analysis was performed using the EPSS 21.0 software. The comparison of proportions was conducted using the chi-square test or Fisher's exact test, with a significance threshold of α = 5%.

3. Results

3.1. Sociodemographic Characteristics and Obstetric History

The majority of the parturients were aged 26 years or younger (2021: 62.5% vs. 2024: 72.5%). The mean age was 24.2 years (SD = 6.6; range: [15–48] years) in 2021 and 25.3 years (standard deviation (SD) = 6.3; range: [14–47] years) in 2024. Homemakers made up more than a third of the study population (2021: 48.8% vs. 2024: 35.6%). Most parturients lived in urban areas (2021: 72.9% vs. 2024: 85.4%), and were approximately 5 km from the healthcare center. The majority of women were illiterate (2021: 62.1% vs. 2024: 57.1%), lived with a partner (2021: 90% vs. 2024: 82.9%), and were multigravida (2021: 66.2% vs. 2024: 72.5%), with secundigravida proportion representing 20% in both 2021 and 2024.

The average number of pregnancies in the study population was 2.9 (SD = 2.1 and 1.8, respectively, for 2021 and 2024; max = 11 pregnancies). A higher proportion of multiparous women was observed in 2024 (67.5%) compared to 2021 (41.7%).

Regarding antenatal care (ANC), 32.5% and 56.7% of pregnant women in 2021 and 2024, respectively, had their first ANC during the first trimester, while 32.5% in 2021 and 60% in 2024 attended more than four ANC visits. Women in 2021 (60%) had better use of insecticide-treated nets (ITNs) compared to those in 2024 (42.9%). The adherence rate three doses of Sulfadoxine–Pyrimethamine (SP3) was 59.6% in 2021 compared with 62.1% in 2024.

The sociodemographic characteristics and obstetric history are presented in Table 1.

3.2. Characteristics of the Newborn

The average weight of newborns was 2995 g (SD = 575 g; min = 900 g; max = 4300 g) in 2021 compared with 2831 g (SD = 494 g; min = 300 g; max = 3800 g) in 2024. More than three-quarters of the newborns had a normal birth weight (2021: 80.8% vs. 2024: 85.4%). Only five newborns were premature, accounting for 2.1%. These data are presented in Table 1.

3.3. Biological Data

The mean hemoglobin level was 11.3 g/dL (SD = 1.6 g/dL; median = 11.4 g/dL; min = 5 g/dL; max = 19 g/dL) (Table 1). Women with hemoglobin levels below the normal value of 12 g/dL were the most represented, accounting for approximately 68% in both 2021 and 2024 (Table 1).

The *Plasmodium* indices were 13.8%, 11.7%, 8.3%, and 11.3% in the venous, placental, cord, and placental apposition blood samples, respectively, in 2021, compared to 6.7%, 5.8%, 2.1%, and 6.3% in 2024 (Table 1). About 50% of infected women had a parasitic density greater than 9736 trophozoites/μL (trz/μL) in venous blood, 5620 trz/μL in placental blood, and 1492 trz/μL in cord blood.

Table 1: Characteristics of the women in the study according to the explored variables.

Variables		2021	2024
Age (years)	⩽26	150 (62.5)	138 (57.5)
	>26	90 (37.5)	102 (42.5)
Occupation	Homemakers	117 (48.8)	85 (35.4)
	Other professions	123 (51.2)	155 (64.6)
Marital Status	Single	24 (10)	41 (17.1)
	Lived with a partner	216 (90)	199 (82.9)
Education Level	No education	149 (62.1)	137 (57.1)
	Educated	91 (37.9)	103 (42.9)
Place of Residence	Urban	175 (72.9)	205 (85.4)
	Rural	65 (27.1)	35 (14.6)
Distance Between Residence and Health Center	⩽5 km	196 (81.7)	165 (68.8)
	>5 km	44 (18.3)	75 (31.3)
Use of ITNs	Yes	144 (60)	103 (42.9)
	No	96 (40)	137 (57.1)
IPTp-SP Uptake	<3	97 (40.4)	91 (37.9)
	⩾3	143 (59.6)	149 (62.1)
Gravidity	Primigravida	81 (33.8)	66 (27.5)
	Multigravida	159 (66.2)	174 (72.5)
Parity	<2	140 (58.3)	96 (32.5)
	⩾2	100 (41.7)	144 (67.5)
Gestational Age at First ANC Visit	>3 months	162 (67.5)	104 (43.3)
	⩽3 months	78 (32.5)	136 (56.7)
Number of ANC Visits	<4	162 (67.5)	96 (40)
	⩾4	78 (32.5)	144 (60)
Hemoglobin Level	<12	165 (68.8)	164 (68.3)
	⩾12	75 (31.3)	76 (31.7)
Pregnancy Outcome	Term	235 (97.9)	235 (97.9)
	Preterm	5 (2.1)	5 (2.1)
Neonatal Anomalies	Anormal	5 (2.1)	5 (2.1)
	Normal	235 (97.9)	235 (97.9)
Birth Weight	<2500 g	46 (19.2)	35 (14.6)
	⩾2500 g	194 (80.8)	205 (85.4)
Peripheral Infestation	Negative	207 (86.3)	224 (93.3)
	Positive	33 (13.8)	16 (6.7)
Placental Infestation	Negative	212 (88.3)	226 (94.2)
	Positive	28 (11.7)	14 (5.8)
Cord Infestation	Negative	220 (91.7)	235 (97.9)
	Positive	20 (8.3)	5 (2.1)
Impression Placental	Negative	213 (88.8)	225 (93.8)
	Positive	27 (11.3)	15 (6.3)

3.4. Factors Associated with TPI Adherence

The data analysis revealed that only three variables were associated with poor adherence to IPTp-SP in 2021: being a homemaker (OR: 2.1; CI [1.25–3.58]; p = 0.005), being multigravida (OR: 2.2; CI [1.27–3.80]; p = 0.004), and having four or fewer antenatal care visits (OR: 6.07; CI [3.05–12.08]; p = 0.0001). In 2024, four variables were associated with poor adherence: being younger than 26 years old (OR = 1.8; CI [1.03–3.02]; p = 0.039), having no formal education (OR = 2.11; CI [1.22–3.64]; p = 0.007), using long-lasting insecticide-treated nets (LLINs) (OR = 1.95; CI [1.14–3.36]; p = 0.015), and having four or fewer antenatal care visits (OR = 43.66; CI [20.29–93.98]; p = 0.0001). Attendance at more than four antenatal care visits increased the likelihood of receiving at least three doses of IPTp-SP by 44-fold (Table 2).

3.5. Factors Associated with Low Birth Weight

Age (2021: p = 0.034 and 2024: p = 0.030), parity (p = 0.001), gravidity (2021: p = 0.0001, 2024: p = 0.009), IPTp-SP intake (2021: p = 0.032; 2024: p = 0.031), presence of anomalies (p = 0.003), plasmodial infestation (2021: venous p = 0.007 and placenta p = 0.018; in 2024: cord p = 0.023), and antenatal care visits (2024: p = 0.009) were associated with low birth weight (Table 3).

3.6. Factors Associated with Placental Infestation

No statistically significant association was observed between placental infestation and IPTp-SP intake. However, women who took fewer than three doses of IPTp-SP were more likely to be infested. Primigravidae (2021: 17.3%, p = 0.053; 2024: 13.6%, p = 0.003) and nulliparous/primiparous women (2021: 15.7%, p = 0.021; 2024: 7.3%, p = 0.431) had higher rates of placental infestation. Women under 26 years of age were more likely to be infested (2021: 12.7%; 2024: 8.7%; p = 0.533 and p = 0.028, respectively). Women exhibiting infection in both peripheral and cord blood were 48 to 966 times more likely to have placental infection (Table 4).

Table 2: Factors associated with adherence to Intermittent Preventive Treatment.

Variables		Year 2021				Year 2024			
		Intermittent Preventive Treatment (IPTp-SP) Uptake N (%)		0R (CI)	*p*	Intermittent Preventive Treatment (IPTp-SP) Uptake N (%)		0R (CI)	*p*
		<3	⩾3			<3	⩾3		
Age (year)	⩽26	66 (44)	84 (56)	1.5 (0.87–2.57)	0.144	60 (43.5)	78 (56.5)	1.8 (1.03–3.02)	0.039
	>26	31 (34)	59 (66)			31 (30.4)	71 (69.6)		
Occupation	Homemaker	58 (49.6)	59 (50.4)	2.1 (1.25–3.58)	0.005	38 (44.7)	47 (55.3)	1.35 (0.68–2.67)	0.108
	Other professions	39 (31.7)	84 (76.4)			53 (34.2)	102 (65.8)		
Marital Status	Single	10 (41.7)	14 (58.3)	1.06 (0.45–2.49)	0.895	18 (43.9)	23 (56.1)	1.06 (0.45–2.49)	0.386
	Lives with a partner	87 (40.3)	129 (59.7)			73 (36.7)	126 (63.3)		
Education Level	No education	65 (43.6)	84 (56.4)	1.42 (0.83–2.44)	0.195	62 (45.2)	75 (54.8)	2.11 (1.22–3.64)	0.007
	Educated	32 (35.2)	59 (64.8)			29 (28.1)	74 (71.9)		
Place of Residence	Urban	68 (38.9)	107 (61.1)	1.27 (0.71–2.25)	0.419	73 (35.6)	132 (64.4)	1.91 (0.93–3.94)	0.075
	Rural	29 (44.6)	36 (55.4)			18 (51.4)	17 (48.6)		
Distance Between Residence and Health Center	⩽5 km	75 (38.3)	121 (61.7)	0.620 (0.32–1.17)	0.321	60 (36.4)	105 (63.6)	0.81 (0.46–1.41)	0.462
	>5 km	22 (50)	22 (50)			31 (41.3)	44 (58.7)		
Use of Insecticide-Treated Nets (ITNs)	yes	44 (45.8)	52 (54.2)	1.45 (0.86–2.46)	1.163	30 (29.1)	73 (70.9)	1.95 (1.14–3.36)	0.015
	no	53 (36.8)	91 (63.2)			61 (44.5)	76 (55.5)		
Gravidity	Primigravida	43 (53.1)	38 (46.9)	2.2 (1.27–3.80)	0.004	26 (39.4)	40 (60.6)	1.09 (0.61–1.95)	0.771
	Multigravida	54 (44)	105 (66)			65 (37.4)	109 (62.6)		
Parity	<2	60 (42.9)	80 (57.1)	1.28 (0.75–2.16)	0.362	34 (43.6)	44 (56.4)	1.42 (0.82–2.47)	0.209
	⩾2	37 (37)	63 (63)			57 (35.2)	105 (64.8)		
Gestational Age at First Antenatal Care (ANC) Visit	>3 months	46 (38.7)	73 (61.3)	0.86 (0.52–1.45)	0.601	40 (38.5)	64 (61.5)	1.04 (0.62–1.76)	0.879
	⩽3 months	51 (42.1)	70 (67.9)			51 (45)	85 (55)		
Number of ANC Visits	<4	85 (52.5)	77 (47.5)	6.07 (3.05–12.08)	0.0001	78 (81.3)	18 (18.7)	43.66 (20.29–93.98)	0.0001
	⩾4	12 (15.4)	66 (84.6)			13 (9)	131 (91)		

Table 3: Factors associated with low birth weight.

Variables		Year 2021				Year 2024			
		Birth Weight of the Newborn		OR (CI)	*p*	Birth Weight of the Newborn		OR (CI)	*p*
		<2500	⩾2500			<2500	⩾2500		
Age Group	⩽26	35 (23.3)	115 (76.3)	2.2 (1.05–4.56)	0.034	26 (18.8)	112 (81.2)	2.40 (1.07–5.37)	0.030
	>26	11 (12.2)	79 (87.8)			9 (8.8)	93 (91.2)		
Parity	<2	37 (26.4)	103 (73.6)	3.63 (1.66–7.93)	0.001	20 (25.6)	58 (74.4)	3.38 (1.62–7.04)	0.001
	⩾2	9 (9)	91 (91)			15 (9.3)	147 (90.7)		
Gravidity	Primigravida	29 (35.8)	52 (64.2)	4.6 (2.36–9.17)	0.0001	16 (24.2)	50 (75.8)	2.6 (1.25–5.46)	0.009
	Multigravida	17 (10.7)	142 (89.3)			19 (10.9)	155 (89.1)		
Intermittent Preventive Treatment (IPTp-SP) Uptake	<3	25 (25.8)	72 (74.2)	2.02 (1.05–3.86)	0.032	19 (19.2)	72 (78.1)	2.19 (1.06–4.53)	0.031
	⩾3	21 (14.7)	122 (85.3)			16 (10.7)	133 (89.3)		
Number of ANC Visits	<4	28 (17.3)	134 (82.7)	0.69 (0.36–1.35)	0.462	21 (21.9)	75 (72.1)	2.6 (1.25–5.41)	0.009
	⩾4	18 (23)	60 (77)			14 (9.7)	130 (90.3)		
Pregnancy Outcome	Term	3 (60)	2 (40)	6.7 (1.09–4.32)	0.05	4 (80)	1 (020)	0.04 (0.004–0.35)	0.002
	Preterm	43 (18.3)	192 (81.7)			31 (88.6)	204 (99.5)		
Neonatal Anomalies	Anormal	4 (80)	1 (20)	18.38 (2–168.66)	0.003	4 (11.4)	1 (0.5)	18.38 (2–168.66)	0.003
	Normal	42 (17.9)	193 (82.1)			31 (13.2)	204 (86.8)		
Hemoglobin Level	<12	29 (17.6)	136 (82.4)	0.7 (0.37–1.43)	0.353	26 (15.9)	138 (84.1)	1.4 (0.62–3.16)	0.413
	⩾12	17 (22.7)	58 (77.3)			9 (11,8)	67 (88.2)		
Peripheral Infestation	Negative	34 (16,4)	173 (83.6)	0.34 (0.15–0.76)	0.007	32 (14.3)	192 (85.7)	0.72 (0.19–2.67)	0.711
	Positive	12 (36.4)	21 (72.7)			3 (18.7)	13 (81.3)		
Placental Infestation	Negative	36 (17)	176 (83)	0.37 (0.16–0.86)	0.018	32 (14.2)	194 (85.8)	0.60 (0.16–2.28)	0.437
	Positive	10 (35.7)	18 (64.3)			3 (21.4)	11 (78.6)		
Cord Infestation	Negative	41 (18.6)	179 (81.6)	0.69 (0.24–1.2)	0.552	32 (13.6)	203 (86.4)	0.105 (0.01–0.65)	0.023
	Positive	5 (25)	15 (75)			3 (60)	2 (40)		

Table 4: Factors associated with placental infestation.

Variables		Year 2021				Year 2024			
		Placental Infestation n (%)		0R (IC)	*p*	Placental Infestation n (%)		0R (CI)	*p*
		Positive	Negative			Positive	Negative		
Age (years)	⩽26	19 (12.7)	131 (87.3)	0.8 (0.33–1.77)	0.533	12 (8.7)	126 (91.3)	0.21 (0.046–0.96)	0.028
	>26	9 (10)	81 (90)			2 (2)	100 (98)		
Occupation	Homemakers	16 (13.7)	101 (86.3)	0.7 (0.3–1.51)	0.344	5 (5.9)	80 (94.1)	0.99 (0.32–3.04)	0.594
	Other professions	12 (9.8)	111 (90.2)			9 (5.8)	146 (94.2)		
Marital Status	Single	4 (16.6)	20 (83.4)	0.6 (0.2–1.98)	0.409	5 (12.8)	36 (87.8)	0.34 (0.11–1.08)	0.069
	Lives with a partner	24 (11.1)	192 (88.9)			9 (4.5)	190 (95.5)		
Education Level	No education	21 (14.1)	128 (85.9)	0.5 (0.2–1.24)	0.134	7 (5)	130 (95)	1.35 (0.46–3.99)	0.389
	Educated	7 (7.7)	84 (92.3)			7 (6.8)	96 (93.2)		
Place of Residence	Urban	13 (20)	52 (80)	0.37 (0.17–0.84)	0.014	11 (5.4)	194 (94.6)	0.6 (0.16–2.28)	0.334
	Rural	15 (8.5)	160 (91.5)			3 (8.6)	32 (91.4)		
Distance Between Residence and Health Center	⩽5 km	18 (9.2)	178 (90.8)	2.9 (1.24–6.84)	0.011	7 (4.2)	158 (95.8)	2.32 (0.78–6.88)	0.106
	>5 km	10 (22.7)	34 (77.3)			7 (9.3)	68 (90.7)		
Use of Insecticide-Treated Nets (ITNs)	Yes	12 (12.5)	84 (87.5)	1.45 (0.86–2.46)	0.743	7 (6.8)	96 (93.2)	1.35 (0.8–6.88)	0.389
	No	16 (11.1)	128 (88.9)			7 (5.1)	130 (94.9)		
Intermittent Preventive Treatment (IPTp-SP) Uptake	<3	15 (15.5)	82 (84.5)	0.55 (0.25–1.21)	0.131	6 (6.8)	85 (90.4)	0.8 (0.27–2.4)	0.695
	⩾3	13 (9.1)	130 (90.9)			8 (5.4)	141 (94.6)		
Gravidity	Primigravida	14 (17.3)	67 (84.3)	0.462 (0.21–1.02)	0.053	9 (13.6)	57 (86.4)	0.19 (0.6–0.58)	0.003
	Multigravida	14 (8.8)	145 (92.2)			5 (2.9)	169 (97.1)		
Parity	<2	22 (15.7)	118 (84.28)	0.342 (0.133–0.879)	0.021	7 (7.3)	89 (92.7)	0.65 (0.22–1.91)	0.431
	⩾2	6 (6)	94 (94)			7 (4.9)	137 (95.1)		

Table 4: *Cont.*

Variables		Year 2021				Year 2024			
		Placental Infestation n (%)		0R (IC)	*p*	Placental Infestation n (%)		0R (CI)	*p*
		Positive	Negative			Positive	Negative		
Gestational Age at First Antenatal Care (ANC) Visit	<4	5 (4.8)	99 (95.2)	6.07 (3.05–12.08)	0.0001	5 (4.8)	99 (95.2)	1.4 (0.46–4.32)	0.553
	⩾4	9 (6.6)	127 (93.4)			9 (6.6)	127 (93.4)		
Infestation Cordon	Positive	15 (75)	5 (25)	47.7 (15–151.9)	0.0001	4 (80)	1 (20)	90 (9.2–880.8)	0.0001
	Negative	13 (5.9)	207 (94.1)			10 (4.3)	225 (95.7)		
Peripheral Infestation	Positive	23 (69.7)	10 (30.3)	92.9 (29.2–295.5)	0.0001	13 (81.3)	3 (18.7)	966 (93–9944)	0.0001
	Negative	5 (2.4)	202 (97.6)			1 (44.5)	223 (99.5)		

4. Discussion

Studies evaluating the effectiveness of Intermittent Preventive Treatment with Sulfadoxine–Pyrimethamine (SP) have been conducted in Côte d'Ivoire since 2016 by the National Malaria Control Program (NMCP) [2,10]. However, limited data are available on the effectiveness of this strategy in Bouna. In fact, Bouna was designated as a sentinel site by the NMCP in 2017 to monitor the effectiveness of antimalarials. The first study on evaluating the effectiveness of Intermittent Preventive Treatment in pregnant women (IPTp-SP) started in 2021, followed by another in 2024. These studies not only verify whether the goals set by the NMCP are being achieved but also help to identify factors that could undermine the effectiveness of this control strategy, enabling corrective action.

In this study, adherence to the third dose of SP (SP3) increased from 59.6% in 2021 to 62.1% in 2024. These SP3 adherence rates are higher than those found by several authors in West Africa [10,13] and elsewhere [14]. However, other authors have reported higher rates than ours [15,16]. The low adherence rate in our series was associated with several factors including occupation, parity, antenatal care visits, age, education level, and use of insecticide-treated mosquito nets (ITNs), depending on the study year. Work constraints, low education levels, limited access to antenatal care, and a sense of security due to ITN use often lead women to underestimate the importance of IPTp-SP. Multiparous women or very young women may perceive a lower risk. This observation shows the interconnection of these factors. Therefore, a multifactorial approach is essential to improve adherence to IPTp-SP among pregnant women. These factors have also been observed by other authors [17,18]. Enhanced community awareness, increased accessibility to healthcare, and targeted training on malaria during pregnancy could help overcome these barriers.

It was observed that regardless of the study year, antenatal care (ANC) was associated with SP intake. In fact, ANC is a key opportunity for healthcare providers to assess a woman's health status and the progress of her pregnancy. According to the WHO, a pregnant woman is considered to have had good ANC coverage if she has attended at least four visits [19]. The ANC coverage rate increased by 30% in 2024 according to this study. This increase reflects the effectiveness of the awareness campaigns conducted by the Ministry of Health, Public Hygiene, and Universal Health Coverage (MSHP-CMU) in raising awareness of the importance of ANC. Good ANC coverage can increase SP coverage. The link found in our study between the number of ANC visits and SP coverage over the two study years can be explained by the fact that for several years, SP has been administered to pregnant women at health centers through the DOT (Directly Observed Treatment) strategy during their ANC visits. These results suggest that, in addition to ANC, other opportunities to administer SP to women, such as involving community health workers, could further increase coverage and adherence to the Intermittent Preventive Treatment (IPTp-SP). However, this strategy could reduce the number of pregnant women visiting health centers. Moreover, raising community awareness about the risks of gestational and congenital malaria and involving and strengthening communication for behavior change among both populations and healthcare workers are essential strategies. Combating malaria in pregnant women is a strategy that will also help increase coverage of SP3 and other malaria control methods. Additionally, training healthcare workers [20] on malaria should be considered. Despite the numerous free campaigns distributing long-lasting insecticidal nets (LLINs), the usage rate of LLINs remains low in Bouna (60% in 2021 and 42.9% in 2023) compared to the NMCP's target. These results highlight the need for the NMCP to strengthen awareness campaigns on the use of LLINs.

The majority of parturients in our study presented with anemia. This result was also observed by Tall et al. in 2023 [21,22]. Several factors could contribute to this, including malaria infection and, notably, pregnancy itself, which is the leading cause of anemia in pregnant women. Pregnant women are particularly vulnerable to malaria, thus requiring protective measures. Since 2008, Côte d'Ivoire has adopted Intermittent Preventive Treatment with Sulfadoxine–Pyrimethamine (IPTp-SP) to protect the mother–child couple from the detrimental effects of malaria. The effectiveness of this strategy is threatened by the spread of SP resistance in Plasmodium falciparum. High prevalence rates of mutations in the resistance genes Pfdhfr and Pfdhps to SP have been reported in Côte d'Ivoire by several authors [23–27]. In this series, it was observed that venous, placental, and cord infestations were less prevalent among women who had taken at least three doses of SP. This finding has also been observed by other authors in Côte d'Ivoire and elsewhere [2,10]. Despite

mutations in the Pfdhfr and Pfdhps resistance genes, SP remains effective and can still be used to prevent malaria in pregnant women in Côte d'Ivoire. However, regular monitoring must be conducted to inform timely decision-making. Women, especially those who are illiterate and multiparous, must be made aware of the benefits of using SP and long-lasting insecticidal nets (LLINs) during pregnancy. In this study, a low SP coverage rate was observed among illiterate and multiparous women. Although multiparous women naturally acquire resistance to *Plasmodium falciparum* during successive pregnancies by producing antibodies against parasitized red blood cells that bind to chondroitin sulfate A in the placenta [28], they must continue to adhere to malaria-preventive measures. In fact, parasite sequestration depends on the level of premunity, which in turn depends on the intensity of transmission [29].

In this study, a reduction in *Plasmodium* infection was observed at the venous, placental, and cord levels from 2021 to 2024. This further supports the effectiveness of IPTp-SP when properly administered. Additionally, the study revealed that with three or more doses of IPTp-SP, there was a significant reduction in low birth weight ($p = 0.03$). This finding has been corroborated by several other authors [2,10,18]. The study showed that the majority of women whose newborns had a birth weight below 2500g were the most infested. A statistically significant link was observed between placental ($p = 0.018$) and venous ($p = 0.007$) *Plasmodium* infection and birth weight in 2021. This link was not observed in 2024, likely due to the lower rate of placental and peripheral infestations. Placental malaria is responsible for maternal anemia, low birth weight, preterm birth, or in utero death. To prevent this, it is essential to implement preventive measures such as IPT-SP and long-lasting insecticidal nets (LLINs). Other factors such as parity, gravidity, IPT-SP administration, presence of anomalies, and prenatal care were significantly associated with low birth weight.

This study evaluated the effectiveness of IPTp-SP and compared adherence over two years to assess its evolution and the impact of public health interventions. However, it can have certain limitations, particularly from confounding factors.

5. Conclusion

The results of this study show that despite high levels of SP resistance markers, IPTp-SP remains effective and can therefore be maintained. However, regular monitoring of its effectiveness and the search for new strategies to combat malaria during pregnancy are recommended. It would also be valuable to extend this study to multiple sites and investigate markers of resistance to Sulfadoxine–Pyrimethamine.

Author Contributions: A.V.B.-T. drafted the manuscript and contributed to data collection. H.E.M., W.Y. and A.K.-T. contributed to the study protocol design and validation. A.K.-T., A.H.V.-B., A.J.S.M., E.G.M.K., F.K.K., P.M.C.K.-B., E.K.A., V.D., H.E.M. and W.Y. participated in the critical review and revision of the manuscript. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by the Global Fund through the National Malaria Control Programme (NMCP) of Côte d'Ivoire. The funding did not cover the publication costs of this article.

Acknowledgments: The authors express their gratitude to the Global Fund and the National Malaria Control Program (PNLP), as well as to the healthcare staff at Maternity in Bouna. Special thanks are extended to the pregnant women who willingly participated in the study.

Conflicts of Interest: The authors declare no conflicts of interest.

References

1. World Malaria Report 2024. Available online: https://www.who.int/fr/teams/global-malaria-programme/reports/world-malaria-report-2024 (accessed on 2 January 2025).
2. Bedia-Tanoh, A.V.; Konaté, A.; Gnagne, A.P.; Miezan, A.J.S.; Kiki-Barro, P.C.M.; Angora, K.E.; Kassi, K.F.; Vanga-Bosson, A.H.; Djohan, V.; Menan, E.I.H.; et al. Effectiveness of Intermittent Preventive Treatment with Sulfadoxine–Pyrimethamine in Pregnant Women in San Pedro, Côte D'Ivoire. *Pathog. Glob. Health* **2021**, *115*, 325–330. [CrossRef] [PubMed]
3. Kuete, T.; Doualla, R.A.C.A.M.; Mangamba, D.K.; Barla, M.E.; Noukeu, D.; Okalla, C.; Ekobo, A.S. Prevalence, Risk Factors and Treatment Outcomes of Congenital Malaria among Neonates Hospitalized in Hospitals of Douala, Cameroon. *Am. J. Epidemiol. Infect. Dis.* **2022**, *10*, 79–88. [CrossRef]
4. Tahirou, I.; Zara, M.O.; Moustapha, M.L.; Kamayé, M.; Mahamadou, D.; Ibrahim, A.; Daou, M.; Soumana, A.; Ibrahim, M.L. Congenital Malaria and Its Associated Factors at Issaka Gazobi Maternity of Niamey in Niger. *Int. J. Pediatr.* **2020**, *2020*, 7802560. [CrossRef] [PubMed]
5. Steketee, R.W.; Nahlen, B.L.; Parise, M.E.; Menendez, C. The Burden of Malaria in Pregnancy in Malaria-Endemic Areas. *Am. J. Trop. Med. Hyg.* **2001**, *64*, 28–35. [CrossRef] [PubMed]
6. Guyatt, H.L.; Snow, R.W. Impact of Malaria during Pregnancy on Low Birth Weight in Sub-Saharan Africa. *Clin. Microbiol. Rev.* **2004**, *17*, 760–769. [CrossRef] [PubMed]
7. Guyatt, H.L.; Snow, R.W. The Epidemiology and Burden of Plasmodium Falciparum-Related Anemia among Pregnant Women in Sub-Saharan Africa. *Am. J. Trop. Med. Hyg.* **2001**, *64*, 36–44. [CrossRef] [PubMed]
8. Hassimi, M. *Paludisme et Grossesse: En Côte d'Ivoire, un Problème de Santé Publique*. Benbere. Available online: https://benbere.org/ladamour/paludisme-grossesse-cote-divoire-probleme-sante-publique/ (accessed on 16 September 2023).
9. PNLP Cote d'Ivoire. «le Paludisme En Côte d'Ivoire», 2021. 2020. Available online: http://www.pnlpcotedivoire.org/paludisme-en-cote-d-ivoire (accessed on 26 October 2024).
10. Toure, O.A.; Assi, S.B.; Bedia, A.V.; N'Guessan, L.T.; Aba, T.Y.; Zika, K.D.; Konaté, A.; Pulcherie Marie Christiane Kiki-Barro, P.M.C.; Yavo, W.; Adoubryn, K.D.; et al. Coverage and Effectiveness of Intermittent Preventive Treatment of Malaria with Sulfadoxine-Pyrimethamine during Pregnancy in Six Sentinels' Sites of Côte d'ivoire. *JPVB* **2021**, *13*, 102–110.
11. Mosha, D.; Chilongola, J.; Ndeserua, R.; Mwingira, F.; Genton, B. Effectiveness of Intermittent Preventive Treatment with Sulfadoxine-Pyrimethamine during Pregnancy on Placental Malaria, Maternal Anaemia and Birthweight in Areas with High and Low Malaria Transmission Intensity in Tanzania. *Trop. Med. Int. Health* **2014**, *19*, 1048–1056. [CrossRef] [PubMed]
12. WHO. *Welcome to Malaria Surveillance Assessment Toolkit*. Available online: https://malsurtoolkit.who.int/ (accessed on 5 April 2024).
13. Dieng, C.C.; Gonzalez, L.; Pestana, K.; Dhikrullahi, S.B.; Amoah, L.E.; Afrane, Y.A.; Lo, E. Contrasting Asymptomatic and Drug Resistance Gene Prevalence of Plasmodium Falciparum in Ghana: Implications on Seasonal Malaria Chemoprevention. *Genes* **2019**, *10*, 538. [CrossRef] [PubMed]
14. Diengou, N.H.; Cumber, S.N.; Nkfusai, C.N.; Mbinyui, M.S.; Viyoff, V.Z.; Bede, F.; Akwah, L.; Tsoka-Gwegweni, J.M.; Judith, A.-K. Factors Associated with the Uptake of Intermittent Preventive Treatment of Malaria in Pregnancy in the Bamenda Health Districts, Cameroon. *Pan Afr. Med. J.* **2020**, *35*, 42. [CrossRef] [PubMed]
15. Anto, F.; Agongo, I.H.; Asoala, V.; Awini, E.; Oduro, A.R. Intermittent Preventive Treatment of Malaria in Pregnancy: Assessment of the Sulfadoxine-Pyrimethamine Three-Dose Policy on Birth Outcomes in Rural Northern Ghana. *J. Trop. Med.* **2019**, *2019*, 6712685. [CrossRef] [PubMed]
16. Ibrahim, H.; Maya, E.T.; Issah, K.; Apanga, P.A.; Bachan, E.G.; Noora, C.L. Factors Influencing Uptake of Intermittent Preventive Treatment of Malaria in Pregnancy Using Sulphadoxine Pyrimethamine in Sunyani Municipality, Ghana. *Pan Afr. Med. J.* **2017**, *28*, 122. [CrossRef] [PubMed]
17. Tiendrebéogo, J.; Drabo, M.K.; Saizonou, J.; Soglohoun, C.T.; Paraïso, N.M.; Sié, A.; Ouedraogo, L.T.; Makoutodé, M. Facteurs associés à la faible couverture du Traitement Préventif Intermittent chez les femmes enceintes de la zone sanitaire béninoise de Pobè-Adja-Ouèrè-Kétou. *Santé Publique* **2015**, *27*, 99–106. [CrossRef]
18. Bamba, S.; Séré, A.; Nikiéma, R.; Halidou, T.; Thiéba, B.; Dao, B.; Guiguemdé, R.T. Traitement Préventif Intermittent à La Sulfadoxine–Pyriméthamine Du Paludisme Chez Les Femmes Enceintes: Efficacité et Observance Dans Deux Hôpitaux Urbains Du Burkina Faso. *Pan Afr. Med. J.* **2013**, *14*, 105. [CrossRef] [PubMed]
19. N'doli, S.D.E. Analysis of access to prenatal care for pregnant women in a primary health facility: Case of the urban community health facility (fsu.com) in the village of abobo-baoulé (abidjan). *Rev. Espace Territ. Soc. Santé* **2020**, *3*, 67–80.

20. Yavo, J.-C.; Amari, A.S.G.; Assi, S.-B.; Assemian, A.; Kouamé, R.; Balayssac, E.; Kamagaté, M. Evaluation of the Knowledge of Intermittent Preventive Treatment during Pregnancy (IPTp) with Sulfadoxine-Pyrimethamine in Ivory Coast. *Therapies* **2019**, *74*, 487–494. [CrossRef] [PubMed]
21. Gutman, J.; Mwandama, D.; Wiegand, R.E.; Ali, D.; Mathanga, D.P.; Skarbinski, J. Effectiveness of Intermittent Preventive Treatment with Sulfadoxine-Pyrimethamine during Pregnancy on Maternal and Birth Outcomes in Machinga District, Malawi. *J. Infect. Dis.* **2013**, *208*, 907–916. [CrossRef] [PubMed]
22. Tall, M.; Coulibaly, O.; Diarra, S.; dit Baber Kayentao, A.K.; Dembéle, M.; Guindo, M.; Traore, A.; Yattara, O.; Kayentao, K. Efficacité in Vivo de La Sulfadoxine Pyriméthamine Chez Les Femmes Enceintes Infectées Par Plasmodium Falciparum Au Mali. *Health Sci. Dis.* **2023**, *24*, 143–149. [CrossRef]
23. Djaman, A.J. Évaluation de La Chimiorésistance de *Plasmodium Falciparum* à Différents Antipaludiques (Chloroquine, Sulfadoxine-Pyriméthamine, Quinine) et Profil Génétique Des Isolats Correspondants. Ph.D. Thesis, Université de Paris-Val-de-Marne, Créteil, France, 2003. Available online: https://www.theses.fr/2003PA120021 (accessed on 29 September 2023).
24. Djaman, J.; Abouanou, S.; Basco, L.; Koné, M. [Limits of the efficacy of chloroquine and sulfadoxine-pyrimethamine in Northern Abidjan (Cote d'Ivoire): Combined in vivo and in vitro studies]. *Sante* **2004**, *14*, 205–209. [PubMed]
25. Djaman, J.A.; Mazabraud, A.; Basco, L. Sulfadoxine-Pyrimethamine Susceptibilities and Analysis of the Dihydrofolate Reductase and Dihydropteroate Synthase of *Plasmodium Falciparum* Isolates from Côte d'Ivoire. *Ann. Trop. Med. Parasitol.* **2007**, *101*, 103–112. [CrossRef] [PubMed]
26. Djaman, J.A.; Kauffy, P.C.; Yavo, W.; Basco, L.K.; Kone, M. In vivo evaluation of sulfadoxine-pyrimethamine efficacy during uncomplicated falciparum malaria in children of Yopougon (Abidjan, Côte d'Ivoire). *Bull. Exot. Pathol. Soc.* **2004**, *97*, 180–182.
27. Ouattarar, L.; Bla, K.B.; Assi, S.B.; Yavo, W.; Djaman, A.J. PFCRT and DHFR-TS Sequences for Monitoring Drug Resistance in Adzopé Area of Côte d'Ivoire After the Withdrawal of Chloroquine and Pyrimethamine. *Trop. J. Pharm. Res.* **2010**, *9*, 565–572. [CrossRef]
28. Mclean, A.R.D.; Ataide, R.; Simpson, J.A.; Beeson, J.G.; Fowkes, F.J.I. Malaria and Immunity during Pregnancy and Postpartum: A Tale of Two Species. *Parasitology* **2015**, *142*, 999–1015. [CrossRef] [PubMed]
29. Oumarou, Z.M.; Lamine, M.M.; Issaka, T.; Moumouni, K.; Alkassoum, I.; Maman, D.; Doutchi, M.; Alido, S.; Laminou, I.M. Malaria Infection in Pregnant Women in Niamey, Niger. *Pan Afr. Med. J.* **2020**, *37*, 365. [CrossRef] [PubMed]