Delivery of Intermittent Preventive Treatment for Malaria during Pregnancy in Antenatal Care Settings: A Cross-Sectional Study in Senegal

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ABSTRACT

Background: Current evidence shows a significant gap between antenatal care attendance and the uptake of intermittent preventive treatment in pregnancy with sulfadoxine-pyrimethamine (IPTp-SP) in Sub-Saharan Africa countries with moderate to high malaria transmission. This study aims to identify factors affecting the uptake of IPTp-SP at antenatal care visits.

Methods: This is a cross-sectional analysis of Service Provision Assessment data from Senegal in 2014 and 2016. The study sample consists of 1,086 antenatal care visits in 370 health facilities ranging from clinics to hospitals. The outcome is a binary variable indicating the receipt of IPTp-SP during an antenatal care visit. The main explanatory variables are pregnant women's IPTp-SP history and week of pregnancy. Logit regression models are used to investigate whether the dose and timing of IPTp-SP were delivered in accordance with Senegal's national guideline.

Results: Women with no IPTp-SP history have an 84% (95% CI = [82%, 86%]) chance to receive the first IPTp-SP prescription at an antenatal care visit, while women with one dose before have an 87% (95% CI = [82%, 92%]) chance to receive the required second dose. Gestational age further modifies the effect of IPTp-SP history, where the modification effect is positive for women with at most one dose and negative for women with at least two doses. In addition, while only an average of 33% of care providers received malaria IPT training in the past 24 months, a one-percentage-point increase in IPT trained staff is associated with a four-time higher odds ratio of providing IPTp-SP to pregnant women at the antenatal care visit.

Conclusions: The dose and timing of IPTp-SP provided at antenatal care settings in Senegal did not always conform with the national guideline. More training for providers and patient engagement are warranted to improve the uptake of IPTp-SP in antenatal care visits.

Keywords

Intermittent Preventive Treatment, Antenatal Care, Service Readiness, Cross-Sectional Study

Key Questions

What is already known?

- Administrating Intermittent preventive treatment (IPTp) with sulfadoxine-pyrimethamine (SP) since the start of the second trimester is recommended by the WHO and incorporated in national malaria prevention guidelines by many countries.
- Current evidence shows a significant gap between antenatal care attendance and the uptake of IPTp-SP among pregnant women in Senegal.

What are the new findings?

- Contrary to WHO recommendation and the national guideline, we find a significant gap in IPTp coverage in Senegal, where not all pregnant women receive the recommended SP dose at antenatal care visits, despite the fact that most health facilities have the national guideline and SP stock available.
- Providers' training is a significant predictor of IPTp provision at antenatal care visits in Senegal, as a one-percentage-point increase in IPT trained staff is associated with a four-time higher odds ratio of providing IPTp-SP to pregnant women at the antenatal care visit. However, only an average of 33% of care providers received malaria IPT training in the past 24 months.

What do the new findings imply?

- Converting guideline recommendations at the policy level to care delivery in the field is the key to malaria prevention yet remains challenging.
- More training for care providers and patient engagement are warranted to improve the uptake of IPTp-SP in antenatal care visits.

INTRODUCTION

Pregnant women are among the most vulnerable populations to malaria infection. Every year, approximately 25 million pregnant women worldwide are exposed to malaria, of whom 12 million reside in Sub-Saharan Africa (SSA).[1] Malaria infection is life-threatening, accounting for over 10,000 maternal and 200,000 neonatal deaths per year.[1, 2] Other adverse outcomes include increased risks of maternal anemia, prematurity, and low birthweight. It is estimated that malaria infection during pregnancy in the moderate-to-high transmission SSA countries results in 822,000 newborns with low birthweight.[2]

Among the core interventions to prevent and control malaria in pregnancy, intermittent preventive treatment in pregnancy (IPTp) is particularly recommended for pregnant women living in moderate-to-high transmission areas. IPTp with sulfadoxine-pyrimethamine (SP) is found safe in pregnancy and effective in reducing the risk of malaria during pregnancy and associated maternal anemia, placental parasitemia, and incidence of low birthweight.[3-7] It was estimated that, without pregnancy-specific interventions, 9.5 million pregnant women would have been exposed to infection, leading to 750,000 low birthweight deliveries.[8] The World Health Organization (WHO) currently recommends at least three doses of IPTp-SP administrated at antenatal care (ANC) visits.[2] IPTp-SP can be administered as early as possible in the second trimester and at monthly intervals up to the time of delivery.

Despite that 33 moderate-to-high transmission SSA countries have adopted IPTp to reduce the burden of malaria during pregnancy, the gap between IPTp policy target and actual administration remains large. According to the WHO Malaria World Report (2020), 80% of pregnant women report using ANC services at least once; yet, only 62% of pregnant women receive at least one dose of IPTp, far below the recommendation target. If every pregnant woman who reported using ANC services received one dose of IPTp, an additional 56,000 low

birthweights would be averted in these 33 countries. Understanding how IPTp is delivered at reproductive health programs is crucial to closing the gap to IPTp policy target. Especially when countries such as Senegal have developed proper infrastructure for most clinical facilities, had sufficient medicine supply, adopted the WHO recommendation in their national Malaria prevention and treatment guidelines, and had high ANC utilization, it is the care provided by reproductive health services the cornerstone of the IPTp delivery.[9,10] Surprisingly, little empirical work has investigated IPTp delivery in those settings. This work aims to fill in the knowledge gap.

We identify the IPTp-SP provision gaps during ANC visits and investigate the key factors influencing the IPTp-SP provision to pregnant women using the Service Provision Assessment (SPA) data from Senegal, one of the moderate transmission countries in the African regions. The results will allow for a better understanding of how the integration between reproductive health and malaria care can improve IPTp delivery and reduce the risk of malaria in pregnancy.

STUDY SETTING

Senegal has an annual malaria incidence rate of 50.5 cases per 1,000, ranking it the lowest 33 percentile among countries in the African region.[2] Senegal currently focuses on achieving universal coverage of effective malaria interventions, including IPTp, insecticide-treated nets (ITNs), indoor residual spraying (IRS), malaria diagnostic testing, and treatment of all malaria cases with artemisinin-based combination therapies (ACTs).[11] IPTp is one of the country's earliest malaria interventions adopted since 2005.[12] In 2016, about 50% of pregnant women in Senegal received two or more SP doses (IPTp-SP2+), above the 44% average among African countries.[2,13]. However, compared to its 96% ANC utilization rate (2016), Senegal still experiences a substantial gap between ANC service and IPT provision similar to other SSA countries.[14] As Senegal sets a goal to increase the proportion of pregnant women who take

at least three doses of SP (IPTp-SP3+)[1] to at least 80%, understanding how IPTp is provided at ANC visits and the roles that facility-level readiness factors play is important for relevant and timely malaria interventions.[14]

Senegal has a pyramidal health system, with the bottom tier being clinics and health posts attached to the health centers, the middle tier being district health centers and networks, and the top tier being regional hospitals. Clinics, health posts, together with community health workers staffed health huts provide basic services, including the diagnosis and treatment of uncomplicated malaria. They are important contact points for community-based health interventions in rural areas. Health centers are staffed by nurses or midwives and oversee the district's prevention efforts. Hospitals provide specialized care and are set up at the regional, departmental, or communal level. Senegal's health system has a network of regional pharmacies that supply the facilities and care providers of the corresponding regions. These regional pharmacies receive supplies from the national pharmacy. In addition to public sector facilities, there is also an increasing number of private clinics and health posts throughout the country.[15]

METHODS

Study design:

This is a cross-sectional analysis examining data on the provision of IPTp-SP during ANC visits in the 2014 and 2016 Service Provision Assessment (SPA) survey from Senegal.

Data source and study sample:

The Service Provision Assessment (SPA) is a facility-based survey of the overall availability and readiness of different health services in a country, in accordance with USAID and WHO's

[1] In 2012, WHO changed the recommended SP doses from two to three, but Senegal did not complete the new IPTp training on the new recommendation until 2016 [13]. It also did not update the national malaria treatment and prevention guideline based on the new recommendation until 2016 [23].

service readiness indicators.[16] The analysis focuses on the interaction between service providers and pregnant women and how facilities' readiness measures such as providers' training, medicine inventory, availability of treatment guidelines. We combine four datasets generated by the following SPA questionnaires to form an analysis sample: ANC visit protocol observation, antenatal client exiting interview questionnaire, SPA facility questionnaire, and provider questionnaire.

SPA surveys in Senegal are sample surveys of health facilities in all 14 regions, including 50% sampling of hospitals and health centers and 20% sampling of clinics and affiliated health huts.[17] The sampling is representative at the national level by facility type, ownership, and geographic regions. In 2012, Senegal began to conduct SPA surveys on an annual basis. While the facility questionnaire and provider questionnaire are administered every year, ANC observation and client survey are conducted biannually. Hence our analysis is only based on and pool over data in 2014 and 2016. Among all sampled facilities, health huts are the smallest community-based facility units yet comprise the fastest increase since 2012[2]. However, due to their limited capacity and dedicated role in community health, health huts do not collect ANC visits and medicine inventory information. Our analysis thus precludes health huts, which account for about 20% of the sampled facilities.

Our analysis sample consists of 1,076 ANC visits which are convenient samples of all ANC visits in 369 health facilities in survey waves 2014 and 2016. As shown in Appendix A.F1, visits excluded are due to lack of track in pregnancy history and IPTp history (951 visits), unsuccessful merge with facility data (1 visit), incomplete information on pregnant women's demographics (22 visits), and measurement errors (10 visits). Although the sample size

[2] Author's calculation based on 2012-2017 Senegal SPA facility surveys.

decreases from 587 of the 2014 survey to 489 of the 2016 survey, the distributions of urban (vs. rural) and facility types do not significantly differ between survey years.

Measures:

This study examines the extent to which Senegalese care providers practice and interact with pregnant women at ANC visits in accordance with malaria treatment and prevention guidelines. Our key measures are constructed as the following.

Outcome Variable: The outcome variable indicates whether a pregnant woman receives a dose of IPTp-SP at the ANC visit. We construct this binary variable directly from the reported provider-patient interactions from the ANC visit protocol observation survey, the malaria section. Visits where providers "gave malaria prophylaxis medicine (SP) to [the] client during the consultation" or "prescribed malaria prophylaxis medicine (SP) to [the] client to obtain elsewhere" are coded as 1, indicating the pregnant women's recipient of IPTp-SP treatment from the focal ANC, and 0 otherwise.

Explanatory Variables: Our main explanatory variables are pregnant women's IPTp-SP history and week of pregnancy. As documented in WHO recommendation and Senegal's national guidelines, both factors shall precisely predict the likelihood a pregnant woman receives IPT-SP treatment at the ANC visit. According to Senegal national guidelines of 2013 and 2015, "All pregnant women shall receive at least two doses of sulfadoxine-pyrimethamine (SP) after the onset of active fetal movements. […] The first dose should be given from the 16th week of amenorrhea or the perception of active movements of the fetus. The second dose should be given at least one month after the first dose (authors' translation)." In the 2016-2020 National Strategic Plan, the recommended IPTp-SP treatment was updated to at least three doses according to the most recent WHO recommendation.

We obtain the week of pregnancy for each pregnant woman from the client exit interview questionnaire. To construct the IPTp-SP history prior to the focal ANC visits (the ex-post SP history), we first collect each pregnant women's ex-post IPTp-SP history—number of IPTp-SP received *after* the completion of the focal ANC visit—from the client exit interview questionnaire. We then recover each pregnant woman's ex-ante SP history based on the SP prescription of the current visit and whether the provider was observed to update the medical card. Appendix T1 illustrates the reconstruction algorithm. Column (1) categorizes visits that care providers did not prescribe SP or did not update the medical card. For those 355 pregnant women, we consider their ex-ante SP history the same as the ex-post history. Column (2) categorizes visits that care providers prescribed SP and wrote on the medical card. For those pregnant women, their ex-ante SP history is one dose fewer than the ex-post history.

Other Variables: We also explore facility characteristics as plausible explanations of variation in the likelihood that the providers prescribed SP.[18-20] Following Taylor et al., we measure the readiness of malaria services of each facility as additional explanatory variables.[15] For the relevance of IPTp, we construct the following variables: (1) a dummy indicating whether a national guideline for the diagnosis, treatment, and prevention of malaria is physically presented at the facility, (2) a dummy of whether the facility has at least one unit of valid medicine inventory, and (3) the share of care providers on the day of the survey with the training of malaria IPTp.[21] In addition, we control for characteristics of pregnant women, including age, education, a dummy for the first pregnancy, and a dummy for planning delivery at the focal facility. Lastly, we control for regional fixed effects, year fixed effects, and a dummy for the rainy season between June and October.

Analysis:

Using data on ANC visit protocol observations, we examine the likelihood that a pregnant woman is prescribed SP during the ANC visit conditioning on the number of SP dose(s) she has received prior to the focal visit. We first group ANC visits into three groups based on the ex-ante IPTp-SP history: (1) pregnant women who never had any SP dose before (IPTp-SP0), (2) pregnant women who had 1 SP dose before (IPTp-SP1), and (3) pregnant women who had at least 2 SP doses before (IPTp-SP2+). According to Senegal's national malaria treatment and prevention guideline, IPTp-SP0 women ought to receive their first IPTp-SP dose at the ANC visit if they are at least 16th weeks of pregnancy or active movements of the fetus are detected. Hence, we expect the probability of receiving IPTp-SP to be close to 100% for ANC visits after 16-week pregnancy in this category. Similarly, ANC visits of the second category should have a probability of receiving an IPTp-SP prescription near 100% conditioning on the last IPTp-SP dose at least a month earlier. Additional IPTp-SP doses are recommended by the WHO guideline and Senegal's national guideline but are not required[3].[2, 22, 23] Therefore, the probabilities of receiving IPTp-SP treatment or prescription of ANC visits in the third category are not explicitly hypothesized but shed light on the interactions between pregnant women and care providers. For each group, we bin pregnant women by gestational age at every four weeks increment and report the share of receiving an SP prescription with a 95% confidence interval (CI). We pool the two survey years when reporting the summary statistics.

We then use logit regression models to investigate factors that influence the IPTp-SP delivery at ANC visits. We conduct logit regression analyses on two specifications. The first

[3] Current scientific evidence suggests that at least two doses of IPTp-SP are required to achieve optimal benefit in most women. Some studies in HIV-infected pregnant women have demonstrated that monthly dosing of IPT, with most women receiving three to four doses, is necessary to achieve optimal benefit [6, 7].

specification uses the categorical variable of IPTp-SP history as the main explanatory variable, controlling for patient characteristics, facility characteristics, facilities' malaria readiness measures, seasonality, and year and region fixed effects. The second specification adds the interaction between IPTp-SP history and week of pregnancy as additional explanatory variables. The sample is weighted by facility weights provided by the SPA assuming equal individual weights throughout. All analyses are conducted using Stata17.

Patient and public involvement:

No patients were involved in the process of generating the research question, designing the study, and implementing the study. No patients were asked to advise on writing up or interpretation of results. There are no plans to disseminate the findings to study participants or the relevant patient community.

Role of the funding source:

This research is funded by the Major Project of the National Social Science Fund of China (Grant ID: 20&ZD147 & 20VMG027). This funding source had no role during the course of study design, data analysis, finding interpretation, and manuscript writing.

RESULTS

On average, pregnant women in our final sample are 27-year old and 26.7-week pregnant at the time of visit (see Table 1). 76% of them are pregnant for the first time [standard deviation (SD) = 43%]. More than 51% of pregnant women have completed primary school, and 22% have completed secondary school or a higher level of education.

Table 1: Summary Statistics of Pregnant Women

	SP is optional at current visit		Need SP at current visit		Full Sample	
	Mean	SD	Mean	SD	Mean	SD
Age	26.7	6.7	26.8	6.4	26.8	6.5
N. week of pregnancy	35.2	3.6	24.0	8.4	27.3	8.9
1st pregnancy (%)	76.7	42.4	75.9	42.8	76.1	42.7
Ever attended school (%)	48.9	50.0	52.2	50.0	51.2	50.0
Total N. of woman-visit	317		759		1,076	

Notes: Pregnant women sample pools over Senegal SPA facility survey data, antenatal care questionnaires 2014 and 2016. SD stands for standard deviation.

As to the facilities we studied, about 42% of health facilities are located in urban areas (See Table 2). As the top-tier facility in Senegal's healthcare provider pyramid, hospitals comprise about 5% of the entire sample, and more than 96% of hospitals are located in urban areas. Health centers account for another 11% of the sample, with 85% located in the urban area. The remaining facilities (84% of the sample) are clinics, and contrary to the other two facility types, 67% of clinics are located in rural areas. In terms of facility ownership, near 90% of facilities are government-owned. Private not-for-profit (NFP) and private for-profit jointly account for another 10%. About 90% of facilities are equipped with malaria treatment and prevention guidelines. In comparison, only about 64% of facilities have unexpired SP in stock. Lastly, the share of staff trained with malaria IPTp among all facilities averages 33.3%, with a tight standard error of 1%.

Table 2: Summary Statistics of Facilities

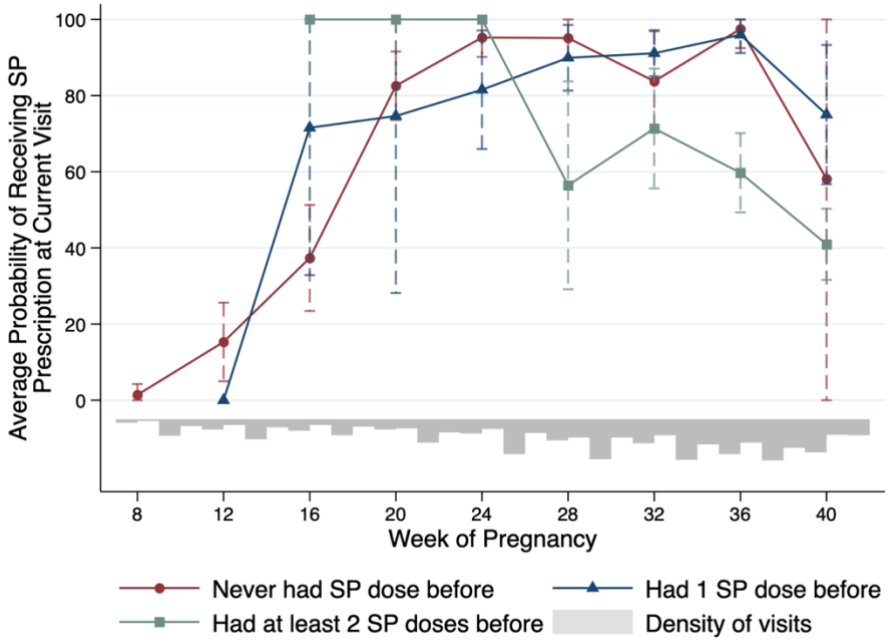
Location	N.	%
Urban	183	49.6
Rural	186	50.4
Facility Type	N.	%
Hospital	43	11.7
Health center	81	22.0
Clinic	245	66.4
Managing Authority (ownership)	N.	%
Government/public	318	86.2
NGO/Private not-for-profit	22	6.0
Private for-profit	22	6.0
Mission/faith-based	7	1.9
Malaria Service Readiness	Mean (%)	SD
Malaria guideline available	92.1	26.9
Valid SP in stock	61.0	48.8
% of staff trained with malaria IPT	31.9	24.5
Total N. of facilities	369	

Notes: Facility sample pools over Senegal SPA facility survey data 2014 and 2016. Three variables of malaria service readiness are calculated by the author using questions from the SPA facility survey and the SPA provider survey. SD stands for standard deviation.

For the conditional probability of IPTp-SP prescription for each ANC visit category along with gestational age, we collapse the ANC visits at the 4-week interval to compute the mean likelihood and 95% CI (see Figure 1). In addition to the color-coded probability curve of each IPTp-SP history category, we plot the distribution density of the unconditional ANC visits along the week of pregnancy at the time of interview. Contrary to what the national guideline requires, we find that pregnant women who previously never received IPTp-SP (red line) were not always been prescribed with SP. Specifically, only 37% (95% CI = [23%, 51%]) of pregnant women of 4-month pregnancy and needed the first IPTp-SP received the prescription. The probability increases to 83% (95% CI = [74%, 92%]) for women of 5-month pregnancy with the same IPTp-SP history, but is still statistically significantly different from 100%. Although women further along in pregnancy had SP prescription probability not statistically different

from 100%, the overall probability curve rejects the hypothesis that the first dose IPTp-SP prescription is accordant to the national malaria treatment and prevention guideline.

Figure 1: Main Result of Mean Probability of Receiving IPTp Prescription at ANC Visits, by IPTp History



Notes: The x-axis is the gestational age measured by month approximated by every 4-week interval. ANC visits in corresponding categories of IPTp history (color-coded) are collapsed at the same time interval to compute the mean probabilities (y-axis) and corresponding 95% confidence intervals. The bottom gray histogram plots the distribution density of the unconditional ANC visits along the week of pregnancy.

The blue line visualizes the probability curve for ANC visits that required the second dose IPTp-SP. Unlike the previous category, women of 4-month pregnancy or longer all have SP prescription probability not statistically different from 100%. However, this result is primarily due to the wide CIs of the sample means. The probability ranges from 71% in the fourth month of pregnancy to 96% in the ninth month.

Lastly, the green line depicts the probability curve for ANC visits that IPTp-SP prescription was optional according to the national guideline. Interestingly, ANC visits in this category have a high chance of receiving SP prescriptions. For instance, women who are 4-6 weeks pregnant in this category all received the optional SP prescriptions. Among all women who already had the required 2 IPTp-SP doses, more than 50% received the SP prescriptions at the ANC visits.

We predict probabilities a pregnant woman receives IPTp-SP prescription using our logit regressions results (see Table 3; logit regression coefficients are reported in Appendix A.T2, predicted probabilities). We use the IPTp-SP history of never having any SP dose before (IPTp-SP0) and its interaction term, when applicable, as the reference group. Without the interaction between IPTp-SP history and the week of pregnancy (specification 1), the probability that IPTp-SP1 women receiving SP prescriptions is not statistically different from IPTp-SP0 women. In comparison, IPTp-SP2+ women whose SP prescription is optional at the time of ANC visits are 0.08-0.50 times as likely to be prescribed with SP. The differences across IPTp-SP types are statistically significant. In specification 2, we add the interaction terms between IPTp-SP types and weeks of pregnancy. At mean gestational age and other covariates, an IPTp-SP0 patient has an 84% chance to receive an SP prescription. The probability is similar for IPTp-SP1 women, but reduces to 70% for IPTp-SP2 women, 61% for IPTp-SP3 women, and 42% for IPTp-SP4 women.

Table 3: Predicted Probability of Receiving IPTp Prescription at ANC Visits, Main Results from Logit Regressions

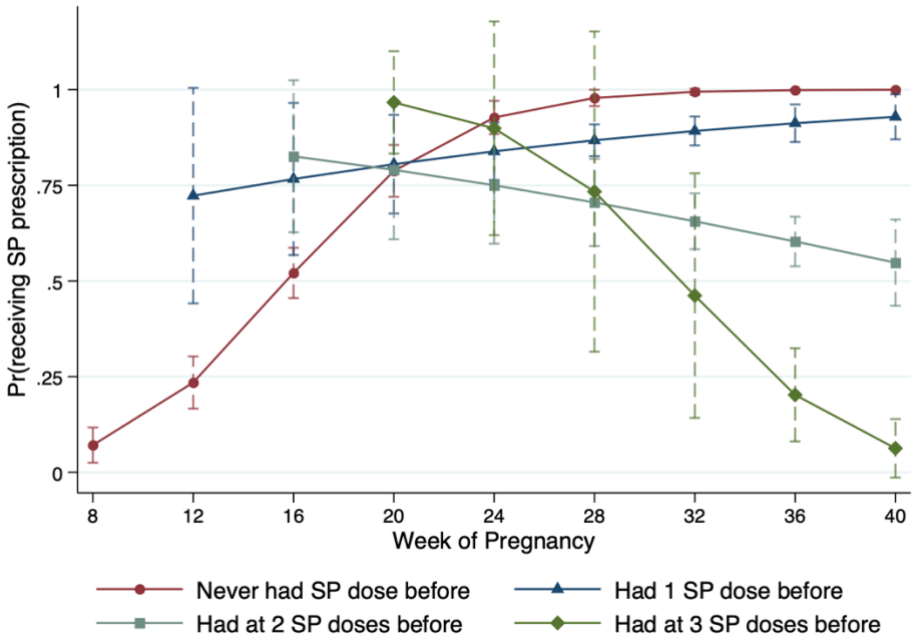
IPTp History	Specification 1 (N = 1,076)														
	IPTp-SP0			**IPTp-SP1**			**IPTp-SP2**			**IPTp-SP3**			**IPTp-SP4**		
	Mean	95% C.I.		Mean	95% C.I.		Mean	95% C.I.		Mean	95% C.I.		Mean	95% C.I.	
Predicted Prob.	0.823	[0.799	0.846]	0.784	[0.736	0.831]	0.391	[0.328	0.454]	0.065	[0.019	0.110]	0.193	[-0.010	0.397]

IPTp History	Specification 2 (N = 1076)														
	IPTp-SP0			**IPTp-SP1**			**IPTp-SP2**			**IPTp-SP3**			**IPTp-SP4**		
	Mean	95% C.I.		Mean	95% C.I.		Mean	95% C.I.		Mean	95% C.I.		Mean	95% C.I.	
Predicted Prob.	0.844	[0.827	0.861]	0.854	[0.792	0.916]	0.699	[0.605	0.793]	0.608	[0.419	0.796]	0.415	[-0.001	0.831]
Wk Pregn.	Mean	95% C.I.		Mean	95% C.I.		Mean	95% C.I.		Mean	95% C.I.		Mean	95% C.I.	
1st mo.	0.017	[-0.001	0.034]	0.623	[0.151	1.094]	0.904	[0.710	1.098]	1.000	[0.999	1.001]	0.991	[0.866	1.117]
2nd mo.	0.071	[0.025	0.117]	0.675	[0.301	1.049]	0.882	[0.679	1.085]	0.999	[0.995	1.004]	0.978	[0.726	1.231]
3rd mo.	0.235	[0.166	0.303]	0.723	[0.441	1.005]	0.856	[0.651	1.061]	0.998	[0.980	1.015]	0.949	[0.491	1.407]
4th mo.	0.521	[0.455	0.587]	0.767	[0.568	0.965]	0.826	[0.627	1.024]	0.990	[0.936	1.044]	0.888	[0.123	1.653]
5th mo.	0.788	[0.720	0.855]	0.805	[0.676	0.934]	0.790	[0.609	0.972]	0.967	[0.833	1.100]	0.772	[-0.281	1.825]
6th mo.	0.927	[0.884	0.971]	0.839	[0.764	0.914]	0.750	[0.597	0.903]	0.899	[0.620	1.178]	0.592	[-0.445	1.629]
7th mo.	0.978	[0.957	1.000]	0.868	[0.826	0.909]	0.705	[0.591	0.819]	0.734	[0.315	1.152]	0.382	[-0.273	1.036]
8th mo.	0.995	[0.987	1.003]	0.892	[0.854	0.930]	0.656	[0.583	0.729]	0.462	[0.142	0.782]	0.201	[-0.040	0.443]
9th mo.	0.999	[0.997	1.001]	0.912	[0.863	0.961]	0.603	[0.538	0.668]	0.202	[0.080	0.324]	0.088	[-0.054	0.231]
10th mo.	1.000	[0.999	1.000]	0.929	[0.870	0.988]	0.548	[0.435	0.661]	0.063	[-0.014	0.139]	0.034	[-0.084	0.151]

Notes: Predicted probability of receiving IPTp prescription uses estimates from the logit regressions (reported in A. Table 2). Confidence intervals are calculated using standard errors adjusted for survey design. Specification 1 regresses the outcome variable on the categorical variable of women's IPTp history and facility characteristics, women's demographics, and other controls (see main text). Specification 2 adds the interactions between the IPTp history and women's gestational age at the visit. CI stands for confidence interval.

To further unpack the relationship between SP prescription, IPTp-SP history, and women's gestational age, Figure 2 presents the marginal mean probability of SP prescription along the week of pregnancy. For illustration simplicity, we use the same color codes as in Figure 1 to distinguish between IPTp-SP types. For IPTp-SP0 (red circle) and IPTp-SP1 (blue triangle) women, the marginal mean probability of SP prescription increases as women are further along in pregnancy. Note that the probability of a 16-week pregnant IPTp-SP0 patient who needs SP prescription the most is only about 52%. This number is not only statistically significantly lower than the national recommendation, but also statistically significantly lower than that of an IPTp-SP1 patient who has a similar or longer pregnant length as well as that of women whose IPTp-SP prescription is optional. For pregnant women whose IPTp-SP treatment is optional (IPTp-SP2+), the marginal mean probability of receiving SP prescription decreases with gestational age.

Figure 2: Predicted Probability of Receiving IPTp Prescription Varies by Gestational Age and IPTp History



Notes: This figure presents the marginal mean probabilities and corresponding confidence intervals of IPTp prescription along the week of pregnancy. The x-axis is the gestational age measured by 4-week intervals. Color coding and line pattens are the same as in Figure 1 for the same category of IPTp history.

Characteristics of pregnant women also have a strong correlation with the probability of receiving IPTp-SP. Older women tend to have a lower probability of receiving IPTp-SP treatment or prescriptions. Women who are pregnant for the first time are more likely to receive SP but only significant at 10% level. Among facility characteristics, we find facility location (rural vs. urban) does not significantly impact IPTp-SP provision. Different types of hospitals also have similar effects, except that providers in private for-profit facilities shrink the likelihood to treat with or prescribe IPTp-SP by a factor of 0.05 compared to providers in other types of facilities[4]. Lastly, a higher share of care providers who ever received IPTp training is positively correlated with the likelihood of IPTp-SP treatment and prescription.

DISCUSSION

Despite the national guideline requiring care providers to prescribe at least two doses of IPTp-SP[5] to pregnant women at scheduled ANC visits, a significant proportion of pregnant women in Senegal did not receive IPTp-SP prescriptions per the guideline. Specifically, IPTp-SP0 pregnant women who are the prime target of IPTp intervention have a chance as low as 52% to receive their first IPTp-SP dose at ANC visits in the 4th month of pregnancy (84% throughout the course of pregnancy). A similar gap also presents among the IPTp-SP1 women, who only have an 85% chance on average to be prescribed the second required SP dose by ANC providers throughout the course of pregnancy.

Notably, this gap could not be explained by the lack of proper infrastructure for malaria services at the facility level. The national guideline of malaria treatment and prevention is available to 92% of facilities (Table 2). There is also evidence suggesting that the national

[4] Odds ratio is calculated using logit regression coefficients.

[5] Because Senegal issued the minimum three doses IPTp-SP guideline and completed the corresponding training in 2016 (see footnote 1), we refer to the earlier IPTp-SP2+ requirement in the discussion, which was in effect during the data collection of our analysis sample (SPA 2014, 2016).

guideline is to some extent binding for care providers. The probabilities of receiving the first two IPTp-SP doses at ANC visits are statistically higher than those of additional doses. The positive modification effect by gestational age among the IPTp-SP0 and IPTp-SP1 women also accredits the achievement of current interventions. Moreover, though only about 61% of facilities have unexpired SP in stock (Table 2), the availability of SP does not significantly predict a woman's chance of receiving an IPT-SP at her ANC visit.

The positive association between a pregnant woman's accumulative IPTp-SP history and her likelihood of receiving an IPTp-SP at an ANC visit during the second trimester highlights the importance of the interaction between care providers and pregnant women in improving IPTp-SP delivery and broadly the prevention of malaria in pregnancy. On average, women who never received IPTp-SP before have a 75% chance of receiving IPTp-SP prescription at their second trimester ANC visits. The probability increases to 80% for IPTp-SP1 women, 78% for IPTp-SP2 women, and 94% for IPTp-SP3 women. Although the SPA surveys do not document the interactions leading to whether or not to provide IPTp-SP, the higher likelihood among pregnant women to whom the IPTp-SP is optional suggests IPTp history-dependent disparity. This disparity might possibly be explained by the characteristics of care providers and pregnant women. For instance, pregnant women who had received IPTp-SP before could be more aware of the risk and the adverse consequence of malaria infection; thus, they could be more likely to be proactive and initiate the conversation regarding IPTp-SP with ANC providers. Conversely, pregnant women who have none or low IPTp-SP history may be less aware of the importance of IPTp-SP and rely on ANC providers to complete the required IPTp-SP doses.

After the IPTp intervention has been adopted in Senegal for near a decade, converting guideline recommendations at the policy level to care delivery in the field remains challenging. These findings raised the question: what steps can further close the gaps to the IPTp policy

targets? As Crawley et al. pointed out, collaboration with reproduction health programs is the key step in implementing malaria prevention policy targeting pregnant women at risk.[24] One area of actionable improvement is malaria IPT training. For each sampled facility, only an average of 32% (SD = 24.5%) of care providers received malaria IPT training in the past 24 months. At the facility level, moving from the bottom quintile in the sharre of IPT trained staffs to the top quantile is associated with a near four-time higher odds ratio[6] (CI = [1.54, 9.8]) of providing IPTp-SP to pregnant women at the ANC visit. Emphasis on malaria IPT training among ANC providers would be an effective step to narrow the gap between IPTp policy-making and care delivery.[25, 26] As Senegal moves from a minimum of two IPTp-SP doses to a three doses requirement, updating training programs and enforcing regular care provision assessment are necessary to ensure a smooth transition to the latest IPTp policy goal as well as future intervention upscaling.[13] While improving training for the provider side is necessary, dissemination of IPTp education among pregnant women such that more women at risk are aware of the IPTp-SP as an integrated part of ANC will help accelerate the improvement of IPTp-SP provision.[27-29]

This study has several limitations. First, our results draw from a cross-sectional analysis using a convenient sample. They are thus prone to non-response bias if pregnant women who participate in the survey differ from those who do not. The results are also prone to recall bias if care providers do not report training history accurately. Moreover, lacking panel data to track individual pregnant women's ANC and IPTp-SP history, we can only draw association, rather than temporal causality, between the likelihood of receiving IPTp-SP at ANC visit and explanatory variables.

[6] Odds ratio is calculated using logit regression coefficients.

Second, we use IPTp-SP treatment or prescription by the care providers to approximate for IPTp-SP administration. This approximation may be problematic if the patient compliance level is low, which would negatively bias our estimations, and is likely to have a differential effect on IPTp history.[30, 31] Thus, our results shall be interpreted as the best-case scenario probabilities. Further research is needed on IPTp compliance and its interaction with IPTp provision.

Third, we recover the IPTp-SP history for each interviewed pregnant woman based on interviewers' observations and records from pregnant women's ANC cards, assuming that the ANC cards were updated timely and accurately. Although we removes observations that appear to contradict the 16 weeks of pregnancy minimum before the first dose and the one-month interval between doses requirements[7], recall bias/measurement error could bias our results away from the null. On the other hand, if those erroneous observations are a truthful reflection of IPTp history, they raise a concern about over-provision. Future IPTp policy shall address this issue to avoid the resulting adverse outcome such as SP resistance.

CONCLUSION

This study shows that the dose and timing of IPTp-SP provided at antenatal care settings in Senegal did not always conform with the national guideline. Specifically, women with no previous IPTp-SP history have a chance significantly lower than 100% to receive the first IPTp-SP prescription at an ANC visit. More research on the interaction between care providers and patients is warranted to further explain this phenomenon. Also, more training for care providers could be integrated into future interventions aiming at improving IPTp-SP uptake.

[7] Our sample excludes 10 pregnant women who received at least 1 dose of IPTp-SP in the first 15 weeks of pregnancy.

LIST OF ABBREVIATIONS

ACTs: artemisinin-based combination therapies

ANC: antenatal care

CI: confidence interval

IPTp: intermittent preventive treatment in pregnancy

IPTp-SP0/IPTp-SP1/IPTp-SP2/IPTp-SP3+: having had zero/one/two/at least three doses of SP

IRS: indoor residual spraying

ITNs: insecticide-treated nets

SD: standard deviation

SP: sulfadoxine-pyrimethamine

SPA: Service Provision Assessment

SSA: Sub-Saharan Africa

WHO: World Health Organization

DATA AVAILABILITY STATEMENT

Data are available in a public, open access repository. Available at https://dhsprogram.com/.

ETHICS STATEMENT

Ethics approval and consent to participate: This is a secondary data analysis using publicly-available, de-identified data which does not constitute research with human subjects.

COMPETING INTERESTS

The authors declare that they have no competing interests.

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APPENDIX

Table A1: Recovery of IPT History

		Recovered N. of IPT Doses Before the Current Visit (ex-ante)			
		(1)		(2)	
ANC card record: observed total IPT doses at the exit interview (ex-post)		Provider did not proscribe SP or update the card (33%)		Provider proscribed SP and wrote on the card (67%)	
IPT dose (e.p.)	%	IPT dose (e.a.)	%	IPT dose (e.a.)	%
0	16%	0	47%	N/A	<1%
1	31%	1	12%	0	41%
2	33%	2	28%	1	35%
3	18%	3	12%	2	21%
4	2%	4	2%	3	2%
Total N. visits		355		721	

Table A2: Logit Regression Results

	Logit, coefficient					
	(1)			(2)		
	Coeff.	95% CI		Coeff.	95% CI	
Main Effects:						
[Reference] 0 dose	-	-	-	-	-	-
1 SP dose	-0.437	[-1.068	0.195]	6.612***	[3.318	9.907]
2 SP doses	-3.435***	[-4.247	-2.622]	9.456***	[5.895	13.017]
3 SP doses	-6.501***	[-7.804	-5.199]	18.166**	[6.729	29.602]
4 SP doses	-4.913***	[-6.918	-2.908]	13.336	[-5.561	32.233]
[Reference] 0 dose X Week of pregnancy				-	-	-
1 SP dose X Week of pregnancy				-0.324***	[-0.457	-0.190]
2 SP doses X Week of pregnancy				-0.472***	[-0.603	-0.340]
3 SP doses X Week of pregnancy				-0.776***	[-1.101	-0.451]
4 SP doses X Week of pregnancy				-0.673**	[-1.242	-0.104]
Patient Characteristics:						
Week of pregnancy	-0.029**	[-0.058	-0.001]	-0.042**	[-0.076	-0.008]
Age	0.198***	[0.157	0.238]	0.398***	[0.302	0.494]
First time pregnancy	0.378	[-0.138	0.894]	0.462	[-0.127	1.051]
Ever attended school	-0.223	[-0.614	0.167]	-0.177	[-0.591	0.238]
Will delivery here	0.202	[-0.249	0.654]	0.455	[-0.046	0.957]
Facility Characteristics:						
[Reference] Urban	-	-	-	-	-	-
Rural	0.624**	[0.025	1.223]	0.374	[-0.260	1.009]
[Reference] Hospital	-	-	-	-	-	-
Health center	0.331	[-0.480	1.141]	0.589	[-0.352	1.531]
Clinic	0.158	[-0.680	0.995]	0.406	[-0.513	1.324]
[Reference] Public	-	-	-	-	-	-
NGO/private not-for-profit	-0.392	[-1.181	0.396]	-0.518	[-1.501	0.465]
Private for-profit	-2.244***	[-3.510	-0.977]	-2.996***	[-4.487	-1.504]
Mission/faith-based	0.141	[-1.525	1.806]	0.034	[-1.166	1.235]
Malaria Readiness:						
Malaria guideline available	0.125	[-0.563	0.814]	0.021	[-0.797	0.838]
SP in stock	0.360	[-0.105	0.825]	0.291	[-0.227	0.809]
Share of staff with IPTp training						
(Reference) 1st quintile	-	-	-	-	-	-
2nd quintile	0.001	[-0.731	0.722]	-0.093	[-0.783	0.598]
3rd quintile	-0.249	[-0.796	0.299]	-0.129	[-0.679	0.421]
4th quintile	0.470	[-0.173	1.112]	0.415	[-0.256	1.085]
5th quintile	1.122**	[0.327	1.918]	1.357***	[0.431	2.282]
Others:						
Rainy season (Jan.-Jun.)	0.275	[-0.249	0.800]	0.483	[-0.058	1.023]
Constant	-3.729***	[-5.270	-2.188]	-7.188***	[-9.318	-5.058]
Year FE		Yes			Yes	
Region FE		Yes			Yes	
Observations		1076			1076	

Figure A1: Data Inclusion Criteria