Asymptomatic malaria and anemia among pregnant women during high and low malaria transmission seasons in Burkina Faso: household-based cross-sectional surveys in Burkina Faso, 2013–2017

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Research

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Abstract

Background: Malaria in endemic countries is often asymptomatic during pregnancy, but it has substantial consequences for both the mother and her unborn baby. In Burkina Faso, the prevalence and risk factors of asymptomatic malaria in pregnancy and its main consequence, anemia, during high and low malaria transmission seasons is underexplored at the household level.

Methods: Data of 1751 pregnant women from October 2013 to March 2014 and 1931 pregnant women from April 2017 to June 2017 were drawn from two cross-sectional household surveys conducted in 24 health districts of Burkina Faso. Pregnant women were tested for malaria in their household after consenting. Asymptomatic carriage was defined as a positive result from malaria rapid diagnostic tests in the absence of malaria symptoms. Anemia was defined as hemoglobin level less than 11 g/dL.

Results: Prevalence of asymptomatic malaria in pregnancy was estimated at 23.9% (95%CI: 20.2–28.0) during the high transmission season (October–November) in 2013. During the low transmission season, it was 12.7% (95%CI: 10.9–14.7) between December and March in 2013–2014 and halved (6.4%; 95%CI: 5.3–7.6) between April and June 2017. Anemia prevalence was estimated at 43.7% (95%CI: 39.3–48.3) during the high transmission season in 2013. During the low transmission season, it was 32.7% (95%CI: 30.1–35.5) between December and March 2013–2014 and 46.6% (95%CI: 44.3–48.9) between April and June, 2017.

Conclusion: Prevalence of asymptomatic malaria in pregnancy was significantly higher during the high malaria transmission season while anemia prevalence was lower. Our study provides an opportunity to assess the prevalence of asymptomatic carriage and one of its main consequences, anemia, among pregnant women at the community level throughout the year. In order to mitigate the harmful effects of asymptomatic carriage for both the mother and fetus, health programs aimed at increasing the number of women coming into contact with health workers are necessary.

Introduction

Every year, about 25% of maternal deaths in hyperendemic malaria regions are due to malaria infection in pregnancy (MiP) [1]. In sub-Saharan African (SSA) countries, MiP is often asymptomatic, which is one of the main challenges in controlling MiP. Indeed, asymptomatic carriage has substantial health consequences for the mother, her unborn baby, and her future newborn. Adverse consequences of MiP for both the mother and her unborn baby include fetal loss, intrauterine growth retardation, preterm delivery, low birth weight, congenital infection, infant mortality, and increased risks of maternal anemia [2–7]. Several studies reported a high prevalence of asymptomatic MiP (ranging from 21–58.4%) in SSA countries [8–12], including Burkina Faso, and this represents a major public health problem since pregnant women living in these communities are not aware they are asymptomatic carriers.

To protect women from asymptomatic MiP and its consequences, the World Health Organization (WHO) recommends combined intervention, including “intermittent preventive treatment during pregnancy” with sulfadoxine–pyrimethamine (IPTp SP) and iron + folic acid supplementation during antenatal care (ANC) [13]. Unfortunately, there is a high prevalence of malarial resistance to SP in most African countries [14, 15]. This situation may leave pregnant women at risk of malaria infection despite the use of IPTp-SP. Even in areas with excellent SP sensitivity, such as in many parts of West Africa, there is still a high prevalnence of placental infections in women receiving less than three doses of SP, particularly during the peak malaria transmission season [16]. Therefore, it is important to diagnosis all MiP cases, at both the health facility and community/household level, to prevent poor pregnancy outcomes.

In Burkina Faso, around three-quarters of the population use self-medication or traditional therapy when signs of malaria are suspected [17]. By implication, around one-quarter of the population attends a clinic when they feel ill or due to scheduled visits (namely ANC), and are treated when there is confirmed malaria. Consequently, asymptomatic MiP cases and anemia remain untreated. The prevalence of asymptomatic MiP among women attending routine ANC was estimated at about 19–51% based on malaria rapid diagnostic tests (RDTs) [18–21], whereas anemia prevalence was estimated at around 60% [20, 21]. To our best knowledge, there is only one community-based study that has estimated the prevalence of MiP [22] at the household level; in this case, conducted in Nanoro and nested within a cluster-randomized controlled trial. In Burkina Faso, the majority of published data on the subject have been obtained in healthcare settings (i.e., in health facilities). It is, therefore, important to have better insight into asymptomatic MiP and its corollary anemia at the community level. This will provide useful indicators to guide decision-making regarding control strategies and to optimize interventions in the context of resource constraints.

In the present study, we estimated the prevalence of asymptomatic carriage of malaria parasites and anemia among pregnant women at home in their community through a household survey during low and high malaria transmission seasons in Burkina Faso. Our study also aimed to identify the potential factors associated with asymptomatic carriage and anemia among pregnant women surveyed at their household.

Material And Methods

Study population, design and Sampling procedures

This study analyzed secondary data collected from 24 health districts located in six regions of Burkina Faso (Boucle de Mouhoun, Center-East, Center-North, Center-West, North, and South-West). The population consisted of pregnant women who were present in the household during the survey visit and who consented to participate in the study. The main project, entitled “Impact Evaluation for Health Performance-Based Financing in Burkina Faso”, was designed to assess the impact of a performance-based financing strategy on the quality of healthcare delivery [23]. The latter aimed to strengthen the public sector and enhance general health, including health indicators, with a particular focus on maternal and child health. This impact assessment was performed through health facility- and household-based surveys and consisted of cross-sectional studies carried out in 2013/2014 (prior to project implementation) and 2017 (after project implementation), in which the health districts were non-randomly selected. The study protocol, including the survey design, are published elsewhere [23]. To provide a snapshot of the prevalence, the timeline of data collection in the field was for a full year of malaria transmission (i.e., for low and high transmission). The first collection was conducted between October 2013 and March 2014, and the second one occurred from April to June 2017.

Data on sociodemographics, health behavior, and economic factors as well as on the health conditions of pregnant women were collected for each household. These data were collected using a computer-assisted personal interview (CAPI) household questionnaire.

From these two cross-sectional household surveys, data on 1751 and 1931 pregnant women were drawn in 2013/2014 (from October 2013 to March 2014) and 2017 (From April to June 2017).

Malaria diagnosis and estimation of hemoglobin

During the household-based survey, blood samples were taken by finger prick to detect the presence of the malaria parasite and to measure hemoglobin levels. In both surveys, malaria was confirmed by serology using RDT SD Bioline, which detects histidine-rich protein II (*HRP-II)*. The hemoglobin level was measured by the hematological acid technique using a hemoglobinometer (HemoCue®), and blood was categorized as anemic if the hemoglobin level was < 11 g/dL and normal if the hemoglobin level was ≥ 11 g/dL [18, 21, 24]. During the field surveys, quality controls were carried out on randomly selected malaria-positive samples (microscopy performed on thick blood smears). Similarly, quality controls were performed on hemoglobin measures using an automated hematology analyzer.

Study variables

Our study assessed two main binary outcomes: asymptomatic carriage of malaria parasites (Yes or No) and anemia (Yes or No).

Our explanatory variables were based mainly on individual- and household-level characteristics. The selection of these explanatory variables was based on epidemiological interest as well as on previous studies that have shown the relationship between potential risk factors and MiP (or anemia) [8, 18–20, 25, 26]. The characteristic explanatory variables for pregnant women were age (< 20, 20–30, and > 30 years old), parity (primigravida, secundigravida, and multigravida (≥ 3)), and gestational age (first trimester (< 14 weeks)), and second or third trimester (≥ 14 weeks)). Other variables included the mother’s education level (no education and educated), ownership of insecticide-treated nets in the household (No and ≥ 1), the household’s standard of living (very poor, poor, moderate rich, rich, and very rich), and place of residence (urban and rural). To analyze malaria transmission among pregnant women, the study period was cut into two seasons: a high transmission season from July to November and a low transmission season from December to June [27].

Statistical analysis

The prevalence of asymptomatic carriage was estimated based on the proportion of pregnant women who tested positive with the malaria RDT. Likewise, the prevalence of anemia was determined as the proportion of pregnant women with a hemoglobin level less than 11 g/dL among those who underwent hematological testing. Descriptive statistics were used to document asymptomatic carriage, anemia, and characteristics of pregnant women. Cross-tabulations were performed separately for each time point of the survey.

For each main outcome (i.e., asymptomatic carriage and anemia), both univariate and multivariable modified Poisson regressions were performed. The selection of variables for multivariable analysis was based on epidemiological interest and based on previous studies that exhibited links between potential risk factors and the study outcomes. Generalized estimating equations (GEEs) were used to estimate unadjusted and adjusted prevalence ratios (Adj. PRs) with 95% confidence intervals (CIs), and two-tailed p values < 0.05 were considered to indicated significance.

All statistical analyses were performed with R statistical software, and regression models were fitted using the “geepack” package.

Results

Population characteristics

A total of 7844 and 8182 households were included for the 2013/2014 and 2017 surveys, respectively. Of the households included in the main study, 21.8% (1709/7844) and 23.4% (1916/8182) had at least one pregnant woman for the 2013/2014 and 2017 surveys, respectively. The sociodemographic characteristics of the pregnant women for each survey are summarized in Table 1. The characteristics of the study population followed the same distribution, with the exception of age, parity, education, and malaria transmission season. In fact, about half of the women were between 20 and 30 years old, and most did not attend a formal school (97.4%). The majority of women lived in rural areas (92.3%) and were multigravidae (66.9%). Additionally, 100% of the women surveyed in 2017 were investigated during the low transmission season (between April and June). Regarding the 2013/2014 survey, 70.2% were investigated during the high transmission season (between October and November), whereas 29.8% were interviewed during the low transmission season (between December and mid-March). More than three-quarters of the women were investigated in the second or third trimester of pregnancy.

Table 1
Sociodemographic characteristics of pregnant women surveyed at the household level in Burkina Faso.

Characteristics	Year		
	2013–2014	2017	p value
Total (number)	1751	1931	
Age, n(%)			**< 0.001**
≥ 30	480 (27.4)	655 (33.9)	
20–30	883 (50.4)	982 (50.9)	
≤ 20	388 (22.2)	294 (15.2)	
Education, n(%)			**< 0.001**
No education	1737 (99.2)	1849 (95.8)	
Educated	14 (0.8)	82 (4.2)	
Household socioeconomic status, n(%)			**0.66**
Poorest	310 (17.7)	349 (18.1)	
Poor	371 (21.2)	374 (19.4)	
Middle quintile	358 (20.4)	388 (20.1)	
Rich	344 (19.6)	400 (20.7)	
Richest	368 (21.0)	420 (21.8)	
Place of residence, n(%)			**0.41**
Rural	1624 (92.7)	1776 (92.0)	
Urban	127 (7.3)	155 (8.0)	
Region, n(%)			**0.74**
Center-North	412 (23.5)	443 (22.9)	
Boucle de Mouhoun	339 (19.4)	356 (18.4)	
Center-East	218 (12.5)	270 (14.0)	
Center-West	292 (16.7)	314 (16.3)	
North	380 (21.7)	416 (21.5)	
South-West	110 (6.3)	132 (6.8)	
Parity, n(%)			**< 0.001**
Multigravida	1067 (60.9)	1396 (72.3)	
Secundigravida	364 (20.8)	325 (16.8)	
Primigravida	320 (18.3)	210 (10.9)	
Trimester of pregnancy, n(%)			**0.81**
Second or third	1336 (76.3)	1481 (76.7)	
First	415 (23.7)	450 (23.3)	
Insecticide-treated nets, n(%)			0.82
At least one	1690 (96.5)	1860 (96.3)	
No insecticide-treated nets	61 (3.5)	71 (3.7)	

Prevalence of asymptomatic carriage of malaria parasites among pregnant women surveyed at the household level

The prevalence of asymptomatic carriage of the malaria parasite was estimated at 15.9% (95%CI: 14.2–17.7) in 2013/2014. After stratification, the prevalence according to season was estimated at 12.7% (95%CI: 10.9–14.7) for the low transmission season and 23.9% (95%CI: 20.2–28.0) for the high transmission season. The sociodemographic characteristics regarding asymptomatic carriage are presented in Tables 2 and 3. Regarding the transmission season, it was noticeable that the prevalence of asymptomatic-carriage was two-fold higher during the high season compared with low season.

Table 2
Risk factors associated with asymptomatic carriage of malaria parasites among pregnant women surveyed at the household level in Burkina Faso in 2013/2014.

Potential factors	N	MiP* cases	Univariate analysis		Multivariate analysis	
			PR (95%CI)	p	Adj. PR (95%CI)	p
Age				**< 0.001**		**< 0.001**
≥ 30	468	59	1		1	
20–30	380	122	1.13 (0.84–1.51)		1.08 (0.80–1.46)	
≤ 20	859	90	1.88 (1.39–2.53)		1.57 (1.03–2.40)	
Trimester of pregnancy				**0.043**		**0.07**
Second or third	1304	194	1		1	
First	404	77	1.7 (1.32–2.20)		1.21 (0.96–1.53)	
Parity				**< 0.001**		**0.62**
Multigravida	1039	138	1		1	
Secundigravida	314	62	1.28 (1.01–1.63)		1.09 (0.78–1.51)	
Primigravida	354	71	1.32 (1.00–1.73)		1.21 (0.83–1.79)	
Insecticide-treated nets				**0.99**		**0.86**
At least one	1650	262	1		1	
No insecticide-treated nets	57	9	0.99 (0.54–1.83)		0.89 (0.48–1.67)	
Education				**0.56**		
No education	1693	268	1		1	**0.56**
Educated	14	3	1.35 (0.49–3.71)		1.13 (0.34–3.78)	
Household socioeconomic				**0.90**		**0.86**
Middle quintile	352	52	1		1	
Poorest	300	51	1.15 (0.81–1.64)		1.10 (0.79–1.54)	
Poor	364	57	1.06 (0.75–1.49)		1.05 (0.74–1.48)	
Rich	338	51	1.02 (0.71–1.45)		1.04 (0.73–1.48)	
Richest	354	60	1.14 (0.81–1.61)		1.16 (0.83–1.63)	
Place of residence				**0.84**		**0.92**
Rural	1586	251	1		1	
Urban	120	20	1.04 (0.69–1.58)		0.97 (0.65–1.43)	
Malaria Season				**< 0.001**		**< 0.001**
Low season	1222	155	1		1	
High season	485	116	1.89 (1.52–2.34)		1.83 (1.47–2.29)	

*MiP: Malaria in pregnancy

Table 3
Risk factors associated with asymptomatic carriage among pregnant women surveyed at the household level in Burkina Faso in 2017.

Potential factors	N	MiP* cases	Univariate analysis		Multivariate analysis	
			PR (95%CI)	p	Adj. PR (95%CI)	p
Age				**< 0.001**		**< 0.001**
≥ 30	623	18	1		1	
20–30	275	41	5.16 (3.02–8.82)		2.73 (1.31–5.71)	
≤ 20	933	58	2.15 (1.28–3.62)		1.74 (1.02–2.96)	
Trimester of pregnancy				**< 0.001**		**< 0.001**
Second or third	1406	74	1		1	
First	425	43	1.92 (1.34–2.75)		2.02 (1.43–2.85)	
Parity				**< 0.001**		**0.037**
Multigravida	1325	55	1		1	
Secundigravida	310	32	2.49 (1.64–3.78)		1.72 (1.03–2.87)	
Primigravida	196	30	3.69 (2.43–5.61)		2.09 (1.10–3.94)	0.08
Insecticidetreated nets				**0.02**		
At least one	1762	108	1		1	
No insecticidetreated nets	69	9	2.13 (1.13–4.02)		1.62 (0.83–3.13)	
Education				**0.58**		**0.86**
No education	1755	111	1		1	
Educated	76	6	1.25 (0.57–2.75)		1.07 (0.5–2.3)	
Household socioeconomic				**0.14**		**0.57**
Middle quintile	360	23	1		1	
Poorest	334	31	1.45 (0.87–2.44)		1.27 (0.76–2.11)	
Poor	363	22	0.95 (0.54–1.67)		0.91 (0.52–1.61)	
Rich	375	17	0.71 (0.39–1.31)		0.79 (0.42–1.48)	
Richest	399	24	0.94 (0.54–1.64)		0.94 (0.55–1.59)	
Place of residence				**0.10**		**0.13**
Rural	1685	103	1		1	
Urban	146	14	1.57 (0.92–2.67)		1.49 (0.97–2.29)	

*MiP: Malaria in pregnancy

Factors associated with asymptomatic carriage among pregnant women surveyed at the household level

The results of multivariate analyses to identify potential factors associated with asymptomatic carriage are summarized in Tables 2 and 3 for 2013/2014 and 2017, respectively. The results show previously identified risk factors for MiP, namely young maternal age, first pregnancy, the first trimester of pregnancy, and the high malaria transmission season. Regarding the transmission season, the prevalence of asymptomatic carriage was 1.83 (95%CI: 1.47–2.29) times higher during the high transmission season compared to that of the low transmission season. During the year 2017, consisting only of women recruited during the low transmission season, the prevalence of asymptomatic carriage halved and was estimated at 6.4% (95%CI: 5.3–7.6). There was no association between asymptomatic carriage of malaria parasites and ownership of insecticide-treated nets, household socioeconomic status, education, nor place of residence.

Prevalence of anemia among pregnant women surveyed at the household level

The results show that about 35.9% (95%CI: 33.6–38.2) of pregnant women had a hemoglobin level less than 11 g/dL in 2013/2014, while the prevalence was 46.6% for 2017. During the low transmission season of 2014 (i.e., December to March), the prevalence of anemia was estimated at 32.7% (95%CI: 30.1–35.5). During the high transmission season of 2013 (i.e., October to November), the prevalence of anemia was 43.7% (95%CI: 39.3–48.3). In general, as shown in Tables 4 and 5, the prevalence of anemia was higher in pregnant women with malaria than in those who had no malaria infection. Likewise, the prevalence of anemia was lower among pregnant women with the richest household socioeconomic status.

Table 4
Potential risk factors of anemia (hemoglobin level < 11 g/dL) among pregnant women surveyed at the household level in Burkina Faso in 2013/2014.

Potential factors	N	Anemia cases	Univariate analysis		Multivariate analysis	
			PR (95%CI)	p	Adj. PR (95%CI)	p
Asymptomatic malaria				**< 0.001**		**< 0.001**
No	1436	479	1		1	
Yes	271	133	1.47 (1.28–1.70)		1.40 (1.22–1.62)	
Age				**0.05**		**0.17**
≥ 30	468	153	1		1	
20–30	859	305	1.09 (0.93–1.27)		1.11 (0.94–1.32)	
≤ 20	380	154	1.24 (1.04–1.48)		1.21 (0.95–1.55)	
Trimester of pregnancy				**0.17**		**0.09**
Second or third	1303	479	1		1	
First	404	133	0.90 (0.77–1.05)		0.87 (0.74–1.01)	
Parity				**0.36**		**0.90**
Multigravida	1039	360	1		1	
Secundigravida	354	130	1.06 (0.9–1.24)		0.97 (0.81–1.17)	
Primigravida	314	122	1.12 (0.95–1.32)		0.95 (0.76–1.18)	
Insecticidetreated nets				**0.46**		**0.46**
At least one	1650	589	1		1	
No insecticidetreated nets	57	23	1.13 (0.82–1.56)		1.07 (0.79–1.45)	
Education				**0.56**		**0.06**
No education	1696	608	1			
Educated	11	4	1.20 (0.65–2.20)		1.07 (0.48–2.36)	
Household socioeconomic				**0.025**		**0.022**
Middle quintile	351	132	1		1	
Poorest	300	101	0.90 (0.73–1.10)		0.88 (0.71–1.10)	
Poor	364	143	1.04 (0.87–1.26)		1.05 (0.87–1.26)	
Rich	338	133	1.05 (0.87–1.26)		1.08 (0.89–1.31)	
Richest	354	103	0.77 (0.63–0.96)		0.80 (0.65–0.99)	
Place of residence				**0.90**		**0.85**
Rural	1586	568	1		1	
Urban	121	44	1.02 (0.79–1.30)		0.99 (0.75–1.31)	
Malaria Season				**< 0.001**		**< 0.001**
Low season	1222	400	1		1	
High season	485	212	1.34 (1.17–1.52)		1.30 (1.13–1.5)	

Table 5
Potential risk factors of anemia (hemoglobin level < 11 g/dL) among pregnant women surveyed at the household level in Burkina Faso in 2017.

Potential factors	N	Anemia cases	Univariate analysis		Multivariate analysis	
			PR (95%CI)	p	Adj. PR (95%CI)	p
Asymptomatic malaria				**< 0.001**		**< 0.001**
No	1714	770	1		1	
Yes	117	83	1.58 (1.39–1.79)		1.63 (1.43–1.86)	
Age				**0.46**		**< 0.001**
≥ 30	623	290	1		1	
20–30	933	426	0.98 (0.88–1.09)		0.96 (0.86–1.08)	
≤ 20	275	137	1.07 (0.93–1.24)		0.91 (0.74–1.11)	
Trimester of pregnancy				**< 0.001**		**< 0.001**
Second or third	1406	707	1		1	
First	425	146	0.68 (0.59–0.79)		0.66 (0.57–0.76)	
Parity				**0.09**		**0.32**
Multigravida	1325	608	1		1	
Secundigravida	310	140	0.98 (0.86–1.13)		0.97 (0.83–1.13)	
Primigravida	196	105	1.17 (1.01–1.35)		1.16 (0.95–1.41)	
Insecticidetreated nets				**0.32**		**0.46**
At least one	1762	817	1		1	
No insecticidetreated nets	69	36	1.13 (0.89–1.42)		1.02 (0.80–1.32)	
Education				**0.75**		**0.59**
No education	1755	819	1			
Educated	76	34	0.96 (0.74–1.24)		0.94 (0.74–1.20)	
Household socioeconomic				**0.003**		**0.006**
Middle quintile	360	161	1		1	
Poorest	334	182	1.22 (1.05–1.42)		1.20 (1.03–1.39)	
Poor	363	169	1.04 (0.89–1.22)		1.07 (0.91–1.25)	
Rich	375	180	1.07 (0.92–1.25)		1.08 (0.93–1.25)	
Richest	399	161	0.90 (0.76–1.06)		0.91 (0.77–1.08)	
Place of residence				**0.50**		**0.42**
Rural	1685	789	1		1	
Urban	146	64	0.94 (0.77–1.13)		0.92 (0.72–1.17)	

Risk factors associated with anemia among pregnant women surveyed at the household level

After adjustment, we observed a lower prevalence of anemia among women in the first trimester of pregnancy, which was more noticeable for the year 2017 (Table 5). Compared with non-infected pregnant women, asymptomatic carriage was associated with a higher prevalence of anemia (1.63; 95%CI: 1.43–1.86). Our results indicated that lower (poorest) socioeconomic status (Adj. PR: 1.20; 95%CI: 1.03–1.39) and high transmission season (Adj. PR: 1.30; 95%CI: 1.13–1.5) were significantly associated with anemia. The prevalence of anemia did not differ according to parity, ownership of insecticide-treated nets, education, nor place of residence.

Discussion

The presence of malaria and anemia in pregnancy, regardless of the gestational stage, are potentially harmful to both the fetus and mother as well as to the family and community [2–7, 28, 29]. Our study provides insights into the extent of asymptomatic MiP and its corollary, anemia, at the community level (i.e., pregnant women surveyed in their own family home) throughout different malaria transmission periods of the year.

Our study findings show that the prevalence of asymptomatic MIP and anemia at the household level was high. This prevalence increased significantly during the high transmission season. In addition, our study shows that asymptomatic MiP was strongly associated with maternal anemia, and the risk of MiP was significantly higher among young women, first pregnancy, and during the first trimester of pregnancy.

The prevalence of asymptomatic carriage found in our household-based study was lower compared with the estimated prevalence reported in previous studies, where it was reported to range from 19–51%, among pregnant women attending health facilities as part of their ANC in Burkina Faso [18–21]. However, the overall aggregate prevalence of asymptomatic MiP (11.0%) reported in our study corroborates the results (12.2%) from the COSMIC household-based survey conducted in Burkina Faso between March 2014 and January 2016 [22, 30]. In addition, the prevalence of asymptomatic malaria at the community level during the low transmission season was slightly lower in our study compared to the prevalence of 9.1% reported from a community-based study conducted in Ethiopia during the minor ("low") malaria transmission season [31]. Therefore, our results underline the need for maintaining effective prevention measures throughout the entire course of pregnancy. These results showed that pregnant women living in Burkina Faso (or other SSA countries) are consistently exposed to malaria risk and its harmful consequences at any time of the year. However, the highest risk of asymptomatic carriage in our study occurred among younger women (primi- or secundigravida), in the second trimester, and during the high malaria transmission season. These risk factors have been documented in other previous studies [8, 18–20, 25, 26, 32–34]. Thus, it is crucial to explore supplementary measures that could increase the chance of accurately detecting and treating MiP by taking into account these risk factors. From this perspective and according to the WHO recommendations [35], several countries, including Burkina Faso, have set up strategies involving community-based health workers (CHWs) whose tasks include community-based sensitization activities, conducting malaria home diagnoses by RDT, and treatment of uncomplicated malaria within their respective communities [22, 36].

Our study showed a high prevalence of anemia among pregnant Burkinabe women living in their communities, though this prevalence was lower compared with the prevalence among pregnant women attending health facilities as part of their ANC [20, 21]. Although the literature states that nutritional deficiencies, particularly of iron and folic acid, are associated with anemia, the highest proportion of pregnant women with anemia in our study were mainly in the second trimester of pregnancy (Adj. PR: 1.52; 95%CI: 1.31–1.76) and during the high transmission season. The difference in prevalence of anemia observed during the transmission season (especially between 2013/2014 and 2017) could be explained by the food shortage period in Burkina Faso in 2017. In addition, in our context, malaria (sequestration of parasitized red blood cells in the placenta), second trimester of pregnancy, and the high malaria transmission season may not be the only causes of anemia in pregnant women. Indeed, the causes of anemia during pregnancy in developing countries are multifactorial and may be a result of other co-morbidities (worm infestation), complication events (placenta previa, placental abruption, etc.), chronic diseases (HIV, sickle cell disease, and TB), or nutritional deficiency (inadequate intake of iron and folic acid and/or inadequate iron + folic acid supplementation) [37–43]. Appropriate community-based strategies to prevent anemia in pregnancy can help to significantly reduce the occurrence of maternal anemia and, thereby, avoid progression to fatal outcomes. In this respect, the capacity of CHWs should be strengthened to allow them to carry out targeted sensitization of the risk factors leading to anemia, ensure effective adherence to preventive measures among the community, detect clinical signs of anemia (pallor, fatigue, bleeding, etc.), and direct people to a health center for appropriate clinical management (such as administering of a double dose of iron) [44].

Although our findings provide an overview of the extent of asymptomatic malaria and anemia in pregnant women at the community level, both during the high and the low transmission seasons in Burkina Faso, some potential limitations need to be considered. First, we defined asymptomatic carriage of malaria parasites using a malaria RDT, which could lead to underestimation (due to false negatives) or overestimation (false positives) of the true prevalence. False negatives from the malaria RDT may be due to the detection threshold of the test (around 200 parasites/μL) [45]. Regarding the false negative results, some studies found that more than half of all false negatives were in cases of parasitemia in which the detected antigen was under the detection threshold (i.e., lower density). False positives could be due to prolonged antigen circulation following clearance of malaria parasites. Indeed, it was shown that *HRP2* antigens can persist in the bloodstream of pregnant women for up to four weeks after successful treatment [46]. However, in high-transmission areas such as Burkina Faso, *HRP2* RDT could be a useful tool for malaria diagnosis, since previous studies found its performance was better than that of microscopy when used in pregnant women [47]. Second, the cross-sectional study design did not allow us to determine cause and effect. Third, the two survey periods (not overlapping) did not allow us to compare outcomes over time, although this was not in the scope of this study.

Conclusion

Our study assessed the prevalence of asymptomatic carriage of malaria parasites and one of its main consequences, anemia, among pregnant women at the community level throughout different malaria transmission periods of the year. Despite the uptake of IPTp-SP and iron + folic acid to prevent MiP and anemia, our study showed a high prevalence of both asymptomatic malaria and anemia during pregnancy, and it indicated the risks increased dramatically during the high transmission season. Thus, infected anemic (or non-anemic) women, apart from consequences to their unborn babies (being considered as reservoirs of parasites that may promote mother-to-child transmission), represent an important parasite reservoir contributing to the cycle of malaria transmission in the community. In order to mitigate the harmful effects of asymptomatic carriage and anemia for both the mother and her fetus, health programs aimed at increasing the number of pregnant women coming into contact with health workers should be at least maintained or strengthened. This could be implemented by strengthening the activities of community-based health workers (regular screening for malaria and anemia in villages and households) in order to reduce the progression of asymptomatic cases to clinical, or even severe, cases before pregnant women can reach the health centers for ANC.

List Of Abbreviations

Adj. : Adjusted

ANC : Antenatal care

CAPI : Computer-assisted personal interview

CHW : Community-based health workers

CI : Confidence intervals

GEE : Generalized estimating equations

HIV : Human immunodeficiency viruses

HRPII : Histidine-rich protein II

IPTp : Intermittent preventive treatment during pregnancy

MiP : Malaria infection in pregnancy

PR : Prevalence ratios

RDT : Rapid diagnostic tests

SP : Sulfadoxine–pyrimethamine

SSA : sub-Saharan African

TB : Tuberculosis

WHO : World Health Organization

Declarations

Ethics approval and consent to participate

The main research protocol from which the present study extracted the data was approved by the National Ethics Committee for Health Research of the Burkina Faso Ministry of Health. Authorization to work in the selected health regions was obtained from the Burkina Faso Ministry of Health. Informed consent was obtained from the participants or guardians before performing RDT and hemoglobin tests

Consent for publication

Not applicable.

Availability of data and material

The dataset containing individual and household level records is available at the Centre MURAZ in Burkina Faso.

Competing interests

The authors declare that they have no competing interests.

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Authors' contribution

SS and FKS designed the study protocol. RT performed the statistical analysis and draft the manuscript. HH performed coordination of field activities and supervised data collection. TR, SS, MO HH, HT, and FKS contributed to the manuscript by making substantial intellectual contributions. All authors read and approved the final manuscript

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