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Malaria and typhoid co-infection: Prevalence, awareness and associated risk factors in patients attending Bafmeng Medicalised Health Centre in Fungom subdivision, North West region, Cameroon

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Malaria and typhoid coexists in communities, with varied risk factors. This study aimed to analyse the situation of malaria/typhoid co-infection in Bafmeng, Cameroon. 367 participants, were given questionnaires, and venous blood collected from January To March 2021 for *Plasmodium* screening and Widal test. The malaria prevalence was 27.5% (101/367) and 32.7% (120/367) for typhoid. Malaria prevalence in males 33.9% (43/127) was higher (*p*<0.0480) than in females 24.2% (58/240). The ≤5 years old had the highest malaria prevalence of 51.3% (*p*≤0.005). Out of the 101 participants infected with *Plasmodium* spp., 37.6% (38/101) were co-infected. Co-infection was high in males (18/43) than in females (20/58). The 25 to 44 years old had the highest co-infection prevalence 11.9% (12/101). GMMPD±SD were higher in co-infected patients (3517±139 parasites/µL,) than in those infected with malaria only (2437±142 parasites/µL) (*p*<0.001). More participants were aware of malaria (86.6%) than typhoid (48.0%). Those associated with malaria risk factors were the 15–24 years old (*p*=0.003, *OR*=0.189; *C.I*: 0.062–0.574), and the farmers (*p*=0.025, *OR*=2.76; CI: 1.136–6.704). Malaria/typhoid co-infection is high in Bafmeng, with malaria parasitaemia exacerbated in co-infected patients. Therefore, there is need to step up sensitisation on malaria prevention, GHP to prevent typhoid infections; and provide source for portable water.

Key words: Malaria, typhoid, co-infection, rural area, Bafmeng, North West region, Cameroon

INTRODUCTION

Malaria is one of the most life-threatening diseases and causes serious health problem in the world. Globally an estimated 229 million malaria cases in 2019 in 87 malaria endemic countries, declining from 238 million in 2000. At the Global technical strategy for malaria 2016–2030 (GTS) baseline of 2015, there were 218 million estimated malaria cases (WHO, 2020). Malaria case incidence (that is, cases per 1000 population at risk) reduced from 80 in

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2000 to 58 in 2015 and 57 in 2019, globally. Between 2000 and 2015, global malaria case incidence declined by 27%, and between 2015 and 2019 it declined by less than 2%, indicating a slowing in the rate of decline since 2015 (WHO, 2020). Globally, deaths due to malaria have reduced over the period of 2000 to 2019, from 736 000 in 2000 to 409 000 in 2019 (WHO, 2020). The percentage of total malaria deaths among children aged less than 5 years was 84% in 2000 and 67% in 2019. Globally, the malaria mortality rate (that is deaths per 100 000 population at risk) reduced from about 25 in 2000 to 12 in 2015 and 10 in 2019, with the slowing of the rate of decline in the latter years (WHO, 2020). About 95% of malaria deaths globally were in 31 countries: Nigeria (23%), the Democratic Republic of Congo (11%), the United Republic of Tanzania (5%), Mozambique (4%), Niger (4%) and Burkina Faso (4%) accounted for about 51% of all malaria deaths globally in 2019 (USAID, 2017; WHO, 2020). Malaria deaths in the WHO African Region reduced by 44%, from 680 000 in 2000 to 384 000 in 2019, and the malaria mortality rate reduced by 67% over the same period, from 121 to 40 deaths per 100 000 populations at risk (WHO, 2020). *Plasmodium falciparum* which is predominant in sub-Saharan Africa is still the deadliest species (Gething et al., 2010; WHO, 2020). Malaria interventions by vector control using long-lasting insecticidal nets (LLINs) or indoor residual spraying, chemoprevention and case management including diagnosis and treatment of infections are highly effective although not all can afford chemotherapy. These interventions have led to a significant reduction in malaria prevalence (Nimpaye et al., 2001; Kamgang et al ., 2011; Ndo et al., 2011; WHO, 2017 and WHO, 2020). According to Gangue et al. (2018), education of the population about malaria clinical signs, burden and appropriate prevention and treatment measures should be of high interest to create awareness against wrong beliefs of populations and therefore avoid/limit inappropriate habits in controlling the disease and equally translated into policy to preserve the achievements reached so far in the fight against malaria. Typhoid fever outbreaks can be linked to poor water management. Typhoid fever is a systemic prolonged febrile illness caused by certain *Salmonella* serotypes. However, in sub-Saharan Africa, non-typhoidal *Salmonella* can be invasive and cause paratyphoid fever, which requires immediate treatment with antibiotics. Typhoidal serotypes can only be transferred from human-to-human, and can cause food-borne infection, typhoid fever, and paratyphoid fever (Ryan and Ray, 2004). Typhoid fever is caused by *Salmonella typhi* invading the bloodstream (the typhoidal form), or in addition spreads throughout the body, invades organs, and secretes endotoxins (the septic form). This can lead to life-threatening hypovolemic shock and septic shock. Typhoid fever is common among crowded and impoverished populations with inadequate sanitation and is transmitted through ingestion of water or food that has been contaminated by faeces or less commonly, urine of infected humans. Without effective treatment, typhoid fever has a case fatality rate of 10-30% (Allen and Honest, 2010). Other contributing factors include delay in diagnosis, emergence of antibiotic-resistant strains, problems in the identification and management of carriers and the lack of availability of safe, effective and cheap vaccine.

Malaria and typhoid co-infection studies have already been carried out in many Africa countries, some of which are; including Nigeria (Florence et al., 2003), Richmond et al. (2011), in Ghana, Meseret et al. (2014), in Ethiopia. In Cameroon, it has been reported that, of 200 patients presenting with fever, 17.0% had concurrent malaria and typhoid fever (*Salmonella typhi*) based on bacteriological proven diagnosis and 47.9% based on Widal test. A higher proportion of 32.5% had malaria coexisting with *S. typhimurium* than others strains (Ammah et al., 1999). Malaria is still a major health problem, despite access to all interventions in the reduction of malaria, like improved case management, and scale-up of long-lasting insecticidal nets (LLINs) and indoor residual spraying (IRS) and early diagnosis and treatment and environmental managements (NMCP, 2015; WHO, 2017), little has been done about malaria and typhoid co-infection in rural communities, therefore data were collected so as to analyse the situation of malaria/typhoid co-infection in Bafmeng, a rural village in order to assess the severity of the two infections coexisting in the community. The main source of water for domestic use and drinking particularly during the dry season in Bafmeng is spring and stream which are exposed to human and animal pollutants (faeces, urine etc.), thereby predisposing the community with *Salmonella* bacterium infection. The majority of the native living within the village are uneducated and may not even know what malaria and typhoid fever are all about. No research has been carried out to specifically investigate malaria and typhoid co-infection and the implication(s) of typhoid on malaria severities, hence the objectives of this study were to investigate the prevalence of both diseases and their co-infection, awareness, and associated risks factors in Bafmeng.

MATERIALS AND METHODS

Study area

This study was hospital based and conducted in Bafmeng, in Fungom Subdivision, Menchum Division of the North West (NW) Region of Cameroon.Malaria and typhoid tests were made in Bafmeng Medicalised Hospital. Bafmeng is one of the villages that made up 26 villages in Fungom subdivision. Bafmeng is located on the NW flank of Mount Oku (about 77.2 km from Mount Bamenda and 10.8 km from Lake Nyos). It lies between longitude 10°08’30’’E and 10˚16’30’’E, and latitudes 6°20’08’’N and 6°26’30’’N. It has a population of about 18,738 inhabitants according to government official census in 2005 (BUCREP, 2005), but the population is more than this number as of now. The area is subjected to a Cameroonian type equatorial climate characterized by fairly constant temperatures averaging 23°C ranging between 15 and 32°C, and two seasons: a short dry season (November to mid-March) and a long rainy season which run from mid-March to October (Ndoh-Mbue et al., 2016). The main economic activities here are subsistence farming and "petit" trading.

Ethical considerations

An ethical clearance was obtained from the Ethical Committee of the University of Bamenda lodged in the Faculty of Health Sciences. An authorisation was obtained from the hospital where the research was carried out. Participants were included into the study only following their informed consent attached to the questionnaire. Each participant name was coded numerically and data managed strictly confidentially.

Sample size estimation

The sample size for this study was calculated from the past prevalence (59.22%) of malaria obtained from the hospital (from the period of January to March) at 95% confident level (Z-score = 1.96) and assuming an error margin of 0.05 using the Cochran's formula (Cochran, 1977).

$$n_0 = \frac{Z^2 pq}{e^2}$$

With: p=0.59; q=1-0.59; e=0.05 and Z=1.96. A minimum of 367 samples were collected.

Study design

The study was a cross sectional study, which started from January to March. The methods of investigation included the use of structural questionnaires and laboratory investigations. Blood samples were collected from each participant and later analysed in the laboratory of the Bafmeng Musicalized Health Centre.

Questionnaire survey

Participants, parents or guardians of eligible children or elderly were given structured and pretested questionnaires with closed and opened ended questions. Questions included socio-demographic, environmental, awareness habit, sanitary, etc. information. This was to have information about the population's awareness and associated risk factors of malaria and typhoid. The questionnaire was developed in English language and orally translated into 'pidgin' for participants that could not read. All questionnaire sheets were coded.

Malaria test

Malaria parasite was determined by observing thick blood films stained with Giemsa according to Cheesbrough (2006). Thick blood films were prepared and stained with 10% Giemsa for 20 min. The stained films were observed at oil immersion magnification (×100) objective of light microscope for malaria parasites. The parasite numbers were quantified by counting the numbers of parasites observed against 200 white blood cells (Cheesbough, 2006). The values were used to estimate the number of parasites, assuming a standard white blood cell count of 8,000 cells/mm^3 blood, by using the following formula:

$$\text{Parasite load}\left(\frac{\text{number}}{\mu l}\text{blood}\right) = \frac{\text{Number of Parasites counted}}{200\ \text{cells}/mm^3\ \text{blood}} \times 8{,}000\ \text{cells}/mm^3\ \text{blood}$$

Typhoid test

Typhoid was diagnosed using the Widal test. The test was a rapid slide test to detect the presence of *Salmonella* antibodies in the patient's serum that react with the respective *Salmonella* "O" somatic antigen O and *Salmonella* "H" flagellar antigen H in a suspension to give a visible agglutination (Nicholas et al., 2014).

Data analysis

The data obtained was entered into Microsoft Excel and cleaned. Analyses were made using the Statistical Package for Social Sciences (SPSS) version 23 at the confidence level of 95% (α=0.05). Categorical data was expressed as percentage frequency and compared using the Chi-square (χ^2) test. The non-categorical value was expressed as Mean±SD using Mann-Whitney U Test to compare two variables and Kruskal-Wallis Test to compared more than two variables, respectively within groups. The Tukey Test (Post hoc test) was used to compare variables between groups. Custom tables were made to relate prevalences to significant data obtained from the questionnaire and correlation were made to relate some parameters to others.

RESULTS

Socio-demographic characteristic of the study population

A total of 367 participants' samples were examined (Table 1). Participants were of both sexes, aged one year and above. More females 240 (65.4%) than males participated in the study, the age group 25-44 years were the most represented 116 (31.6%) and among occupations, farming was done by the majority of people 131 (35.7%) (Table 1).

Prevalence of malaria and typhoid based on sex and age

Out of 367 participants examined, the overall prevalence of malaria was 27.5% (101) (Table 2). Males had a malaria prevalence of 33.9% (43), significantly higher than females 24.2% (58) (*p* = 0.0480) (Table 2). There was a significant difference (*p* = 0.005) in *Plasmodium* spp. infection between the age groups.

The age group ≤ 5 years had the highest *Plasmodium* spp. prevalence of 51.3% (20) while the age group 25-44 years recorded the lowest prevalence of 19.9%(23) (Table 2). For typhoid, 32.7% (120) of the participants had typhoid (Table 2). The prevalence of typhoid in males was 36.2% (46) and the one in female was 30.8% (74), but there was no significant difference (*p* = 0.2953) (Table 2). Patients of the age group 45-64 years had the highest prevalence of 49.2% (31) and the least infected

Table 1. Socio-demographic characteristic of the study population.

Parameter	Number examined (%)	Mean ± SD (range)
Total participants	367 (100)	-
Sex		
Males	127 (34.4)	-
Females	240 (65.4)	-
Age group (years)		
≤ 5	39 (10.6)	-
6 – 14	33 (9.0)	
15 - 24	81 (22.1)	-
25 - 44	116 (31.6)	-
45 - 64	63 (17.2)	-
≥ 65	35 (9.2)	-
Mean age ± SD		32 ± 21 (1 – 89)
Occupation		
Non-worker	69 (18.8)	-
Civil servants	6 (1.6)	-
Student	60 (16.3)	-
Apprentice	18 (4.9)	-
Professionals	41 (11.2)	-
Trading	42 (11.4)	-
Farming	131 (35.7)	-

N: number of cases considered. SD: means Standard deviation.
Source: Authors 2023

Table 2. Variation of malaria and typhoid with respect to sex and age.

Overall prevalence	N	Malaria parasites % (n)	Typhi/Paratyphi antigens % (n)
	367	27.5 (101)	32.7 (120)
Sex			
Male	127	33.9 (43)	36.2 (46)
Female	240	24.2 (58)	30.8 (74)
Significance		χ^2=3.9108, *p* =0.0480	χ2=1.0952, *p* =0.2953
Age group (years)			
≤ 5	39	51.3 (20)	17.9 (7)
6 - 14	33	36.4 (12)	33.3 (11)
15 - 24	81	28.4 (23)	25.9 (21)
25 - 44	116	19.9 (23)	40.5 (47)
45 - 64	63	25.4 (16)	49.2 (31)
≥ 65	35	20.0 (7)	8.6 (3)
Significance		χ^2=16.9407, *p* =0.005	χ2=25.8321, *p* =0.0000

N=number examined, n= number of cases.
Source: Authors 2023

were of the age group ≥ 65 years with prevalence of 8.6% (3) and there was a strong significant difference in the infection between different age groups ($p < 0.001$) (Table 2).

Prevalence of malaria and typhoid co-infection in patients

Out of the 101 positive cases of malaria, the overall

Table 3. Variation of malaria and typhoid co-infection with respect to sex, age and occupation.

Parameter		Malaria parasite only %n (N = 101)	Typhoid infection only %n (N = 120)	Malaria and typhoid co-infection %n (N = 101)
Sex	Males	24.8 (25)	23.3 (28)	17.8 (18)
	Females	37.6 (38)	45.0 (54)	19.8 (20)
	Total	62.4(63)	68.3 (82)	37.6 (38)
	$\chi^2(p)$	30.969(0.707)	81.523(0.071)	4.8749(0.1812)
Age (years)	≤ 5	17.8 (18)	4.2 (5)	2.0 (2)
	6 - 14	7.9 (8)	5.8 (7)	4.0 (4)
	15 - 24	11.9 (12)	8.3 (10)	10.9 (11)
	25 - 44	10.9 (11)	29.2 (35)	11.9 (12)
	45 - 64	6.9 (7)	18.3 (22)	8.9 (9)
	≥ 65	6.9 (7)	2.5 (3)	0 (0)
	$\chi^2(p)$	180.56(0.475)	410.00(0.421)	56.01000(0.0000)
Occupation	Non worker	21.8 (22)	10.8 (13)	1.0 (1)
	Civil servant	1.0 (1)	0.8 (1)	0(0)
	Student	15.8 (16)	10.0 (12)	6.9 (7)
	Apprenticeship	3.0 (3)	0.8 (1)	1.0 (1)
	Professional	2.0 (2)	10.8 (13)	4.0 (4)
	Trading	5.9 (6)	6.7 (8)	9.9 (10)
	Farming	12.9 (13)	28.3 (34)	14.9 (15)
	$\chi^2(p)$	190.191(0.897)	89.468(*0.043*)	106.113(0.813)

N: Total cases; n: case considered.
Source: Authors 2023

prevalence of co-infection was 37.6% (38) (Table 3). There were 18 (18/43) males and 20 females (20/58) that were co-infected with an overall prevalence of 17.8 and 19.8%, respectively. There was no significant different in co-infection between males and females (p = 0.1812) (Table 3). There was a significant difference in prevalence of co-infection between age groups ($p <$ 0.001). Patients of the age group 25-44 years had the highest prevalence of co-infection 11.9% (12) while those in the age group ≥ 65 years had zero 0% (0) prevalence of co-infection (Table 3). With respect to occupation, farmers had a co-infection of 14.9% (15/101); traders, 9.9% (10/101); students, 6.9% (7/101) and civil servants, 0% (0/101) prevalence. However, there was no statistically significant difference (p = 0.813) (Table 3).

Malaria parasites densities in patients co-infected with typhoid

The geometric mean parasite density (GMPD) in males that were co-infected with typhoid was significantly higher (3710±149 parasites/µL) than those infected with malaria only (2714±211 parasites/µL) (p = 0.006) (Table 4). Equally females who were co-infected with typhoid had higher malaria parasitaemia (3352±228 parasites/µL) than those who were infected with malaria only (2269±189 parasites/µL) (p = 0.003). Therefore, irrespective of sex, the overall parasitaemia in co-infected patients were higher (3517±139 parasites/µL) than those infected with malaria only (2437±142 parasites/µL) with a significant difference ($p <$ 0.001). There was no statistically significant variation of parasitaemia with age neither within those infected with *Plasmodium* spp. only nor those co-infected (p = 0.930; p = 0.902 respectively) (Table 4).

Awareness of the population about malaria and typhoid and associated risk factors

The overall awareness about malaria and typhoid is shown in table 5. Majority of the study population (86.6%, 318/367) were aware that mosquitoes transmit malaria; 76.8% (282) opened doors and windows at 6am whereas 49.3% (181) closed doors and windows at 6pm; 88.6% (325) of the study population had insecticide treated mosquito nets and 86.4% (317) obtained it; with 69.8% (256) using it in ≤ 3 years. Tears on nets were minimal. Forty eight percent (176) of the study population were aware that typhoid is caused by a bacterium/germ; others 52.3% (192) mentioned consuming dirty water or food

Table 4. Malaria parasite density among malaria patients co-infected with typhoid based on sex and age.

Parameter		Co-infection cases	GMPD ± SEM (Range)		Mann-Whitney U test
			Malaria only	Malaria + Typhoid coinfection	
Sex	Males	18	2714 ± 211(720 - 4360)	3710 ± 149(2360 - 4600)	*p =0.006*
	Females	20	2269 ± 189 (520 - 4440)	3352 ± 228(1320 - 5000)	*p =0.003*
	Total	38	2437 ± 142(520 - 4440)	3517 ± 139(1320 - 5000)	*p =0.000*
	Mann-Whitney U test		*p* =0.181	*p* =0.478	
Age (years)	≤ 5	2	2645 ± 203(1240 - 1241)	3908 ± 640(3320 - 4600)	*p* =0.126
	6 - 14	4	2663 ± 462(715 - 4360)	3105 ± 701(1880 - 5000)	*p* =0.808
	15 - 24	11	2351 ± 351(680 - 4280)	3639 ± 229(1640 - 4360)	*p =0.016*
	25 - 44	12	2343 ± 336(720 - 4120)	3262 ± 297(1320 - 4840)	*p* =0.079
	45 - 64	9	1807 ± 569(520 - 4440)	3853 ± 130(3000 - 4440)	*p =0.042*
	≥ 65	0	2715 ± 466(1240 - 4080)	0	-
	Kruskal Wallis Test		*p* = 0.930	*p* = 0.902	

Source: Authors 2023

Table 5. Some attitude, practices and knowledge about malaria and typhoid.

Parameter		N	Level of awareness [% (n)]
Malaria	Malaria awareness	367	86.6% (318)
	Non-malaria awareness		13.4% (49)
	Open vents at dawn		
	5 AM		18.3% (67)
	6 AM		76.8% (282)
	7 AM		4.9% (18)
	Close house vents at dusk		
	5 PM		6.3% (23)
	6 PM		49.3% (181)
	7 PM		39.0% (143)
	≥ 8 PM		5.2% (19)
	Use of insecticide		4.6% (17)
	Ownership of ITNs		88.6% (325)
	Usage rate of ITNs		86.4% (317)
	Duration of ITNs usage (years)	317	
	≤ 3		69.8% (256)

Table 5. Cont'd

	4 - 7		11.7% (43)
	≥ 8		4.9% (18)
	Tears/mosquito net		
	1-3		3.2% (10)
	4-6		3.5% (11)
	7-9		1.9% (6)
	Total		8.5% (27)
	Typhoid awareness		48.0% (176)
	Non typhoid awareness		60.3% (191)
	Wash hands after toilet		
	Always		52.3% (192)
	Often		31.3% (115)
	Sometimes		16.3% (60)
	Wash hands before eating		
Typhoid	Always	367	85.6% (314)
	Often		10.4% (38)
	Sometimes		4.1% (15)
	Washing of hands with soap		
	Always		4.1% (15)
	Often		54.0% (198)
	Sometimes		38.4% (141)
	Never		3.5% (13)

N= total answers; n= number of cases.
Source: Authors 2023

(Table 5). Participants in the age group 15-24 years were significantly associated with malaria risks factors (*p*=0.003, OR = 0.189; CI: 0.062 – 0.574). This was followed by patients of the age group 25-44 years (*p* =0.018, OR = 0.199; C.I: 0.052 – 0.754) and age group 15-24 years (*p* = 0.024, OR = 0.253; CI: 0.076 – 0.835). Participants aged 6-14 years were slightly associated with malaria (*p* =0.055, *OR*= 0.371; C.I: 0.135 -1.019) (Table 6). There was no risk variation with sex (*p* =0.380, OR = 1.276), presence of bushes around houses (*p* = 0.360, OR =1.421; CI: 0.670 – 3.013) and time to close doors (*p*=0.853, OR = 0.903) while users of ITNs were significantly associated with malaria risks factors (*p* = 0.011, OR = 0.413; CI: 0.210 – 0.814) than non-users (Table 6). Those with tears on the ITNs showed no association with malaria risks factors. It was also noticed that typhoid patients were slightly associated to malaria risks factors (*p*=0.189*;* OR =1.442; CI: 0.835 – 2.488), just as family size of 6-10 persons and > 11 persons (*p*=0.371; OR > 1). In terms of occupation, farmers were significantly associated to malaria risk factors (*p* = 0.025 OR =2.760; C.I:1.136 – 6.704) (Table 6).

DISCUSSION

Malaria and typhoid fever are public health problems in sub-Sahara African countries including Cameroon. Malaria is a parasitic disease

Table 6. Logistic binary regression assessment of malaria risk factors.

Determinant		Independent variable = Malaria outcome							
		Cases	Beta	S.E	Wald	*p*	Odd ratio (OR)	95% C.I. for OR	
								Lower	Upper
Age (years)									
≤ 5	Ref	39			9.611	0.087			
6 - 14		33	-0.990	0.515	3.696	*0.055*	0.371	0.135	1.019
15 - 24		81	-1.664	0.566	8.643	*0.003*	0.189	0.062	0.574
25 - 44		116	-1.376	0.610	5.092	*0.024*	0.253	0.076	0.835
45 - 64		63	-1.617	0.681	5.636	*0.018*	0.199	0.052	0.754
≥ 65		35	-0.670	0.647	1.071	0.301	0.512	0.144	1.819
Sex									
Females	Ref	240							
Males		127	0.244	0.278	0.770	0.380	1.276	0.740	2.199
No bushes around house	Ref	53							
Bushes around house		313	0.351	0.384	0.838	0.360	1.421	0.670	3.013
Non ITNs user	Ref	50							
Users of ITNs		316	-0.883	0.346	6.525	*0.011*	0.413	0.210	0.814
Tears on ITNs									
Zero tears	Ref	339			0.431	0.934			
1 - 3 tears		10	-19.990	5.150	0.000	0.999	0.000	0.000	.
4 - 6 tears		11	-0.464	0.842	0.304	0.581	0.629	0.121	3.273
7 - 9 tears		6	-0.455	1.212	0.141	0.707	0.634	0.059	6.824
Closing vents at dusk (pm)									
5	Ref	23			1.143	0.767			
6		181	-0.355	0.536	0.439	0.508	0.701	0.245	2.003
7		143	-0.102	0.550	0.034	0.853	0.903	0.307	2.656
≥ 8		19	-0.381	0.733	0.270	0.603	0.683	0.162	2.875
Typhoid									
Negative	Ref	247							
Positive		120	0.366	0.278	1.725	0.189	1.442	0.835	2.488
Family size (persons)									
1 - 5	Ref	224			1.292	0.524			

Table 6. Cont'd

6 - 10		127	0.265	0.296	0.799	0.371	1.303	0.729	2.328
≥ 11		15	0.634	0.708	0.801	0.371	1.885	0.470	7.555
Occupation									
Non-workers	Ref	69			9.066	0.170			
Civil servant		6	-0.021	0.462	0.002	0.963	0.979	0.396	2.420
Student		60	-0.312	1.142	0.075	0.785	0.732	0.078	6.870
Apprenticeship		18	0.034	0.589	0.003	0.954	1.034	0.326	3.285
Professional		41	-0.389	0.722	0.290	0.590	0.678	0.165	2.792
Trading		42	-0.546	0.543	1.009	0.315	0.579	0.200	1.680
Farming		131	1.015	0.453	5.027	*0.025*	2.760	1.136	6.704

Ref= reference, SE= standard error, Independent variable = Malaria outcome.
Source: Authors 2023

while typhoid is caused by Gram negative bacillus. The two coexist especially when the living conditions are very poor. The overall prevalence of malaria in the study population was 27.5% as compared to prevalence gotten from the hospital records from January to March 2020, which was 59.22%. The drop in prevalence could be because ITNs (Howitt et al., 2012) were recently distributed to the community within the period of September to December, 2020 and the study was conducted from January to March 2021. Males had the highest prevalence of malaria (33.9%). Probably the high prevalence in males might be due to the fact that they keep late night. The overall prevalence was highest, 51.3% in the age group ≤ 5 years and the trend decreased with increase in age, then increased in the age groups 45-64 years (25.4%) and ≥ 65 years (20.0%). This could be due to acquired immunity against the parasite overtime due to repeated exposure, as well as drop in immunity with age and it was statistically significant. The risks of transmission of malaria cut across all age groups, which have little to no immunity against *Plasmodium* spp. infections (Wanjala et al., 2011). The overall prevalence of typhoid was 32.7%, with no significant variation with gender even though males had the highest prevalence 36.2%. The high prevalence in males might be due to the fact that they eat more frequently at road site restaurants with poorly managed hygienic conditions (Ryan and Ray, 2004). The prevalence and geometric mean parasite density of malaria patients was higher in males than in the females and in the age group of 15-24 years, though there were no significant differences in the sex and age. The low plasmodia density in females and within some age groups could be due to the immunity level of the infected patients or antimalarial prophylaxis taken previously before consulting the hospital (Orish et al., 2019). Males delayed more than women before going to hospital. Malaria and typhoid co-infection prevalence within *Plasmodium* spp. infected participants were 37.6% and the prevalence of co-infection in females was 19.8% and was slightly above males. This high prevalence in females could be due to reasons that females are more involved in activities like farming that exposed them to mosquito bites and domestic chores whereby they are constantly in contact with water from the springs or streams that are poorly managed and might be contaminated with *Salmonella* spp. The age group 25-44 years had a prevalence of 11.9%, followed by age group 15-24 years (10.9%) and the age group ≥ 65 years which had 0% prevalence. The reason could be, the former age groups are very active age groups that engage in a lot of activities like farming, keeping late night, eating at events, eating at the road site and many more, all these predisposes them to malaria and typhoid risk factors compared to the age group ≥ 65 years which are more of the elderly and have very reduced activities.

Prevalence of co-infection in terms of occupation shows that farmers had the highest prevalence of 14.9% that could be because they do not protect themselves against mosquito bites while carrying out their farming activities as well as lack of personal hygiene on the type of water source (Khan et al., 2015) they drink in the farm since all carry out peasant farming with very low level of sensitisation on prevention against acquiring infection while farming. It was noticed that patients who were co-infected with malaria/typhoid had high parasitaemia as compared to those who were infected with malaria only irrespective of sex and age and there was a strong significant difference ($p<0.001$) in parasitaemia in both sexes co-infected with malaria/typhoid than those infected with malaria only. This finding corroborates research carried out by Ndip et al. (2015) in Kumba Health District, Southwest Cameroon. The high parasitaemia level could be as a result of the *P. falciparum* since it is predominant in Cameroon, as compared to other *Plasmodium* species (Anstey et al., 2009; White et al., 2009), couple with the fact that when co-infected, the immunity of the patients dropped giving room for the malaria parasites to multiply rapidly comparatively. Malaria transmission in this study was high in those who engaged in farming activities without protecting themselves from mosquito bites. Poor sanitation, poor personal hygiene and lack of good water supply, water management were predisposing risk factors for the transmission of typhoid in the area. The severities of these risk factors which expose individual to both infections are being undermined by the population. Majority of the study population (86.6%) were aware about the cause of malaria whereas their awareness about the cause of typhoid was below average (48.0%). Therefore, the study population were well sensitised about malaria in accordance with Gangue et al. (2018), although users of ITNs were slightly exposed to malaria risk factors. This might be due to their outdoor activities without taking preventive measures against mosquito bites and the degree of household crowding (Ferrari et al., 2016; Gangue et al., 2018). In addition, living in homes with bushes around was a malaria risk factor just as late acquisition of mosquito net and its utilisation. However, the overall malaria prevalence is still high given the fact that the study was hospital based and not community-based study to really assess the prevalence, as reported by Minsante (2018) and Massoda et al. (2018), that the whole country is exposed to risk of transmission.

Conclusion

The study has shown that malaria and typhoid coexist in Bafmeng. The overall prevalence of malaria and typhoid were 27.5 and 32.7%, respectively. The Age group ≤ 5 years had the highest malaria prevalence of 51.3%. Out of the 367 participants, 38 were co-infected giving a prevalence of 10.4%. Therefore, of the 101 participants infected with *Plasmodium* spp., 37.6% were co-infected. Patients of the age group 25-44 years had the highest prevalence of co-infection. The malaria parasitaemia in co-infected patients was higher (3517±139 parasites/µL) than in those infected with malaria only (2437±142 parasites/µL) in both genders. Eighty six percent of participants were aware that mosquitoes transmit malaria and 88.6% of the study population had insecticide treated mosquito nets while 86.4% used it. 48.0% were aware that typhoid is caused by a bacterium/germ or others like consuming dirty water or food. The age group 15-24 years were significantly associated (p = 0.003) with malaria risks factors just as farmers (p=0.025; OR = 2.760).

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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