

Are Malaria Risk Factors based on Gender? A Mixed-methods Survey in an Urban Setting in Ghana.

Virginia Quaresima (✉ quaresima.virginia@gmail.com)

University of Brescia: Università degli Studi di Brescia <https://orcid.org/0000-0001-8858-3236>

Tsiri Agbenyega

KNUST: Kwame Nkrumah University of Science and Technology

Bismark Oppong

Hopexchange Medical Centre - Kumasi

Julia Ann D.A. Awunyo

Hopexchange Medical Centre - Kumasi

Priscilla Adu Adomah

Hopexchange Medical Centre - Kumasi

Eunice Enty

Hopexchange Medical Centre - Kumasi

Francesco Donato

University of Brescia: Università degli Studi di Brescia

Francesco Castelli

University of Brescia: Università degli Studi di Brescia

Research Article

Keywords: Malaria, Gender, preventive measures, exposure behaviors, insecticide-treated nets

Posted Date: January 14th, 2021

DOI: <https://doi.org/10.21203/rs.3.rs-143789/v1>

License: © ⓘ This work is licensed under a Creative Commons Attribution 4.0 International License.

[Read Full License](#)

Abstract

Background

Malaria still represents one of the most debilitating and deadly disease in the world; an estimated 229 million cases of malaria occurred globally in 2019 resulting in 409 000 deaths. The ongoing struggle for malaria elimination requires the scientific community to employ new methods. Gender-based medicine continues to acquire more importance in non-communicable as well as communicable diseases. It has been suggested that malaria has different impact on women and men due to both social and biological factors. A gender perspective is therefore important to understand how to eliminate malaria.

Methods

The enrolment of this study was conducted between June and October 2018 at the HopeXchange Medical Centre (HXC), located in the suburbs of Kumasi (Ghana). A sequential mixed-methods design comprising quantitative and qualitative methods was used. The quantitative methods consisted in the prospective assessment of malaria cases presented to hospital with malaria infection, along with a case-control investigation in the hospital catchment area. Whereas focus group discussions and in-depth interviews were employed as qualitative approaches.

Results

One hundred-and-twenty-four individuals were diagnosed with malaria at HXC and enrolled. This study found a low ownership (40%) and use (19%) of insecticide-treated nets (ITNs) compared to the national data (57%). Most malaria cases were women (62%), who were less educated and had more external risk factors associated with infection. Our study reported a trend of preferring malaria self-medication at home. This was practiced mostly by men (43%) and more among cases (38%) than controls (21%). Many misconceptions and beliefs about malaria still exist in some Kumasi communities.

Conclusions

The mixed methods approach employed in this study allowed the identification of gender differences in risk factors for malaria infection. The study unexpectedly found a decreased ITN use and an increased self-medication preference among respondents. Our data suggest that women are more likely to be exposed to malaria infections than men, especially due to their prolonged exposure to mosquito bites during the most dangerous hours. Our study highlighted the need for future malaria control policies to be more focused on social and behavioral aspects, and not only concentrated on biological or clinical factors.

Background

Malaria is a debilitating and deadly disease that still causes 409 000 deaths every year and results in significant suffering and human misery, predominantly in Sub-Saharan -Africa (1). In 2019, 27 African

countries out of the 29 globally, accounted for 95% of the malaria cases, as documented in the World Malaria Report 2020. Sixty-seven per cent of deaths due to malaria occur among children aged under 5 years (1). Although 9 million fewer malaria cases were registered in 2019 than in 2000 (respectively 229 million and 238 million of malaria cases) significant progress in reducing global malaria cases have not been made yet.

In the World Malaria Report 2019, Ghana has been listed along with Nigeria among the countries with the highest increase in cases of malaria in 2018 (8% increase, 0.5 million more cases) (2). As such, Ghana has been included among the 11 highest burden countries which World Health Organization (WHO) and Roll Back Malaria (RBM) identified withing the high burden to high impact (HBHI) approach proposed to support countries to achieve the Global technical strategy for malaria 2016–2030 (GTS) milestones (3).

The 2030 Agenda for Sustainable Development includes malaria as one of the major diseases to be eliminated by 2030 (Target n. 3.3) (4).

Despite the current availability of standard malaria treatments, most tropical countries, including African populations, rely on medicinal plants. In Ghana since the late nineties the scientific community had been supporting and encouraging scientists including biochemists, doctors, pharmacologists, to scientifically investigate some herbal preparations (5).

It has been suggested that malaria has a different impact on women and men (6) due to social and biological factors (7). Immunological, physiological and anatomical differences between males and females may influence exposure, recognition, clearance and even transmission of microorganisms. It is increasingly important to acknowledge sex differences in immune responses especially considering the marked differences seen between males and females in various diseases (8–11).

The term *gender* refers to the economic, social and cultural attributes and opportunities associated with being male and female, whereas the term *sex* refers to male and female differences in immunological, anatomical and physiological differences that influence exposure, clearance and susceptibility to infections. Gender relations thus define how women and men at all ages organize their lives in all aspects, including duties, responsibilities, and opportunities. A previous study conducted in Ghana highlighted the importance of approaching malaria management from a gender perspective. This includes looking within the household at how the social and economic power of women and men can influence decisions to respond to illness (12). Addressing the gender-specific dimensions of malaria (13) can direct resources towards interventions, research and programs to reduce the many gaps in our understanding (14–16).

Previously little has been documented about malaria and gender in Ghana, specifically in Kumasi, the second largest city in the country.

A 2015 review demonstrated that malaria risk in urban and rural areas markedly differs; urban malaria transmission is widely heterogenous and closely related to clusters of people living near parks, water, and

small-scale agriculture lands (17, 18).

In Ghana, as in many other West Africa countries, the rapid urban growth and the transformation of agricultural in urban land have deeply influenced the local livelihoods causing negative effects on environmental and health (19). As cities expand physically, the frontiers between urban, peri-urban and rural activity are more undefined and could merge. Peri-urban areas are those areas surrounding cities which are in most ways integrated with the city. These areas also have high growth rates and receive up to 70% of the migrants from rural areas as well as migrants from the city itself (20). The peri-urban area could be defined as an intermediary space between urban and rural.

The combined use of both quantitative and qualitative methods in Low-Middle-Income-Countries (LMICs) has been recognized as the most suitable to address complex research questions, especially in highly urbanized setting (21, 22).

Quantitative and qualitative research are contrasting methods. Qualitative research is based on observation, all different aspects of the reality are socially constructed and hence subjectively interpreted. In contrast, quantitative research is usually based on observable and measurable reality that can be quantified and objectively interpreted. Qualitative research can provide additional understanding about a research topic that may be inaccessible using quantitative methods (23).

Noteworthy, in recent years the two methodologies have been often combined in public health research, generally referred to as “mixed methods”.

A lot needs to be yet documented and further investigated concerning the influence that emerging and continuously changing urban settings in LMICs might have on infectious disease, and specifically on malaria.

This study is based on a combined approach of qualitative and quantitative methods, to investigate malaria in a gender prospective, in highly urbanized setting in Ghana, where urban malaria is not fully understood and comprehensively investigated.

Aims

Taking up the United Nations Development Programme (UNDP) challenge on Gender and Malaria(24) which expresses the need of developing and collecting data on gender-specific indicators, our study aimed to investigate malaria from a gender prospective in a private health facility, HopeXchange Medical Centre (HXC) based in Kumasi (Ghana).

The main objectives of the study were:

1. to ascertain whether clinical symptoms and laboratory parameters of *P. falciparum* malaria in adult cases differ by sex;

2. to identify factors influencing differences in *P. falciparum* malaria exposure behaviors for female and male adult cases.

A secondary objective was to investigate malaria treatment-seeking behaviors within households, with regard to gender dynamics, using qualitative research methods.

Methods

Study site and patients

This study was conducted during the 2018 rainy season (between June 1st and October 22nd) at the HXC, located in the suburbs of Kumasi (Ghana) (25, 26).

Ecologically speaking, Ghana can be divided in three ecological zones: coastal, forest and northern savanna, which differ by climate and general environment characteristics. The forest zone occupies the central area of the country and it is where HXC is located. The Ashanti region is one of the 10 administrative regions present in Ghana, and Kumasi is the main city of that region. Kumasi is the second largest city in the country, and the health facility where this study was conducted is part of the district named Kumasi Metropolitan Assembly (KMA) and of the Bantama Sub-metro. KMA represents a perfect example of the contrast between headcount rate and population experiencing poverty; despite a low poverty rate in urban areas (5.4%), it ranks as the second municipality for the highest number of poor persons in the country (88935 poor persons) (27). While remote and rural areas may have a lower poverty rate due to their small population size, urban areas such as Kumasi, the poverty rate may be low although hosting a large number of poor people.

The HXC catchment area includes urban villages such as Fankyenembra, Odeneho Kwadaso, Santasi, Aburaso as well as peri-urban villages such as Darko, Hemang, Apire, Nwamase, and Ampatia.

The study population comprised of recruited adults (≥ 18 years) presenting with symptoms suggestive of malaria, who lived for the last 30 days in the same household. Pregnant women were not eligible for enrollment. The diagnosis was confirmed by Malaria Rapid Diagnostic Test (RDT) and microscopy. The severity of the disease was analyzed according to the WHO definitions (28, 29) based on symptoms and selected laboratory parameters (glycaemia (Gly), parasite density (PD), hemoglobin (Hb) values).

A case-control study was performed to investigate malaria awareness amongst malaria cases and in a sample of healthy subjects (controls). The cases were the malaria patients enrolled in the clinical study. The controls were household members living with cases and who had no symptoms of malaria. The controls were above 18 years old, who had lived for the last 30 days in the same household as the case.

Quantitative methods

The characteristics of clinical and laboratory confirmed *P. falciparum* malaria cases in adults were assessed. Two quantitative approaches were employed to achieve the main objectives of the study: the

prospective assessment of malaria cases and case-control investigation.

Prospective assessment of malaria cases in adults

Blood samples (finger prick or venous blood) for thick films and malaria RDT were collected from the patients at entry and Parasite Density (asexual parasites/ μ l) was determined by trained laboratory technicians(30). Two types of RDTs were used – MalariAg Pf™ test kit (SD Bioline), based on the qualitative detection of *P. falciparum* histidine-rich protein II (HRP-II) antigen and malaria AgPf (HRP-2/pLDH) RDT (SD Bioline), with *P. falciparum* double antigens (HRP-2 and lactate dehydrogenase, LDH). Throughout the study both RDTs were employed, following the HXC Laboratory Malaria Diagnostic Algorithm.

Hb values were assessed by the semi-automatic device Cell Dyn Ruby Hematology analyzer, (Roche) or, in case of shortage of reagents, a point-of-care portable device Hemocue 201 + ™ (Hemocue). Gly was measured by the portable device Statstrip Xpress Glucometer (Nova). As an additional parameter, Hb electrophoresis was performed by a semiquantitative method to detect sickle cell trait, sickle cell anemia, and C trait.

The case-control study aimed to investigate malaria awareness amongst malaria cases (cases) and in a sample of healthy subjects (controls), a specific questionnaire was designed based on malaria toolkit materials (31) and other previous studies conducted in Africa and specifically in Ghana. (12, 32–34). The questionnaire addressed : (i) composition of the household, (ii) literacy, (iii) occupation, with reference to malaria exposure risk, (iv) availability of bed nets in the household and their use, (v) general malaria preventive measures (vi) and attitude towards self-initiated medication; (vi) the household tasks which might lead to exposure to mosquito bites, and the decision-making process when needing to access health services were also investigated, along with (vii) household composition, (viii) house building materials, (ix) water sanitation services, (x) general economic status and (xi) different mosquito breeding habitats.

Hospital staff attended a pre-test training for questionnaire administration prior to the study period. Research Field Workers (RFWs), which included a research nurse, a community health nurse and a health promoter, were trained and oriented on enrollment procedures and questionnaire administration.

The RFWs administered the questionnaire in the local language (*Twi*). Cases and Controls were administered similar questionnaires, differing only in a few questions about symptoms, which were exclusively asked to patients.

Qualitative methods

Focus Group Discussions (FGDs) and In-depth Interviews (IDIs)

A total of four focus group discussions (FGDs) (35, 36) were conducted separately for women and men within the communities surrounding HXC. Two FGDs took place in Fankyenebra and two in Darko. The FGDs were conducted. Each FGD ranged between 5 and 8 consenting participants per group. RFWs conducted the discussions in *Twi*. Interviews lasted approximately 45 minutes each and were audio and video recorded. The recorded materials were translated and transcribed for subsequent analysis. Open-ended questions were used, and these were adapted over the course of FGDs. Representative quotations and statements of interest were extracted and reported to support the qualitative findings. The FGDs topics included general information about malaria, malaria first-aid, herbal drugs, and homemade preventive measures.

Fourteen in-depth Interviews (IDIs) were also conducted at HXC, including 3 management and administration staff, the hospital IT manager, 5 laboratory technicians, 2 nurses, 1 health promoter, and 2 medical doctors, aiming to analyze the habits and attitudes towards malaria in a group of people with higher levels of education and directly working in the health service. All IDIs were conducted in English because all interviewed staff are fluent English-speakers.

Statistical analysis

The sample size has been established to achieve one of the main aims of the study, which is the association between malaria and female gender in adults in the prospective case-control study. Particularly, in the prospective study a 1:4 ratio between cases and controls is expected with at least 100 adult cases and 400 controls. Given that the proportions of females among cases and controls are expected as 70% and 50%, respectively, with an odds ratio for female gender of about 2, the study has 90% power using a two-sided test with $\alpha = 0.05$.

Categorical variables were described as frequencies and continuous variables were expressed as mean, standard deviation (SD) and range. The comparisons of proportions between males and females, and between cases and controls were performed using the chi-square test, with a threshold of < 0.05 considered to be significant. Computations were carried out using the STATA program for personal computer, version 14.0. (STATA Statistics/Data Analysis 12.0 – STATA Corporation).

Ethical considerations

Ethical approval was obtained from the Committee on Human Research, Publications and Ethics of Kwame Nkrumah University of Science and Technology (KNUST), School of Medical Sciences & Komfo Anokye Teaching Hospital (KATH). The study was conducted in compliance with recognized international standards, including the principles of the Declaration of Helsinki. The chiefs of the communities surrounding HXC were also informed. An information sheet about the study rationale and participant's rights was provided to participants in *Twi*. Written consent by signature or thumb print (those who could not write) was obtained from participants. Measures were taken to ensure privacy and respect of the dignity of all interviewees.

Results

Quantitative results

Prospective assessment of malaria

Clinical and laboratory features of *P. falciparum* malaria infection

Out of 203 adult patients (126 women and 77 men) diagnosed with malaria at HXC during the study period, 124 were included in the analysis. Seventy-nine patients were excluded because were positive on RDT but negative on microscopic confirmation ($n = 8$), the PD was not reported in the records ($n = 11$), did not show clinical malaria symptoms ($n = 3$), or were pregnant ($n = 3$). Fifty-four patients (32 women, 22 men) were excluded because they did not receive the questionnaire to fill out.

Less than 20% of the enrolled cases were over 50 years old, approximately 61% reached the HXC from villages outside the facility catchment area, equally distributed among male and female (Table 1). Only 16 (12.9%) had not attended school and out of the 108 individuals who received an education only 14.8% reached higher education levels. The majority of women (49.2%) have only completed primary education, while men mostly attended up to secondary school (53.3%). Regardless of the education level achieved, significantly more females than males could not read a simple English sentence (49.4%, 21.3%, $p = 0.007$). Most of the women were traders and retailers (39% vs 10.7%), whereas more men than women were students (men 25.5%, women 10.4%), farmers, or had other professions.

The most frequent symptom was fever (63%), followed by headache (48%), chills (36%), general malaise (26%), vomiting (23%), body-ache (14%), dizziness (11%) and diarrhea (8%), with no differences between male and female. There were no differences in the levels of Hb and Gly (Table 2) between female and male patients. Hb electrophoresis, tested in 116 patients indicated that 82% of the cases were Hb-AA and 10% Hb-AC. Nine patients showed the S-trait, 2 in homozygosis and 7 as carriers. Although very variable, PD did not differ in the two genders and in all patients was much lower than 100·000/ μl with 80% that fell below 10·000/ μl , and 42% that ranged between 1000/ μl and 10·000/ μl .

Patients who required infusion therapy and admission were 29 (16%).

Table 1 Socio-demographic characteristics of malaria patients (cases)			
	Male	Female	Total
	n = 47 (%)	n = 77 (%)	n = 124 (%)
Age (years)			
18–29	19 (40.4)	29 (37.7)	48 (38.7)
30–49	21 (44.7)	32 (41.6)	53 (42.7)
> 50	7 (14.9)	16 (20.8)	23 (18.6)
Place of Residence			
Catchment area	16 (34.0)	33 (42.9)	49 (39.5)
Outside catchment area	31 (66.0)	44 (57.1)	75 (60.5)
Education*			
No Education	2 (4.3)	14 (18.2)	16 (12.9)
Educated	45 (95.7)	63 (81.2)	108 (87.1)
School attendance			
primary	13 (28.9)	31 (49.2)	44 (40.8)
secondary	24 (53.3)	24 (38.1)	48 (44.4)
higher	8 (17.8)	8 (12.7)	16 (14.8)
Literacy*			
poor	10 (21.3)	38 (49.4)	48 (38.7)
good	35 (74.5)	36 (46.8)	71 (57.3)
visually impaired	2 (4.3)	3 (3.9)	5 (4.0)
Occupation*			
skilled labors	7 (14.9)	7 (9.1)	14 (11.3)
students	12 (25.5)	8 (10.4)	20 (16.1)
arts and crafts	3 (6.4)	14 (18.2)	17 (13.7)
cooking and catering	2 (4.3)	6 (7.8)	8 (6.5)
traders and retailers	5 (10.7)	30 (39.0)	35 (28.2)
transport	5 (10.6)	-	5 (4.0)

Table 1**Socio-demographic characteristics of malaria patients (cases)**

farmers	5 (10.6)	2 (2.6)	7 (5.7)
unskilled labors	4 (8.5)	4 (5.2)	8 (6.5)
others	4 (8.5)	6 (7.8)	10 (8.1)
*p < 0.05			
<i>Note:</i> Occupations: Skilled labors include (engineering and construction, healthcare and teaching); students; arts and crafts include (photographer, beading and decoration, stylish and fashion, sewing jobs); cooking and catering; traders and retailers; transport; farmers; unskilled labors include (cleaners, porters, watchmen, and receptionist); others (unemployed, retired, public sector jobs)			

Table 2**Laboratory parameters of malaria patients (cases)**

	Male		Female	
	n	Mean	n	Mean
Parasite density (p/μl)*	47	2344.4 (1374.3–3999.1)	77	1422.6 (848.1–2386.5)
Hemoglobin (g/dl)	47	14.1 (± 1.2)	70	12.0 (± 1.4)
Glycemia (mmol/L)	44	6.2 (± 1.8)	67	6.9 (± 3.6)
* Geometric mean and range, n = number				

Gender differences of factors possibly influencing *P. falciparum* malaria incidence and severity

As many as 97% of respondents answered positively to the question “Do you know what malaria is?” (Table 3). An equal proportion of men (95.7%) and women (97.4%) know what malaria is. Likewise, malaria advertisements spread by radio, television, posters and newspapers (92%) were the most effective way of sharing information. Surprisingly, only 37% of interviewees mentioned Community Health Worker (CHW) talks or hospitals (females 43%, males 28%), and schools (31%). Self-initiated medication for malaria as for other diseases, is a common practice; in this study 32% of malaria cases stated they had taken antimalarial drugs in the last month. Thirty-two out of 40 patients who self-initiated antimalarial drugs, stated that they got those medications from pharmacies, shops or markets. Self-initiation was more common in men than women (42.6% and 26%, $p = 0.055$). More than 37% of patients stated they used mosquito repellent coils, 39% usually spray indoor mosquito repellents, 54% had window screens and 40% owned insecticide-treated nets (ITNs, 43% males and 38% females). However, about 20% of the ITN owners reported sleeping under the net “sometimes” or “never”, and 29% declared that the

nets are not well maintained. 61% of interviewees usually go into open spaces during night hours for any household activity. Regarding socializing outdoors and the need to carry out household tasks in the evening, most of respondents (74%) spent time in open spaces after the sunset, often for church activities, work related issues, or household tasks. In the preceding month, 50% joined “special social gatherings” such as funerals or church events. These were generally held in open space and lasted many hours after the sunset. Significantly more women (60%) than men (37%) went into open spaces earlier than 6 am ($p < 0.05$).

A total of 73 heads of households were interviewed at home. Structurally, houses had mainly cement-made walls and floors and metallic roofs. Heads of households were shown images representing different types of mosquito breeding habitats. They then identified that natural swamps were present in 73% of the visited household surroundings; puddles in 29%, cultivated swamps in 27% and open drains in 25%. Amongst households, 44% were equipped with ventilated pit latrines (improved or with slab). Ninety-five percent of the residence compounds had electricity; television and radios were present in approximately 90% of the houses. Thirty-eight percent of residences reported owning a computer and 29% owning a car. Water for cooking or drinking was mostly collected (about 70%) from standpipes, boreholes and protected wells. For cooking, charcoal was mainly used (88%), followed by gas (71%), wood (12%) or electricity (4%).

Table 3

malaria awareness, exposure behaviors and preventive measures among cases (male vs female) and controls

	Male	Female	Total	Cases	Controls	Total
	n = 47 (%)	n = 77 (%)	n = 124 (%)	n = 102 (%)	n = 159 (%)	n = 261 (%)
Malaria Awareness						
knowledge about malaria	45 (95.7)	75 (97.4)	120 (96.8)	97 (95.1)	158 (99.4)	255 (97.7)
advertisements (television, radio, poster/billboard, newspapers)	43 (91.5)	71 (92.2)	114 (91.9)	93 (91.2)	154 (96.9)	247 (94.7)
community based approaches (CHWs, community health events, hospital)	13 (27.7)	33 (42.9)	46 (37.1)	31 (30.4)	64 (40.3)	95 (36.4)
anywhere else (school, information center, etc...)	13 (27.7)	26 (33.8)	39 (31.5)	22 (21.6)	36 (22.6)	58 (22.2)
Malaria medication self-initiation	20 (42.6)	20 (26.0)	40 (32.3)	39 (38.2)	33 (20.8)	72 (27.6)
Malaria preventive measures						
mosquito coil	14 (29.8)	32 (41.6)	46 (37.1)	44 (43.1)	79 (49.7)	123 (47.1)
indoor spray	19 (40.4)	29 (37.7)	48 (38.7)	42 (41.2)	69 (43.4)	111 (42.5)
windows screen	27 (57.5)	40 (52.0)	67 (54.0)	61 (59.8)	96 (60.4)	157 (60.2)
door screen	9 (19.2)	18 (23.3)	27 (21.8)	29 (28.4)	43 (27.0)	72 (27.6)
ITN ownership	20 (42.6)	29 (37.7)	49 (39.6)	40 (39.2)	53 (33.3)	93 (35.6)
ITN use						
always	11 (55.0)	13 (44.8)	24 (49.0)	17 (42.5)	34 (64.2)	51 (54.8)
sometimes - never	9 (45.0)	16 (55.2)	25 (51.0)	23 (57.5)	19 (35.9)	42 (45.2)
ITN maintenance						

Table 3

malaria awareness, exposure behaviors and preventive measures among cases (male vs female) and controls

fully intact	17 (85.0)	19 (65.5)	36 (73.5)	31 (30.4)	39 (24.5)	70 (26.8)
damaged	3 (15.0)	10 (34.5)	13 (26.5)	9 (8.8)	14 (8.8)	23 (8.8)
Malaria exposure behaviors						
first step-out in open space						
earlier than 6am	17 (36.2)	46 (59.7)	63 (52.1)	44 (43.1)	95 (59.8)	139 (53.3)
later than 6am	29 (61.7)	29 (37.7)	58 (47.9)	56 (54.9)	61 (38.4)	117 (44.8)
unknown	1 (2.1)	2 (2.6)	3 (2.4)	2 (2.0)	3 (1.9)	5 (1.9)
going in open space, during the night hours (10 pm – 6 am)	33 (70.2)	43 (55.9)	76 (61.3)	59 (57.8)	88 (55.4)	147 (56.3)
socializing in open space after the sun set						
often	36 (76.6)	56 (72.7)	92 (74.2)	71 (69.6)	111 (69.8)	182 (69.7)
sometimes - never	11 (23.4)	21 (27.3)	32 (25.8)	31 (30.4)	48 (30.2)	79 (30.3)
last month gathering and sleeping outside	25 (53.2)	38 (49.4)	63 (50.8)	49 (48.0)	70 (44.0)	119 (45.6)
ITN, Insecticide treated nets; CHWs, community health workers						

Case – Control analysis

Among 124 interviewed patients, 102 (38 males, 64 females) were examined in the case-control analysis. RFWs could not administer the questionnaire to 22 housemates of cases, as such these patients could not be included in the analysis. Overall, 159 controls (62 men and 97 women) were included. Occupations including studying or trading were equally represented in both cases (15.7% and 29.4%) and controls (15.7% and 30.2%, $p = 0.75$). Between cases and controls, the level of education and literacy were similar. Table 3 shows high rates of malaria awareness in both cases and controls ($p = 0.01$). Radio and television advertisements were more effective in spreading malaria health messages, compared with community health approaches or schools. More cases than controls reported self-initiated antimalarial

drugs in the last month (38.2% and 20.8%, $p < 0.05$). Malaria preventive measures and exposure behaviors were very similar in both groups ($p > 0.05$). Controls step out from home earlier than cases (60.9% and 44%, $p < 0.05$). An additional analysis (not shown in table 3) revealed that mostly among controls who step out from home before 6 am, men were 53.2% and women 63.9% ($p < 0.05$).

Women's perspective

Combining female interviewees among cases ($n = 84$) and controls ($n = 97$), 69% were women with children ($n = 125$) and 44% had more than 3 children. The malaria preventive measures mainly used by the interviewed mothers were mosquito nets (32%) and mosquito coils (25%). 47% stated they were directly responsible for child-wellbeing. Women who had a partner (61%) stated they were allowed to accept a health treatment and pay for it if the partner is absent (91%). The most frequent daily activities conducted by females were trading in the street (36%), queuing for water (31%) and cultivating gardens (18%). These activities were reported to be conducted either "before the sunset" (73%) or "after the sunset" (63%).

Qualitative results

Focus group discussions (FGDs) and in-depth interviews (IDIs)

General knowledge about malaria symptoms and transmission

FGDs clearly indicated that males and females were well informed about *etiridii* (Twi: "malaria") clinical manifestations, without knowledge differences between Fankyenebra and Darko inhabitants. The majority of symptoms were: chills, diarrhea, joint pains, nausea, loss of appetite, fever, headache and general body weakness. *Ntomntom* (Twi: "mosquitoes") were identified as the sole cause of malaria, often specifically referring to the female of *Anopheles* mosquito by all the participants, but malaria infection was also attributed to smoking weed (marijuana) and alcohol abuse by the male groups. In particular one elder of Fankyenebra stated that "*if you overdrink you might get malaria*", and some young participants of the Darko group declared that one young subject who died of malaria the week before instead died because "*he smokes too much weed*".

As expected, IDI respondents showed a strong and very detailed knowledge about malaria infection. Most of them (12 out of 14) mentioned television, radio, schools, hospitals and churches as the main information sources or places where messages about malaria are spread.

Exposure and vulnerability towards malaria

Open drains surrounding the houses, bushy environment, bath drains, and uncovered basins for drinking and cooking water were identified by all responders as mosquito breeding sites. However, it is interesting

to note the association of the spread of malaria with hygienic conditions. One female in the Fankyenebra group stated that *"Since 50 pesewas (Pesewas are the coins and 100 pesewas make 1 cedi which is the currency of Ghana) are paid for accessing the public toilet, often people defecate in plastic bags leaving them all over"*. A woman remarked that the town is full of *bola* (rubbish) everywhere. Also men often referred to personal hygiene and general house cleanliness as elements linked to malaria infection. Regarding a person who died recently in Darko of severe malaria, someone said *"He got severe malaria because he was not bathing enough"*; another one stated, *"I never get malaria because I always keep the house clean"*. For Fankyenebra men *"keeping the bedroom well organized and hanging the clothes up"* reduce the risk of malaria because *"cleanliness is close to godliness"*. Finally, for one Fankyenebra woman *"Living [with] many clothes hung in the room and leaving the room messy, might foster mosquito bites"*.

Remarkably, during the urban FGDs (Fankyenebra), sickle cell disease (SCD), anemia, "red blood cell status" were mentioned as conditions leading to more serious symptoms of malaria.

Nutrition was taken into great consideration by all woman; both urban and peri-urban female linked malaria infection to oily food because *"Eating a lot of oil makes you prone to get malaria"*.

Malaria comorbidities and severe malaria

All responders stated that malaria is more dangerous than HIV and is a deadly disease. Only the Fankyenebra female group was aware of the potential risk of developing permanent consequences from malaria infection and they reported that *"Malaria results in convulsions and if not treated might also develop in psycho-motion [psycho-motor] disfunction"*. The Darko female group linked the condition of severe malaria to convulsions and a woman said that *"malaria causes injury to the brain, that's why convulsions might occur"*. On the other hand, during the Darko discussion a man reported that *"it is not true, malaria can't (cause disabilities). Diabetes can lead to amputation"*.

Gender-related habits and malaria

For the Darko male group *"The ladies get malaria more easily, because they often use the public toilet"*, while *"The majority of men don't get malaria because they are always outside the house"*. On the other hand, for Darko females *"Men get less malaria because they wear trousers, while women's dressing code exposes them much more to mosquito bites and consequently to malaria more often"*. The Darko female group described also some household activities generally carried out by women during late evening as further exposure to mosquito bites *"Women sit outside for a long time and they also sell goods until late in the evening, exposing themselves much more than men"*.

The nurses and the health promoter interviewed during the IDIs convincingly stated that *"trading is one of the most common activities in the region and the tendency is to spend much time in open spaces"; "...*

when they come from work people tend to refresh outside or chat a lot before going inside”.

Ten respondents described joining watchnight services at least once per week, and therefore being exposed in open spaces from 10 pm to 4 am. The watchnight masses are generally practiced by Christian churches and are an occasion for prolonged outdoor praying sessions.

Orthodox drugs versus homemade remedies for malaria prevention and treatment

Malaria prevention homemade measures are orange pills known as *gari* (a powder obtained from roasted cassava flakes) which are burned on charcoal and whose smoke repels mosquitoes. Conventional preventive measures such as mosquito nets on doors and windows, mosquito repellent spray, and mosquito coils are also used. The maintenance and use of ITNs was well known among interviewees, despite most of them being reluctant to sleep under them because of heat, claustrophobia and skin rash. In addition, bednets do not adapt easily to the bedroom/house arrangement (square-morphology bednets are the types mainly distributed by Government or Non-government Organization programs).

The malaria preventive measures used by IDI respondents included mostly mosquito nets on doors and windows, and indoor spraying, however bednet use is intermittent or absent. Only 3 out of 14 participants described always sleeping under the mosquito bednets. *“...people feel uncomfortable sleeping inside the net because of the heat”* and some others reported suffocating feelings. As also mentioned during the FDGs, some interviewed nurses described mosquito bednets’ shape as a problem for users, because square nets were more challenging to install in a home than the round type, which instead require only a single hook to be installed.

As described during the IDIs, *Meffee* is used as malaria repellent and consists in *“burning palm nut chaff during the night, keep mosquito away”*. Charcoal-burned lemon or orange pills were also mentioned as preventive measures to repel mosquitoes. The health promoter reported the practice of burning empty egg cartons as another method for repelling mosquitos. When feeling the early manifestations of malaria, both women and men in Darko drink much more water. One male respondent even admitted drinking his own urine as malaria treatment *“When you think you have malaria you can drink your own urine to recover. If the body doesn’t want the urine, if you take it back, anything wrong disappears”*. In Fankyenebra most respondents rely on hospitals if they suspect they have malaria, while Darko males buy medications at drugstores or pharmacy. On the contrary, female of peri-urban areas use as malaria first aid, *Taabia*, a herbal medicine sold in the market, *enema* a mixture of herbs or ginger grinded with pepper that is injected in the anus or *Dudo*, a homemade herbal remedy made of moringa leaves and lemon leaves, or pineapple skin that is brewed for drinking.

For convulsions, especially in affected children, garlic is rubbed on the body or the legs are immersed in a water pool. All these “non-conventional” malaria treatments are never applied for children, who are usually immediately rushed to the hospital.

All IDs interviewees stated that “*whenever people feel sick they first choose for self-medication from the pharmacy and going to the hospital just when the condition worsens*”; “*female are more prone to access the hospital than male, who rather prefer self-first-aid*”, although “*the work schedules are also another reason forcing males to not easily attend hospital*”. Nurses described the belief “*Men do self-medication much more than female, when they are sick they just go to the pharmacy shop.... They always want to appear healthy*”.

Ten IDs’ respondents out of 14, admitted to having used herbal drugs for treating malaria at least once in their lives. “*In Ghana the use of herbal drugs is tremendously common, especially in rural communities*”. Most respondents had been exposed throughout their lives to herbs and to herbal medication knowledge. They were taught by family elders how to recognize and use herbs properly. Only managers and academic personnel were never exposed to such traditional practices. All respondents however did not use herbs sold in the market indiscriminately, without any certification or control by the Food and Drugs Authority (FDA) in Ghana. Most of the interviewees were able to mention some homemade remedies still in use. Some mentioned *neem* tree leaves or *theack* tree leaves to be brewed and drunk, another had been taught to make a mixture of leaves from mango tree, guava tree and indian almond tree to be boiled and drunk or inhaled.

Discussion

Even though symptoms and laboratory parameters of *P. falciparum* malaria do not differ by sex in adults, this study revealed different malaria exposure behaviors and preventive measures between males and females. In addition, the mixed method approach showed the existence of economic, cultural and social triggers which influence malaria exposure behaviors and preventive measures.

More women than men presented to hospital with malaria infection during the study period, but neither parasite density nor clinical manifestations suggested gender differences.

This study demonstrated that women with malaria have less formal education than men because only 4% of men didn’t receive formal education compared to 18% of women ($p < 0.05$). This feature is in line with the Multiple Indicator Cluster Survey Six (MICS 6), conducted in 2017-18 by Ghana Statistical Service (GSS), revealing that 19% of women didn’t attend school or pre-primary education compared with 10% of males. In addition, a higher proportion of our respondents only completed primary school (women 49%, men 29%, $p > 0.05$) with less having attended secondary school (women 38%, men 53%, $p > 0.05$) or reached higher education levels (women 13%, men 18%, $p > 0.05$). More females (49%) than males (21%) couldn’t read, confirming the unbalanced education distribution between genders ($p < 0.05$).

Infectious diseases responses require multifactorial components, including not only the availability of adequate clinical care but also improvements in the living conditions of citizens and access to education. The most vulnerable groups are likely to be affected by the dual burden of low literacy and high prevalence of infections (37).

The other important gender difference in malaria incidence is related to occupation. Indeed, significantly more female malaria patients were principally traders, while males were mostly students from the surrounding boarding schools. This is in agreement with data reporting that, in Ashanti, 51% of the female population are engaged in service and sales occupations in comparison to only 19% of their male counterparts (38). The main female service and activities were trading in the market (37%) or queueing for water (31%), which were generally accomplished either before the sunrise (73%) or after the sunset (63%). This is probably the reason why more women (61%) than men (37%) with malaria step-out into open spaces earlier than 6 am, when there is a higher risk of mosquito bites.

Although we have no specific data regarding the economic conditions of the respondents, education, literacy and occupation are suggestive of different socio-economic status between women and men.

The uneven distribution of wealth in Ghana and in Kumasi might be explained by two major phenomena: urbanization (39) and migration (40). Regions in the southern half of the country have received more migrants from other regions in the country, particularly the northern regions (40, 41). Ashanti Region has 61% of the population living in localities classified as urban (2010). The 2010 Census showed a higher proportion of females in urban than rural localities. This may be due to the recent phenomenon of relatively more female than male children migrating from rural communities into urban areas (42). The young migrants, especially those from the north, mainly work in the informal sector and are largely self-employed. Many young migrant women from the north are involved in head-load carrying or *kayayei* as an adaptive response to poverty, and this could increase their vulnerability to poverty and poor health (40, 43).

Ghana has a long history of using mass media and other communication channels to educate the population about malaria (6). The Ashanti Region has the highest rate of household ownership of information and communication technology (ICT) equipment according to the MICS 6. These ICT features could explain the high rate of malaria awareness found among our study population, mainly attributable to radio and television advertisements.

Differently from that reported in the MICS 6 57% of household in Ghana own at least one ITN (38), but in line with other studies conducted in sub-Saharan African countries showing a similar trend in ITN use (44, 45), our survey revealed that only 39.6% and 33.3%, of cases and controls respectively own an ITN. However, the use of ITNs is higher among healthy controls (64%) than subjects with malaria (43%, $p < 0.05$) suggesting that controls could have a better use of ITNs. Similarly, this study shows a very low use of ITN among highly educated healthcare professionals. The low ITN use especially in a highly urbanized setting could be explained by the adoption of different malaria prevention measures; for example, wealthier households tended to have better access to housing improvements like window screens and closed eaves that reduce exposure to indoor mosquito bites (15). Having a decreased perception of vulnerability to malaria also resulted into decreased net use (46). Another recent study also found that net ownership and use vary widely across sociodemographic groups within and across countries (44). Among 261 subjects, including both controls and cases, window screens were the most common

preventive measure applied (60%), followed by mosquito coil (47%), indoor spraying (43%), and only 36% of interviewees mentioned ITN.

Qualitative research can be more suitable for investigating socio-culture aspects of health. Both IDIs and FGDs, used to investigate socio-culture aspects of health perception, indicated that the interviewees find ITNs uncomfortable, referring to heat and claustrophobic feelings. Both male and female interviewees in Fankyenebra complained because of the four-square-net, the type of ITN generally available in pharmacies and shops or provided free of charge during Government Malaria Prevention Campaigns, cannot be easily installed in their small houses. Poor housing is common in these regions, where most people live in uncompleted buildings with no indoor toilets, potable water, electricity or waste disposal facilities, the most common toilet facility is the public toilet used by 41% of the population, and also used by two of five urban households in the country (39). In urban areas, 30% of households are disposing liquid waste into the gutter. Therefore, often the words “hygiene”, “cleanliness”, “waste” and “environment” were mentioned as the most favorable habitats for mosquito breeding during all FGDs.

Indeed, the FGDs interviewees mentioned precarious conditions of dwellings as a source of malaria infection, while Darko male respondents proposed that women get more malaria because they more frequently use public toilets, which are potential areas of mosquito activity due to septic tanks within communities acting as potential vector breeding sites (47).

The misconceptions about being more susceptible to malaria if eating oily foods or not having good personal hygiene reported by the community members in our study are very similar to those reported in southern Ghana about twenty years ago (48).

Notably, socio-cultural practices of interviewees appear to be the main reasons to mosquito exposures, among both males and females, and cases and controls. with 70% of them spend time in open spaces after the sunset. A similar finding was described in a study conducted in Tanzania, where the men’s habit of spending time outdoors drinking alcohol and watching television was linked to malaria risk (33).

Prescribing anti-malarial drugs for patients without parasitemia is a common practice both for severe as well as uncomplicated malaria, as documented in Kenya and Uganda (49, 50).

The quantitative measure of PD did not reveal gender differences in our cohort, which is consistent with other investigations conducted in Ghana (51, 52) and may be due to the widespread use of personal antimalarial measures, greater awareness of malaria as a deadly disease and adequate knowledge about its prevention among the more urbanized and better educated population (51).

Urban environments are less favorable for vectors which have a strong preference for unpolluted waters (18, 53). Mosquito dispersal is also limited in urban areas due to the higher housing density (54) and vector breeding sites are common in areas with slum-like conditions (55). Therefore, the low parasite density found in our patients may be attributable to the urban setting where they live. It could be

hypothesized that in urban settings people being less exposed to malaria could develop a weaker immunity response and a symptomatic malaria clinical status besides the low parasitemia

Preference for home treatment and self-initiated medication mostly by men (43%) and more among cases than controls is highlighted by the quantitative approaches as much as by the FGDs. Herbal remedies were also identified as a preferred method of malaria treatment in other research conducted in Kintampo in 2016 (56). In contrast, a different attitude towards sickness in children is reported, mostly relying on formal health facilities instead of self-initiated medication. The same feature was described for another study conducted in the Upper west Region (57) where about 3% of children with malaria was treated at home using herbs and leftover drugs. The employment of mixed methods we have used for this study gave multiple insights concerning malaria traditional beliefs and herbal preparations, which are also used elsewhere in Africa (58, 59).

Conclusions

The data suggest that women are more exposed than men to malaria infections, because the main female house-tasks are trading in the streets and queuing for water; as such, women spend much more time in open spaces than their male counterparts and therefore they undergo prolonged exposure to mosquito bites during the most dangerous hours. Women's use of ITN appears also lower than men, though not statistically significant.

The mixed methods approach employed in this study allowed us to identify gender differences in malaria exposure, prevention and treatment. The patients were studied from a clinical perspective, but risk factors linked to exposure behaviors and preventive measures were also considered. The study unexpectedly shows lower incidence of ITN use and an increased self-initiated medication among respondents compared to other studies. Changing people's behavior and practices is a long journey and will require a deep cultural and political shift, especially in LMICs. As seen for Ebola during the most recent outbreak in West Africa (60) and for HIV in South Africa the community engagement in public health could be the best approach in LMICs and the empowerment of front-line health workers and communities could create an effective surveillance system. Moreover, the health literacy (HL), which refers to the ability of people to access and use information to make decisions related to their health (37), is the way for understanding new trends in our communities such as unwillingness to adhere to immunizations policy or the indiscriminate use of antibiotics or, more recently, deliberately neglecting precautions and protective behavior during the COVID-19 pandemic (61). The investment on community engagement and HL should be the way for malaria elimination in LMICs but also other infectious diseases all over in the world.

The mixed methods approach used in this survey has proved to be valuable for investigating people's behaviors and awareness as regarding effective malaria prevention measures. Our study highlighted the need to invest in future Malaria policies and research tools more focused on people's social and behavioral aspects and not only concentrated on biological or clinical factors. Malaria is an intricate and compelling story: each chapter should be considered in order to understand the entire plot.

Limitations And Constraints

This study was the first attempt in this area of Kumasi, in a recently established healthcare facility and employing a novel research approach. Inevitably, we encountered some challenges. The sample sizes are not large enough to draw strong statistical conclusions. In addition, being Kumasi the second most populated city of the country with the highest number of poor inhabitants, the field activities were extremely difficult and challenging. The arrangement of household visits for controls' interviews was complex and demanding. The study only captures data from communities surrounding HopeXchange, hence more investigations should be conducted for a wider understanding of malaria transmission patterns in Kumasi and within the Ashanti Region. Despite these limitations, the findings from this study provide new insights into gender and malaria risk factors.

Abbreviations

Community Health Worker (CHW)

Focus group discussions, FGDs

Glycemia, Gly

Hemoglobin, Hb

HopeXchange medical centre, HXC

In-depth Interviews, IDIs

Information and communication technology, ICT

Insecticide-treated nets (ITNs)

Insecticide-treated nets, ITN

Kumasi metropolitan assembly, KMA

Low-middle-income countries, LMICs

Parasite density, PD

Rapid diagnostic test, RDT

Research field workers, RFW

World Health Organization, WHO

Declarations

Ethics approval and consent to participate

Permission to conduct the study was obtained from the Committee on Human Research, Publication and Ethics - School of Medical Sciences - *Komfo Anokye* Teaching Hospital, College of Health Sciences, *Kwame Nkrumah* University of Science and Technology (KNUST), Kumasi (Ghana), with Reference Number CHRPE/AP/327/18. The study got also the academic ethical approval in Brescia (Italy), as a collaborative agreement between the University of Brescia and KNUST for conducting scientific research. Written consent to join the study was obtained from all study participants.

Consent for publication

The consent to publish the findings was obtained from individual participants. Moreover, we have removed identifiers from the data presented, so it cannot be linked to any participants.

Availability of data and materials

The datasets used during the current study are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests.

Funding

The research was made possible by the UNESCO Chair and HopeXchange Medical Centre funds. The generous support of the Proloco Mompiano association was worthy too.

Authors' contributions

VQ and FC designed the study. VQ, FC, TA and FD drafted the work and substantively revised the manuscript. VQ, BO, JADAA, PAA, EE had an essential role in the acquisition and analysis of data. All authors read and approved the final manuscript.

Acknowledgements

The authors wish to thank the study participants in Bantama sub-metro (Kumasi) who volunteered their time to take part in this research. We are very grateful for the assistance received from HopeXchange

Medical Centre management office, in the person of Dominic Osei-Kofi, Christian A. Sappor and their collaborator Peprah Michael Boamah. We want to thank especially the laboratory staff of HopeXchange Medical Centre for their amazing expertise in analyzing malaria slides (Salim Mohammed, Edward Owusu Amponsah, Michael Kusi Addai, Samuel Opoku Amponsah, Peter Kojo Brenya). We also acknowledge the support of Dominic Nyarko who helped in retrieving data by “National Malaria Control Programme (NMCP)” network. The IT department of HXC was also irreplaceable (Ernest Adjei and Christian Addai). The Saint Patrick hospital service in performing electrophoresis tests was extremely helpful too (Ehiem Raymond Charles and Christabel Ameyaw Temah). The research topic was gratefully inspired by Prof. Taramelli D. and her team (Department of Pharmacological and Biomolecular Sciences, University of Milan). A special gratitude goes to Dr. Luisa Imberti for kindly editing this manuscript.

References

1. World Health Organization. World Malaria Report 2020 [Internet]. Vol. WHO/HTM/GM, World Health. 2020. 238 p. Available from: <https://www.who.int/publications/i/item/9789240015791>
2. World Health Organization. World malaria report 2019 [Internet]. WHO, editor. 2019. Available from: <https://www.who.int/publications/i/item/9789241565721>
3. WHO RP to EM. High burden to high impact A targeted malaria response “ A MASSIVE. :1–8. Available from: <https://www.who.int/malaria/publications/atoz/high-impact-response/en/>
4. Sustainable Development Goals :. Sustainable Development Knowledge Platform [Internet]. [cited 2019 Jul 15]. Available from: <https://sustainabledevelopment.un.org/?menu=1300>
5. Tsey K. Traditional medicine in contemporary Ghana: A public policy analysis. Soc Sci Med [Internet]. 1997 Oct 1 [cited 2019 May 12];45(7):1065–74. Available from: <https://www.sciencedirect.com/science/article/abs/pii/S0277953697000348?via%3Dihub#aep-abstract-id3>
6. Roll Back Malaria. Gender and Malaria. 2015;667(September 2015):2. Available from: http://www.rollbackmalaria.org/files/files/about/SDGs/RBM_Gender_Fact_Sheet_170915.pdf
7. Pell C, Straus L, Andrew EVW, Meñaca A, Pool R. Social and cultural factors affecting uptake of interventions for malaria in pregnancy in Africa: A systematic review of the qualitative research. PLoS One. 2011;6(7).
8. Abdullah M, Chai P-S, Chong M-Y, Tohit ERM, Ramasamy R, Pei CP, et al. Gender effect on in vitro lymphocyte subset levels of healthy individuals. Cell Immunol [Internet]. 2012 Jan 1 [cited 2019 Jun 8];272(2):214–9. Available from: <https://www.sciencedirect.com/science/article/abs/pii/S000887491100270X?via%3Dihub>
9. Klein SL, Flanagan KL. Sex differences in immune responses. Nat Rev Immunol [Internet]. 2016;16(10):626–38. Available from: <http://dx.doi.org/10.1038/nri.2016.90>
10. Muenchhoff M, Goulder PJR. Sex differences in pediatric infectious diseases. J Infect Dis. 2014;209(SUPPL. 3).

11. vom Steeg LG, Klein SL. Sex Matters in Infectious Disease Pathogenesis. *PLOS Pathog.* 2016;12(2):e1005374.
12. Tolhurst R, Nyongato FK. Looking within the household: Gender roles and responses to malaria in Ghana. *Trans R Soc Trop Med Hyg.* 2006;100(4):321–6.
13. Yaya S, Udenigwe O, Bishwajit G, Ekholuenetale M, Kadio B. Knowledge of prevention, cause, symptom and practices of malaria among women in Burkina Faso. *PLoS One.* 2017;12(7):1–14.
14. United Nations Development Programme. Discussion Paper: Gender and Malaria. 2015;(December).
15. Tusting LS, Bottomley C, Gibson H, Kleinschmidt I, Tatem AJ, Lindsay SW, et al. Housing Improvements and Malaria Risk in Sub-Saharan Africa: A Multi-Country Analysis of Survey Data. *PLoS Med.* 2017;14(2):1–15.
16. Maslove DM, Mnyusiwalla A, Mills EJ, McGowan J, Attaran A, Wilson K. Barriers to the effective treatment and prevention of malaria in Africa: A systematic review of qualitative studies. *BMC Int Health Hum Rights.* 2009;9(1):1–10.
17. Wilson ML, Krogstad DJ, Arinaitwe E, Arevalo-Herrera M, Chery L, Ferreira MU, et al. Urban Malaria: Understanding its Epidemiology, Ecology, and Transmission Across Seven Diverse ICENR Network Sites. *Am J Trop Med Hyg.* 2015;93(3_Suppl):110–23.
18. Klinkenberg E, McCall PJ, Wilson MD, Amerasinghe FP, Donnelly MJ. Impact of urban agriculture on malaria vectors in Accra, Ghana. *Malar J.* 2008;7:1–9.
19. Karg H, Hologa R, Schlesinger J, Drescher A, Kranjac-Berisavljevic G, Glaser R. Classifying and Mapping Periurban Areas of Rapidly Growing Medium-Sized Sub-Saharan African Cities: A Multi-Method Approach Applied to Tamale, Ghana. *Land.* 2019;8(3):40.
20. FAO - X0076e [Internet]. [cited 2021 Jan 1]. Available from: <http://www.fao.org/unfao/bodies/COAG/COAG15/X0076e.htm>
21. De Allegri M, Sileunou I, Abihiro GA, Ridde V. How far is mixed methods research in the field of health policy and systems in Africa? A scoping review. *Health Policy Plan.* 2018;33(3):445–55.
22. Gilson L. Understanding the Nature of Social and Political Reality. *Health Policy Syst Res a Methodol Read [Internet]*. 2012;34–7. Available from: http://www.who.int/alliance-hpsr/alliancehpsr_reader.pdf
23. 1d - The Principles of Qualitative Methods | Health Knowledge [Internet]. [cited 2019 Nov 29]. Available from: <https://www.healthknowledge.org.uk/public-health-textbook/research-methods/1d-qualitative-methods>
24. UNDP. Discussion Paper Gender and Malaria. 2015;(December).
25. World Weather Information Service - Kumasi [Internet]. [cited 2019 Jun 30]. Available from: <https://worldweather.wmo.int/151/c00922.htm>
26. Rockville, Maryland, USA: GSS, GHS and ICF International. 2015. Ghana Statistical Service (GSS), Ghana Health Service (GHS), and ICF International. 2015. Ghana Demographic and Health Survey 2014. Rockville, Maryland, USA: GSS, GHS, and ICF International. 2014.
27. Ghana Statistical Service (GSS). Ghana Poverty Mapping Report. 2015;

28. World Health Organization. Guidelines for the treatment of malaria – 3rd edition. 2015;
29. Management of severe malaria: a practical handbook - 3rd ed. [Internet]. Vol. 7, Geneva, World Health Organization. 2010. 27–38 p. Available from: <http://www.embase.com/search/results?subaction=viewrecord&from=export&id=L358193594%5Cnhttp://dx.doi.org/10.2217/thy.09.81>
30. WHO. Malaria Microscopy Quality Assurance MANUAL - ver.1. 2009;Version 1.
31. Toolkit | World Malaria Day [Internet]. [cited 2019 Jun 30]. Available from: <https://www.worldmaliaday2018.org/toolkit/>
32. Asenso-Okyere WK, Dzator JA. Household cost of seeking malaria care. A retrospective study of two districts in Ghana. *Soc Sci Med*. 1997;45(5):659–67.
33. Dunn CE, Le Mare A, Makungu C. Malaria risk behaviours, socio-cultural practices and rural livelihoods in southern Tanzania: Implications for bednet usage. *Soc Sci Med* [Internet]. 2011;72(3):408–17. Available from: <http://dx.doi.org/10.1016/j.socscimed.2010.11.009>
34. Accorsi S, Somigliana E, Farese P, Ademe T, Desta Y, Putoto G, et al. Gender Inequalities in Remote Settings: Analysis of 105,025 Medical Records of a Rural Hospital in Ethiopia (2005–2015). *J Community Health*. 2017;42(4):806–12.
35. P WL. Medical Education Singapore Med Focus group discussion: a tool for health and medical research [Internet]. Vol. 49, J. 2008 [cited 2019 Jul 28]. Available from: <http://smj.sma.org.sg/4903/4903me1.pdf>
36. Stalmeijer RE, McNaughton N, Van Mook WNKA. Using focus groups in medical education research: AMEE Guide No. 91. *Med Teach* [Internet]. 2014 Nov 29 [cited 2019 Jul 28];36(11):923–39. Available from: <http://www.tandfonline.com/doi/full/10.3109/0142159X.2014.917165>
37. Castro-Sánchez E, Chang PWS, Vila-Candel R, Escobedo AA, Holmes AH. Health literacy and infectious diseases: Why does it matter? *Int J Infect Dis*. 2016;43:103–10.
38. GSS. Snapshots on key findings Ghana Multiple Indicator Cluster Survey 2017/18. 2017;
39. Ghana Statistical Service (GSS). 2010 Population and housing census report - Urbanisation in Ghana. 2014; Available from: [http://www.statsghana.gov.gh/gssmain/fileUpload/pressrelease/Urbanisation in Ghana.pdf](http://www.statsghana.gov.gh/gssmain/fileUpload/pressrelease/Urbanisation%20in%20Ghana.pdf)
40. Ghana Statistical Service (GSS). 2010 Population and Housing Census Report - Migration in Ghana.
41. Anarfi JK, Kwankye SO, Ababio, Emmanuel Ofosu-mensah RT. Migration From and To Ghana: A Background Paper. 2010;(December).
42. Fielmua N, Gordon D, Mwingyine DT. Migration as an Adaptation Strategy to Climate Change: Influencing Factors in North-western Ghana. 2017;10(6):155–68.
43. Nyarko SH, Tahiru AM. Harsh working conditions and poor eating habits: Health-related concerns of female head porters (Kayayei) in the Mallam Atta market, Accra, Ghana. *Biomed Res Int*. 2018;2018.
44. Olapeju B, Choiriyyah I, Lynch M, Acosta A, Blaufuss S, Filemyr E, et al. Age and gender trends in insecticide-treated net use in sub-Saharan Africa: a multi-country analysis. *Malar J* [Internet].

- 2018;17(1):423. Available from: <https://malariajournal.biomedcentral.com/articles/10.1186/s12936-018-2575-z>
45. Tapera O. Determinants of long - lasting insecticidal net ownership and utilization in malaria transmission regions: evidence from Zimbabwe Demographic and Health Surveys. *Malar J* [Internet]. 2019;1–7. Available from: <https://doi.org/10.1186/s12936-019-2912-x>
 46. Auta A. Demographic factors associated with insecticide treated net use among nigerian women and children. *N Am J Med Sci*. 2012;4(1):40–4.
 47. Yamamoto S, Louis VR, Sié A, Sauerborn R. Household risk factors for clinical malaria in a semi-urban area of Burkina Faso: a case–control study. *Trans R Soc Trop Med Hyg* [Internet]. 2010 Jan 1 [cited 2019 Jun 23];104(1):61–5. Available from: <https://academic.oup.com/trstmh/article-lookup/doi/10.1016/j.trstmh.2009.07.003>
 48. Agyepong IA. Malaria: ethnomedical perceptions and practice in an Adangbe farming community and implications for control. *Soc Sci Med* [Internet]. 1992 Jul [cited 2019 Jun 6];35(2):131–7. Available from: <http://www.ncbi.nlm.nih.gov/pubmed/1509302>
 49. Amboko BI, Ayieko P, Ogero M, Julius T, Irimu G, English M. Malaria investigation and treatment of children admitted to county hospitals in western Kenya. *Malar J*. 2016;15(1):1–9.
 50. Sserwanga A, Sears D, Kapella BK, Kigozi R, Rubahika D, Staedke SG, et al. Anti-malarial prescription practices among children admitted to six public hospitals in Uganda from 2011 to 2013. *Malar J*. 2015;14(1):1–10.
 51. Malaria in urban and rural areas of southern Ghana: A survey of parasitaemia, antibodies, and antimalarial practices. *Bull World Health Organ*. 1984;62(4):607–13.
 52. Amoah LE, Nuvor S V, Obboh EK, Acquah FK, Asare K, Singh SK, et al. Natural antibody responses to *Plasmodium falciparum* MSP3 and GLURP(R0) antigens are associated with low parasite densities in malaria patients living in the Central Region of Ghana. *Parasites and Vectors*. 2017;10(1):1–9.
 53. Coene J. Malaria in urban and rural Kinshasa: the entomological input. *Med Vet Entomol* [Internet]. 1993 Apr 1 [cited 2019 Jun 23];7(2):127–37. Available from: <http://doi.wiley.com/10.1111/j.1365-2915.1993.tb00665.x>
 54. Byrne N. Urban malaria risk in sub-Saharan Africa: Where is the evidence? *Travel Med Infect Dis* [Internet]. 2007 Mar 1 [cited 2019 Jun 23];5(2):135–7. Available from: <https://www.sciencedirect.com/science/article/abs/pii/S1477893906000652?via%3Dihub>
 55. De Silva PM, Marshall JM. Factors Contributing to Urban Malaria Transmission in Sub-Saharan Africa: A Systematic Review. *J Trop Med*. 2012;2012:1–10.
 56. Febir LG, Asante KP, Afari-Asiedu S, Abokyi LN, Kwarteng A, Ogutu B, et al. Seeking treatment for uncomplicated malaria: Experiences from the Kintampo districts of Ghana. *Malar J*. 2016;15(1):1–11.
 57. Dalaba MA, Welaga P, Oduro A, Danchaka LL, Matsubara C. Cost of malaria treatment and health seeking behaviour of children under-five years in the Upper West Region of Ghana. *PLoS One*. 2018;13(4):1–14.

58. Tabuti JRS, Kukunda CB, Kaweesi D, Kasilo OMJ. Herbal medicine use in the districts of Nakapiripirit, Pallisa, Kanungu, and Mukono in Uganda. *J Ethnobiol Ethnomed* [Internet]. 2012;8(1):1. Available from: *Journal of Ethnobiology and Ethnomedicine*
59. Lamorde M, Tabuti JRS, Obua C, Kukunda-Byobona C, Lanyero H, Byakika-Kibwika P, et al. Medicinal plants used by traditional medicine practitioners for the treatment of HIV/AIDS and related conditions in Uganda. *J Ethnopharmacol* [Internet]. 2010 Jul 6 [cited 2019 Jul 16];130(1):43–53. Available from: <https://www.sciencedirect.com/science/article/pii/S0378874110002357?via%3Dihub>
60. Marais F, Minkler M, Gibson N, Mwau B, Mehtar S, Ogunisola F, et al. A community-engaged infection prevention and control approach to Ebola. *Health Promot Int*. 2016;31(2):440–9.
61. Paakkari L, Okan O. COVID-19: health literacy is an underestimated problem. *Lancet Public Heal* [Internet]. 2020;5(5):e249–50. Available from: [http://dx.doi.org/10.1016/S2468-2667\(20\)30086-4](http://dx.doi.org/10.1016/S2468-2667(20)30086-4)