



Research article

Social perceptions of malaria and diagnostic-driven malaria treatment in Burkina Faso

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ABSTRACT

Malaria is a parasitic disease, endemic in many tropical and sub-tropical countries. Malaria is a well-known disease, familiar to almost all people in endemic regions, as they or their family are regularly confronted with it; everyone in these regions has probably experienced the disease, at least once in their life. To investigate the social perceptions of malaria in Burkina Faso, including its diagnosis-driven treatment, we have conducted a survey in both urban (Saint Camille Hospital, Ouagadougou HOSCO) and rural (Boussé Hospital) areas. Fifty-six individuals, mostly representatives of the society variability, were surveyed by questionnaires and 2 focus groups were organized with traditional healers. In general, populations seem to have grasped the causes, symptoms and means of preventing the disease. However, the majority of interviewees make a marked confusion between malaria and dengue; dengue fever is considered like a severe form of malaria. The care modalities (modern and/or traditional medicine) are plural and the choice of therapeutic practice depends on both the socio-economic conditions and education level of the patient. Whereas some patients mark preferences for one type of medicine, others simultaneously recourse to both; for these, a medicine does not outperform the other and their combination multiplies the chances of a quick recovery. Whether for modern or traditional medicine, the diagnosis is considered very important for effective disease management. Modern medicine uses diagnostic tools based on light microscopy and immunochromatography (rapid diagnostic tests; RDT); traditional medicine has its own diagnostic logic but nevertheless recognizes modern medicine diagnosis to guide its therapy.

90 % of those interviewed first use modern medicine to seek an accurate diagnosis of their disease and thus to receive adequate treatment. Presumptive treatments are still widely prescribed and accepted by most patients who trust the judgment of their caregiver, not perceiving any benefit to an objective diagnosis. In front of a negative diagnosis, patient reactions are diverse, some accepting investigations for other diseases (45 %), others opting for self-medication (15 %), others resorting to traditional medicine (20 %).

All are unanimous in the importance of diagnosis and are in favor of in-development diagnostic technologies, provided these obviously meet the features of reliability, ease of use, availability and, of course, economical accessibility.

1. Introduction

According to the World Health Organization, almost half of the world's population is exposed to malaria, an endemic disease in many countries, with 92 % of exposed people in Africa with the highest death

rate (93 %) [1]. In Burkina Faso, in 2018, malaria is the second cause of medical consultations (31.7 %) after acute respiratory infections (35.5 %) [2]. In the country, although *P. falciparum* is the most frequent parasitic species, *P. vivax* and *P. ovale* are also present [3]; in the absence of systematic species identification, no reliable information is however

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available on species proportions. The victims mainly come from poor populations, the most vulnerable being under 5-years-old children and pregnant women. Being very widespread on the continent, malaria is perceived as a familiar and well-known disease [4], which raises a paradox. As much as this disease is "known", it remains lowly controlled by the populations, resulting in very high mortality rates. Indeed, the perceptions of malaria (cause, modes of prevention and treatment) within a given population considerably vary, depending on age, socio-economic level, living environment and level of education [5, 6, 7]. Questions related to malaria are part of a vast cultural and medical heritage, combining endogenous perception and modern health systems. Since the discovery of malaria transmission vectors, a vast system of prevention, methods of avoidance and treatments has been built around malaria, both in traditional and modern medicines. Thus, the therapeutic routes have become plural at community level [4]. Different medical systems and therapeutic options are proposed, each with its own therapeutic and symbolic coherence, creating competition, contradictions and, often, conflicts. Such a situation was summarized by the anthropologist Didier Fassin: "the patient quest for diagnosis and treatment appears to be the result of multiple logics, representation systems of the disease and its place in society" reported by Bibeau [8].

For many diseases, therapeutic choices and confidence in treatment are built by diagnosis efficiency and diagnosis-driven management of the disease; in this scheme, the cost-effectiveness-availability of a treatment and therapeutic saving time are often determining factors. By contrast, for malaria care and control, whereas the WHO's policy encourages diagnosis prior to treatment, the unavailability or material impossibility of diagnosis has led to a widespread "presumptive treatment" strategy (symptoms-driven treatment), despite its many limits. This policy has resulted in reducing people's confidence in the efficacy of modern medicine treatments that are inefficient when the etiology of symptoms is not malaria; this also resulted in countless useless treatments that probably contributed to develop *Plasmodium* resistances. The current WHO initiative "Test Treat Follow" [9] consists in treating only proven malaria cases, also implementing disease monitoring tools. Such a strategy can only be envisaged if the health systems of the concerned countries have access to diagnostic tests that are "robust", "sensitive, inexpensive and widely deployable in remote areas" [10, 11]. Our group has recently proposed a new technology to detect and quantify malaria pigment through its magnetic and spectral properties, an attractive possibility to develop an efficient diagnostic tool for malaria. In view of this development, it is important to consider the expectations and perceptions of the beneficiary populations towards a potential new diagnostic method. The beneficiaries are the patients (mainly pregnant women and children under 5) and the healthcare personnel (doctors, biomedical technologists, midwife) who play a high importance role in developing and respecting the guidelines for an efficient care [12]. This study was designed to assess the knowledge of populations on malaria, the care routes used and the expectations regarding a new diagnostic method and a diagnosis-driven selection of treatments.

2. Methodology

2.1. Study site and sampling

For this purely qualitative pilot study that aims to understand and compare the social perceptions of malaria and malaria management, two sites were selected in Burkina Faso, both in urban (Saint Camille Hospital in Ouagadougou HOSCO) and rural areas (Boussé Hospital). Boussé is located about 53 km from Ouagadougou (see Figure 1). The study took place from July 22 to 26 2019 in Boussé and from July 29 to August 03 2019 in Ouagadougou.

HOSCO (Ouagadougou) is a non-profit health care, hospitalization and paraclinical exploration establishment, headed by Camillian religious. HOSCO is staffed and organized through 9 health services: maternity, maternal and child health, laboratory, pharmacy, general pediatrics, new

pediatrics, neonatology, general medicine and specialized medicine with 20 specializations [13].

Boussé hospital in "Plateau Central" region represents a medical reference for more than 150,000 inhabitants, distributed into 5 municipalities (Boussé, Laye, Niou, Sourgoubila and Toeghin) (see Figure 1). The hospital presents a capacity of 47 beds and is equipped with a hematology counter, a cold chain, a mucus aspirator, two delivery tables, a gynecology office, two surgical aspirators and four private drug deposits [14].

For each study site, 56 individuals (5 modern health workers, 25 pregnant women, 15 people accompanying sick children, 10 men and 1 traditional healer) were interviewed, in addition to a focus group; in Boussé and Ouagadougou, the focus groups included 6 (4 men and 2 women) and 10 (7 men and 3 women) traditional healers, respectively. Focus group consisted in gathering several traditional healers around the same questions. Each traditional practitioner has the possibility to comment on the raised questions and on the answers of others. Compared with individual interviews, this approach makes it possible to collect relevant information in a short time. The interview guides are available as supplementary material. Thirty min were devoted to interviewing each health worker, 20 min to each patient and 2 h to each focus group.

2.2. Sociological survey

An introduction letter, explaining the objectives and needs of the study, was sent by mail to the 2 hospitals, one week before the survey. The interviews were conducted individually in either French, Mooré or Dioula, according to the preferences of the interviewee. Approached people were free to participate in the study or not. Equipped with the interview guide, the investigators made sure that each participant felt good and open to dialogue; they ensured that healthcare personnel was not present during interviews with patients, which might influence the patients' responses. The investigator was courteous, carefully listening to all statements; he refrained from interrupting or giving his opinion on any question to avoid influencing answers.

2.3. Data analysis

We opted for a manual counting, which consisted in organizing and classifying the responses of the interviewees in an Excel workbook, from which tables of responses correlations were deduced, according to the different profiles interviewed.

The collection and use of personal data were conducted in accordance with the principles of anonymization as set out in the Helsinki Declaration (World Medical Association, 2013) [15].

3. Results

3.1. Beneficiaries (patients)

3.1.1. Personal information

The study population represents the ethnic diversity of the study regions. Compared to Boussé, Ouagadougou, as a town, gathers several ethnic groups and so presents a higher diversity in ethnicity. Most of the persons concerned by this investigation were living in a conjugal relationship; marriage, customary, religious or civil, has effectively a strong cultural symbolic value, notably socializing pregnancy. The pregnant women in our study were between 18 and 38 years old. People accompanying sick children and men were between 21 and 56 years old. In Boussé, about 60 % of the interviewed people were illiterate and the others had reached the second cycle of high schools. In Ouagadougou, 20 % of interviewees were illiterate, 4 % had a university level and the rest had the second cycle of high schools. In Boussé and Ouagadougou, 16 % and 30 % people worked in the formal sector, respectively; the rest had activities in the informal sector (trade, sewing, hairdressing, art, driver etc.) and the housewives were numerous among the women. Traditional



Figure 1. Study areas of the sociological survey. A: geographic location of Burkina Faso. B: the study sites, Ouagadougou and Bousse. C: the 5 municipalities of the city of Bousse.

healers were also cultivators. Educational level and activity sector are summarized in Figure 2 A and Figure 2 B respectively.

3.1.2. Therapeutic logics and recourse to remedies

(Note: in this section, the answers obtained from Bousse and Ouagadougou are regrouped).

There are many variations in terms of pathways of care, depending on several factors, economic, social and personal.

3.1.2.1. Levels of knowledge on malaria and malaria etiology

3.1.2.1.1. Malaria signs and symptoms. In general, the symptoms that the respondents attribute to malaria are: cold feeling, stomach pain, bloating, yellowish vomiting with a very bitter taste, diarrhea, fever, headache, dizziness, chills, sweating, body aches, joint pain, muscle paralysis, general fatigue and drowsiness, poor appetite and weight loss, yellow or very pale eyes (white), yellow discoloration of urine, and hypertension. When it concerns children, the baby cries a lot and his temperature rises. Figure 3A shows the percentage of citations for the different symptoms.

3.1.2.1.2. Malaria causes and transmission modalities.

a. Natural causes

Most people (90 %) know that mosquitoes are the vectors of the disease and educational campaigns have played a part in this. For others respondents (3 %) however, malaria is a much more complex phenomenon: “it is said the mosquitoes transmit malaria, but weird thing is that we get malaria in the dry season when there are no mosquitoes, it is difficult to understand”. For the latter, mosquitoes are more numerous in rainy seasons and it is the number of bites that will cause the occurrence of malaria and not the act of biting itself. A part of the respondents (15 %) do not believe that mosquito bites are the only cause of the disease; according to them, even people who respect good hygienic conditions are affected and seeking to suppress the water puddles larval niches is useless, the causes of malaria being elsewhere: “even the people who live in large houses and are very clean around them, also have malaria”. It should not be overlooked that some of the respondents (3 %) ignore the causes of malaria or have been silent about this issue. So, although malaria is a familiar and supposedly well-known disease, some people still ignore its causes. The main causes associated with malaria according to the respondents are recorded in Table 1.

We note here that, in the collective mind of most people (90 %), the mosquito is the vector of malaria. Other factors are of course linked to the transmission of malaria; indeed, when the respondents speak of “dirt” in general and “dirty water” as a mode of transmission of malaria, they identify here the conditions favorable to the development and spread of mosquitoes. However, other factors cited such as heat, consumption of cucumber or shea do not have proven scientific significance, but they are cultural norms that are passed on between generations; these certainly indicate a confusion between malaria and other diseases.

b. Malaria supernatural causes

Evoking unnatural causes related to malaria is often done with caution. There are, however, 18 % of people have claimed that, besides the mosquito, other “forces” can cause malaria, as pointed out by a pregnant woman: “wizards and geniuses can cause malaria, they use various

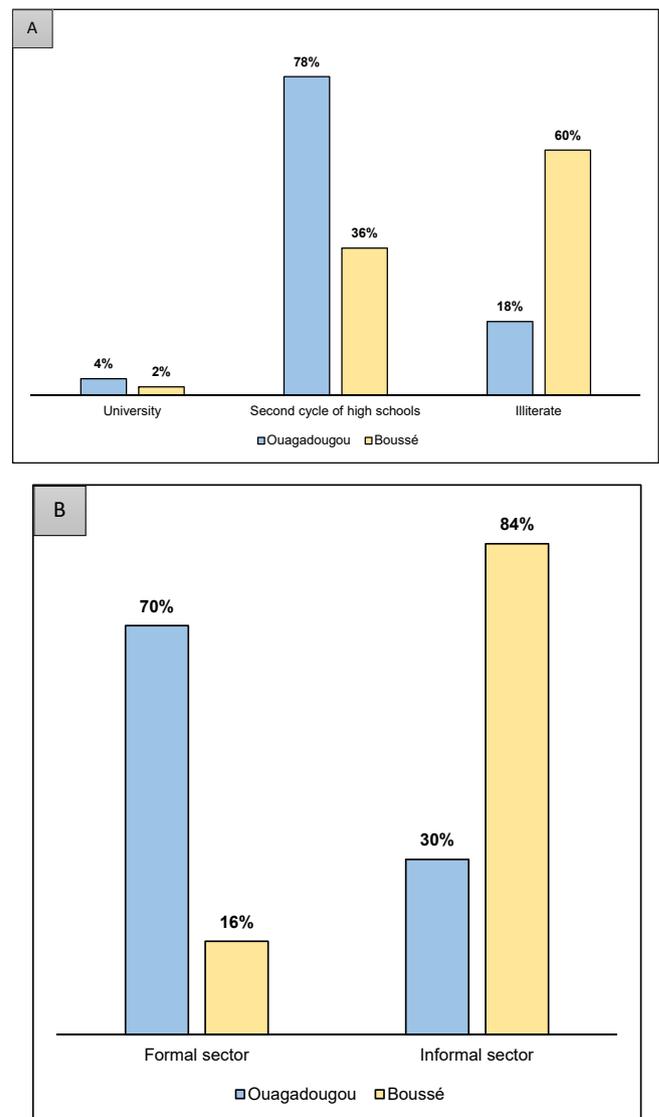


Figure 2. Demographic data on the interviewees who participated to the study. A: educational level; B: activity sector.

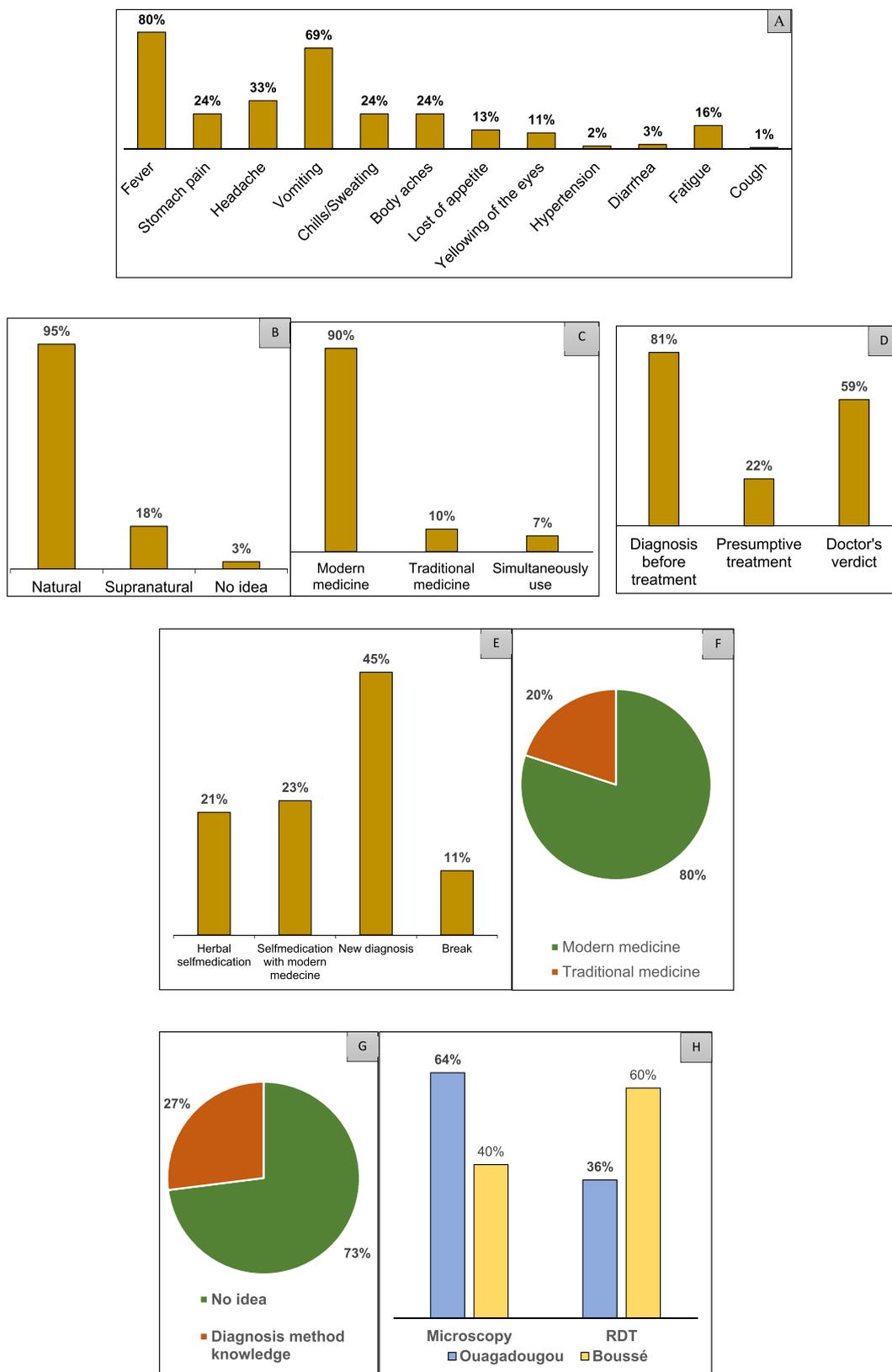


Figure 3. Proportions of responses for the questions raised. A: malaria symptoms; B: malaria causes; C: first medicine used in case of malaria; D: diagnosis priority for respondents; E: in case of negative malaria diagnosis test with symptoms, peoples have different behavior; F: among people who choose a new diagnosis in E, they use modern or traditional medicine; G: respondents knowledge about diagnostic means; H: difference knowledge between microscopy and RDT in rural and urban area.

Table 1. Summary of "knowledges" reported on malaria by beneficiaries (Note: multiple answers were allowed for all questions).

Cited causes and transmission vectors	Cited types of malaria	Cited prevention tools
Collected on both locations		
<ul style="list-style-type: none"> mosquitoes (90 %) Boussé: 94 % Ouagadougou: 86 %	<ul style="list-style-type: none"> simple malaria (25 %) called "weogo"¹¹ with fever and vomiting and body aches Boussé: 16 % Ouagadougou: 34 %	<ul style="list-style-type: none"> sleeping under a mosquito net (94 %) Boussé: 92 % Ouagadougou: 96 %
<ul style="list-style-type: none"> dirt and dirty water (20 %) Boussé: 14 % Ouagadougou: 26 %	<ul style="list-style-type: none"> severe malaria (6 %) Boussé: 4 % Ouagadougou: 8 %	<ul style="list-style-type: none"> covering the body especially in the rainy season and protect babies by dressing them with loose clothes (7 %) Boussé: 4 % Ouagadougou: 10 %
<ul style="list-style-type: none"> bad fatty food (7 %) Boussé: 12 % Ouagadougou: 2 %	<ul style="list-style-type: none"> malaria-dengue (23 %) Boussé: 24 % Ouagadougou: 22 %	<ul style="list-style-type: none"> burning mosquito coils (pyrethrum) in houses, spraying insecticides in bedrooms, burning baobab leaves and roots to keep mosquitoes away (21 %) Boussé: 24 % Ouagadougou: 18 %
<ul style="list-style-type: none"> cold (10 %) "<i>when the rain beats you frequently, that gives you cold and this is beneficial for malaria. It makes you cold and your body becomes weak</i>" Boussé: 12 % Ouagadougou: 8 %		<ul style="list-style-type: none"> taking anti-malarial drugs for prevention, for example, for pregnant women, sulfadoxine-pyrimethamine (5 %) Boussé: 2 % Ouagadougou: 8 %
<ul style="list-style-type: none"> supernatural causes (18 %) Boussé: 20 % Ouagadougou: 16 %		<ul style="list-style-type: none"> draining stagnant water; i.e. "<i>being clean around you by sweeping your yard</i>" (42 %) Boussé: 34 % Ouagadougou: 50 %
		<ul style="list-style-type: none"> avoiding eating bad fatty food (7 %) Boussé: 12 % Ouagadougou: 2 %
Collected only in Boussé		
<ul style="list-style-type: none"> excessive consumption of shea (12 %) 	<ul style="list-style-type: none"> yellow malaria (8 %) which makes coloring eyes in yellow "<i>it is less dangerous, it is very easily cured with tablets, injections and decoctions of medicinal plants</i>" 	<ul style="list-style-type: none"> avoiding eating too much shea (12 %)
<ul style="list-style-type: none"> consumption of cucumber (6 %) 	<ul style="list-style-type: none"> white malaria (6 %): "<i>it is when malaria lasts in your body for long time</i>". It does not make eyes yellow, but is very dangerous: "<i>when you have it you have nightmares, you dream a lot; for treatment, it is necessary that the doctor is well informed the patient should not be injected otherwise he dies</i>" 	<ul style="list-style-type: none"> reducing the consumption of coffee and cigarettes as this weakens the body and is favorable for malaria; washing hands each time you leave the toilet, return from the field or from dirty work (6 %)
<ul style="list-style-type: none"> unhealthy food (6 %) "<i>when you don't wash your vegetables before cooking them</i>" 		<ul style="list-style-type: none"> protect yourself from the sun and the heat (12 %)
<ul style="list-style-type: none"> heat (12 %): "<i>when I speak of heat, I mean the sun and the fire, when you are always around big fires to prepare either dolo or food</i>" 		<ul style="list-style-type: none"> praying: "<i>It is God who protects, and everything is done according to him</i>" (4 %)

ways to give a fever and paralyze your activities; it will be said that you have malaria, however it is supernatural forces that are thrown at you". Another adds that: "it is possible to put a spell on you in the form of malaria". So, for some people, the mosquito can be just an instrument used by certain evil forces "because wizards can turn into mosquitoes". The mosquito fulfills in these cases a mission, that of transmitting the evil to destroy physically and spiritually. In these cases, management in modern health center may not be helpful. These words go in the same direction "the sorcerers and the geniuses can give malaria; these supernatural forces can cast a spell on you and the cause of your illness is unknown; the exams and the doctor will say that it is malaria but it is not". For many, "natural" malaria can be easily treated in a health center "because when malaria is a natural disease, doctors will be able to treat me; but if it is not natural, I will not be cured, and I have to use traditional medicine²".

Malaria can thus be associated with interventions of gods or of malicious people through geniuses, sorcerers. In these cases, compliance with the care and recommendations of traditional practitioners is considered as best indicated. In Burkina Faso, traditional therapy is in fact a vast field which encompasses both basic cares based on herbal medicines, but also various practices combined with several substances and products, notably plant decoctions, esoteric mixtures called "black powders", incantations, etc. Quite often, a combination of different therapeutic practices is considered to overcome diseases. Figure 3B shows the frequency of natural and supernatural causes of malaria.

3.1.2.1.3. Different variants of malaria. Most of our interviewees (80 %) suggest different typologies of the disease, with a marked confusion between dengue and malaria (23 %): "I know 2 types of malaria: there are malaria-dengue and simple malaria; simple malaria is manifested by fever, headache and sometimes vomiting; for malaria-dengue, there is a high fever, blood vomiting, the blood leaves the nostrils" or "malaria-dengue is more dangerous than simple malaria; malaria-dengue is manifested by bloody diarrhea, nosebleeds, fever and vomiting". For others, there are several types of malaria even if they cannot name them and the distinction is made through the symptoms (12 %). Table 1 summarizes the "rich" repertoire of malaria types according to the respondents. People's appreciation of the different types of malaria is varied but highlights that there are generally two types of malaria: "simple malaria" and "severe malaria". Several complications related to severe malaria emerge as "yellow malaria", jaundice, seen in approximately 2.5 % of patients as a sign of massive hemolysis and liver problems [16], and "white malaria", with anemia, altered consciousness and convulsions.

3.1.2.1.4. Means for malaria avoidance. The prevention tools mentioned by the communities are varied, as recorded in Table 1. Most people are aware that the living environment must be cleaned up to prevent the mosquito's proliferation. Mosquito net distribution campaigns organized every year for the population probably largely contribute to this knowledge on the management of the disease [17]. Despite the reported efficacy of impregnated mosquito nets [18] the still-alarming malaria statistics indicate a probable limit in terms of distribution and good use practices, so that the coverage of people at risk remains largely imperfect; available partial data indicate that the use of these measures results in a reduction of the premunition to malaria [19] and therefore higher severity of infections for lower parasitemia.

3.1.2.1.5. Malaria severity. At this level, unanimity exists on the appreciation of the gravity of malaria which is generally appreciated through the notion of "death"; this is especially the case for pregnant women (40 %) who express themselves in these terms: "associations and doctors have said malaria isn't a joke; malaria can be a cause of miscarriages and also death of mothers if it is not treated; malaria is a very dangerous disease because if you don't go quickly to the hospital you can die from it; with malaria poorly treated or not treated in time, there is a risk of miscarriage, or low birth weight; it's a disease that kills adults and can lead to stillborn baby".

Some of interviewed men (60 %) have the same idea on malaria severity: "malaria can weaken and kill; many people die from malaria without knowing it; it is a deadly disease, not to be overlooked and it is important to find a vaccine; malaria becomes serious when it is neglected or when you first recourse to traditional medicine with wrong management formulas, the consequences are the risk of abortion in pregnant women; premature delivery; low birth weight babies; stillborn babies; mother death and economic handicap".

Most of our interviewees (75 %) recognize that untreated or ill-treated malaria can quickly progress to death. Here also, awareness-raising campaigns play an important role in people knowledge on malaria severity, an important step forward in the fight against malaria. Another remark that emerges from these data is that, for some of our interviewees (70 %), traditional healers do not provide a correct management of malaria during pregnancy because "they don't know a correct formula". Thus, all interviewed pregnant women (100 %) prefer a hospital management of their pregnancy. Given that we conducted our interviews in hospitals, there is a definite possibility of bias for this assumption that should be evaluated by a larger survey. Emphasis is also placed on the development of a malaria vaccine, since prevention methods (impregnated mosquito nets) are not considered satisfactory in practice.

3.1.2.2. Choice of modern medicine or traditional medicine as a first therapeutic option. Even if the education level is often considered as a basic explanation for the choice of modern medicine as a first therapeutic option, our survey indicates this is not a determining marker in the choice of care.

In the rural hospital of Boussé, 92 % of interviewed women claim to use modern medicine as a first therapeutic line, often associated with "home medicine"³. This choice is partly justified by the numerous awareness-raising campaigns directed to women: "we use modern medicine because of health associations sensibilization for using Health Care Center. It is said that this can help, especially in our state of pregnancy to keep our baby healthy". Indeed, malaria is a cause of low weight at birth and is associated with significant risks of prematurity [20]. Another element of justification is "confidence" for more than 50 % of women: "because I have more confidence in the products and treatments of the hospital". Confidence is justified by modern diagnostic techniques and the effectiveness of care, through the control of dosage. According to women, control of the dosage is essential for the survival of their baby: "I prefer modern medicine because of its good drug dosage, even if we have some undesirable effects". Confidence, according to pregnant women, can also be explained by the possibility to prevent a worsening of the disease. For these women, in contrast to traditional medicine, modern medicine has the tools to alleviate complications during pregnancy, ultimately providing, if needed to save the child and the mother, a cesarean. Most of pregnant women justify their choice: "the price of drugs is affordable and, even if it is expensive, you will recover; also, we have more listening here, more help and follow-up". At this level, supervision and follow-up are mentioned; hospital consultations follow pregnant women during pregnancy and, in principle, the child after birth. During our investigation, we met women who attended prenatal consultation and others who were new mothers coming for newborns consultation and weighing. The proximity to the health center is also a reason for consultation: "I live just behind the hospital; I am not far from Boussé hospital; I live right next to it". In fact, this health center proximity is positive on the patient's economic activity, avoiding impacts of distance on time loss.

In urban area, the practices are not so different. Interviewed pregnant women (100 %) claim to use modern medicine as a first option, based on confidence in services and accessibility to facilities. In town, the care pathways are effectively characterized by the proximity and availability of health facilities and modern medicine; most interviewees (88 %)

¹ In mooré, local language.

² Spiritualists and ritualists are considered as traditional healers [40].

³ Use the rest of medication from a previous episode of malaria, medication based on your own knowledge.

appreciate the efficiency and quality of healthcare and the presence of specialists greatly comfort them. At the hospital, they consider possible that a correct diagnosis is made: “I consult a health center, I prefer that; the reason is that I don't know what the baby is suffering in my belly or what I really suffer from, the doctors can tell me”. In town, modernity justifies the therapeutic choices: “in case of fever I consult a health center for the simple reason that we are in a modern world and we have to adapt our practices”. Modernity implies the availability and access to modern means of diagnosis, care and therapy. Numerous awareness-raising sessions are regularly held in the goal to encourage people to attend health centers, especially pregnant women and children. 90 % of interviewed pregnant women state not to seek traditional healers in the event of illness while 5 % of pregnant women and people accompanying sick children⁴ view traditional medicine as a preventive medicine: “I use the plants of traditional medicine to wash my child even if he is not sick because they often have good products, this protects the newborns against possible diseases”. The interviews being conducted in hospitals, a possible bias for these assumptions should be confirmed by a larger survey.

In our discussions, it emerged that some of the respondent men (30 %) turn towards traditional medicine for certain conditions such as sexual weakness, fractures or lymphatic filariasis. According to interviewees (25 %), the population still widely recurs to this medicine, considered a precious and powerful therapy for diseases difficult to treat by modern medicine. Traditional medicine is then considered an auxiliary medicine: “I call on traditional healers in case modern medicine cannot cure my pain”. Indeed, for them, there are “easily curable diseases” that modern medicine can diagnose and treat and “diseases undetectable” by the devices of modern medicine, better managed by traditional medicine. In total, 90 % of respondents use modern medicine first in the event of illness, compared to 10% for traditional medicine; and 7 % use both medicines together (Figure 3C).

In general, for both living environments, our interviewees indicate that modern medicine is sought for conditions such as malaria, tuberculosis, sickle cell anemia, yellow fever, bronchitis, diarrhea, migraines, dental pain, sexually transmitted infections (STIs).

Some differences emerged between the two health centers. Firstly, Ouagadougou city is characterized by the presence of a diversity of public and private health centers. For patients, this offers the possibility of a wider choice of medical care (medical equipment, specialists) and some “medical shopping” is possible. This contrasts with Bousé in which the access to care is very limited; when financially and medically feasible, it is common for rural regions patients to be referred to hospitals in Ouagadougou for specialized care; this is an important aspect to be considered so that all social strata of the population could have the same chances for quality care. Secondly, the educational level influences the perceptions of the populations concerning the choice of a therapeutic pathways. In Ouagadougou, most of interviewed participants had a higher level of education compared to Bousé. The educational level certainly impacts knowledge of diseases, causes and treatment means but the choice of first-line medicine depends more on the financial resources and beliefs (natural or supernatural cause of the disease) of the patient. A bias likely exists into this study because the patients were all enrolled in a health center. This could explain why most of them claim to use modern medicine as first-line medicine. A more in-depth study has to be planned in the future to sample populations apart from health centers. This approach will provide an overview of therapeutic routes selection by the general public.

3.1.2.3. Association of different medicines. Interviewed patients systematically indicate that, during an episode of illness, communities tend to combine modern care and traditional medicine. Medicines prescribed by doctors are associated with plants bought in markets, according to a prescription from a traditional healer (“traditional medicine”) or to own knowledge of the patient (“folk medicine”). Some interviewees (7 %)

confirm this: “I always come first to the hospital; now if it does not go well I go to the traditional healer who, based on the results of the hospital exams, will quickly find a drug for me”, “we can later associate herbal teas with doctor's drugs prescription”, “after the hospital diagnosis, we combine the medicinal plants”. For many people (7 %), a traditional healer or a doctor cannot cure all diseases and so, the combination of medicines multiplies the chances of recovery. Some women say: “I use modern and traditional medicine. I went to school, that's why I like modern medicine because I know its importance. But my husband uses traditional medicine because he knows a lot of plants”.

In Mossi culture, although women are under the authority of men, the wife tends to select care pathways for her and her children, which can be difficult: “I consult a health center when my husband is absent, I run quickly to go and get treatment and come back; but if he is there, I treat myself with what he gives me and my children too. It is himself who rub the body of a suffering baby with a black product”. Men state to have pragmatic strategies: “If the symptoms are not very serious (fever, migraines) we start with traditional medicine and if the condition does not improve, we must go to the hospital. In addition, I well know the leaves and I will collect them by myself”. In Moaga country and among the Mossi, the men, as “zaksoaba”⁵ responsible for their families, have knowledge in therapy, acquired from their parents, to provide first aid to family members who are under his authority: drinking potions, amulets buried in the courtyard or at the entrance to concessions and houses, leftover drugs from previous malaria access, or drugs found in local markets and pharmacies. This is conditioned by the therapeutic inspiration of the moment, the individual and personal knowledge and the availability of plants: “according to the signs, I go first to the pharmacy and if it does not go well I go to consultation in the hospital”; “in case of malaria, I buy the drugs in pharmacy and, if I do not recover, I will consult a traditional healer; if there is still no improvement I go to the hospital, the hospital is the last resort; it is for lack of resources that I do not go directly to the hospital”; “I go to hospital but before, I treat myself with my knowledge of the products, I buy artemether in pharmacy”; “I first use domestic medicine with the rest of the medicines I have at home; if it is me I take Efferalgan⁶ and if it is the child I give him acetaminophen syrup; if the disease persists, then I go to the hospital for a consultation, this is an habit when the product is available at home”. Many drugs are sold at the pharmacy without a prescription, making them easy for the patients to obtain. For some people (11 %), some symptoms (“headache, cough, cold”) do not necessarily deserve to go to the hospital because they are considered as not severe and easily treated. With a supposed experience of diseases, people believe they “master” the drugs of common diseases such as malaria as “the same products that are taken at home are those given in the hospital”. Since malaria is most often associated with fever, self-medication is a general first-line measure. In urban areas, this is justified by the availability and easy access to medicines and products. Self-medication justifies somewhere a desire for independence and sovereignty [7].

For all our interviewees, neither modern medicine nor traditional medicine can cure all diseases. For certain diseases (malaria, injuries, gastric pain, persistent migraines) modern medicine is best indicated; for others, such as mycosis, traditional medicine is rather sought. A pregnant woman in Ouagadougou said: “I use modern medicine for all kinds of illnesses except children mycosis whose very long management is better in traditional medicine.”. Traditional medicine is considered to overcome problems like madness, supernatural and mystical diseases. In general, traditional medicine is a rescue medicine, a medicine that often relieves when hopes are lost: “It is when the hospital cannot cure that I turn to traditional healers”.

3.1.2.4. Therapeutic quality in modern health center

3.1.2.4.1. Importance of diagnosis before treatment. In medical consultations, communication remains an important diagnostic tool: “in the

⁴ All the people accompanying sick children in our study were women.

⁵ Owner and responsible for the house and all the people who live there.

⁶ Local brand of acetaminophen.

Health Center, at the hospital, the health worker is interested by the patient's history and prescribes a medicine; the health worker asks questions to find out the patient's clinical history, then does a blood exam before giving a prescription to pay for the drugs; in a consultation in modern medicine, the doctor asks questions to find out the patient's clinical history, the weight, the body's temperature, performs RDT⁷ exams and then prescribes the products". For most of respondents (81 %), the act of blood analysis remains important for the patients, a reassuring process: "for treatment in the Health Center, doctor first draws my blood for exam; that tells us if it is malaria or not and, after this, he prescribes me medication and that reassures me". Whereas most of the respondents have no precise idea of the exams that are carried out, diagnosis based on blood sample is considered as imperative for better management of the disease, as a guarantee that they will be well cared for, as a reassuring measure and as a route to diagnosis acceptance. Diagnosis-driven treatment is preferable for all of the respondents as the only way to discover the origin of the disease: "I prefer treatment under diagnosis, so that the doctor discovers all my ills, he discovers the real disease; in the past I suffered from muscle pain, fever and vomiting; I thought it was malaria and when the doctor made a diagnosis this revealed to be typhoid". For the patient the blood test makes the major difference between modern medicine and traditional therapy; sometimes even, results of blood tests are used by the traditional healers to initiate a treatment. This highlights the importance that patients place on diagnosis for the assurance of being treated for the real harm they are suffering from.

Nevertheless, presumptive treatments are still considered highly relevant, and many interviewees (22 %) have pointed out: "last year, I had malaria, the doctor gave me a treatment without diagnosis and I have not recovered; and when I underwent diagnosis in another hospital, I was in fact suffering of dengue". Or again: "it is a habit for doctors to prescribe medicines and ordering to start treatment without exam, they take the temperature and prescribe you drugs; when you are not cured and you come for the second time, then they perform a RDT". This reminds us that, even if the WHO directives recommend an examination before any treatment, presumptive treatment can still be customary. Most often, the presumption is based on the classic but non-specific symptoms of malaria, namely fever, and on environmental conditions; many healthcare workers believe they recognize the disease because they face it regularly. Indeed, in Burkina Faso, the rainy season (June–September) is the peak period of malaria and most fever cases are probably malaria; but fever occurs in many parasitic, viral and fungal infections and only a differential diagnosis can precise the adequate care.

Even if the patient does not endorse the principle of presumptive treatments, he depends on health workers, who suggest the exams to be made and prescribe the treatment; the patient rarely finds the need or the courage to ask by himself for a diagnostic test: "once I asked for the test myself, but the nursing staff did not accept this coming from the patient; they say the patient wants to show them how to work", "the doctors don't like it, it's like doing their job for them", "once I asked for a test, but they told me there was a rupture of RDT, I preferred to follow the presumptive diagnosis". 59 % of patients affirm to accept the doctor's verdict. Figure 3D present the importance of diagnosis for the respondents.

3.1.2.4.2. "Malaria" treatment upon a negative diagnostic test. After a negative diagnostic test, the situations are different according to the categories of people. Pregnant women, whatever the result, receive a treatment: "the midwife gave me a prescription of iron and other products", "the doctor gave me a prescription to relieve my pain or antibiotics", "when the diagnosis is negative, the doctor nevertheless prescribes iron, vitamins and other products". Some health workers suggest additional tests in negative diagnostic cases, according to the patient's financial resources: "the doctor performs symptomatic treatment, he prescribes Efferalgan® or acetaminophen to treat the fever and suggests typhoid exam in case of vomiting".

In front of a negative malaria diagnosis, when no treatment is offered, some patients engage anyway in malaria self-medication (street medicine, domestic care, folk and traditional therapy) or pursue a further confirmation of their presupposed diagnosis, because of social representations of this familiar disease for which a certain therapeutic knowledge is common (Figure 3E):

- In terms of folk and traditional therapy, some (21 %) say: "I go home and do self-medication: I look for leaves in the bush such as neem (*Azadirachta indica* A. Juss.), kôhôsafanè⁸ (*Vernonia colorata* (Willd.) Drake) and papaya (*Carica papaya* L.) that I use as a decoction and wash my body with; if it does not work, I will see my traditional healer". Another adds (20 %): "I turn to the traditional healers' more affordable and more available pharmacopoeia". They consider that plants can cure⁹ even if modern medicine fails to confirm their suspicion of disease.
- In terms of self-medication, some (23 %) say, "I know other ways to have medicines; I'm going to buy the street drugs" or "I prefer to pay for a new drug at pharmacy or take an old drug that was at home or street drugs, but there are expired drugs so you have to be careful". They have in mind that the drugs should not be expired, and they seek the same drugs that would be prescribed in hospital for malaria or fever.
- In terms of further "confirmatory" tests, 45 % of the respondents indicate they seek another health center (80 %) or a traditional healer (20 %) for new consultation (Figure 3F). This attitude is more common in urban areas (52 % vs 38 % in rural areas) because infrastructures and healers are within reach; there is indeed a wide choice and some interviewees (12 % in Ouagadougou and 5 % in Boussé %), according to their financial resources, even prefer to attend private clinics for this second diagnosis. This indicates a high importance of diagnosis for these patients; in the case of a negative diagnosis, the patient wishes a therapeutic guidance so not to be left to himself.

3.1.2.4.3. Perceptions of new malaria diagnostic technologies. People have vague ideas about the technologies used to diagnose malaria (Figure 3G). Most of them (73 %) are completely unaware of these tests. RDTs are more known than microscopy at Boussé (60 %) because they are more used locally, compared to microscopy (40 %). But for Ouagadougou, RDTs are cited by 36 % and microscopy 64 % (Figure 3H). Pregnant women affirm this: "I only know RDTs, doctor pinch the finger with a syringe, pass the blood on an object and after a moment he gives the result", "I do not know, I just know that the doctor takes blood but I don't know what he does with it", "yes I know the RDT and the thick blood smear; for RDT doctor takes my blood from the finger; he puts on a plate; after a few minutes he gives the result; for thick blood smear he takes my blood and goes back to the laboratory, but I don't know what happens next". It appears here that the action of "carrying out the exam" is more important to the patients than the name and principle of tests. For our interviewees, the essential parameters for new diagnosis technologies reside:

- in the rapidity of the test: "for RDT, it lasts about 15 - 20 min, on the other hand the other exams in the laboratory can last up to 5 h", "thick blood smear takes time: doctors can draw the blood in the morning and results are available in the evening, it is too long". A new method should be fast "to avoid death because if time is shorter, this implies a shorter waiting in hospital, earlier disease management so we can do something else (economic activity)"
- in the reliability and quality of the exams: "the actual tests are not very reliable, there are false negative results when the patient has already taken medication; in my case the RDT is always negative and the confirmation is done with the thick blood smear which is very often positive; but however

⁸ Name in local language.

⁹ In literature, antiplasmodial activities have effectively been reported for *Azadirachta indica* A. Juss [47], *Vernonia colorata* (Willd) Drake [48] and *Carica papaya* L [49].

⁷ RDT = Rapid diagnostic test, a rapid immunochromatography method to diagnose malaria.

they still make us follow the treatment on the basis of RDT and if the condition does not improve and we return to the health center, there the doctor will prescribe a thick blood smear"; "I find that RDT is not reliable and in addition the thick blood smear can also be negative while the child has all the signs of malaria, which makes me doubt of the result"; "with RDT tests, you have to be careful because it is not exact, the test can reveal that you do not have malaria while you have it"; "the new test has to be more reliable than RDT and I want it to be a 100 % reliable test; what is new must be at least as efficient as what exists".

- in the availability of the test: "in rural areas, the laboratory closes at night and for emergency cases it is impossible to make the thick blood smear, we want a method that can be used at any time". A new diagnostic test also increases the range of choices in techniques: "too much meat does not spoil the meal; I believe it would be good because there will be a lot of methods for diagnosing malaria and the patient can choose the diagnostic test and also this will allow several working tools to laboratory technicians".
- in the effectiveness and cost of the tests "if the method is effective, confidence will be established". Cost is an essential element. RDTs are subsidized and so practically free in many cases. In Burkina Faso, for pregnant women and children under 5 years old, RDTs and medicines are free, thanks to government subsidies. This free service is only effective in public health centers but obviously influenced by the available stocks. Women report that it very often happens that there is a shortage of medicines, so they are obliged to spend money to get them from outside pharmacies. They are calling for a regular supply through public pharmaceutical stores. According to respondents, a microscopy analysis costs between 1000 and 1500 francs CFA (i.e. 1.7 to 2.5 US\$) in a public or private health center, respectively. Interviewed people say they are favorable to the introduction of new technologies in the management and diagnosis of malaria. They are not opposed to technology, but they want the new technology also free of charge and this is a determining factor for their adhesion: "apart from emergency cases, I will choose the free method even if it takes much more time" or "free tests already exist and if you want to introduce something new, it has to be made free or very affordable".
- in a confidence in obtained data, which therefore depends on the results and their acceptance. Confidence is very important but, for about 25 % of people, in majority men: "I do not fully trust the white technologies because they send in Africa everything that is not good, the machines can be faulty"; "we generally have old equipment in our laboratories".

For another people the device must be able to give hemoglobin and white blood cells level, which inform about other the status of the patient and eventual infections, respectively, and to propose a therapeutic strategy.

The expectations are therefore numerous for an eventual new diagnostic device, even if interviewees are rightfully circumspect: "I cannot say anything, it is difficult because I do not know the new device". To prove its value, the device must be available, and, to clearly define its performance, analyses must be carried out comparatively to routine methods on patients with widely different levels of parasitemia.

To collect the opinion of beneficiary population is very significant. Indeed, such study can measure the level of knowledge of the questioned populations on malaria: causes, treatments, means of avoidance. Our results highlight it may be necessary to provide them more information about the disease. For example, for the most participants, mosquito bites are the main cause of malaria. A very small proportion mentions transfusion and congenital malaria. To integrate these aspects in the information provided to the populations in the future represents a key issue. According to the conclusions of the survey on malaria indicators 2017–2018, 40 % of women say to receive information about malaria in a health center, against 31 % on the radio and 11 % on television [21].

Also, during this study, some participants affirmed to appreciate our approach to communicate on what we are doing and specially to query for their opinions. They sense a positive feeling. It will also help to increase trust and collaboration between doctor and patients.

3.2. Modern health professionals

3.2.1. Perceptions on the technical aspects of laboratory diagnostic methods

The diagnostic methods used for malaria at Boussé hospital and at HOSCO are RDTs and light microscopy (thick and thin blood smear). RDTs are most often performed by the nurse, doctor or midwife in the consultation room; all health workers receive basic training in the use of RDTs, according to the Director of Boussé hospital. The blood smears microscopy is performed in laboratory by trained biomedical technologists (TBMs), university-educated senior health technicians qualified to practice microscopy. The thick blood smear confirms the presence of the parasite and the thin blood smear allows identification of plasmodial species, with semi-quantified parasitemia (generally expressed as +, ++ or +++). All the TBMs (100 %) have strong reservations about the RDTs reliability compared to microscopy: "for a hospital laboratory, a positive RDT means nothing as it may correspond to a negative thick blood smear; and for a negative RDT, the corresponding thick blood smear can be strongly positive". At HOSCO, some nurses (50 %) share this opinion: "before we performed RDTs here during the consultation for pregnant women, but not anymore because RDTs are not reliable; it happens that the same sample yields positive and negative data on two RDTs ran at the same time". Although it is true that there are no major difficulties in RDT handling, the sensitivity of (previously) commercialized devices can be very different [22, 23, 24]; it is possible that wrong results obtained with low-performances, low-quality or ill-conserved devices have discouraged their use [25]. Also many RDTs detect the *Plasmodium* histidine-rich protein 2 (HRP2) and are lowly effective in zones infected with HRP2(-) parasites [25]; and the persistence of HRP2 after clearance of infection leads to many wrongly positive results [26, 27]. RDTs are useful [28, 29] but their use must be correctly regulated [30].

3.2.2. Difficulties and points to improve for routine techniques and expectations for an eventual new device

The technical working conditions (permanent accessibility to electricity, condition of the premises, condition of the equipment) imply cautions. The RDTs can be stored at room temperature, which is ideal, but they are sensitive to variations in environmental conditions, as stated by the medical director of Boussé hospital: "humidity, dust can have impacts on the validity of a RDT"; improving their robustness, i.e. their sensitivity to conditions of storage and use, are considered important steps to enhance efficiency. In Boussé, malaria remains a major cause of consultation with peaks during August. For 2018, 17,108 suspected cases of malaria with fever were subjected to RDT exam with only 10,750 tests positive (62.8 %), a result questioned by the medical staff. According to the head nurse: "some negative RDTs become positive after the recommended waiting time", a frequent source of doubting¹⁰. It is noteworthy that a patient released on the basis of a negative RDT is practically impossible to call back if the test later becomes positive; and it's only if the patient comes back with persisting or worsened symptoms that a microscopy exam can be proposed. For the head nurse, it is important to respect the manufacturer's instructions: "respecting the number of blood drops to use, the time to wait to declare a positive or negative slide". Several types of RDTs exist and Boussé hospital generally uses one type as SD BIOLINE Malaria P.f/

¹⁰ Note: a RDT should be performed only according to the manufacturer indications and a test getting positive with time should not be considered. However, given previous experiences with RDTs variable quality (locally suspected from data conflicting with microscopy and medical exams), it is understandable that delayed positivity raises doubts among the medical staff.

Pan®¹¹). A positive RDT is useful but should always be followed by a thick blood smear to confirm and determine the parasitic load, which is rarely the case. For the diagnostic method by light microscopy, the laboratory (availability of reagents, and equipment) and working conditions need to be improved. For TBMs, the main difficulty linked to microscopy is related to staining: “when the staining is well done, there is no problem; always check the dye solution that must be extemporaneous and health workers should also be applied to achieve quality thick and thin blood smears that simplify the exam”. In practice, as a TBM points out: “we use plain water to prepare reagents, which gives trouble in identifying *Plasmodium* species; water does not yield good coloring reagents and should be replaced by buffer solutions, which are extremely expensive; buffer solutions must be made available or reagents supplied to the laboratory so that we can prepare them ourselves; also the laboratory of Bousé needs more TBMs, with focus on TBM continuous education”. One TBM admits this: “personally, I have not yet had the opportunity to participate in a recycling although I work here for many years”. TBMs recognize the importance of an effective recycling, fundamental for their operability. A midwife concurs: “the lack of TBMs continuous training, exchange meetings and follow-up implies a risk of losing skills, especially for the identification of species and detection of low parasitemia”. Indeed, continuous training of TBMs, combined with the implementation of a quality assurance system, is imperative to maintain confidence in the results of microscopy [31].

In local working conditions, microscopy of blood smears is therefore not a fully reliable method and the parameters that affect reliability are many, including the laboratory reagents and equipment, the level of TBM qualification and the patient-related variables (self-medication, immunity to a certain level of parasitemia [32].

For health workers, the introduction of a fully reliable malaria diagnostic technology would be of great interest. Indeed, malaria remains the dominant local disease, in terms of reasons for consultation, and requires a caregiver-patient quality relationship, reinforced through quality diagnosis. For them, the main criteria necessary for the introduction of a new diagnostic method are:

- the reliability: a method should yield full confidence in the results and this is a major criterion for health workers: “it would be necessary for a device to come to replace RDTs, it is always good to improve the methods of hospital exam to aim at 100 % effectiveness; I would like it to be more reliable than RDT and faster than thick blood smear and even more reliable”.
- the time to complete the test: “the method of microscopy¹² lasts at least 45 min; including slide preparation (30 to 35 min) and examination (10 to 15 min per slide)”. It should be noted however that the patient does not get results within 45 min; very often, consultation and exams are done in the morning, results being available to the patient in the afternoon, but, except for emergencies, the subsequent medical consultation to interpret the results is very often shifted to the following morning. Thus, faster diagnostic methods will undoubtedly yield faster patients care, a key to avoid complications in malaria, a disease that may rapidly evolve. At HOSCO, the hospital works 24 h a day and there are also emergency procedures that provide test results within an hour, but these are mostly intended for hospitalized patients.
- the ease of use and interpretation, combined to the determination of parasitemia level and parasite species: “a new diagnostic method will only be beneficial if it reduces the analysis time and makes it possible to measure the parasitemia level, an important parameter not provided by RDTs”. Indeed, the parasitic load is a very important parameter in the interpretation of the results and the therapy to be adopted:

“parasitemia is very important, it is an indication for the doctor of severe malaria cases; the density of the parasite depends on the parasite’s cycle and sometimes we examine thick blood smears twice daily to confirm the evolution of parasitemia”. “Having a method which would yield the same performances as microscopy in about 15 min would be a great step forward”; “you have to think of a system like the RDT which, instead of 2 compartments would have 3: one for the positive result, one for the negative result and one for the parasitic load”. The parasitemia is effectively an important parameter that affects the choice and mode of administration (oral or intravenous) of antimalarial drugs; repeated measurements along treatment also provides important information on therapy outcome (failure, resistance). Determining the parasite species is also an important parameter for health workers: “if the device can specify the exact species of parasite, it would be very important”.

- the availability: “it is very important for the new equipment to be available in all health centers in towns and villages”; “the device should not be reserved for people in cities, and, like RDTs, should be made available in all primary healthcare centers”.
- the ability for the new device to avoid blood drawing: a TBM in urban areas states: “it is desirable to avoid sampling pricks”. On the other hand, according to TBMs in rural areas, drawing blood is not a problem as they are specifically trained for that type of sampling, also necessary for other basic biological investigations; they would not find convenient to work on other body fluids (saliva, urine) in rural areas where hygiene is rarely a priority.

So, for health workers, it is imperative to emphasize in malaria diagnosis the availability, reliability, ability, rapidity, ease of use of tests, combined with parasitemia determination and parasite species discrimination. According to health workers, people’s acceptance of a new method depends on some of its performances: “even if the patient has very little interest in the type of test performed, speed, reliability and cost are still very important, as much for the health worker as for the patient”. Time is considered an important parameter for bringing people to modern healthcare centers; as the time spent in center/hospital deeply impacts on economic activity, most people avoid them, resorting to domestic medicines, sometimes with catastrophic results. In this respect, diagnosis reliability is paramount; doubtful diagnoses require re-checking, a considerable waste of time for TBMs and patients. It should be emphasized that effective therapy combines both diagnosis and treatment; even if the diagnosis is correct, the administered treatment must also be effective and complied with to avoid therapeutic failures and relapses. As stated by TBMs, “free access is a parameter that many patients have integrated for the treatment of malaria”.

3.2.3. Application of WHO recommendations

Healthcare staff recognize the merit of compliance with WHO guidelines that state that “any suspected case must be confirmed by a diagnosis before starting anti-malarial treatment” [9]. Indeed, this strategy (i) allows to treat malaria properly; (ii) allows drug sustainability; (iii) delays the eventual appearance of parasites resistance; and (iv) permits a rapid and proper medical care of non-malaria diseases. However, in practice compliance with this strategy appears difficult. In the Bousé rural hospital, the chief doctor indicates: “the dispensary is limited in terms of technical means for the search of other causes; this research can also be costly for the financially limited patients who prefer to treat malaria even if the diagnosis is negative”. He explains that, if the hospital does not provide a prescription and treatment, the patients anyway obtain antimalarial drugs, notably in local pharmacies¹³. The healthcare worker has no control on this aspect. He should be able to provide correct therapeutic directives to a negative malaria diagnosis patient; unfortunately, this is rarely the case: “the most affluent patients request their negative test reports and seek other tests, often in other health facilities; for most patients,

¹¹ Result in more or less 15 min; detection of *P. falciparum* histidine-rich protein II (HRP-II) and lactate dehydrogenase (pLDH); sensitivity with >50 parasite/ μ L of blood, 98–100 %.

¹² The current reference method.

¹³ No prescription is required for this.

antibiotics are offered for psychological relief". Given the low-reliability reputation of RDTs and the limited availability of microscopy, presumptive treatment is not always excluded: "it may happen that the patient has all the signs with a negative RDT and the laboratory is not available to produce a thick blood smear and confirm the diagnosis; when the patient presents fever, yellowish and bitter vomiting, he is put on malaria therapy".

One of the frequent reasons for the negative results of diagnostic tests (RDTs and thick blood smear) for patient presenting major signs of severe malaria (headache, vomiting, dizziness, fever, chills) resides in pre-diagnosis self-medication, willfully unreported to health workers: "it sometimes happens the tests to be negative because there is a reduction in the level of parasites in the blood following self-medication". The pediatrician at HOSCO suggests that, to reassure herself, she may then request an additional test in another laboratory (another hospital) before making a decision: "in severe cases, we must act quickly and, often, we must repeat malaria treatment: in general, when we see a negative thick blood smear, with or without high white cells blood level, we initiate antimalarial treatment; for those who cannot afford an additional diagnosis, treatment is started anyway".

Developing a diagnostic method as reliable as microscopy, carried out at any time by moderately qualified personnel would be a great importance. But this ideal situation would be largely insufficient by itself; to effectively apply the WHO recommendations, diagnosis must be accompanied by concrete and practical measures.

3.3. Traditional health professionals

3.3.1. Traditional therapy and cultural proximity

Traditional healers are recognized and occupy an important place in the health system; their practice is largely based on medicinal plants, numerous and applicable for many types of diseases [33, 34, 35, 36, 37]. A panoply of diseases would find solutions in traditional therapy, such as fractures, colds, mycoses, hemorrhoids, cysts and fibroids, persistent wounds, sinusitis, ulcers, sexual weaknesses, madness, snake bites without forgetting malaria or tuberculosis. Beyond these, there are also supernatural illnesses which can be expressed in various forms: "pain, migraines, unexplained accidents, in the forms of diseases unknown to modern medicine"; "modern medicine, despite all its technology, will not be able to treat these cases but we can"; "these are secrets we keep; we observe the stars and question them, this is part of our diagnostic tools, there are products when we give them to the patient who has unknown pains, after having drunk them he vomits all the evil in him; we use mice to establish the diagnosis". For the patients, "traditional healers are scientists who know how to recognize these specific cases"¹⁴.

Traditional practitioners (TPs) have acquired their knowledge of traditional medicine, herbal remedies, incantations and diverse products in different ways, mostly by familial inheritance or revelation. In Burkina Faso, more than 30,000 traditional healers are nationally listed [38] grouped in diverse associations and efforts are made for the supervision and training of this practice [39]. The TPs' approach to the patient generally emphasizes the psychological aspect to prepare the framework and conditions for healing; the management of the disease is often psychosomatic and traditional healers entirely integrate this into their practices: "whatever the severity of the disease, I play on their psychology, their morale by saying that it is nothing and that I will treat it quickly; to approach a patient, we give him all the assurance that he can trust us; in our profession, trust allows the patient to fully confess himself, it is one of our diagnostic methods". The basis of diagnosis is confidence, an important and capital element in the healing process, considering that a reassured patient is half cured [4]. Trust is built and maintained through conversation: "the choice of words to bring the patient to confide is important, we welcome him with respect, as a member of our family". Some traditional

healers consider to be more attentive to the patient, compared to modern medicine healthcare workers: "we consider ourselves with the patients as a big family; there is no superiority between us and the patients unlike in hospitals with healthcare workers". Also, the cultural proximity is very important, joking relationships facilitate the building of confidence; they reassure the patient that his illness will find a cure without any discrimination, whatsoever: "we treat all the sick without distinction of skin, language, religion". Communication and exchanges are pillars of this medicine. For traditional healers, patients come from themselves as: "our reputation is built by the satisfied patients themselves who talk about it around them".

3.3.2. Knowledge about malaria

For the traditional practitioner, there are several degrees of malaria and the treatments offered depend on the degree of malaria. We have:

- SAMBWOUNGA or malaria which affects the brain and causes disorders, and fainting,
- SABWEOGO in this case "the whole body freezes especially the hands and feet",
- SAWALA "very dangerous malaria which can kill in just 3 days, manifested by diarrhea and vomiting".
- WEOOGO "you can neither walk nor stand upright and you have pain everywhere on your body".

SAMBWOUNGA and WEOOGO are like cerebral malaria with disorders of consciousness, convulsions and coma. The care provided to the patient thus depends on the type of malaria he presents. The products of traditional healers are administered in different ways: as a drink and wash decoction, as a mixture with food (porridge, dolo), as fumigation, as inhalation, etc.

3.3.3. Cooperation between modern and traditional medicine

In Burkina Faso, the collaboration between these two practices is not formalized. According to the opinion of modern medicine health workers "the general trend is that the patients first recourse to traditional medicine and then, when the condition does not improve, they turn to modern medicine". By contrast, traditional healers claim that patients come by themselves, either at the beginning of the disease or when modern medicine could not offer a solution. Modern medicine practitioners recognize that the two medicines are simultaneously resorted to, traditional therapy being rooted in the local culture; sometimes "even during hospitalization, the parents of some patients continue to give them decoctions of plants". Nevertheless, chief doctor indicate that many patients conceal such a combination of practices.

According to our informants, a pharmacist working in Boussé hospital had once developed a formal meeting framework, aiming at regulating medical practice at the level of traditional healers; but this is no longer organized. According to the chief doctor, renewing such exchange meetings would be very important to understand traditional practices and establish collaborative bases. He recognizes that the two medicines should work in complementarity, with their own therapeutic specificities and specialties, especially given that there is no possibility of emergency care in traditional medicine. Interestingly, traditional healers echo these comments: "as they receive all the patients in the hospital, as we also receive them, we are used to treating many diseases and we can base on the results of biological and hospital exams that patients bring us; when we cannot treat the patient, we refer him to our TP colleagues, considering that, even in the hospital, doctors cannot treat all the patients and often refer to other doctors; individually, we cannot control everything, that is why we group in association to pool our knowledge; our relationships with modern health workers is better than before, we often have informal joint meetings and training and sometimes doctors refer patients to us". Indeed, one of the patients confided that:

¹⁴ Specific cases are "natural" diseases and, according to cultural beliefs, those "which would be due to other entities".

“following my child's leg fracture, in consultation in hospital, the doctor advised me a traditional healer¹⁵; after treatment I asked for a radio to reassure me that everything went well, and I was satisfied”. Thus, it appears that modern medicine recognizes that, in certain conditions, traditional therapy appears as a better alternative. Traditional healers also recognize taking advantage of modern medical diagnoses: “we use the results of analyzes to treat more easily; the results of the tests, analyzes and diagnosis, established in the hospital, allow us a complementary view of the patient so we can offer adequate therapy”.

This is encouraging to progress in the direction advocated by WHO to both develop a complementarity between modern and traditional medicines and regulate practices, practitioners and products [40]. As stated by TPs, “both types of practitioners have to learn from each other”.

Interviewed traditional healers develop a proposal to allow better integration of the two medicines: “we get along well with doctors, we often have meetings in Ouagadougou with the Health Ministry in which we receive training; we often ask our patients to do exams in the hospital and come back with the results so we can find out what they are suffering from; the doctors refer the patients to us, unfortunately, sometimes they do not tell us what the patient is suffering from because they could not determine the disease; we want the doctors to refer the patients to us with a note; we also want to have a place in the hospital, we want us to be able to discuss serious diseases and jointly develop the right method to use for treatment”. According to WHO objectives, THs are key persons in healthcare and frank collaboration is required; for the benefit of patients, their practice should be encouraged but closely monitored and integrated in a seamless continuum with modern medicine [41]. It is necessary to combine efforts so that all stakeholders are winners.

3.4. Opinion on pharmacotherapy: research of new anti-malarial drugs from the rich heritage of medicinal plants

The contribution of traditional healer in the management of different pathologies remains important. Certain local herbal decoctions are stated to be effective in the treatment of malaria and many infections. Plants are recognized as an endless source for the exploration and discovery of new substances to fight diseases [42, 43, 44, 45]. Many of the molecules used in modern medicine to treat malaria have their origin in plants. Among them the first molecule, namely quinine comes from quinquina (*Cinchona officinalis* L.), a shrub native to South America, and artemisinin comes from a traditional Chinese herb, *Artemisia annua* L.. Both molecules are leads for some of the most important modern antimalarial treatments.

Traditional healers consider as an opportunity the research and development of new molecules from the plants they use; this would prove that they have expertise and that their medicines effectively treat, giving them more publicity and conveying people to join and respect their work. Such a self-centered approach may in fact indicate a possible conflict between the two medicines, some THs apparently seeking collaborations as a purely marketing advantage: “the patients should make the choice; modern medicine treats well but that does not prevent us from being there too and we often treat the same diseases”; “we believe that, if there is a new method that can quickly identify malaria, it is very good, doctors can discriminate malaria from other diseases that they can or cannot treat, and we will take over”; “traditional medicine has always co-existed with modern medicine, it is an ancestral knowledge that must always be preserved; we are not against modern technology, but we must remain authentic: leaving our knowledge to the profit of white people to treat our patients will make our traditions disappear”.

For modern healthcare staff (100 %): “it would be a good thing to value our local knowledge, it is not necessarily what comes from elsewhere that is better; the adhesion of the population will be quite natural when the confidence will be installed through the effectiveness of a product; certain traditional drugs we use are part of national guidelines for health centers; we must always seek

to enhance our local research”. For them, the main problems of traditional medicine reside in the control of dosages which is “required to master the side effects of herbal medicines”. Interestingly, the major potential quality problems of herbal therapy (misidentification of plant species, adulterations, contaminants, processing errors,...) and its challenges (mid- and long-term toxicities, over- and under-duration of treatment, unknown competence of THs, treatment adaptation to patient physiology,...) [46] have not been underlined by our interlocutors.

According to modern healthcare staff (10 %), the search for new antimalarials is essential as some clues hint at possible resistance to artemether-lumefantrine¹⁶: “patients treated with this combination often return to consultation for the same cause of malaria after a short time”; and some conditions remain difficult to treat: “amodiaquine is prohibited in children due to adverse effects and artesunate interferes with sulfadoxine-pyrimethamine which is used in prevention in pregnant women”, confides the Chief Doctor of Bousé who recognizes that: “the fight against malaria must be carried out on several fronts: diagnosis but also effective and varied treatments”. All healthcare workers are unanimous that the development of an antimalarial phytomedicine, manufactured from locally available raw material, could make the treatment affordable to all social groups. However, the establishment of a protection program for the concerned medicinal plants, especially for ligneous species, would be a priority to avoid negative environmental impacts. This is essential: “we believe that, if this should happen, we must join forces to plant trees otherwise there will be deforestation”.

4. Conclusion

This purely qualitative study, in prelude to the introduction of a new method for malaria diagnosis, highlights the concepts of the disease (causes, modes of transmission, modes of avoidance) and its treatments (the reasons inciting the choice of a care style) for Burkina Faso beneficiary patients, healthcare workers and tradipraticians; the study also underlines their expectations regarding phytomedicines and new technologies. This information needs to be taken into account whenever a new diagnosis technology or phytomedicine is developed and is considered for introduction in African urban and rural settings. As a perspective, we propose to extend the sociological study to a larger sample of the population. This will help to more accurately estimate the knowledge of the population about malaria. These new results would permit to develop new communication tools on the disease, increasing the quality of information to be diffused to the general public, i.e. by explaining the merits of rapid treatment and by creating a climate of trust between patients and health workers. Furthermore, interviews with more health workers could aid to better identify their needs and to evaluate the possible contribution of the proposed magneto-chromatographic device and the necessary information to convey.

Declarations

Author contribution statement

O. Traore, A. Ouedraogo, M. Campaore.
K. Nikiema and A. Zombre: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.
M. Kiendrebeogo, P. Duez and B. Blankert: Conceived and designed the experiments; Analyzed and interpreted the data; Wrote the paper.

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¹⁵ Some healers are bonesetters, highly specialized in bone trauma.

¹⁶ Given the widespread circulation of counterfeit and fake drugs [50], it is not possible to substantiate such claims of resistance to artemether-lumefantrine.

Declaration of interests statement

The authors declare no conflict of interest.

Additional information

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