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Assessment of community-based resilience to malaria in two transmission settings in Western Burkina Faso

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Abstract

Malaria transmission in Burkina Faso is continuous throughout the year. Anthropogenic changes in the environment affect the risk of disease transmission and the ability of communities to respond. This study aimed to evaluate the resilience of two communities in different malaria transmission settings in Western Burkina Faso by examining their ability to absorb, adapt, and transform regarding malaria burden. Conducted in Western Burkina Faso, this study focused on two localities, Bana and VK5, representing two distinct malaria transmission settings: a natural savannah and a rice-growing environment. A mixed-methods approach was employed in this study. Quantitative data were collected through a census of compounds in the two localities: 75 compounds in VK5 and 104 in Bana, using the KoboToolbox platform. Qualitative data were gathered through semi-structured interviews with 13 individuals from both localities. Quantitative data were subjected to descriptive statistics, whereas qualitative data were processed manually. The results showed that both communities demonstrate resilience through preventive measures and socio-economic strategies. Universal bed net coverage was higher in VK5 (74.33%) than in Bana (61.39%), significantly reducing malaria cases ($\chi^2 = 6.60$, $p = 0.0102$). Communities adopted diverse economic adaptations, with 71.29% of compound chiefs in Bana and 78.38% in VK5 improving financial conditions through trade, farming, and vegetable cultivation. While Bana relied heavily on financial aid (76.47%) during illness, VK5 exhibited stronger community organization for environmental sanitation and broader social support networks. The strategies used to address malaria-related absences, the scope of solidarity networks available to assist affected families, and the nature of collective assistance provided, demonstrate that VK5 shows greater flexibility and resilience than Bana. Overall, the findings emphasize communities' commitment to improve their health and socioeconomic conditions. This commitment could be a key element in a potential community health insurance scheme.

Keywords Burkina Faso, Community, Resilience, Malaria, Strategies

Background

Malaria negatively affects economic production, education, and public health expenditure [1, 2]. The level of global investment in malaria control is reported to be below the estimated resources needed to achieve the progress targets. Under tight funding constraints, evidence relating to the unit cost and cost-effectiveness of malaria control interventions has become increasingly important, and resource allocation is under increased scrutiny [3].

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In Africa, malaria costs more than US$12 billion annually [4]. Protecting one person per year ranges from $1.18 to $5.70 with vector control and from $0.53 to $5.97 with chemoprevention [3], while the cost to the health system per case diagnosed ranges from US$1.94 to $136, depending on clinical severity [3, 5, 6]. In addition to direct financial costs, malaria results in indirect costs, such as sick leaves [5] and impacts the psychological and physical health of the attendants [7]. Patients' sick leaves are influenced by the severity and duration of the illness, as well as the responses/reactions of both the patients and their family members [6].

Efforts are underway to reduce the incidence of the disease. The distribution of long-lasting impregnated insecticides bed nets (LLIN), indoor spraying, seasonal malaria chemoprevention administered to children aged 03 to 59 months, and therapeutic combinations are strategies that have been developed to treat the disease [8–10]. These different control tools have made it possible to avoid 663 million cases of malaria between 2010 and 2015, thus reducing the overall incidence of malaria by 21% [11]. The years following 2015 marked a stall in the decrease in malaria worldwide, particularly in the sub-Saharan region of Africa [12]. This is due to the growing resistance of mosquitoes to insecticides as well as the resistance of parasites to drugs, but it is also due to a general lack of funding and poor life conditions [13, 14].

Malaria is a major public health concern in Burkina Faso. In 2020, health facilities recorded 13,231,086 malaria cases and 4,355 malaria-related deaths due to malaria. The disease accounts for approximately 37.3% of all outpatient consultations, 55.9% of hospital admissions, and 15% of all deaths [15]. In Houet Province, located in western Burkina Faso, 744,889 cases and 375 deaths were reported during the same period. These statistics included 707,762 cases of uncomplicated malaria and 37,127 cases of severe malaria, corresponding to a prevalence rate of 46.79%. Pregnant women and children under five years of age are the main victims of the disease [15].

Considering this stagnant progress, the World Health Organization and the African Union (AU) are calling for continued research to develop innovative strategies and control means that can help accelerate the elimination of malaria [12]. Community-based resilience strategies for malaria prevention and control are among the most encouraged solutions. These strategies require a comprehensive and integrated approach to address the impact of the disease on communities. This involves a range of factors, including access to effective prevention and treatment measures, engagement and participation in the promotion of general health [16], a resilient and strong health system [17], the capacity to respond to outbreaks, and social and economic factors that can influence vulnerability and adaptation to the disease. Efforts to build community resilience can focus on areas such as physical and psychological well-being, economic well-being, communication, social connectedness, and the integration and involvement of community-based organizations [18].

Physical and psychological well-being are important for fulfilling a meaningful life and building resilience. This can help individuals navigate through challenges and uncertainties that arise. This relates to the provision of adequate health information, perception of good health status, good healthcare acceptability support, and good mental health [19, 20]. In addition, communities with higher levels of economic well-being usually have greater access to healthcare resources, contributing to a better capacity to respond to health emergencies and recover quickly from disasters or other health crises [21].

Social connectedness relates to matters such as spending time with family members, including children and elderly people, involvement in different healthy exercises and sports activities, following a schedule or routine, and taking breaks from traditional and social media, which can help overcome mental health issues [22]. Social cohesion during a disaster has been designated a pillar of the United Nations Research Roadmap for COVID-19 Recovery [23]. There are several forms of community involvement in health promotions including community-based surveillance for timely detection of diseases. Such surveillance systems require a simple design, reliable supervision, and early and routine monitoring and evaluation to ensure data validity [24]. Participation may be in the co-development of strategies to promote their health [25–29] and can be assessed through "community resilience indicators" by comparing different sets of measures [30, 31] which should facilitate community participation.

Evidence suggests that access to accurate health information is critical for reducing the psychological impact of health crises, including stress, anxiety, and depression [20]. Effective communication plays a vital role in fostering community engagement and social cohesion, while education is essential for building resilience. These two elements are intrinsically linked as information on resilience-building strategies is often disseminated through educational and public awareness programs [32]. Such initiatives empower communities to mobilize resources, take proactive measures, and effectively respond to health challenges. The shared information may be drawn from various sources, including historical data, experiences from other regions, and broader societal contexts. Furthermore, the timing and the distribution of this information across all relevant stakeholders, including local leaders, administrative bodies, household members,

and fieldworkers, are crucial to ensuring its effectiveness in enhancing resilience [33].

Community resilience is a multi-faceted concept. Several factors in a community's day-to-day life either promote or undermine it. Malaria, which is endemic to Burkina Faso, is a stressful disturbance to communities. Studies have mainly focused on vulnerability to malaria, whereas an opposing strategy could potentially identify the forces that accelerate the fight against the disease in the context of integrated control. Communities naturally develop strategies to consider this in their daily lives. However, little is known about the strategies that have been implemented. This study aims to understand how communities cope with the burden of persistent malaria in two different malaria transmission settings through their absorptive, adaptive and transformative capacities to face the malaria burden.

This study is based on Berkes and Ross's [34] conceptual framework of community resilience as a function of strengths or characteristics identified as important, leading to agency and self-organization. According to these authors, community strengths that assist in the development of resilience vary from community to community. However, case studies indicate a set of characteristics that play key roles: people-place connections, values, and beliefs; knowledge, skills, and learning; social networks; engaged governance (involving collaborative institutions); a diverse and innovative economy; community infrastructure; leadership; and a positive outlook, which includes readiness to accept change. These strengths are derived from the combined influence of agency and self-organization. Thus, the characteristics of resilience and the processes of agency and self-organization are important foci for developing an integrated concept of community resilience.

Methodology

Study area

The study area is located in Houet Province, western Burkina Faso. The spatial sample comprises the localities of Bana and VK5 (Fig. 1) in the commune of Bobo-Dioulasso.

Bana is a village located approximately 20 km west of Bobo-Dioulasso, in the natural savannah region of

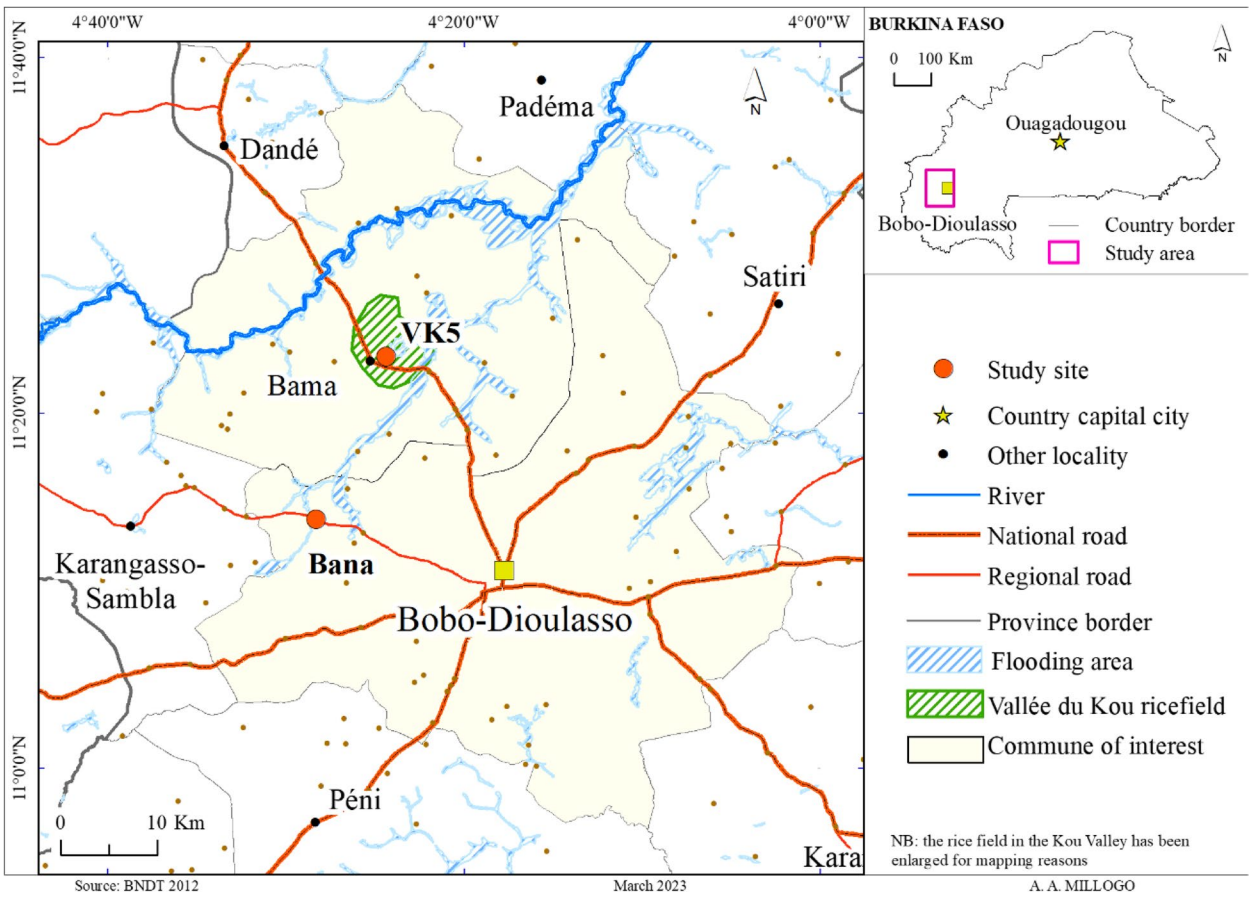

Fig. 1 Location of the research area

western Burkina Faso. It is a typical administrative village where rain-fed agriculture serves as the primary livelihood activity. The village comprises two settlements: one functions as the administrative center (Bana-Center), and the other serves as the economic hub (Bana-Market). These settlements are divided by a tributary of the Kou River [35]. According to a 2014 census conducted by the Institut de Recherche en Sciences de la Santé (unpublished data), Bana had 762 inhabitants, with 319 residing in Bana-Center and 443 residing in Bana-Marché. Residents primarily rely on single-harvest rain-fed agriculture for their livelihood. Healthcare services are accessed at the Espoir dispensary, located 0.8 km from the village, and the CSPS of Nasso, 5.5 km to the east.

VK5, on the other hand, is one of the seven districts within the Vallée du Kou rice-growing perimeter (VKRP), established in 1974 in the commune of Bama, approximately 30 km northwest of Bobo-Dioulasso. Located in the center of the rice fields, VK5 benefits from low-lying topography, which maintains a relatively high level of humidity throughout the year, hence its nickname "poto-poto" (mud in Dioula). This sustained humidity, supported by year-round irrigation, creates favorable conditions for high densities of malaria vectors. The population of VK5 was 989 in 2011 [36]. The primary economic activity is irrigated agriculture with two annual harvests, providing substantial income to the local population. Health services for VK5 residents are available at the Bama Medical Center (1.9 km away) and the VK health center (3.4 km from the district).

While Bana exhibits a typical rural spatial organization with seemingly random settlement patterns, VK5 follows a structured grid layout reflecting its planned development within the rice-growing perimeter.

Study population

The populations of VK5 and Bana were estimated at 885 in 2018 [37] and 848 in 2020 [38], respectively. Bana is essentially inhabited by the 'Bobo' ethnic group, practicing rain fed agriculture, while VK5 is mainly inhabited by the Mossi ethnic group, originally from the central plateau region of Burkina Faso [37]. Their principal activity is irrigated rice growing.

The choice of these localities is justified by the need to compare the resilience of populations living in two epidemiological settings of malaria transmission, the rice-growing environment and the tropical savannah [39], within a single zone of continuous transmission of the disease. VK5 has been exposed to malaria research for over three decades [40], whereas Bana has experienced malaria research for approximately a decade [35].

Data collection

Data were collected using a mixed-method (MM) with a quantitative-dominant structure combination (QUAL + quan) [41–43] from March to April 2018. These two complementary surveys were simultaneously conducted [42, 44]. The data were collected from different targets and were subjected to convergent analysis [41, 44]. The choice of MM is justified by the fact that community resilience to malaria is a complex picture and MM offers more possibilities for understanding the scope of the research as well as corroborating the results [41].

Quantitative data were collected within the framework of a georeferenced survey (Supplementary file 1) at the compound scale. The collection form was designed using KoboToolbox (https://www.kobotoolbox.org/), which is a mobile open-source data collection, management, and visualization platform. Data were collected in the field using the Kobocollect application installed on Android smartphones. Given the small sizes of the two localities (75 compounds in VK5 and 104 in Bana), we chose to survey all compounds to ensure sufficient statistical power rather than using sampling. The chiefs of the compounds were the primary respondents. In the context of Burkina Faso, a 'compound' refers to a group of buildings within an enclosed area, typically housing an extended family. The enclosure may be a wall, fence, or even the buildings themselves arranged around an open space. The compound is usually managed by its chief, who is typically the chief of the family.

The survey form was organized into three main sections, focusing on the social burden of the disease through local strategies to: *i)* address multiple episodes of malaria and minimize their impact on the community, *ii)* prevent malaria using both conventional and traditional medicines, and *iii)* manage malaria cases. Organizing the form in this way allowed us to address the key parameters of malaria control at the community level.

Qualitative data were collected through semi-structured interviews conducted in the *Dioula* language, using interview guides with resource people (Supplementary file 2). A guide was prepared for each category of resource persons. A total of 13 people from both localities were interviewed: three head nurses (ICP), two community-based health workers (CBHWs), four traditional health practitioners (THPs), two village development councillors, and two associations. These interviews made it possible to collect information on strategies implemented at the health system and community levels as well as the contribution of traditional medicine to the management of the disease. The interviews were recorded on a dictaphone, transcribed, and processed manually.

Data processing and analysis

Quantitative data were first downloaded from the Kobotoolbox platform to Microsoft Excel®. Manual checks were then performed to correct data entry errors. Finally, the data were used for statistical analyses. These were mainly descriptive statistics, correlation tests, and graphical representations, performed using MS Excel® 2016. The data table was then imported into GIS in ArcGIS® 10.8 for mapping.

The interviews were transcribed using multimedia software VLC version 2 and MS Word® 2016. The translation from *Dioula* to French was conducted at the time of the transcription. The data were then subjected to an empirical analysis. These results complement and support those obtained from the quantitative analyses [41, 44].

Results

Prevention and treatment of malaria cases

A total of 230 malaria cases were reported in Bana, compared to 267 cases in VK5 during the year preceding the data collection. Data were not normally distributed. The median prevalence rates were 22.22 and 25.83 for Bana and VK5, respectively, with no significant difference observed (Mann–Whitney test, $p=0$). These cases predominantly affected the age groups 0–4 years and 5–14 years, accounting for 36.96% and 19.57% of the cases in Bana and 29.96% and 33.71% in VK5, respectively.

The bed net was the main tool used by almost all compounds: 99.01% and 98.65% in Bana and VK5, respectively. However, the results showed that 61.39% of compounds had universal coverage of mosquito nets in Bana, compared to 74.33% in VK5. A chi-squared test of independence showed a significant difference in malaria cases between Bana and VK5 under universal and non-universal bed net coverage ($\chi^2=6.60$, $p=0.0102$). Universal bed net coverage was associated with fewer expected malaria cases in both areas (Bana: 89.60 vs. 10.40; VK5:65.40 vs. 7.60). This finding suggests that universal coverage reduces malaria cases in both communities.

Other prevention methods are used at different levels in the localities. Tools such as aerosols, repellent ointments, coils commonly known as "mosquito plants" (mainly *Azeratum conozoides)*, window screening, and fumigation are only used by a very small part of the population. Seasonal chemoprevention was mentioned by 8.91% and 1.35% of the respondents, in Bana and VK5 respectively.

Environmental sanitation is practiced for four compounds in VK5 and nine in Bana. At the community level in VK5, leaders organize environmental sanitation. According to O. E., president of the village development council (VDC) in VK5: *'The villagers go out to clean when there is too much dirt. Women have a group that cleans streets once a week. Young people also often clean the channels between compounds*, whereas in Bana, there is no community organization for sanitation. RS, from Dispensaire trottoir association emphasized: *"The focus should primarily be on improving environmental sanitation and maximizing the use of insecticide-treated mosquito nets (ITNs) in Bana."*

However, the community receives information through sensitization efforts. As stated by SM. a Community-Based Health Worker (CBHW) in Bana: *"We conduct awareness campaigns on hygiene and wastewater management. Currently, even children know that mosquitoes are responsible for transmitting malaria here in Bana."* The spearman correlation coefficient between number of prevention measures and malaria prevalence was 0.66 in Bana and 0.53 in VK5, suggesting that communities using more preventive measures tend to report more malaria cases. This may be because of the higher incidence of malaria drives the use of multiple control tools.

The management of malaria cases involves traditional and conventional medicine. The drugs recommended for the treatment of uncomplicated malaria by conventional medicine are artemisinin-based combinations: Artesunate + Amodiaquine or Artemether + Lumefantrine orally for uncomplicated malaria and injectable artesunate, artemether, or quinine for severe malaria [45].

As far as traditional medicine is concerned, the practices in the two localities do not differ fundamentally. Interviews with SD, a THP at Bana showed that the primary plants used for the treatment of malaria are *Trichilia emetica Vahl* (*Soula finzan* in the local *Dioula* language)*, Securidaca longepedunculata (Sessa, or Sesse in Bobo),* and *Moringa oleifera* (Telesogo in Bobo Langage or ardjina yiri in dioula). According to SA, another Traditional Health Practitioner (THP) residing in VK1, a neighbouring district of VK5, treating the population of this district, the main plants used include *Blighia sapida Koenig (finsan yiri* in *Dioula*)*, Annona senegalensis* (*Mandé sounsoun* in *Dioula*), *Landolphia heudelotii* (ponponi *dji* in *Dioula*), and *Cassia tora* (*kriki* in *Dioula*). The root bark was boiled or soaked in water, and the obtained solution was administered to the patient. Regardless of the treatment choice, the disease often results in hospitalization for several days.

The solidarity network to assist an affected family

Burden of malaria on study communities

Statistics show that the length of hospitalization and convalescence of malaria patients varies between 1 and 68 days in Bana, with an average of 4.76 days. In VK5, it ranged from 1 to 37 days, with an average of 6.03 days.

Whether in the hospital or during convalescence, the patient requires almost permanent assistance, usually from a relative. The positions of the patients' attendants at the health center within the family varied considerably. 69.64% of the patients in Bana and 57.41% of those of VK5 were accompanied by their mothers or fathers. Moreover, 51.78% and 18.52% of the attendants in Bana and VK5, respectively, were chiefs of compounds. Other family positions (brother or sister, aunt, or uncle) were represented in various ways. The two localities showed fairly similar trends, aside from the fact that friends, neighbors, and spouses did not appear on the list of people assisting patients in Bana, unlike in VK5. Absences of illness leads to family disruption and loss of economic production (farm labor, household chores at home, etc.). Therefore, strategies are required to address these difficulties.

Social mobilisation to provide various forms of support to the affected family

To manage absences and maintain an optimal workforce, communities implement several strategies, depending on the role of the absent person. Figure 2 illustrates the situation in the study area.

Figure 2 shows the strategies developed by the population to cope with absences caused by malaria. A total of 44.90% of the population in Bana and 38.78% in VK5 did not observe any impact of the disease on their activities. Others have used different strategies to compensate for absences from production. In VK5, 23.47% stopped working, 3.06% divided work among healthy working members, 1.02% used free outside help, and 4.08% replaced absent members with other family members. In Bana, these values are 46.94%, 0.00%, 1.02%, and 7.14%, respectively. A comparison of the strategies for managing absences due to illness between the two localities showed that Bana population is more vulnerable to disruption from malaria than VK5 population. The effects of the disease on agricultural activities were either null (no effect) or total (no work). In VK5, cases of work stoppages were fairly representative; however, other strategies were used more frequently than in Bana. The impact of this disease extends beyond the loss of working hours. In addition, patients and their families have certain immediate needs that must be met. These requirements directly contribute to the care of patients and their families (Fig. 3).

Figure 3 shows the forms of assistance received by the compounds that registered malaria cases. In Bana, aids received by the affected family was in the form of food (17.65%), money (76.47%), and moral support (5.88%). By contrast, in VK5, the affected family received material aid (3.17%), advice (17.46%), as well as food aid (14.29%), financial aid (47.62%), and moral aid (17.46%). Food aid consists of meals prepared for the patient, those accompanying them, and often for all family members, since in addition to rendering the patient inactive, the disease mobilizes other people who may be responsible for daily tasks. Financial assistance helps with expenses such as prescriptions and hospitalization. Material assistance includes the loan of a vehicle to transport the patient to the hospital as well as physical assistance during hospitalization or during the convalescence period. As for advice, it mainly concerns the care itinerary to adopt, the choice of THPs or health center, and the treatment to take in the case of self-medication. Moral assistance consists of regular visits to comfort patients. Support may come from a family member or another network of acquaintances. While most of this aid comes from the patient's locality of origin, financial aid may come from another locality, country or continent in the event of a severe situation.

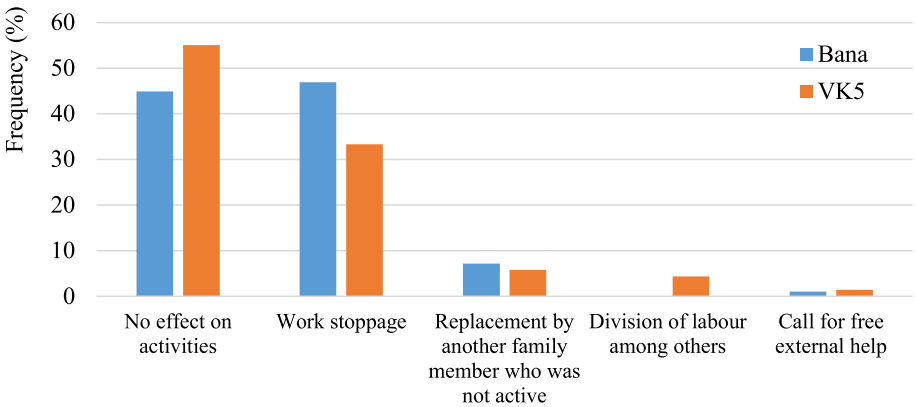

Fig. 2 Strategies to manage sickness absence. Source : A. A. Millogo, 2018

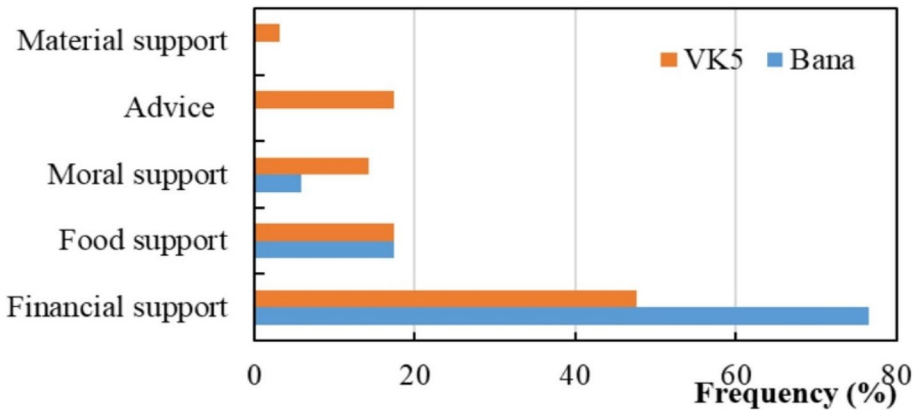

Fig. 3 Forms of support received by families that registered patients. Source: A. A. Millogo, 2018

Financial mobilisation from an international solidarity network

Among the compounds in Bana and VK5, a significant proportion (39.6% and 48.65%, respectively) was capable of receiving aid from only one or two individuals outside the village. Those who could request assistance from more than two people represented 0.99% of the respondents in Bana and 2.7% in VK5. The spatial materialization of this potential support network is shown in Fig. 4.

Figure 4 shows the sources of potential financial support. The majority of potential sources of aid were from the respondents' localities. Then, there is the city of

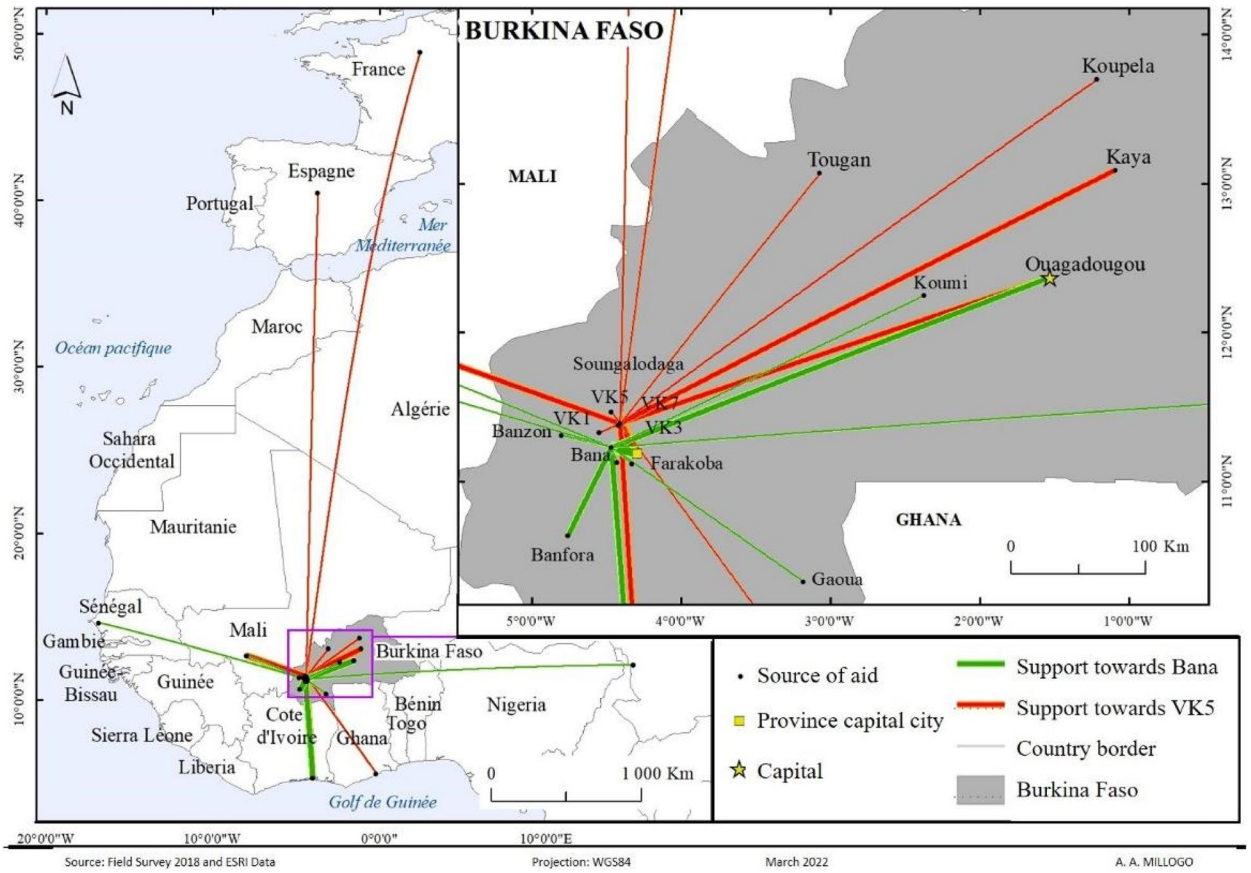

Fig. 4 Source of potential financial support. Source : AAM, 2018

Bobo-Dioulasso, because of its geographical proximity. The presence of the sons from these villages who migrated to the city for various reasons (e.g., trade, salary activities.) can explain this. We observe that the network of Bana is mainly developed in the western part of the country and Africa, whereas the VK5 network is oriented towards the center and north of the country, as well as having links wider to Africa and Europe. With the experience of recurrent malaria episodes, most of the population in the study area understood that they were living with permanent stress that required sustainable responses.

Individual and family entrepreneurship: a solution to face the challenges of malaria

The results showed that the communities developed their own reactive resilience strategies to address actual health issues. Thus, 13.98% and 26.76% of the chiefs of compounds in Bana and VK5, respectively, admitted to have at least once either taken out a loan, or guaranteed or sold an asset to support the care of a recent case of malaria in their families. Those who had not used the facility to mobilize resources by the time this study was completed reported that they would likely do so in the future. In detail, we noted that 80.77% of the chiefs of compounds in VK5 versus 72.5% of those in Bana were certain to do so in the case of need. To avoid the need to take on debt or sell assets, people have adopted strategies to increase their incomes.

Respectively, 96.04% and 97.30% of the chiefs of compounds in Bana and VK5, respectively, decided to change their behavior and that of their family members. While some of the changes are geared towards preventing the disease through vector control, hygiene of the living environment, use of mosquito nets, coils, etc., the bulk of the changes mentioned are geared towards improving financial conditions (Fig. 5).

Figure 5 shows the changes made to improve socio-economic conditions. These changes were undertaken by 71.29% of the compound chiefs in Bana, and 78.38% of those in VK5. The initiatives developed broadly showed the same trends in both localities. The main changes were trade (31.11% and 35.85%, respectively in Bana and VK5), vegetable growth (22.96% and 22.64%, respectively), and the expansion of farm areas (17.78% and 23.58%). It can be seen that there is a very good level of commitment by the population to improve their health conditions. However, some differences can be observed between the two localities, as trade is relatively more practiced as a complementary activity in VK5 than in Bana, and gold panning, the practice of traditional medicine and rural exodus are not among the changes we see being made in VK5.

Discussion

This paper provides a comparative assessment of resilience to malaria in two rural communities in western Burkina Faso, the village of Bana in a non-anthropic, environment and the developed rice-growing district of VK5. Both localities showed reasonable levels of resilience to malaria. This can be attributed to collective efforts made over several decades by a multitude of stakeholders in the fight against malaria. These include the World Health Organization (WHO), health ministries, and non-governmental organizations (NGOs) that have implemented prevention and control programs. Additionally, the knowledge acquired, and measures taken by communities for disease prevention and control must be acknowledged [10].

Bednets are the main protection tool used by almost all against mosquito bites. Compounds with universal

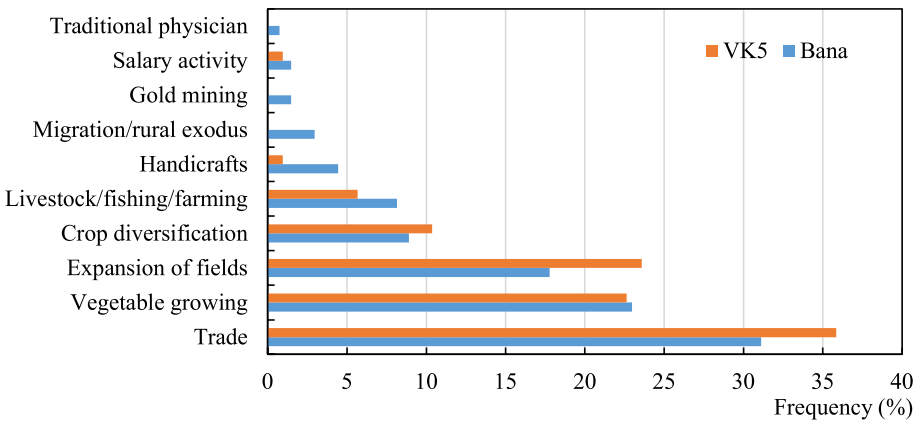

Fig. 5 Changes made to improve financial conditions. Source: A. A. Millogo, 2018

net coverage stand at 61.39% in Bana and 74.32% in VK5. These results suggest that universal coverage significantly reduces malaria incidence and provides better protection than non-universal coverage does. Additional control methods are used to reinforce protection, particularly in living areas and at times of the day when nets are ineffective or are simply not used. These include the sanitization of living environments, wearing long clothing, fumigation, the use of aerosol sprays, coils and plants with repellent fragrances.

Despite the presence of conventional health centers, traditional practitioners intervene in the treatment of malaria using specific plants. These plants grow in the domestic space of the village, and their effectiveness has been demonstrated in mosquito control [46]. Moreover, they are abundant during the rainy season when malaria is at its peak. This medicine is relatively more financially, geographically and socially accessible, as the practitioner is generally a member of the village community. However, differences can be observed between the plants used in other geographical areas of Burkina Faso [47] and other countries in the sub-region, such as Côte d'Ivoire [48, 49] and Mali [50]. This is evidence of the close link between this medicine and the eco-geographical environment in which it is practiced.

Because of its level of prevention, management capacity and innovations in dealing with malaria cases, the rice-growing district of VK5 has a relatively higher level of resilience than Bana. The difference in levels between the two localities can be explained by several factors. Indeed, the population of VKRP has been subjected to an extremely high level of culicidal nuisance since the establishment of the perimeter in 1970, compared to Bana in the natural environment [51]. Consequently, since that time, they have adopted habits of reinforced protection against mosquitoes with the acquisition of additional bednets and other means of protection, such as aerosol cans and mosquito coils [52]. In addition, irrigated agriculture provides this population with substantial income wich can be used for protection expenses and case management [53, 54]. Finally, since the 1980s, the perimeter has hosted longitudinal malaria research programmes [51, 55–58]. These programs have disseminated information on malaria, such as the vector, transmission mode, means of prevention, whereas Bana only benefits from classic informational-educational-communication activities carried out by the health system. These factors have contributed to the development of knowledge about the disease, helping build a relatively higher response capacity.

With regard to patients who require assistance, the main active population is mobilized in Bana, whereas in VK5, this task is assigned to inactive people or those who are not directly involved in agricultural production. It has been shown that the existence of accompanying illnesses is a source of impoverishment. This is even more critical when active individuals are involved in this task [6, 7]. In addition, this rice-growing district records fewer cases of work stoppages due to illness, and strategies for managing absences due to malaria episodes are more diverse than those in Bana [59]. Finally, the population of Bana receives fewer forms of aid (three) than those of VK5 (five), whereas diversity of aid allows for a better balance in the care of the sick and consequently minimizes the effect of the disease on the socioeconomic balance of the family. It can be deduced that the VK5 population tends to be more resilient than the Bana population in the event of illness.

These forms of support are strongly recommended by the African Union for malaria, tuberculosis, and HIV-AIDS [60]. These results are comparable to the observations made in Bobo-Dioulasso on HIV-AIDS, according to which patients benefit from several forms of assistance [61]. In the absence of a universal health insurance scheme, solidarity plays a very important role in the care of people with illnesses, as it is expressed in a system of social organizations traditionally expressed and determine the rights and duties of everyone [62]. The solidarity that the family is called upon to show towards the patient is presented as an obligation to assist people in difficulty, especially as it is one of their relatives [61]. This assistance can be attributed to community competence; because the populations recognize that malaria is a common concern. They commit themselves to limit the influence of this disease and mobilizing, within their own environment, the necessary help to preserve their quality of life [63]. This form of health *empowerment* [29] should be used in the operationalization of emerging health insurance schemes in Africa.

Bana's network is mainly developed in the western part of the country and Africa, whereas VK5's network is oriented towards the center and north of the country, followed by Africa and Europe. There are several possible reasons for this discrepancy. Indeed, the indigenous populations of Bana have mainly developed relations with neighboring villages through migrations, alliances, friendships, etc. As for VK5, their relationships are based on their geographical origins in the center and north of the country. Regardless the locality, potential aid from Ouagadougou, other African countries and Europe comes from emigrant relatives. The case of VK5 is explained by the strongly developed migrant tradition of the *moaga* ethnic group [64].

The relatively low proportion of chief of compounds who have resorted to loans or the pledging of their assets is partly explained by the fact that free healthcare relieves

people of the costs of treating malaria in children under five years of age and pregnant women. Similar strategies have been used in the central plateau of Burkina Faso [65] and the Kilombero Valley in Tanzania [66]. However, regardless of the situation, the propensity to use these channels is based on mechanical solidarity which requires community members to assist each other in difficult times. Moreover, for patients who do not benefit from this type of favour, malaria treatment remains affordable currently, especially with generic drugs and free healthcare programs for pregnant women and children [67].

The difficulties in managing cases of illness can be alleviated by establishing a community health insurance scheme or universal health insurance. A presidential initiative for free healthcare was instituted to address this issue. The program is a political initiative, but it is constrained by several practical difficulties [68]. These include shortage of medicines and delays in payment, which result in the population being obliged to pay for healthcare that is supposed to be free [69]. The main resilience strategy is the development of income-generating activities. This is the only strategy that allows for improved disease prevention through the acquisition of protective equipment such as bednets, window screens and aerosol cans, and the management of cases through easier access to health centers and the acquisition of medicines. However, in addition to prevention strategies and case management, this research highlights the constitution of a spontaneous solidarity network based on mechanical solidarity in the sense of sociologist Durkheim [70], to support families affected by the disease. Mobilization of additional financial resources was found to be the most popular strategy among the two populations.

Conclusion

This study analyzed the resilience of rural populations in western Burkina Faso to malaria. It uses a comparative approach between a traditional village in a natural savannah and a rice-growing district in a developed environment. The data were mobilized using a mixed method that combined the use of quantitative and qualitative data. The results showed that, despite the recurrence of malaria in their environment, the populations have developed endogenous resilience strategies. These include conventional means of control, such as prevention by bednets or medication, and local methods, such as the use of local plants for vector control, traditional medicine for treatment, and, above all, the reliance on a network of solidarity around the patient and the patient's family to reduce the burden of the disease at various levels. Additionally, the use of substantial financial resources is the best strategy for resilience against malaria. These results remind us of the importance of operationalizing the health insurance scheme for all age groups and throughout the country.

Supplementary Information

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Supplementary Material 1.

Supplementary Material 2.

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Data access
The original data presented in this study are included in the article and further inquiries can be directed to the corresponding author.

Authors' contributions
AAM, YL, FCO, AD: Conceptualization and Methodology. AD: Funding acquisition. AAM: Investigation, Data Curation and Writing - Original Draft. YL, LP, RZ, FCO and AD: Writing - Review and Editing. All authors reviewed and approved the final version of manuscript.

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Data availability
The original data presented in this study are included in the article, and further inquiries can be directed to the corresponding author.

Declarations

Ethics approval and consent to participate
Approval for this study was obtained from Le Comité d'Éthique Institutionnel pour la Recherche en Sciences de Santé (CEIRES) of IRSS (Approval No.: 2017-0108/MESRI/SG/CNRST/DG/DS). The study complied with both the Declaration of Helsinki and the Nuremberg Code. Given the low-risk nature of the study, which did not involve the collection of biological samples, the research was ethically acceptable as part of an integrated vector management project for malaria control in the area. Participants' rights were respected and protected throughout the interviews. For data collection, participants received an information sheet in French, which was then explained to them in their local language before obtaining their informed consent. Consent for participation was obtained from all study participants.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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