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Understanding perceptions of malaria control measures in Burundi: a qualitative descriptive study using a socio-ecological approach

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Abstract

Background In Burundi, malaria remains the leading cause of morbidity and mortality and persists as a major public health problem despite control strategies implemented nationally since 2000. While some quantitative studies have evaluated specific interventions, qualitative research examining the perceptions and practices of target populations regarding prevention measures is lacking. Such research is particularly important in the current context, where multiple control strategies are simultaneously implemented, potentially leading to confusion or reluctance among the population to adhere to prevention measures.

Methods A qualitative descriptive study was conducted from March to May 2023 in the health districts of Kinyinya and Ryansoro, combining 60 individual interviews and 28 focus group discussions (FGDs). The sample consisted primarily of farmers, with a slight female predominance (53% for individual interviews, 57.5% for FGDs). The collected data underwent thematic content analysis using a socio-ecological approach.

Results The study explored participants' perceptions and practices regarding four major interventions: distribution of long-lasting insecticidal nets (LLINs), indoor residual spraying (IRS), intermittent preventive treatment during pregnancy (IPTp-SP), and environmental management. The study identified factors influencing malaria prevention behaviours across three main interconnected levels: intrapersonal (perceived needs and adverse effects), organizational (information dissemination and hygiene conditions at healthcare facilities), and policy/environmental (need for context-sensitive adaptation of interventions and addressing socio-economic constraints).

Conclusion Effective malaria prevention in Burundi requires a multifaceted approach addressing communication needs, contextual adaptation, management of adverse effects, understanding of local priorities, and socio-economic constraints. Integrating these five dimensions into programme design and adapting prevention messages accordingly would significantly improve both acceptance and effectiveness of malaria control interventions.

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Background

Malaria remains a major public health challenge, particularly in Africa where the WHO African Region reported 246 million cases and 569,000 deaths in 2023, representing more than 94% of the global case burden and 95% of the global death burden [1–3]. Children under 5 years of age are the most affected, accounting for 76% of deaths in the region in 2023 [1]. In some sub-Saharan African countries, the prevalence of malaria in children under 5 years is higher in households living in poverty and decreases with improved economic status, highlighting the significant impact of wealth on malaria risk [1]. In Burundi, this endemo-epidemic infection is the leading cause of morbidity and mortality, with a high incidence fluctuating between 470 and 815 cases per thousand inhabitants between 2017 and 2021 [4]. Contrary to the African trend that saw a 40% reduction in cases between 2000 and 2015 [5]. Burundi experienced a significant increase in cases and mortality, reaching a mortality rate of 32% [6]. Since 2000, various malaria prevention strategies have been implemented in Burundi. These strategies include the distribution of long-lasting insecticidal nets (LLINs), indoor residual spraying (IRS), chemoprophylaxis for pregnant women, and communication efforts in close collaboration with community leaders and populations (including community dialogue).

The distribution of LLINs began in 2003 with occasional sales in certain districts. In 2005, LLIN distribution was integrated free of charge into routine services at health centres for pregnant women and children. Mass distribution campaigns began in 2009, initially targeting the most vulnerable individuals (children under 5 years and pregnant women). Subsequent campaigns in 2011, 2014, 2017, 2019, and 2022 adopted World Health Organization (WHO) standards of one LLIN for every two household members [6]. LLIN coverage reached high levels after mass campaigns: 98% in 2014 and 96.7% in 2019 [7]. However, several studies on LLIN durability conducted in Burundi have shown a rapid decrease in their effectiveness with significant reduction in protection after just 8–9 months [8, 9].

IRS was reinitiated in 2002 in response to the major epidemic of 2000–2001 in the northern part of the country [10], a strategy that had been used for several decades as part of the malaria control project [11]. A pilot trial combining annual IRS and LLIN distribution was conducted in Karuzi in 2002–2005 [12], with spraying coverage exceeding 99%, and between 14,000 and 18,000 houses sprayed each time [13]. These interventions significantly reduced vector density and decreased the prevalence of infection and risk of clinical malaria by 40–50% in areas where residents slept under LLINs [10, 14]. Despite these promising results, IRS was not resumed until 2016, annually targeting four health districts with high incidence (Vumbi, Gashoho, Ngozi, and Kiremba), with occasional spraying in other districts in response to epidemics.

In addition to vector control interventions, other preventive strategies have been deployed in Burundi. Following WHO recommendations for areas of moderate to high transmission of *Plasmodium falciparum*, intermittent preventive treatment during pregnancy with sulfadoxine-pyrimethamine (IPTp-SP) was introduced in 2016 to reduce the risk of anemia in pregnant women. Although the number of gestational malaria cases increased until 2016, it has stabilized since [6]. More recently, in June 2021, the country strengthened its preventive approach by implementing community dialogues for Social and Behavioural Change Communication (SBCC) and Information Education and Communication (IEC) in all provinces, involving 66 key stakeholders per province [3]. Environmental management for malaria control in Burundi encompasses specific activities promoted through national guidelines since 2013, including: clearing vegetation around dwellings, filling holes and ditches to eliminate stagnant water, and managing waste containers that could harbor mosquito breeding sites. According to the 2023 National Malaria Control Guidelines, these environmental sanitation measures are promoted by Community Health Workers (ASC) during household sensitization activities [3]. At multiple levels, these activities are encouraged by the government and technical/financial partners working in malaria control (Ministry of Public Health, World Vision, Caritas, MSF) through community activities such as awareness campaigns, drainage cleaning, and vegetation clearing. The privileged channels outlined in Burundi's Communication Plan for Malaria Control 2018–2023 include: community dialogues led by Community Health Workers, schools as ambassadors for environmental hygiene messages, churches, and community work initiatives [15].

The study was conducted in two health districts where Médecins Sans Frontières (MSF-OCB) intervened against malaria from 2017 to 2023: Kinyinya, located in

the plains at 1,250 m altitude in the East and characterized by high endemicity (annual incidence of 50.7% in 2020) and a case fatality rate of 0.34 per thousand for all age groups in 2020, and Ryansoro, a mountainous area located at 1,780 m altitude in the Centre with meso-endemicity (annual incidence of 15.19% in 2020) and a case fatality rate of 0.11 per thousand in 2020, according to DHIS2 epidemiological surveillance data on malaria deaths and cases in 2020. In these districts, in addition to the usual distribution of mosquito nets and IPTp-SP, MSF implemented two interventions: IRS and free malaria case management in hospitals and health centers. In Ryansoro, two IRS cycles were carried out in 2018 and 2021. Malaria case management was free in 2018, 2021, and 2023 at health centers and hospitals, and free from 2022 to 2023 in the context of community health worker management. In Kinyinya, similar interventions were carried out from 2019 to 2022, without the community component. Despite these interventions, Kinyinya is still considered a high-risk area and Ryansoro a medium-risk area [16].

Several quantitative studies conducted in Burundi have evaluated some of these interventions, particularly the use of mosquito nets [17, 18] and IPTp-SP [17], but little data exists on IRS or environmental management. Furthermore, there is limited qualitative data on perceptions and practices regarding prevention measures from the perspective of target populations. This approach is all the more necessary in a context where control strategies are implemented simultaneously, which can lead to confusion or reluctance to adhere to prevention measures among the population. This study responds to a dual observation: the need to examine perceptions associated with the various malaria control interventions in Burundi in combination, rather than as isolated interventions, in order to understand the acceptability or reluctance that will influence future interventions; and the current lack of qualitative data on the perceptions and behaviours of the Burundian population regarding these interventions. Indeed, LLIN or IRS coverage rates are not sufficient to understand how and why these measures are adopted or rejected by the population. This research is even more relevant as qualitative studies conducted in Burundi or in other contexts [19, 20] have demonstrated that understanding the perceptions and practices of target populations can significantly contribute to the improvement of malaria control strategies. This study aimed to address three primary research questions emerging from this dual observation: (1) What are the perceptions and practices of target populations regarding malaria prevention measures (LLINs, IRS, IPTp-SP, and environmental management) when implemented simultaneously in Burundi? (2) What factors explain the acceptability or reluctance toward these combined malaria control interventions that will influence future programme success? (3) How do local contexts, socioeconomic constraints, and competing priorities impact community adoption or rejection of these prevention strategies?

Methods

A qualitative descriptive study was conducted from March to May 2023 in the health districts of Kinyinya (now Kinyinya-Gisuru following an administrative change in 2022) and Ryansoro, as part of operational research by Médecins Sans Frontières (MSF-OCB) in collaboration with the Institute of Tropical Medicine in Antwerp (ITM) and the National Malaria Control Programme (NMCP) of Burundi. This approach was chosen because qualitative description is specifically designed for health research that seeks comprehensive understanding of phenomena from participants' perspectives. This orientation was well-suited to exploring community perceptions and practices regarding malaria control measures, as it allows for flexible data collection methods and systematic analysis to generate practical insights that can directly inform programme implementation and policy development. This qualitative descriptive study was conducted in conjunction with four other studies examining malaria control interventions in these districts.

Adult participants were recruited from 49 hills (administrative division in Burundi) (19 hills in Kinyinya, 30 in Ryansoro) using a convenience sampling method, ensuring diversity of profiles (age, gender) and good geographical distribution. Local chiefs and other local resource persons (e.g. hill chiefs and institutional leaders) served as guides, helping to orient the research team towards the identified sub-hills and facilitating access to the different categories of participants. However, they would not be involved in selecting participants, explaining the objectives, or making the final selection decisions. For targeted categories (community health workers, uniformed men, pregnant and breastfeeding women, supervisors, young community club members, healthcare personnel), purposive sampling was used with maximum variation based on age, sex, seniority, and residence. Sixty individual interviews were conducted with households, selected based on the following criteria: exercising some influence over the community (e.g., community leaders, hill chiefs), presenting some vulnerability to malaria, or belonging to groups known by health promoters to have previously refused IRS. In addition, twenty-eight focus group discussions (FGDs) were conducted with various groups including community leaders, health personnel, community health workers, pregnant women, youth and community club supervisors, religious leaders, local administrators, military and police officers, members of

Batwa groups (pygmies), refugees and returnees, adults housed in boarding schools and surrogate mothers in orphanages. For FGDs with health personnel, participants worked in a health center or hospital: nurses and health promotion technicians, health facility hygienists, night watchmen, district supervisors, doctors. The recruitment of participants was organized by the principal investigator, accompanied by 12 interviewers, in collaboration with the research coordinator, co-investigators (MSF-OCB, LuxOR, ITM) and NMCP supervisors. In each hill, hill chiefs contributed as guides for the selection of participants.

Community mobilization meetings were organized in each district to present the study and its voluntary nature, and to prepare an information message about the study. An interview guide, developed in French and then translated into Kirundi, covered the main themes: perception of malaria, modes of malaria transmission, locations and period of exposure, risk groups, healthcare-seeking and medication use, and preventive interventions (mosquito nets, IRS, IPTp-SP, environmental management) (see Supplementary Material Table 1). The guide was tested during interviewer training and during a pilot survey with 12 households in Ryansoro. These pilot interviews were also transcribed and included in the analysis. Individual interviews took place in households, while FGDs were held in small private rooms not far from the chief towns of municipalities in Gisuru (Kinyinya) and Gishubi (Ryansoro). FGD participants were reimbursed only for their travel expenses. All participants or their witnesses gave written informed consent. No participant refused to participate in the study. For each individual interview or FGD, two interviewers were present (a moderator and a note-taker). All interviews and FGDs were recorded. The end of the interviews was dedicated to answering participants' questions about malaria and intervention strategies. The interviews and FGDs were translated and transcribed from Kirundi to French by the interviewers, with verification by the NMCP and MSF-OCB supervisors.

The thematic content analysis followed an iterative approach involving three researchers: the principal researcher (TN), the coordinator (RN), and the ITM supervisor (MM). Data management and analysis were conducted manually using systematic coding procedures rather than qualitative analysis software. This approach facilitated intensive collaborative analysis among the multidisciplinary research team, allowing for real-time discussion of emerging themes and iterative refinement of the coding framework. This analysis was based on the themes of the interview guide, while allowing for the emergence of new themes. A preliminary code structure was collectively validated, then the interviews were coded by the principal researcher with validation by the supervisor. The analysis process involved multiple iterations of coding refinement and constant comparison between emerging themes and raw data. Weekly meetings between the three researchers allowed for discussion of the analyses, refinement of the code structure, and resolution of divergences by consensus, including a reflexivity exercise on potential biases. These team validation processes ensured analytical rigor throughout the process. The validity of the results was strengthened by their presentation to the team during the sharing of a preliminary report.

Conceptual framework: the social ecological model

This study employed the Social Ecological Model (SEM) to examine factors influencing the uptake of malaria control strategies in Burundi. The SEM provides a comprehensive framework for understanding health behaviours by recognizing that individual actions occur within broader social and environmental contexts that both constrain and enable behaviour change [21].

The SEM posits that health behaviours are shaped by dynamic interactions across five interconnected levels of influence: intrapersonal (individual), interpersonal, organizational, community, and policy factors [22]. This multi-level perspective is particularly relevant for understanding malaria prevention behaviours in Burundi. At the intrapersonal level, individual factors such as perceptions and personal experiences with malaria prevention strategies influence behaviour. The interpersonal level encompasses social networks, family dynamics, and relationships with healthcare providers that affect health-seeking behaviours. The organizational level includes healthcare facilities, traditional healing systems, and community organizations, including their policies, resources, and service delivery approaches. The community level captures community characteristics, leadership structures, social capital, and collective attitudes toward health interventions. Finally, the policy level encompasses laws, policies, economic conditions, and broader systems affecting intervention accessibility and implementation [23].

This framework was well-suited for examining malaria control measures uptake in Burundi, where health-seeking behaviours are influenced by complex interactions between individual, social, and structural factors. This model has been used previously in malaria prevention studies [24, 25]. The SEM enabled systematic identification of barriers and facilitators across three main levels while exploring how factors interact to influence intervention uptake. By applying this framework to our qualitative findings, the study aimed to identify opportunities

for developing more effective multilevel intervention strategies to improve health outcomes.

Ethical considerations

This study received approval from the IRB of the Institute of Tropical Medicine (Protocol 1585/22, IRB/RR/AC/097) on June 20, 2022, from the MSF ERB on July 20, 2022, and from the National Ethics Committee of Burundi (Decision CNE/28/2022 on September 13, 2022). Statistical Visa No. VS2023002 CNIS was granted by ministerial decision No. 540/95/0501/2023 on February 3, 2023. Local authorities approved the conduct of the study in their respective areas.

Results

Socio-demographic characteristics of participants

In this study, a total of 60 people participated in individual interviews, including 24 in the Kinyinya health district and 36 in Ryansoro. Women constituted 53% (n = 32) of the total and men 47% (n = 28). The most represented age group was 25–35 years with 22 people (37%). Farmers were the majority, with 49 participants out of 60 (82%). In addition, 28 FGDs were conducted (14 in Kinyinya and 14 in Ryansoro), each with 6 to 8 participants, totaling 219 people. In total, 22 FGDs with the general population and 6 FGDs with health personnel were conducted in the two districts. Women represented 57% of participants while men represented 43%. The age extremes were 18 and 93 years with a median age of 35 years in Ryansoro and age extremes of 19 and 77 years with a median age of 31 years in Kinyinya (see Supplementary Material Tables 2 and 3).

The main results of the study are described here by types of interventions: mosquito nets, Indoor Residual Spraying (IRS), Intermittent Preventive Treatment during pregnancy (IPTp-SP), environmental management.

Mosquito nets

The analysis of perceptions and practices regarding LLINs revolves around the five key areas: type of mosquito nets, distribution methods, use and non-use, recycling and repurposing, and maintenance and repair.

Most participants appreciated the effectiveness of the 2022 mosquito net distribution compared to previous years (2011, 2014, 2017, and 2019). They believe there are few complaints to report because the entire community was served. However, several FGD participants reported an insufficient number of LLINs distributed. Two logistical reasons were mentioned, on the one hand the delay between the distribution of the voucher and the acquisition of the LLIN and, on the other hand, the calculation of the number of LLINs based on the number of people rather than the number of beds, as can be seen in the following quotes:

> *"If I try to analyse the distribution of mosquito nets in previous years, they did the enumeration, they gave you the voucher and you kept it for several days. Some people lost their vouchers, but with the distribution of mosquito nets done recently, they gave you the voucher on the day and distributed the mosquito nets the next day, which meant that no one lost their voucher." (FGD with community health workers, Kinyinya)*
>
> *"During the calculation, they did not count the beds in the household but rather the number of household members; so if a mother and her son lived in a household, they were given only one mosquito net even though they don't share the same bed; they each have their own bed; in this case, if she has the means, she buys another one (mosquito net)." (FGD with teachers, supervisors and youth/students, Kinyinya).*

Participants reported that using mosquito nets at night is important even though it is sometimes difficult to do when it is hot, given the discomfort it can cause, the feeling of suffocation, and difficulty breathing. Undesirable side effects were also mentioned, especially if installation instructions are not followed:

> *"Sometimes mosquito nets cause skin irritations, if you see that it's time to change the old mosquito net, we first spread the mosquito net under a little wind in the evening so that the effect of the insecticide decreases a bit." (Female farmer, 26 years, Ryansoro)*

An unpleasant or uncomfortable odour was cited as a barrier to use. Other reasons for non-use include the lack of perceived need because the person has never contracted malaria. Rare participants explain non-use by a lack of value given to interventions when they are offered free of charge or by a lack of prioritization of health problems compared to other activities deemed more important. Socio-economic factors were also reported, such as the difficulty in using it when sleeping on the floor, or when cooking and sleeping in the same room. Living in a small house with a single room is mentioned as a barrier, as there is an increased risk of fire spreading:

> *"You see that we live in different houses, because we have not yet all had housing, how can you install it if you have a small house of a size comparable to this place [he shows the small room of the house where the FGD was taking place]! We decide not to install it to prevent it from being burned by fire." (FGD with the Batwa community, Kinyinya)*

The results revealed that there is a distinction between the recycling of mosquito nets and repurposing. Recycling consists of reusing mosquito nets deemed ineffective or degraded in other activities such as construction (making ropes), livestock farming (making chicken coops, ropes, litter transport bags), agriculture (transport or conservation of harvests, drying, seed protection), food (collecting winged termites) or as mattress support:

"Yes, for a damaged mosquito net, it can be used for the preparation of rice nurseries to protect the rice against birds." (Female farmer, 38 years, Kinyinya)
"When a mosquito net is deteriorated, it can be used to collect winged termites and to dry cassava." (FGD with returnees, Kinyinya)
"They are used in the transport of litter for our livestock or are used in the making of ropes to tie animals." (Male farmer, 35 years, Ryansoro)

As for the repurposing of still effective or new LLINs, several participants mentioned that LLINs in good condition are also sometimes used for other purposes. It was also reported that LLINs are resold in border countries. Participants explained that the repurposing of LLINs is primarily linked to the economic precariousness of households, which leads them to prioritize other essential needs:

"Some people do it out of ignorance or as a result of poverty, the lack of ropes to tie livestock. Mosquito nets are effective in making ropes." (Farmer/breeder, 66 years, Ryansoro)
"[The] other reasons that push people to use mosquito nets for something else is [hesitation] poverty. The lack of means to obtain objects that serve to dry crops causes the use of the mosquito net given that it is received free of charge. Others sell them to satisfy their needs, such as buying soap for example or any other good." (FGD with uniformed men, Kinyinya)

Participants reported the ineffectiveness of LLINs after a certain time, after 5 months for some or a year for others. LLIN maintenance practices varied. Participants noted it was sometimes possible to repair torn LLINs by sewing them or by knotting the torn parts. However, other participants think that the mosquito net needs to be replaced because it cannot be sewn. As for washing, practices and types of soap used vary: some deliberately avoid powdered detergent, others use any type of soap available (solid or powdered); still others only wash the dirty part or wash it gently to prevent the insecticide from being lost. Several participants regret not having obtained sufficient information on the type of soap to use. As for the frequency of washing, some mention once or twice a year, others once a week. Regarding drying, participants mentioned several methods: in the shade or in the sun, on fences or on arranged drying racks.

Indoor residual spraying (IRS)

The analysis of perceptions regarding IRS reveals several key aspects: organization of the activity, implementation schedule, perceptions and representations of IRS, perceived purpose and impact of IRS, refusal or reluctance to benefit and the reasons given.

Several participants agree on the importance of prior awareness-raising through different communication channels (churches, community health workers, local administrators, community meetings, etc.) before sprayers start spraying houses. Study participants appreciate their involvement in IRS because they themselves made water available and prepared sprayable spaces in advance. Participants identified the areas targeted by spraying: the interior of the house, the corners of the house, as well as stables and showers. However, some participants regretted that IRS was not carried out in other places such as toilets or vegetation around the house:

"When you do IRS, you should also spray around households, where there are bushes around our houses to eliminate mosquitoes both inside and outside the house. Indeed, greenery promotes mosquito breeding. Another thing, you spray inside the houses while leaving aside the latrines, and if you're not bitten at home, you won't escape when you go to the toilet. This phenomenon should be reviewed." (FGD with administrative and religious leaders, Kinyinya)

Several operational challenges were identified during the implementation of IRS. Participants mentioned the difficulty in spraying certain dark or inaccessible places, the difficult working conditions for sprayers and potential health impacts (excessive fatigue and hunger), the recruitment of sprayers from outside the targeted hills and occasional non-compliance with set appointments.

For many participants, the time chosen to carry out IRS is not appropriate since IRS received during the dry season is deemed ineffective and should rather be carried out when there are mosquitoes during the field work.

As for representations of IRS, several participants reported that it is an activity contributing to the reduction of mosquitoes and, therefore, malaria cases in the community. Participants also mentioned other changes caused by IRS, notably the disappearance of other harmful insects (e.g. bedbugs, fleas, chiggers, cockroaches). Participants appreciate IRS as a government effort to preserve the health of the community:

"The main objective was the prevention against malaria in the region and we were lucky, this insec-

ticide destroyed other insects that threatened us like fleas, bedbugs and chiggers and also lice; all these things have disappeared." (FGD with farmers-rice growers, Kinyinya)

Most participants mentioned a limited insecticide residual efficacy of six months maximum:

"If I try to remember, the residual duration was 4, 5 or 6 months and they organized a spraying campaign again but now mosquitoes still enter, we protect ourselves with mosquito nets." (FGD with farmers-rice growers, Kinyinya)

However, some participants did not receive information about residual efficacy:

"(…) The PID staff do not provide any guarantees regarding the insecticide used in the PID, so we do not know when the house walls will be renovated." (FGD with administrative and religious leaders, Ryansoro)

Participants often mentioned only two IRS campaigns, combining the last two IRS of 2020 and 2021 and qualifying them as "recent IRS" compared to the "first IRS". Their comparison was based on the organization of the activity—including choice of sprayers, training received, time taken to apply the insecticide -, and the product used—residual duration, effectiveness, odor of the insecticide, and traceability on sprayed places. Perceptions regarding these two IRS cycles vary, with the second round more appreciated in Kinyinya:

"For the first IRS session, the sprayers did their work in the required number of households; but there were those who worked quickly to finish the number of households and those who worked by applying what they learned during the training; that's why then we realize that they were different because we found that mosquitoes were biting us despite the indoor residual spraying, but for the second session of indoor residual spraying I really appreciated it very much." (FGD with watchmen and hygienists, Kinyinya)

Perceived impact of IRS are summarized in a table (see Supplementary Material Table 4). Health benefits included the decrease in malaria cases and harmful insects, the reduction in medical consultations, and the improvement in house hygiene. Socio-economic benefits were also highlighted, including job creation. In addition, the reduction in diseases has had positive cascade effects: greater school attendance, families were able to meet their needs without missing workdays, and reduction in health expenses.

The analysis of IRS acceptability revealed a generally low refusal rate. Nevertheless, the reluctance expressed revolved around four main dimensions: health, social, spiritual, and logistical. Health concerns constituted a major reason for reservation, with several participants fearing side effects, particularly respiratory and skin problems. Others questioned the relevance of the intervention itself, either because they have never contracted malaria, because they observe the persistence of malaria in their community, or because they had the necessary resources to get treatment if needed.

Social explanations refer to the lack of anonymity and the desire to remain anonymous, particularly linked to the feeling of shame that some people developed in situations of great poverty associated with sleeping on straw mats, bags, or torn mats. This desire to remain anonymous has also been mentioned by people in more affluent situations who do not wish their possessions to be exposed in broad daylight. The following quotes illustrate these two points:

"I saw only one who refused to have IRS done and closed his house, the reason was poverty, he didn't want people to see the torn and dirty mats on which he and his children sleep; I would say it was shame that people might take out his belongings and enter to see the inside of his house." (FGD with teachers/supervisors and youth/students, Kinyinya)

"What I see for people who don't accept IRS methods, in our locality, there is one who refused because he is a rich man and it is difficult to take out all the materials and other things he has in his house and it is difficult to put them back in, the sprayers enter his house to verify that it's the reality and they really see them so they sprayed in the living room only." (FGD with female farmers and rice growers, Ryansoro)

Social reasons for refusal were also linked to the country's historical context. Some residents perceived the intervention as a potentially intrusive government initiative, a perception influenced by events of the 1990s when home visits could be likened to searches. Spiritual considerations also played a determining role, with IRS representing an intrusion into spaces considered sacred. Furthermore, the need to move furniture, harvests, and domestic animals constituted a major constraint. This temporary reorganization required time and availability, which could constitute a barrier to the acceptance of IRS. Finally, refusals were motivated by renovation projects, with some residents planning to renovate the walls of their house. The renovation of house walls, called retouching, is often carried out between June and September, a period devoted to preparations for family celebrations. Regarding the recommended waiting

period between spraying and renovation, participants had received information but received different waiting periods:

> *"We were told not to plaster directly, that it is necessary to wait for the necessary time if possible a year to plaster the walls in order to keep the residual duration of the insecticide." (FGD with community health workers, Kinyinya)*
> *"(...) we were given a period to paint our houses, a period of 6 months. Because even after a week the insecticide was still causing tearing." (Female farmer, 20 years, Ryansoro)*

Intermittent preventive treatment during pregnancy (IPTp-SP)

Several results appear important, particularly regarding perceptions of IPTp-SP, its importance, and possible reasons explaining non-acceptability or non-use during pregnancies. Men seemed very little informed about this treatment and several claimed not to feel concerned by this intervention:

> *"I am not aware of this treatment even if my wife is pregnant, I have never heard her say that she has been on a preventive treatment against malaria//I often notice that my wife brings tablets when returning from antenatal consultation but I don't know if these tablets are part of this treatment." (FGD with border men, Kinyinya)*

However, this lack of knowledge also emerged among women, for instance during an FGD with female farmers:

> *"I don't know it, maybe it's a new system.//I don't know them either//I don't know them either, at the time we gave birth at home." (FGD with female farmers, Ryansoro)*

Perceptions of IPTp-SP as a preventive measure were contrasted among participants. Several participants questioned its effectiveness, reporting cases of malaria that occurred during or after treatment. Conversely, some women testified to significant beneficial effects, emphasizing the overall protection it offers for the health of mother and child and preventing potential miscarriages:

> *"I too have seen the importance of IPTp-SP: before I conceived this child, I often suffered from malaria, but until now, since the conception of this pregnancy, I have taken IPTp-SP seriously, I have recovered. I have not yet seen any sign of malaria either on me or on my child. Until now, he is 2 years and 6 months old and we have not yet been diagnosed with malaria." (FGD with pregnant and breastfeeding women, Kinyinya)*

The analysis of adherence to IPTp-SP reveals a complex dynamic where the responsibilities of target populations and healthcare providers interact. Communication and awareness-raising constituted a major issue from the populations' point of view. Interviews and FGDs highlighted several gaps: insufficient awareness about the treatment, lack of clarity in information regarding its importance and effectiveness, and sometimes incomplete explanations from healthcare staff. The very notion of preventive treatment seemed to remain difficult to comprehend for some participants who, in the absence of symptoms, did not perceived the need for medication. The conditions of treatment administration also raised concerns. Participants notably reported worrying hygiene practices, such as the use of a single shared cup among all women during antenatal care visits.

Furthermore, the side effects of the treatment were a major concern. Reported symptoms within 24 h following medication intake included notably dizziness, loss of consciousness, fatigue and a sensation of weakness. Other adverse effects were mentioned: discomfort if taken on an empty stomach, drowsiness accompanied by excessive sweating, an increased risk of spontaneous abortion. These potential side effects represented a burden, and some of them suggested that small snacks be offered by health centers if needed. Others preferred to take the tablet at home. A health professional (nurse) discusses this situation:

> *"If we base ourselves on the IPTp-SP mentioned above, when pregnant women come for antenatal care, you often give them tablets and sometimes they tell you that they don't take medications without eating anything because they feel unwell. And then they ask you if they can go home with these medications to take them at home." (FGD with nurses and health promotion technicians, Ryansoro)*

However, this option is rarely possible because healthcare providers generally require medication intake under their supervision at the Health Centre. Healthcare providers justify this requirement by stating that some patients might either throw away the tablets once they return home or keep them to administer to their children:

> *"You can agree to give her the medications to take them at home because she refused to take them on site but we are not sure that she will take them because they say that even these multivitamin tablets have a bad smell, this type of medication causes a lot of bleeding during childbirth." (FGD with nurses and health promotion technicians, Kinyinya)*

Healthcare providers highlighted several obstacles in implementation, including organizational constraints and limited time to adequately inform target populations. In addition, the new focused antenatal care policy, which prioritizes quality rather than frequency, could compromise the objective of administering a minimum of three doses during pregnancy—the ideal protocol providing for monthly intake from the second trimester. A nurse explained that work overload did not allow for appropriate awareness-raising of target populations:

> *"The first constraint is noticeable at the level of health facilities. The time allocated to health education (HE) is very short. If we follow the health standards, a nurse cannot have time for HE, while he must receive at least 200 people per day. If the health policy says that to fight against malaria, all pregnant women must receive FANSIDAR [SP], the healthcare provider will be content with giving the order to all pregnant women as he also received it. A nurse may have 150 pregnant women who have come for antenatal care. Consequently, he will not have time to explain everything. He only says that the directives say: 'You should take IPTp-SP in front of the healthcare provider.'" (FGD with doctors and health district supervisors, Kinyinya)*

Factors influencing adherence or reluctance to this treatment have been classified into 4 categories in a table (see Supplementary Material Table 5).

Destruction of larval breeding sites/environmental management

The analysis focuses on three aspects: community practices, the importance of environmental management, and implementation challenges. Participants considered that environmental management plays a crucial role in eliminating factors promoting mosquito multiplication:

> *"First, we do the clearing around the house, plugging holes, we clear all around the house and in the evening, we have installed mosquito nets, these are the measures often used." (Male farmer, 35 years, Ryansoro)*
>
> *"What we know about malaria is to often clear the bushes that surround the house.//For the prevention of malaria, you eliminate the bushes that are around the house and do continuous sweeping, fill in the ditches because if you don't fill them in, mosquitoes often come, they settle in the bushes and stagnant water; that's prevention." (FGD with the Batwa community, Kinyinya)*

According to the participants, these activities contribute to reducing the incidence of malaria and lightening the workload of health facilities:

> *"The importance is paramount because without these measures, we would not exist, we would not be human, we would be dead, you find many patients at health facilities without them having enough space to be hospitalized." (Male farmer, 51 years, Kinyinya)*

Participants described three main activities conducted around their dwelling: 1) management of stagnant water (filling in ditches, filling holes and drainage channels, closing ditches created during brick making); 2) management of used objects (broken pots, vehicle tires, unused pots and pans, open bottles, and any object containing water); 3) clearing (clearing the surroundings of the dwelling, pruning corn or banana leaves). However, some participants highlighted the difficulty of clearing crops close to the house, fearing to compromise harvests. One of the participants specified that this activity was only undertaken by people able to carry it out:

> *"Those who can do it leave a free space, without crops around the house to prevent mosquitoes from sheltering there." (FGD with uniformed men, Kinyinya)*

Participants regularly mentioned difficulties in implementing these environmental management measures. The issue of prioritizing needs emerged as a recurring challenge: families with small plots could neither reduce cultivated areas nor move their kitchen utensils far from the house. This problem also affected people residing on rough or hard-to-access terrain. Economic precariousness constituted a major obstacle. Some families, forced to prioritize their subsistence activities, could not devote time to maintaining their land. Moreover, the need to preserve foliage to feed livestock contradicted the recommendation to eliminate vegetation close to dwellings:

> *"Like these days, goats don't leave the goat pen, a neighbor might refuse to clear the surroundings of their house supposedly because these bushes will facilitate the feeding of these goats; hence we find that constraints cannot be lacking." (FGD with border men, Kinyinya)*

Other mentioned constraints were the lack of time and material resources to apply these measures:

> *"This is due to lack of time, people are always looking for something to eat, they come home only to sleep." (Female farmer, 32 years, Ryansoro)*

"This is often due to poverty, often the person is busy with daily activities in order to have something to eat, they are not interested in environmental sanitation activities for lack of time." (Male farmer, 40 years, Ryansoro)

Living with neighbours who have a different perception of clearing was also mentioned several times. Regarding the pruning of banana trees, participants mentioned the risks of injuries and bites.

Beyond the environmental management strategies, participants mentioned various approaches to protection against mosquitoes. These included repellents, whether natural or synthetic: anti-mosquito creams and lotions, products like Baygon, repellent coils or sticks, cedar leaves to burn, citronella and Artemisia plants. Other measures were mentioned, such as closing doors and windows at dusk, or wearing long and rough clothes. A participant working at night highlighted the difficulty of protecting the face:

"We have raincoats and boots for our protection. However, since the face remains uncovered, mosquitoes bite us." (FGD with uniformed men, Kinyinya)

Discussion

This research provides the first comprehensive qualitative examination of perceptions towards malaria prevention methods in Burundi, revealing key issues that highlight the complexity of malaria control and the need for an integrated approach. Using the Social Ecological Model as the theoretical framework, this study examines factors influencing malaria prevention behaviours across three main interconnected levels of influence. This multilevel analysis demonstrates how individual actions occur within broader social and environmental contexts that both constrain and enable behaviour change in malaria prevention.

In the Burundian context, available data in the literature to examine and evaluate different malaria intervention strategies are limited. The study on malaria trends and control interventions in Burundi from 2000 to 2019 [6] traced the chronology of preventive and curative interventions since the resurgence of cases in 2000 and their implications. According to a quantitative study, approximately one household in two (51%) owns at least one mosquito net, treated or not [17]. Usage rates vary significantly: a 2018 national study found that 83% of those with access to an LLIN reported having slept under an LLIN the night preceding the survey and 81% reported sleeping under an LLIN every night [18], while earlier studies showed that, in 35% of surveyed households, only 40% of children under 5 and 44% of pregnant women slept under nets the night before the interview [17].

Internationally, several qualitative studies have sought to understand perceptions regarding prevention measures across Africa (Rwanda, Uganda, Tanzania, Nigeria, Mozambique) and South Asia (Nepal) [19, 20, 26–29], providing valuable comparative contexts for the present study.

Intrapersonal level: individual perceptions and personal experiences

At the intrapersonal level, individual perceptions and personal experiences might significantly influence malaria prevention behaviours. The need for information appears as a cross-cutting issue to all prevention interventions. Participants express a desire to be better informed, both before and after the implementation of measures. Their expectations particularly concern the objectives of interventions, their technical specifics (such as changes in insecticide), targeted areas, and practical aspects of use (for example, maintenance and repair of mosquito nets). Several participants regretted not having obtained sufficient information on the type of soap to use for washing LLINs, with practices varying widely from once weekly to twice yearly.

Individual perceptions about perceived need emerged as an important factor across interventions. The present study shows that certain preventive behaviours may be linked to the lack of perceived need. Several participants say they do not use mosquito nets during the dry season, as indicated by older studies conducted in Burundi [30] or Ghana [31], as well as studies recently conducted in India and Nepal [26, 32]. These observations highlight the importance to be given to the perceptions of target populations, in a context where malaria transmission in Burundi is perennial, requiring the use of LLINs every night, all year round [16]. The lack of perceived need has been mentioned by several participants for all preventive measures. This appears particularly when a person has never been affected by malaria, or when they feel healthy (especially for IPTp-SP). Similar observations have been made in other studies where lack of perceived need and doubt about the effectiveness of the treatment have been mentioned by pregnant women [25, 33, 34]. More rarely, the lack of perceived need has also been mentioned in this study when the person says they are able to pay for healthcare. Some women question the necessity of using a preventive treatment that does not ensure total protection, having been affected by malaria despite the treatment. Specifically regarding IRS, participants want to better understand the importance of such an activity, its expected results, and the duration of insecticide effectiveness. Although IRS benefits from high general

acceptability, this study highlights various reluctances within the population. These resistances are primarily organized around health fears, particularly related to potential side effects, but also social and logistical considerations.

The questioning of the usefulness of the intervention by some participants, either due to lack of personal experience with malaria or skepticism about its effectiveness, underscores the importance of better communication on the collective benefits of IRS in the fight against malaria. The present findings align with other studies showing variations in population perceptions regarding IRS importance [35] and objectives [36, 37]. A study conducted in Rwanda by Asingizwe and colleagues highlights that the perceived effectiveness of IRS is improved when awareness campaigns precede the activity [27]. According to them, social and behavioural change communication (SBCC) regarding malaria should not be perceived only as a one-time activity or a short-term process [38]. The lack of capacity and funding for SBCC generally results from attributing lower priority to communication in health ministries, which reduces its impact in various interventions [38]. In the Burundian context, this suggests a need to elevate the priority of communication strategies within health ministry budgets and planning. In this context, interventions could rely more on community health workers and train them for better awareness of communities about malaria prevention strategies [19, 39].

Alongside perceived needs, the question of their prioritization regularly emerges in this study. For LLINs, their use may be limited in families where protection against malaria is not a priority, in favour of needs deemed more pressing such as the search for means of subsistence. In some cases, new or still effective LLINs may be diverted for subsistence activities (construction, agriculture, livestock, fishing) or resold. However, participants report that recycling practices are also frequent, for mosquito nets deemed ineffective or with holes. These observations join those of Magaço and colleagues in Mozambique who found that ineffective or holed LLINs are reused in other activities at the household level [20].

It appears that mosquito nets still in good condition are used differently from the consensus declaration on the repurposing of LLINs provided to malaria control programmes and partners of WHO recommendations which provides for three types of reuse: beneficial reuse (use of inactive LLINs other than during sleep to protect against malaria infection), neutral reuse (use of inactive LLINs for household uses not intended to prevent mosquito bites), and misuse (use of an active LLIN for purposes other than the intended use). Based on these findings, we recommend developing communication messages that acknowledge the economic realities of the target populations and this would notably avoid blaming people for the use of mosquito nets in a diverted way when, in fact, they are recycling LLINs that have become ineffective.

Prioritization constraints extend beyond the use of mosquito nets. For the implementation of larval breeding site management activities, it is manifested particularly when people lack arable land; the population prioritizes crops in the only available spaces, sometimes in the immediate vicinity of houses, to have something to eat or feed their livestock.

These findings suggest that prevention messages need to specifically address misconceptions about seasonal needs for protection and emphasize that partial protection is valuable even if not complete. The literature confirms these observations. A study conducted in Burundi concludes that appropriate health education and information should be developed and promoted by health personnel, local authorities, and teaching staff. The objective would be not only to improve comfort by reducing nuisances caused by insects but also to reduce the considerable burden of malaria in the community [30]. A qualitative study conducted in the rural high river valleys of Nepal shows that many participants use LLINs only for a short period of the year (3–6 months per year), avoiding their use during winter due to the limited number of mosquitoes [26]. In Rwanda, it has been shown that, while participants consider the LLIN as an effective measure, some community members think that the malaria problem exceeds the capacity of LLINs due to its severity perceived as high [27].

Personal experiences with adverse effects strongly influenced individual adoption decisions. Adverse effects are reported by several participants in our study as a major obstacle in the use of preventive interventions. Regarding IPTp-SP, the side effects caused by the molecule are varied: participants mention discomfort when taking it before eating, vomiting, dizziness, and weakness. These effects are also documented in the scientific literature [33, 40–43]. In Mali, women report discomfort and dizziness, and vomiting associated with taking SP when they were hungry [33, 40]. Furthermore, several women in Kenya thought that SP was too powerful to be used during pregnancy and could harm the baby or cause a miscarriage [40]. These concerns are reflected in the present study in Burundi and these aspects should be further discussed with the target populations. According to the WHO, mild and transient side effects such as nausea, vomiting, weakness, or dizziness may occur. These risks should be openly addressed and managed as part of antenatal consultations [44]. The findings suggest that information should be more systematically integrated into prevention messages during antenatal care in Burundi.

Concerns related to adverse effects are not limited to IPTp-SP. A qualitative study conducted in Nepal shows that while participants generally appreciate the positive impact of IRS, particularly the reduction in malaria cases and health-harmful insects, they also mention unintended negative consequences such as the loss of bees, the increase in bedbugs, and allergic reactions in elderly people [26]. This has also been observed in the present study in Burundi. Regarding the effects of insecticides impregnated in LLINs and those used during IRS, participants emphasize that the odour or possible toxicity could constitute an obstacle to the use of mosquito nets or the acceptance of IRS. Discomfort and skin irritability are also reported in another study as barriers to the use of LLINs [35].

Given the existence of these effects, the IRS implementation guide in Burundi provides for a pre-survey on possible adverse effects as well as the establishment of a surveillance cell for recording adverse effects and post-spraying reactions [36]. Unfortunately, this cell has never been operationalized. The study results suggest an urgent need to activate this surveillance mechanism to monitor and address adverse effects. Nevertheless, positive approaches are emerging. In a study conducted by Asingizwe and colleagues in Rwanda, participants explain that the discomfort caused by mosquitoes is more annoying than the irritability caused by the insecticide-treated mosquito net, thus serving as an argument to favour behaviour change among people reluctant to use mosquito nets [26]. The risks of adverse effects and strategies to prevent them should, therefore, be an integral part of messages intended for target populations.

Organizational level: healthcare facilities and service delivery

At the organizational level, healthcare facilities and service delivery systems influence the implementation and uptake of malaria prevention interventions. The issue of information also arises for IPTp-SP, where the desired information relates to its importance and limitations in terms of prevention. Participants in the study mention a lack of information distributed within health facilities, especially in the case of new interventions. The observations show that care providers responsible for informing patients are insufficient in number and overworked, which limits the time dedicated to health education (HE) to correctly inform all women during antenatal consultations. Quantitative data corroborate these observations. For IPTp-SP, a quantitative study carried out in the Muramvya health district reveals that only 13% of women received at least 3 doses of SP/Fansidar during the pregnancy of their last live birth [17]. This study indicates that the majority of surveyed women did not take the full dose of IPTp-SP and that general knowledge was considered good in only 32% of pregnant women who were informed about it. This lack of knowledge is explained in particular by the lack of sufficient information given to pregnant women by nurse providers on this intervention in the districts and the lack of staff or time allocated to this information [17, 45]. These findings are confirmed by Nkunzimana and colleagues in Muramvya, central Burundi [19]. Their quantitative study also highlights the important contribution of health facilities in terms of communication, in a context where the need for information is also mentioned by target populations, insufficient staff, limiting the time given to HE at the health center level [19].

Hygiene conditions constitute a major obstacle to IPTp-SP compliance. Several participants mention inadequate hygiene conditions during SP administration, notably the use of the same cup for all women in antenatal consultation. This hygiene problem (lack of drinking water and cups) is also observed in health facilities in Tanzania, and it constitutes a brake on the use of IPTp-SP for pregnant women [46]. The training manual on the use of IPTp-SP recommends the presence of a cup washing device in antenatal care services. However, this device is rarely available, forcing women to provide drinking water and the cup themselves, which creates inequality for women in poverty situations. This study recommends that closer supervision of health facilities could address this type of issue, joining the findings made during a study conducted in Nigeria, revealing that supervision constitutes an important step to facilitate adoption, coverage in health facilities, and maintenance of hygiene [47].

Policy and environmental level: structural and system-wide factors

The policy and environmental level addresses broader structural and system-wide factors that influence malaria prevention programme implementation and effectiveness.

The need to adapt interventions to the local context constitutes a major issue identified in the present study. The WHO recommends that the number of mosquito nets be determined according to usual sleeping patterns and family size, based on demographic data obtained during a pre-intervention assessment [48]. This recommendation makes perfect sense in light of the present study results and other studies. In a qualitative study conducted in several countries (Burkina Faso, Mozambique, Nigeria, and Rwanda), the authors demonstrate the need to take into account family structures, available sleeping spaces, and other preferences regarding bed sharing when determining the number of mosquito nets to distribute [49].

In the present study, the need to further adapt certain measures to the context of the target populations was mentioned by several participants. Indeed, the counting was done on the number of people and not on the number of sleeping spaces, which implied insufficient distribution in some households. In addition, in Burundi, the last population census dates from 2008 and calculations are derived from projections. Adaptations are also necessary to integrate community members into the intervention team, as this strategy seems to be better received by the population. Finally, the destruction of larval breeding sites for families in socio-economic precariousness is very difficult to apply and this reality should be integrated into the design or dissemination of these measures. This need for adaptation is all the more important in the Burundian context where there is little recent data to examine and evaluate different intervention strategies. Regarding the use of mosquito nets or IPTp-SP [17, 18], the information obtained in the rare research on this subject in Burundi remains relatively superficial and does not allow for firm conclusions on this subject, as observed in other studies [50]. The WHO recommends adapting intervention strategies to local contexts within the framework of integrated vector management (IVM) [51]. This pragmatic approach proposes various vector control methods, often combined synergistically, that can adapt to different ecological and socio-economic contexts. Such an approach has notably been studied in Uganda [52].

The present study highlights a number of socio-economic constraints limiting the appropriate use of mosquito nets. Sleeping on the floor, combined with the cramped nature of housing where a single room serves as both kitchen and sleeping area, makes the use of mosquito nets very difficult or even dangerous for the inhabitants. This risk to safety in case of limited space has also been observed in a qualitative study conducted in Nigeria [29]. Regarding IRS, it appears that non-respect of anonymity constitutes an important factor to take into account for people reluctant to make visible their great precariousness, or conversely their wealth, these two aspects also emerging from a study in Tanzania [53]. The constraints observed in Burundi join those identified in other contexts. A study in Mozambique on the acceptance of IRS reveals that the level of education, rural or urban situation, and profession of the target person can favour the acceptance or refusal of the intervention. Those who refused IRS in 2016 were mainly from urban neighbourhoods with a secondary and higher level of education, including teachers, drivers, and civil servants [20].

The literature identifies several other refusal factors, including the selection process and performance of sprayers, negative experiences from previous campaigns (perceived ineffectiveness, strong odor, marks left by the insecticide), change of insecticide, political conflicts, the difficulty of removing heavy furniture, and the preference for insecticide-treated mosquito nets over IRS [20, 53–55]. The quality of implementation also appears determinant. A study in Rwanda shows that perceptions regarding the spraying team are important. Participants felt that the new team—community health workers having been replaced by district administration security members—did not carry out IRS correctly, by not respecting usage instructions (dilution of the insecticide) and lacking training in spraying techniques [27]. Regarding environmental management, it is the lack of material resources that constitutes a brake, particularly the absence of tools or arable land.

Based on the present findings, it is recommended to implement a more context-sensitive approach to malaria prevention in Burundi that moves beyond one-size-fits-all interventions and considers local sleeping arrangements, community involvement, and socioeconomic realities. Given the socio-economic constraints faced by target populations of malaria control programmes, it is recommended to adapt prevention messages to specific local realities and developing alternative strategies when standard measures cannot be implemented. Stakeholders should collaborate with actors from other sectors to develop actions responding to the socio-economic needs of households. Awareness messages could be adapted to different situations, particularly by providing more information on the installation and storage of mosquito nets during the day for households living in a cramped house or by encouraging the population to plant crops around houses that do not have many leaves. Regarding IRS, our study shows that the waiting time to respect the residual duration of the insecticide seems to be information understood by participants. However, the details regarding the exact delay do not reach consensus. This finding invites questioning the coherence of the content of information messages, as well as more broadly how the message is transmitted to target populations.

Overall, the findings suggest an urgent need for improved communication strategies that address both the content and delivery of prevention information across all malaria interventions in Burundi.

Strengths and limitations

This research presents several significant assets. On one hand, it provides primary information adapted to the context that will be added to the limited literature of Burundi and can serve for planning future interventions carried out by NMCP and other partners. On the other hand, the methodological robustness of the study relies on a multidisciplinary team combining complementary

skills: expertise in public health, in-depth knowledge of the field, and mastery of the local language. This multidisciplinary approach enhanced both data collection and analysis by ensuring that interview questions were culturally appropriate and that responses were interpreted within their proper local context. The collection and analysis of data were conducted collaboratively, with validation at several levels ensuring the rigor of the results.

Nevertheless, certain methodological limitations must be highlighted. Firstly, access to discourses and not to practices limits the scope of the observations. An ethnographic approach with long-term observations would have allowed a greater understanding of the actual practices of the population. Secondly, data collection by interviewers working for MSF-OCB may have introduced a desirability bias among participants in individual interviews and FGDs. To mitigate this potential bias, interviewers were trained to emphasize that there were no right or wrong answers. Additionally, the sampling approach may not have fully captured the perspectives of certain marginalized groups, particularly those with the most limited access to healthcare. Selection bias represents a potential limitation of this study. Reliance on local leaders (hill chiefs, institutional leaders) to identify and facilitate access to participants may have introduced selection bias, as these leaders might have directed the researchers toward individuals who are more compliant with health interventions or hold favourable views of local authorities. This could have potentially limited the diversity of perspectives captured in the findings. To mitigate this bias, the study specifically included participants who were known to have refused previous IRS interventions, ensuring that critical perspectives were represented in the sample. However, the possibility that some dissenting voices remained unrepresented cannot be entirely excluded. Finally, the study's geographic limitation to two health districts with specific ecological and socioeconomic characteristics limits transferability to other regions of Burundi with different malaria transmission patterns, cultural contexts, or economic conditions, which must be considered when interpreting and generalizing these results.

Conclusion

This qualitative descriptive study explored the perceptions and practices of target populations regarding malaria prevention measures in the health districts of Kinyinya and Ryansoro. The results confirm that LLIN, IRS, IPTp-SP, and destruction of larval breeding sites are recognized as effective measures. However, several barriers and constraints have been identified by participants.

Applying the Social Ecological Model revealed that malaria prevention challenges operate across interconnected levels: intrapersonal factors (perceived needs and adverse effects), organizational factors (healthcare service delivery and information dissemination), and policy/environmental factors (socio-economic constraints, need for context-sensitive intervention adaptation). This multi-level analysis demonstrates that effective information dissemination is crucial, before, during, and after the activity, as demonstrated elsewhere [56]. The results also demonstrate that certain interventions should be better adapted to the context and more attentive to the living conditions of target populations, particularly to socio-economic factors that limit the ability of the population to implement certain measures. The management of adverse effects related to different interventions must be taken seriously in order to avoid refusal by target populations. The study also highlights the importance of taking into account perceived needs and their prioritization in messages intended for target populations.

In conclusion, effective malaria prevention in Burundi requires a multi-level approach that addresses communication needs, contextual adaptation, management of adverse effects, understanding of local priorities, and mitigation of socio-economic constraints. The SEM framework demonstrates that sustainable malaria prevention requires simultaneous intervention across individual, organizational, and policy levels [24]. The findings suggest that integration of these multiple dimensions into malaria control programmes would significantly improve both acceptance and effectiveness of prevention measures.

These observations highlight the necessity of establishing a continuous and bidirectional dialogue with communities at all socio-ecological levels. This approach implies not only transmitting information to communities but also listening to their experiences, concerns, and suggestions. Reciprocal communication thus becomes indispensable for the success and sustainability of malaria control interventions. Messages adapted to the context of targeted populations, accompanied by meticulous preparation and integrated follow-up will allow responding to questions and concerns of local populations while valuing their local knowledge and experiences.

Abbreviations

ANC	Antenatal consultation
CHW	Community Health Worker
DHS	Demographic and Health Survey
DHIS2	District health information software, version 2
FGD	Focus group discussion
IDI	Individual in-depth interview
IPTp-SP	Intermittent Preventive Treatment during pregnancy
IRS	Indoor residual spraying
LLIN	Long-lasting insecticidal net
NMCP	National Malaria Control Programme
SBCC	Social and Behaviour Change Communication
SP	Sulfadoxine-Pyrimethamine
WHO	World Health Organization

Supplementary Information

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Supplementary material 1. Table 1: Interview guides for Individual interviews and FGDs.

Supplementary material 2. Table 2: Socio-demographic characteristics of the participants in the individual interviews.

Supplementary material 3. Table 3: Socio-demographic characteristics of the FGD participants.

Supplementary material 4. Table 4: Perceived impacts of IRS.

Supplementary material 5. Table 5: Reasons related to non-use of IPTp-SP.

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Author contributions
TN, RN, ADA, and MM designed the study; DC, PU, LE, CM, SC, and WVB reviewed and revised the protocol; MM and CD trained the principal investigator, coordinator, and NMCP team in qualitative methods; TN, RN, FM, MM, and CD trained the interviewers and supervisors; TN and RN coordinated data collection; PCN and JS supervised data collection; FU, BA, IN, DM, IB, SN, AR, DaN, DiN, NL, NF, IO, IE conducted data collection and transcription; TN, RN, AR, NI, FN, CD, FU, and MM conducted data analysis and interpretation; TN, RN, MM wrote the research report and the manuscript of this article. The manuscript was reviewed and approved by all authors.

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Data availability
No datasets were generated or analysed during the current study.

Declarations

Competing interests
The authors declare no competing interests.

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