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Factors associated with low coverage in mass drug administration for schistosomiasis in mobile populations in Mali: a cross-sectional study

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Abstract

Background Neglected tropical diseases (NTDs) affect over a billion people globally. From 2020 to 2021, when this study was conducted, Mali remained endemic for multiple NTDs, including schistosomiasis and trachoma. At the time, significant efforts were underway to scale up control and elimination programs, although challenges persisted, particularly in reaching mobile populations such as nomads, migrants, and internally displaced persons (IDPs), with mass drug administration (MDA). These groups were often missed during campaigns, contributing to gaps in coverage and sustained transmission in certain areas. This study was designed to investigate the factors contributing to non-participation in schistosomiasis MDA among mobile populations in Mali, to inform strategies for more equitable and effective delivery.

Methods A cross-sectional study was conducted among adults (18 + years) in two Malian health districts targeting nomads, migrants, and IDPs from March to July 2020. A multi-stage cluster sampling approach was used to select participants. Mobility was defined as temporary or permanent movement for livelihood (e.g., herding, mining) or due to displacement. Structured, interviewer-administered questionnaires were used, after development by the study team and pre-tested in a similar population. Questions focused on barriers to MDA access, mobility patterns, awareness about MDA, and logistical challenges. The main outcome was self-reported participation in the last MDA (i.e., taking praziquantel). Data were analyzed using descriptive statistics and multivariable mixed-effects logistic regression models.

Results A total of 1067 participants were included in the study. All groups had MDA coverage rates below the recomended 75% threshold for schistosomiasis elimination. Only 40.8% of IDPs and 3.62% of migrants participated in the last MDA. The most reported reason for non-participation was a lack of information (64.5%). Lower income and occupations such as mining were significantly associated with non-participation ($p < 0.001$). Mixed-effects

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logistic regression showed that males were nearly three times more likely to miss MDA than females (aOR = 2.89, 95% CI = 1.65–5.06). Participants facing accessibility barriers (e.g., long distances, physical limitations) were also more likely to miss MDA (aOR = 2.60, 95% CI = 1.45–4.66). Nomads and transhumants were more likely to miss MDA compared to IDPs (aOR = 3.16, 95% CI = 1.05–9.47).

Conclusion These findings reveal notable disparities in MDA participation, influenced by mobility patterns, information access, and trust in health programs. Addressing these barriers requires context-specific approaches, such as improved communication, tailored MDA delivery, and greater community engagement. Strengthening these efforts is essential for equitable NTDs control and ensuring mobile populations are not left behind in schistosomiasis elimination efforts.

Keywords Mobile populations, Risk factors, Mass drug administration, Schistosomiasis, Mali

Background

Neglected tropical diseases (NTDs) are a diverse group of 21 diseases and conditions that prevail in tropical and subtropical areas [1]. They affect more than one billion people and cost developing economies billions of dollars every year [2]. The World Health Organization (WHO) recommends preventive chemotherapy as a key for the control and elimination of five NTDs: lymphatic filariasis, onchocerciasis, schistosomiasis, soil-transmitted helminthiasis (hookworm, ascariasis, trichuriasis) and trachoma. Within the context of NTDs, preventive chemotherapy is offered to individuals living in endemic areas without prior diagnosis, in order to prevent transmission, manage morbidity and prevent disability [3].

Mali has largely been successful in its elimination programs for four out of the five preventive chemotherapy NTDs (PC-NTDs). At the time this study was conducted (2020 to 2021), significant progress had been made in the national NTDs program, and continued efforts were focused on interrupting transmission and improving mass drug administration (MDA) coverage. Since 2021, important milestones have been achieved: Trachoma was eliminated as a public health problem in 2023 [4], and all health districts met the criteria for stopping MDA for lymphatic filariasis after the WHO's Regional Program Review Group's 2016 approval. For soil-transmitted helminthiasis, all assessed health districts were free of infected children based on the latest evaluation (Mali National Schistosomiasis and Soil-transmitted helminths control program, unpublished data, 2023). The prevalence of onchocerciasis in five endemic regions has declined to levels that allow for Stop-MDA surveys across all operational transmission zones except for the Kayes region.

Despite these gains, schistosomiasis, particularly *Schistosoma haematobium*, continues to be a significant public health issue in Mali. According to the last evaluation in 2018 prior to the development of this study protocol, schistosomiasis prevalence across districts ranged from 0 to 83.6%, with Kalabancoro reporting approximately 10.83–50.83% for urinary schistosomiasis and intestinal schistosomiasis respectively, and Tominian/San reporting 5.5–20%, in some villages (Mali National Schistosomiasis and Soil-Transmitted Helminths Control Program, unpublished data, 2018). Schistosomiasis is one of the most common and prevalent NTDs in Mali, with at least 97% of school children infected in some areas. A recent study reported 50.2% urinary schistosomiasis prevalence with 36 eggs/10 ml urine average [5]. Mali's endemic regions show varying levels, with some having moderate to high incidence.

NTDs control and elimination may be threatened if groups of untreated individuals remain in communities. It is known that there are groups of people that might have missed the MDA campaigns due to their high mobility and vulnerability [6, 7]. These individuals may not have had access to the MDA due to many factors including sub-optimal performance of community drug distributors, the heavy workload of community drug distributors and health workers, a lack of awareness about the MDA and other programmatic factors [8–10]. At the time this study was initiated, limited data were available on how different mobile populations might contribute to ongoing transmission and the potential re-emergence of PC-NTDs [11, 12]. It is therefore hypothesized that mobile populations could harbor pathogens and may introduce transmission when they move to other regions [13]. As a result, it is hypothesized that mobile populations represent a potential obstacle for elimination programs.

Over the last decade, Mali has been facing major climate variability, insecurity and extreme poverty. These challenges have resulted in the displacement of thousands of people within and outside the country, contributing to a growing number of internally displaced persons (IDPs). These conditions have contributed to new forms of mobility of populations that move towards southern Mali, creating economic migration and internal displacement in addition to existing patterns of mobility due to traditional nomadism and transhumance [14–16].

Given the increased numbers of people in movement, there is also paucity of information on how to best

provide mobile people living in vulnerable circumstances with essential health care [17, 18]. To achieve the objective of Sustainable Development Goals of 'leaving no one behind', MDA campaigns should understand who may be missed particularly in specific populations known to be at risk, such as children, pregnant women, nomadic populations, migrants, inhabitants of conflict, rural and remote areas and other people living in vulnerable circumstances [6].

Previous studies, including our own, had established strong evidence of the vulnerability of mobile populations to missed MDA [6, 7, 19, 20]. In this current paper, we add value to the current literature by providing a deeper quantitative analysis specifically on schistosomiasis MDA, disaggregated by type of mobile population (IDPs, nomads, migrants), and by identifying context-specific barriers and risk factors (e.g., income, occupation, gender, location) through a multivariable model. By focusing on these distinct mobile communities in Mali, we aim to inform MDA interventions, guide programmatic adjustments and identify ways to improve MDA coverage for NTDs in such populations in Mali.

Methods

Defining mobile populations in Mali

For this paper, the term "mobile populations" encompasses diverse groups whose movement patterns vary based on economic, environmental, and sociopolitical factors. These include : Internally displaced persons (IDPs): This term refers to people forced to flee their homes due to conflict, violence, insecurity, persecution, or disasters but who remain within Mali's borders. IDPs are considered some of the most vulnerable groups globally [21]. As of September 2024 there were 378,363 IDPs in Mali according to the International Organization for Migration Displacement Tracking Matrix (DTM Mali) [16] *Nomads and transhumants*. Nomads and transhumants move seasonally to find pastures and water for animals. Nomads include various groups such as nomadic hunter-gatherers, pastoralists and peripatetic communities (which are groups moving among settled populations while offering a craft or trade). Pastoralists can be classified into three groups: (1) transhumants, who are nomadic and move regularly between two grazing areas along fixed routes, (2) pastoralists who follow traditional migration paths but also explore new areas annually, and (3) semi-pastoralists, who have a semi-sedentary lifestyle with occasional movement [22]. Economic migrants, (e.g. gold and sand miners, seasonal agricultural workers) according to the European Commission, this refers to is a person who voluntarily moves from his/her country of origin to another purely for economic reasons, unrelated to refugee status [23]. Additionally, in our study, residence referred to the participant's current place of stay at the time of the survey, regardless of duration [6, 24].

Study design and setting

We employed a cross-sectional study design to identify factors associated with non-participation in the most recent schistosomiasis mass drug administration (MDA) among mobile populations. The last MDA campaign that involves distribution of praziquantel tablets across all communities in the study districts was conducted in the spring of 2019, targeting both the fixed and mobile population. Data collection was conducted from February to June 2020, less than a year after the MDA campaign was conducted. The campaign targeted both fixed and mobile populations through distribution conducted in schools and communities.

The study was conducted in two health districts in Mali (Fig. 1): Tominian (a rural district in the Ségou region, 465 km from Bamako) and Kalabancoro (a semi-urban district in the Koulikoro region). These districts represent rural and semi-urban settings respectively and have highly mobile populations, increasing the likelihood of individuals missing MDA campaigns. The two districts were selected in collaboration with the Mali National Schistosomiasis Control Program due to their highly mobile populations and planned MDA campaigns during the study period.

Related to nomadic movement, Tominian and San health districts serve as transit zones for nomadic and transhumant herders moving their animals southward in search of better grazing areas during the dry season [25]. Kalabancoro, a health district close to Bamako, the capital city, attracts mainly sand exploiters and rice farmers because of the Niger River that runs alongside the district. There are also gold-mining sites that attract thousands of people, even from neighboring countries [26]. With the insecurity in other parts of Mali, many people took refuge in Kalabancoro and Bamako, and the surrounding environs by the time of this research.

Characteristics of participants

Participants had to be at least 18 years old and presently residing in the study districts (Kalabancoro and Tominian). They should be able and willing to provide informed consent in order to be included in the study. People who did not meet our mobile population criteria, i.e. they were not considered as migrants, nomads and transhumants or internally displaced people, were automatically excluded from the study at the time of enrollment.

Sample size calculation and sampling methods

Sample size calculation

The sample size was determined using the Cochran formula $N_0 = Z^2pq/e^2$ [27], where N_0 is the sample size, Z the abscissa of the normal curve that cuts off an area α at the tails (1 – α equals the designed confidence level that was set at 95%), the desired level of precision (set at 3%), p the estimated frequency of an attribute that is present in the population (a non-participation rate of 20% was assumed based on previous MDA coverage reports in Mali among the general population (Program data/unpublished)), and q is 1-p (equal to 1- 0.20). The estimated sample size is $N_0 = (1.96)^2 \times (0.20)$ x (1- 0.20)/$(0.03)^2$ =683 + 10% of non-response (68.30) = 752 community members for both health districts.

Sampling methods

The study employed multi-stage cluster sampling [28] to ensure representation of nomads, seasonal migrants, and IDPs, present in Tominian/San and Kalabancoro health districts during the study period. The study team identified the presence of these three mobile populations in the districts through the local health center also identified the total number of settlements of migrants, nomads, and IDPs within the district and allocated an equal proportion of the sample to each. The team then visited the settlement and interviewed eligible participants aged 18 years or older. In some areas where the settlement was small, all eligible participants in the dwellings were recruited. In other areas where the settlements were larger, two persons (male and female heads of household) were recruited. In some cases, the study team would come to a settlement and find that the population had already moved on. In those cases, the sample was reallocated to another settlement in the district. Before the data collection, field staff were trained in culturally appropriate engagement strategies to facilitate effective communication with mobile populations.

Data collection tools and methods

Data collectors administered a structured questionnaire (see supplementary material 1: questionnaire) to participants, developed to cover several themes on MDA for schistosomiasis. The questionnaire captured participants' demographic information (age, gender, occupation and migration status) and health behaviors, such as frequency and type of interaction with health services, past MDA participation, and awareness of schistosomiasis and MDA campaigns. It also explored barriers to participation, including reasons for non-participation, such as accessibility, campaign timing and trust in health programs. We further examined living conditions and typical migration patterns to better understand the mobility dynamics in these populations. During the survey, participants were asked if they received treatment in the last schistosomiasis MDA campaign, how and where it was delivered. When possible, self-reported participation was cross-checked against drug distribution records. Questionnaires were digitized using Open Data Kit version # 1.27 and administered via Android devices. Data collection was conducted in French and Bambara, the predominant local languages. The questionnaire was developed in French, translated into Bambara during the training sessions, and then back-translated to ensure accuracy and consistency. Translations were validated by the research team familiar with both the local context and research terminology.

Data management and statistical analyses

Data management and statistical analyses were conducted using R version 4.4.2 and RStudio. All variables were screened for irregularities and outliers. Data were cleaned and recoded using the dplyr package [29, 30]. Descriptive statistics were used to summarize the study population characteristics. Categorical variables were then analyzed using frequencies and proportions, while continuous variables were categorized into classes. Differences in MDA participation between sites were analyzed using Chi-squared or Fisher's exact test. Statistical significance was set at $p < 0.05$. Mixed-effects logistic regression was used to identify individual and household factors associated with non-participation in the last MDA, accounting for clustered sampling. Models were adjusted for potential confounders using glmer() function (*generalized linear mixed-effects models*) from the lme4 package [31]. Multicollinearity was assessed using the vif() function *(variance inflation factor)*. A variance inflation factor of 2.5 or greater was considered multicollinear [32]. Univariate analysis in RStudio was used to identify explanatory variables with a p-value of less than 0.2 for inclusion in multivariate modeling. For statistical analyses, lme4 (*linear mixed-effects models using S4 classes*) package [31] in RStudio was used to build mixed models tailored to our dataset. Model results were presented in tabular form using gtsummary [33], which enables informative formatting of results. Graphs were generated with the ggplot2 package [34], offering clear visualization of data and analytical results. Akaike Information Criterion values were used to compare models and choose the best fitted. The model with the lowest value of the Akaike Information Criterion was chosen [35].

Ethics considerations

In accordance with the declaration of Helsinki, the protocol was reviewed and approved by the Ethical Review Committee of the University of Sciences, Techniques and Technologies of Bamako (Mali) [Approval No. 2019/173/CE/FMOS/FAPH]. Additionally, approval was

provided by the University of Ottawa (Canada) [Approval No. H- 02- 23- 8759]. Data were recorded using unique identification numbers to maintain anonymity and confidentiality. All participants signed consent forms before their inclusion in the study. For participants who cannot read, write and/or understand French, a second person who can read, write and understand French also signed the consent form as a witness. Additionally, a lay-language information sheet summarizing the study was provided to all participants.

Results

Data were collected from 1,067 participants (529 IDPs, 414 migrants and 124 nomads) as shown in Table 1.

Socio-demographic characteristics of participants

The majority of participants were male, comprising 60.1% (641/1067), and 43.3% (462/1067) were aged 30 years or younger. IDPs accounted for 49.6% (529/1067) of the overall study population, with a significant variation between the districts. Gold mining was the dominant occupation in Kalabancoro (55.2% (287/520)), while farming and livestock breeding were the most common occupations in Tominian/San, respectively 25% (137/547) and 36.4% (199/547) ($p < 0.001$). The sources of information for the population also varied significantly between the two sites, with TV/radio being the most commonly used source (Table 1).

Among non-participants in MDA ($N = 327$), nearly half of the IDP (48.5% (66/136)) were under the age of 30

Table 1 Socio-demographic characteristics of the study participants

	Health district			
Characteristic	**Overall, *N* = 1 067[1]**	**Kalabancoro, *N* = 520[1]**	**Tominian/San, *N* = 547[1]**	***p*-value[2]**
Sex				0.500
Female	426 (39.9)	213 (41.0)	213 (38.9)	
Male	641 (60.1)	307 (59.0)	334 (61.1)	
Age group				0.098
≤ 30	462 (43.3)	214 (41.2)	248 (45.3)	
31 - 45	352 (33.0)	168 (32.3)	184 (33.6)	
≥ 46	253 (23.7)	138 (26.5)	115 (21.0)	
Population status				<0.001
Internally displaced person	529 (49.6)	106 (20.4)	423 (77.3)	
Migrant	414 (38.8)	414 (79.6)	0 (0.0)	
Nomad/transhumant	124 (11.6)	0 (0.0)	124 (22.7)	
Education				0.169
Madrasa/koranic school	335 (31.4)	171 (32.9)	164 (30.0)	
Not educated	520 (48.7)	260 (50.0)	260 (47.5)	
Primary	148 (13.9)	61 (11.7)	87 (15.9)	
Secondary	64 (6.0)	28 (5.4)	36 (6.6)	
Monthly income				0.763
Minimum wage or more	240 (22.5)	113 (21.7)	127 (23.2)	
Less than minimum wage	412 (38.6)	206 (39.6)	206 (37.7)	
Don't know	415 (38.9)	201 (38.7)	214 (39.1)	
Occupation				<0.001
Merchand/Trader	44 (4.1)	11 (2.1)	33 (6.0)	
Farmer	156 (14.6)	19 (3.7)	137 (25.0)	
Breeder	233 (21.8)	34 (6.5)	199 (36.4)	
Sand miner	127 (11.9)	127 (24.4)	0 (0.0)	
Housekeeper	108 (10.1)	18 (3.5)	90 (16.5)	
Gold miner	287 (26.9)	287 (55.2)	0 (0.0)	
Laborer	112 (10.5)	24 (4.6)	88 (16.1)	
Sources of information				<0.001
TV/radio	248 (38.6)	119 (38.6)	129 (38.6)	
Health center	149 (23.2)	88 (28.6)	61 (18.3)	
Interpersonal communication	118 (18.4)	57 (18.5)	61 (18.3)	
Don't remember	127 (19.8)	44 (14.3)	83 (24.9)	
Unknown	425	212	213	

[1]n (%); hh [2]Pearson's Chi-squared test

years, highlighting a predominantly young population. A similar trend was observed among migrants. For nomads and transhumant groups, more than 80% (32/36) of non-participants were under the age of 45 years. Across all three population groups, men dominated the non-participating subgroup. This male predominance was particularly pronounced among migrants. Overall, the majority of non-participants 64.2% (210/327) were male, across all groups including IDPs, migrants, and nomads (Table 4).

Figure 2 shows the frequency of participation in the last schistosomiasis MDA by the different mobile populations studied (IDPs, migrants and nomads/transhumants). IDPs had the highest participation rate in the last MDA campaign with 40.8% (216/529), while migrants recorded the lowest rate 3.62% (15/414). Over 57% of migrants had not participated in the last MDA campaign targeting schistosomiasis. Among the study participants, over 20% of each mobile group had no recollection of the campaign. For instance, 26% (32/124) of nomads and transhumants in the study stated that they had never taken part in a schistosomiasis MDA campaign (Fig. 1).

Frequency of the most cited barriers to taking part in the most recent MDA campaign targeting schistosomiasis using praziquantel

The reasons for not attending the last MDA using praziquantel for schistosomiasis control are shown in Fig. 3. The most common reason, cited by 64.5% (334/518) of respondents was lack of information. Other reasons include traveling 16.2% (84/518), feeling unconcerned 10.4% (54/518), fear of side effects 4.8% (25/518), and a lack of trust in the drugs 4.1% (21/518) (Fig. 2).

Non-participants were less informed than those WHO participated, with 32.3% (73/226) unable to recall their source of information, compared to only 13% (54/416) of those who participated ($p < 0.001$). Regarding

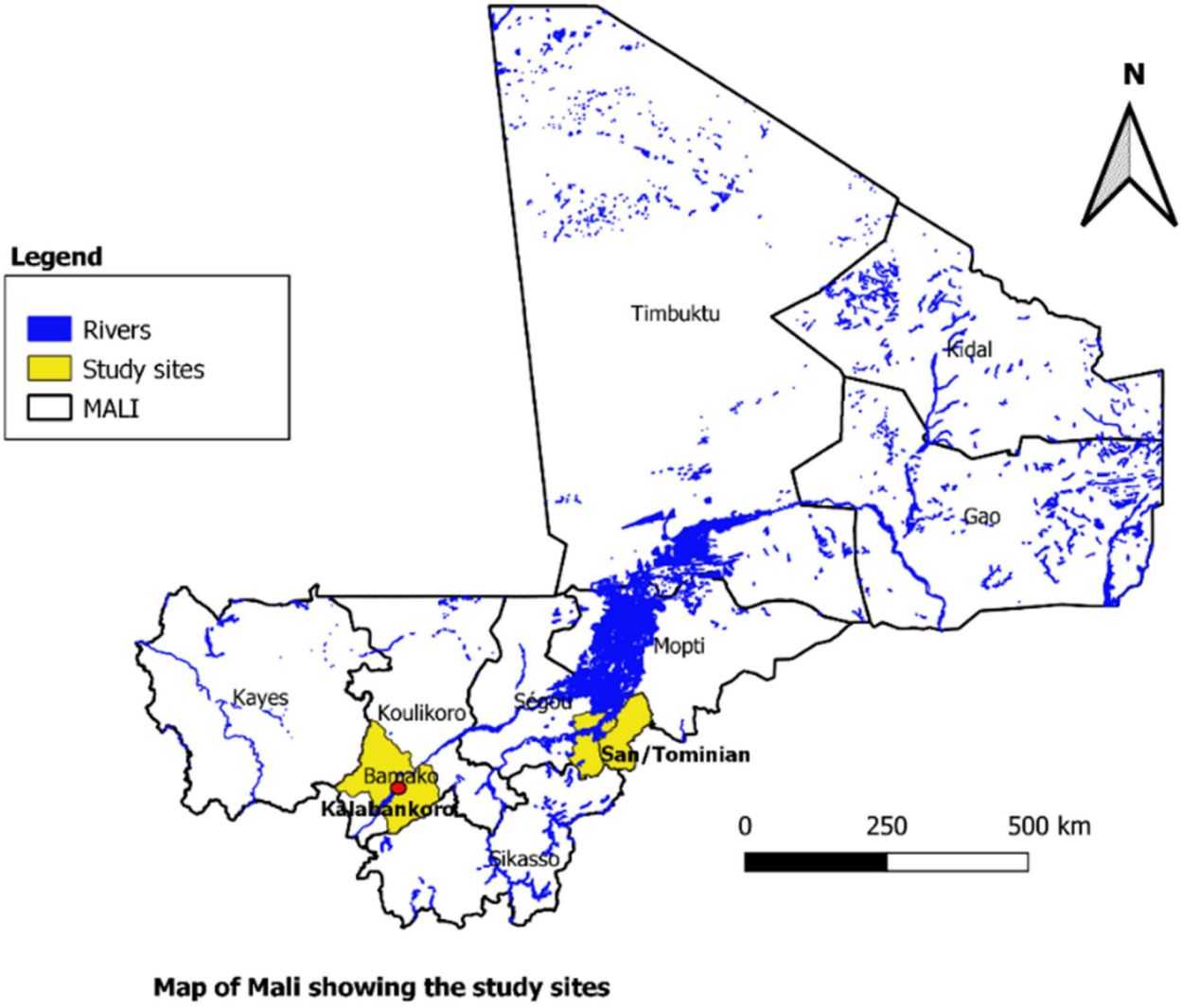

Fig. 1 Frequency of participation in the last schistosomiasis MDA within IDPs, migrants and nomads/transhumants

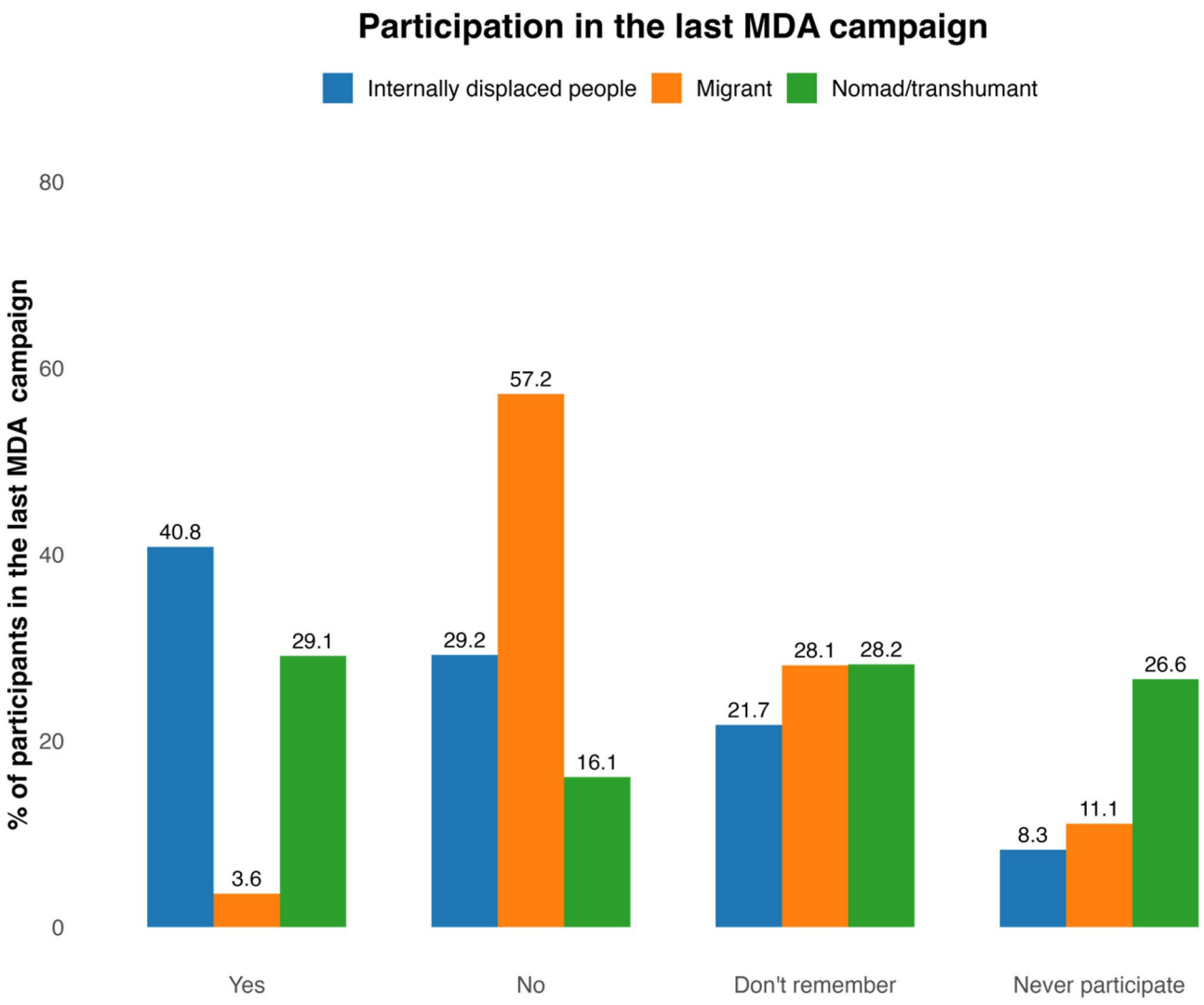

Fig. 2 Frequency of reasons for non-participation in last schistosomiasis MDA among everyone (praziquantel distribution)

socioeconomic barriers, non-participants had lower income levels, with 17.1% (56/327) earning below the minimum wage compared to 25.8% (124/480) earning at or above the minimum wage amongst the MDA participants ($p = 0.034$). Additionally, they were more likely to work in occupations such as livestock breeding 28.5% (137/480) compared to those in non-livestock-related jobs 14.7% (48/327) ($p < 0.001$) (Table 2).

The proportion of respondents who have never participated in schistosomiasis MDA was highest among migrants (12.3%), followed by IDPs (11.7%) nomads/transhumants (8.8%). However, a significant proportion of respondents, particularly 30.7% of IDPs and 30.9% of migrants, stated they do not remember participating in MDA campaign (Fig. 3).

Mixed effects logistic regression model analysis of variables associated with non-participation to the last MDA within mobile populations

Table 3 shows the association between non-participation to the last MDA and sociodemographic factors, socioeconomic status, and environmental factors. Males had a greater likelihood of non-participation compared to females (aOR = 2.89, 95% CI = 1.65–5.06) and Nomads and transhumants were significantly more likely to miss MDA compared to IDPs (aOR = 3.16, 95% CI = 1.05–9.47, $p = 0.040$). Livestock breeders were more likely not to participate in the MDA compared to farmers and merchants. (aOR = 0.15, 95% CI = 0.05–0.42, $p < 0.001$). Individuals who did not report dysuria were more likely to miss MDA compared to those who experienced dysuria (aOR = 1.65, 95% CI = 1.00–2.71, $p = 0.049$), although the significance is borderline. Respondents who faced difficulties accessing MDA, such as long travel distances, lack

Table 2 Frequency of the most cited barriers to taking part in the most recent MDA campaign targeting schistosomiasis using praziquantel

Characteristics	Participation to the last schistosomiasis MDA			
	Overall,	Yes,	No,	*p*-value[2]
Sex				0.042
Female	323 (40.0)	206 (42.9)	117 (35.8)	
Male	484 (60.0)	274 (57.1)	210 (64.2)	
Age group				0.542
≤ 30	353 (43.7)	214 (44.6)	139 (42.5)	
31 - 45	266 (33.0)	151 (31.5)	115 (35.2)	
≥ 46	188 (23.3)	115 (24.0)	73 (22.3)	
Population status				0.061
Internally displaced person	358 (44.4)	222 (46.3)	136 (41.6)	
Migrant	344 (42.6)	189 (39.4)	155 (47.4)	
Nomad/transhumant	105 (13.0)	69 (14.4)	36 (11.0)	
Education				0.368
Educated	409 (50.7)	237 (49.4)	172 (52.6)	
No educated	398 (49.3)	243 (50.6)	155 (47.4)	
Monthly income				<0.001
Minimum wage or more	180 (22.3)	124 (25.8)	56 (17.1)	
Less than minimum wage	315 (39.0)	205 (42.7)	110 (33.6)	
Don't know	312 (38.7)	151 (31.5)	161 (49.2)	
Occupation				<0.001
Farmer/Merchand	137 (17.0)	68 (14.2)	69 (21.1)	
Breeder	185 (22.9)	137 (28.5)	48 (14.7)	
Sand and gold miner	344 (42.6)	189 (39.4)	155 (47.4)	
Laborer/Housekeeper	141 (17.5)	86 (17.9)	55 (16.8)	
Sources of information				<0.001
TV/radio	248 (38.6)	177 (42.5)	71 (31.4)	
Health center	149 (23.2)	100 (24.0)	49 (21.7)	
Interpersonal communication	118 (18.4)	85 (20.4)	33 (14.6)	
Don't remember	127 (19.8)	54 (13.0)	73 (32.3)	
Accessibility				<0.001
Accessible	553 (68.5)	400 (83.3)	153 (46.8)	
Don't know	166 (20.6)	50 (10.4)	116 (35.5)	
Not accessible	88 (10.9)	30 (6.3)	58 (17.7)	

[1]n (%); [2]Pearson's Chi-squared test

of transportation means, or physical limitations, were significantly more likely to be non-participants compared to those without such barriers (aOR = 2.60, 95% CI = 1.45–4.66, $p = 0.001$). Age group, being a migrant, education, income below minimum wage, hematuria, exposure to schistosomiasis, interpersonal communication about the MDA (face-to-face communication), and seasonal movement did not show statistically significant associations with MDA participation (Table 3).

Discussion

This study assessed factors associated with non-participation in mass drug administration (MDA) for schistosomiasis amongst known mobile populations in Mali to help identify implementation challenges in reaching these populations with preventive chemotherapy. The study also identified factors impeding these mobile communities' access to praziquantel during community-based schistosomiasis MDA. The results showed that poor communication and lack of awareness about MDA are the main barriers, while concerns about the drug and its side effects are less significant. The results highlighted gaps in MDA implementation that need to be filled to improve drug accessibility and MDA participation for nomads, migrants, and internally displaced persons (IDPs) Table 4.

Our study revealed significant associations between non-participation in MDA campaigns and gender, occupation, nomadism/transhumance, and geographic accessibility as key determinants of MDA participation. These findings align with the literature showing how socio-economic factors shape health-related behaviors and access to interventions [36].

The study participants mainly consist of young people (defined by the World Health Organization as 10–24 years) [37], reflecting Mali's demography in which 65% of the population is under 25 years according to the Bertelsmann Transformation Index (BTI) [38, 39]. Several studies support our findings on the prominence of young individuals in our study population of highly mobile individuals. This is consistent with the findings of a scoping review by Schwartz et al. (2021) [40], which highlighted the significant representation of youth in nomadic, migrant, and IDPs populations. Additionally, the economic pursuits of young people, including gold mining and trade, are well-documented by Kalinda et al. (2020) in Zambia [41]. Adam et al. (2022), in their scoping review, also identified that most mobile populations are youth seeking economic opportunities and safety [6]. This continuous migration for economic opportunities and the safety of the youth population leads to their absence during MDA campaigns. High mobility among young people impacts MDA participation, as their frequent movement makes it difficult for health interventions to reach them.

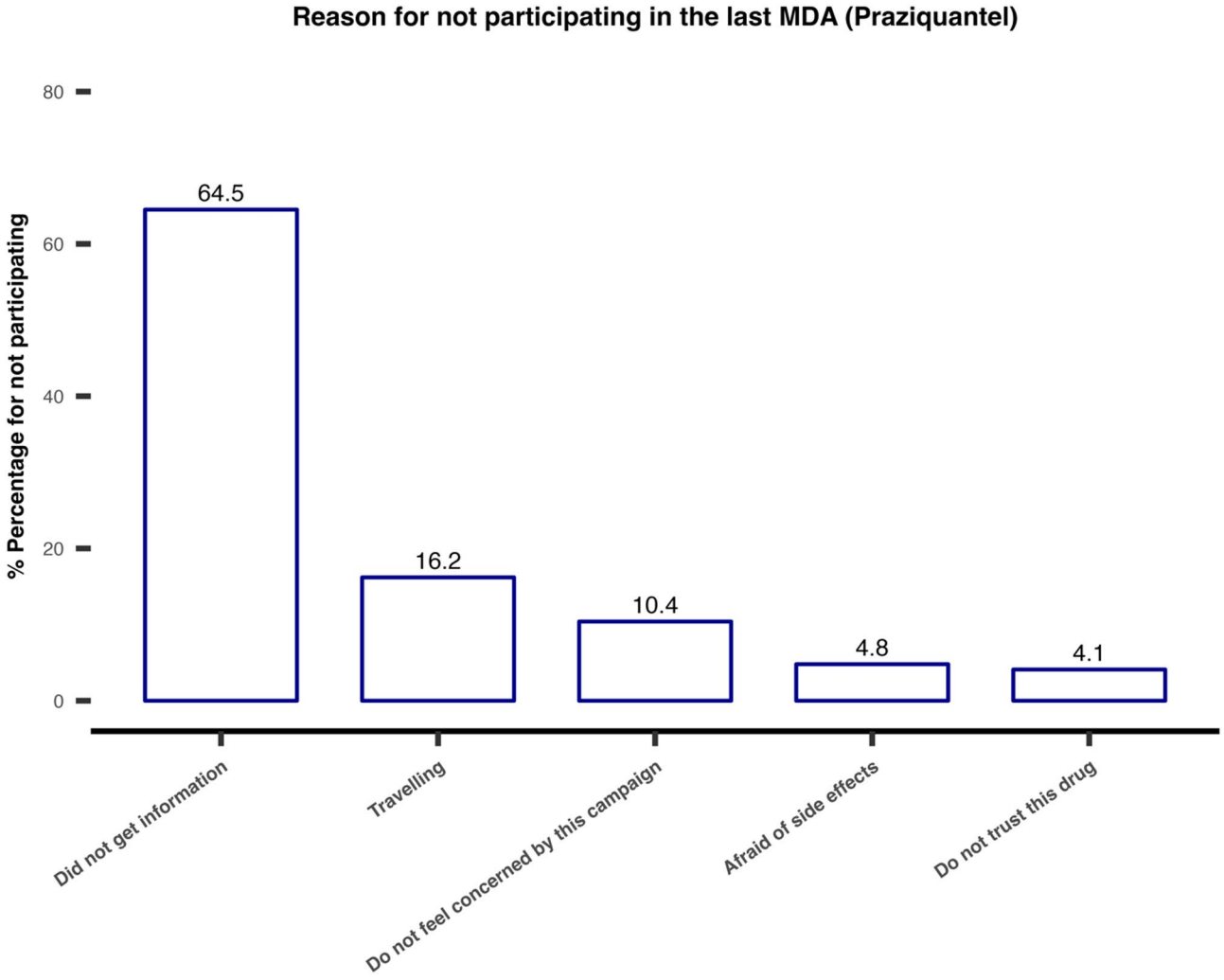

Fig. 3 Distribution of respondents by their most recent participation in mass drug administration (MDA) campaigns

Furthermore, nomads and transhumants taking their livestock out to pasture may not be present in their home communities when treatment is distributed, while those who have fled their villages due to security concerns may not be reached by conventional health programs. This mobility limits their access to MDA-related awareness campaigns, preventing them from understanding the importance of preventive chemotherapy. Similarly, Muchiri et al. (2023) reported that pastoral communities in South Sudan are characterized by high mobility, misunderstandings about NTDs and treatments, limited awareness of MDA, and poor health-seeking behavior which primarily facilitates to low MDA participation [42]. However, these reports have severe implications on schistosomiasis control and most importantly MDA campaign strategies towards the elimination of neglected tropical diseases (NTDs).

In addition to their mobility, young people may have missed the earlier awareness activities that began when MDA was initiated, in some instances, decades ago before they were born. The MDA program in Mali for schistosomiasis has been in place for over 20 years. The adolescents today were not born or were too young to be fully engaged in the early social mobilization efforts. As a result, they may not have received adequate education on schistosomiasis or the importance of preventive chemotherapy. This has resulted in a generational gap of understanding about the disease and the importance of MDA participation. Additionally, for those adolescents who still live within their family household, mobile adolescents often have disrupted schooling due to their families' movement, also reducing their exposure to MDA-related information that is delivered through schools. These gaps in awareness mean that many young people may not recognize the benefits of MDA. The concept of intersectionality is crucial to understanding their situation [43, 44]. These adolescents are economically vulnerable, which influences their mobility and their likelihood of missing

Table 3 Multivariate mixed effects logistic regression model analysis of variables associated with non-participation among mobile populations non-adjusted and adjusted for sociodemographic factors, socioeconomic status, and environmental factors

Characteristics	Non-participation to the last schistosomiasis MDA						
	%	OR[1]	95% CI[1]	*p*-value	aOR[12]	95% CI[1]	*p*-value
Sex							
Female	35	REF	—		REF	—	
Male	65	1.94	1.26–3.00	0.003	2.89	1.65–5.06	<0.001
Age group in years							
≤ 30	42	REF	—		REF	—	
31 - 45	33	1.10	0.71–1.72	0.664	1.10	0.65–1.88	0.715
≥ 46	25	1.07	0.66–1.74	0.789	1.14	0.63–2.06	0.657
Population status							
Internally displaced person	39	REF	—		REF	—	
Migrant	43	1.89	0.86–4.17	0.116	0.70	0.23–2.15	0.534
Nomad/transhumant	18	0.67	0.33–1.33	0.247	3.16	1.05–9.47	0.040
Education							
Educated	55	REF	—		REF	—	
No educated	45	0.71	0.48–1.06	0.091	0.71	0.44–1.13	0.145
Occupation							
Farmer/Merchand	12	REF	—		REF	—	
Breeder	28	0.30	0.15–0.61	<0.001	0.15	0.05–0.42	<0.001
Sand and gold miner	43	0.96	0.36–2.54	0.937			
Laborer/Housekeeper	17	0.63	0.30–1.34	0.232	0.42	0.17–1.03	0.058
Monthly income							
Minimum wage or more	27	REF	—		REF	—	
Less than minimum wage	38	1.65	1.00–2.73	0.050	1.45	0.81–2.58	0.210
Don't know	35	1.94	1.17–3.20	0.010	1.84	1.01–3.35	0.045
Being exposed to schistosomiasis							
No	61	REF	—				
Yes	19	1.20	0.73–1.97	0.481			
Don't know	19	1.24	0.75–2.04	0.410			
Hematuria							
Yes	45	REF	—		REF	—	
No	55	1.82	1.23–2.70	0.003	1.57	0.95–2.57	0.076
Dysuria							
Yes	44	REF	—		REF	—	
No	56	1.96	1.31–2.92	<0.001	1.65	1.00–2.71	0.049
Sources of information							
TV/radio	36	REF	—		REF	—	
Health center	28	1.42	0.86–2.35	0.169	2.20	1.22–3.96	0.009
Interpersonal communication	17	1.62	0.90–2.92	0.109	1.84	0.95–3.56	0.071
Don't remember	19	4.42	2.47–7.90	<0.001	4.38	2.18–8.81	<0.001
Accessibility							
Accessible	73	REF	—		REF	—	
Don't know	17	3.96	2.36–6.65	<0.001	2.60	1.45–4.66	0.001
Not accessible	11	4.65	2.48–8.69	<0.001	5.23	2.48–11.02	<0.001
Move every year							
No	58	REF	—		REF	—	
Yes	42	1.57	1.05–2.33	0.026	1.50	0.94–2.39	0.086

[1]*OR* Odds Ratio, *CI* Confidence Interval, [2]*a* adjusted, *REF* reference

Table 4 Distribution of respondents by age, sex, and participation status

Characteristic	Participation NA, *N* = 260			Participation No, *N* = 327			Participation Yes, *N* = 480		
	Internally displaced person *N* = 171[1]	Migrant *N* = 70[1]	Nomad/ transhumant *N* = 19[1]	Internally displaced person *N* = 136[1]	Migrant *N* = 155[1]	Nomad/ transhumant *N* = 36[1]	Internally displaced person *N* = 222[1]	Migrant *N* = 189[1]	Nomad/ transhumant *N* = 69[1]
Age group									
≤ 30	75 (43.9)	26 (37.1)	8 (42.1)	66 (48.5)	58 (37.4)	15 (41.7)	101 (45.5)	86 (45.5)	27 (39.1)
31 - 45	51 (29.8)	27 (38.6)	8 (42.1)	43 (31.6)	55 (35.5)	17 (47.2)	63 (28.4)	55 (29.1)	33 (47.8)
≥ 46	45 (26.3)	17 (24.3)	3 (15.8)	27 (19.9)	42 (27.1)	4 (11.1)	58 (26.1)	48 (25.4)	9 (13.0)
Sex									
Female	64 (37.4)	34 (48.6)	5 (26.3)	53 (39.0)	51 (32.9)	13 (36.1)	92 (41.4)	87 (46.0)	27 (39.1)
Male	107 (62.6)	36 (51.4)	14 (73.7)	83 (61.0)	104 (67.1)	23 (63.9)	130 (58.6)	102 (54.0)	42 (60.9)

[1]n (%)

health interventions. They may also lack access to trusted health information sources, further exacerbating non-participation in MDA.

Finally, insecurity plays a crucial role in limiting MDA access. Research increasingly shows that conflict and instability not only drive migration but also disrupt public health programs, including MDA [45, 46]. The influence of insecurity on youth migration and health service access is described in Kebu et al. (2023), which explored similar patterns of displacement, disruptions to health programs, and barriers to care in conflict-affected regions of Ethiopia [47]. Together, these factors create multiple barriers to MDA participation, demonstrating the need for targeted strategies to ensure mobile youth are not left out of treatment programs.

Although data were collected in 2020 during the coronavirus disease 2019 (COVID-19) pandemic, the barriers identified by this research which include poor access, mobility, and communication gaps remain relevant to the populations in these two districts and within Mali more broadly. The disruptions that occurred during the COVID-19 pandemic mirror conditions arising in conflict-affected or underserved areas where MDA campaigns continue to face implementation challenges.

Our data highlight that poor communication, lack of information, and lack of awareness are the primary reasons for mobile populations' failure to participate in MDA. This could be explained by the fact that these groups moved across different localities, so they are not reached by usual information channels. Others viewed these campaigns as irrelevant, not perceiving the risk of schistosomiasis or its health consequences. This is consistent with other studies showing that the public does not consider schistosomiasis or NTDs in general as a health threat [48–50]. To ensure all at-risk mobility groups are covered, it would be essential to develop communication channels adapted to each group. Studies have shown that using mobile applications and text messages to disseminate health information, reminders, and MDA alerts are effective across various fields [51–53]. Furthermore, building trust and engaging communities by involving local leaders could help communicate messages effectively as reported by Xie et al. (2024) in their systematic review and meta-analysis on the promotion of immunization [54]. Integrating feedback methods as part of a stakeholder communication plan is also essential, as they help assess and adapt the strategy's effectiveness [55]. Methods, such as surveys, interviews, focus groups and analysis tools can gather diverse perspectives on effective communication. They have been used effectively to improve the quality and experience of care in public health programs, ensuring better service delivery (including MDA delivery) and patient engagement [56, 57]. This data-driven process can be used to gain the perspective of mobile populations on how to communicate effectively about schistosomiasis and the importance of MDA.

The findings reveal important disparities in schistosomiasis MDA coverage among mobile populations in Mali. A significant proportion of participants reported never having received treatment, with migrants and nomads and transhumants reporting the highest rates of non-participation. This suggests that certain subgroups within mobile populations may have been systematically missed by MDA campaigns due to factors such as mobility, lack of awareness, limited community engagement, or exclusion from targeted outreach efforts.

Similar patterns have also been observed in other settings: In Indonesia, a study by Titaley et al. (2022) found that nearly 42% of respondents had never received MDA for lymphatic filariasis, likely an important contributing factor in persistently low coverage [58]. Previous research suggests that the size and characteristics of the never-treated population could play a significant role in sustaining NTDs transmission, posing a barrier to elimination [12, 59]. Furthermore, studies have shown that identifying these individuals and understanding their barriers to treatment is essential for improving MDA delivery, increasing coverage, and promoting equity in communities with previously low participation [60, 61]. Identifying the characteristics of never-treated individuals is crucial

for improving MDA effectiveness, towards ensuring that all population groups in vulnerable circumstances are reached, and addressing persistent gaps in schistosomiasis control and elimination. This approach may also be vital for other NTDs programs, which face similar challenges of low participation in MDA and ongoing elimination and control efforts.

Our findings also reveal a discrepancy between the proportion of respondents who explicitly reported never participating in MDA and those who stated they did not remember participating. This discrepancy may reflect recall bias or limited awareness of the campaigns, particularly among mobile populations. This gap raises concerns about potential recall bias and limited awareness of MDA interventions among mobile populations. It is possible that some individuals who reported "don't remember" may, in fact, have never participated but were unsure due to poor communication, low visibility of MDA campaigns, or a lack of understanding of what constitutes MDA. Similar patterns of recall bias or limited awareness of the schistosomiasis MDA programs have been documented across sub-Saharan Africa. For example, a study by Sangare et al. (2021) in Mali found that a substantial number of respondents who self-reported not treated reported being unaware of the campaign and were unable to reach the distribution point [62]. Studies in Cameroon and Uganda also identified low awareness of schistosomiasis MDA campaigns and occupational, migration, and mobility-related barriers as key factors contributing to high rates of uncertain participation status [63, 64]. These findings suggest that self-reported data on MDA participation among mobile populations should be interpreted with caution.

Implications for policy and practice

Tailored strategies to reach mobile and migrant populations may include: seasonal[65] timing of MDA aligned with known mobility patterns; engagement of community gatekeepers such as traditional leaders and herders' unions; use of text message alerts and radio to disseminate campaign messages; mapping of migration routes for targeted drug distribution. These approaches directly address the key barriers identified in our study, including missed communication, limited awareness about MDA, and geographic inaccessibility. By aligning MDA delivery with the realities of mobile populations, these strategies can enhance coverage and support progress toward schistosomiasis elimination.

Limitations

Firstly, data collection took place in 2020, during coronavirus disease 2019 (COVID-19), at a time when rumors surrounding COVID-19 made some participants hesitant to engage with the study team, coupled with the research team from Bamako having come from an area with a higher number of cases. To address these concerns, data collectors wore masks, used hand sanitizer, and provided information about the pandemic. Secondly, there is a potential bias that individuals may overstate or exaggerate their unmet basic needs when reporting their situation. This overreporting can occur for several reasons. For instance, people might feel that their needs are not being adequately addressed or that they need to highlight their struggles to attract attention or resources. This bias can lead to a distorted picture of the population's actual needs, influencing policy decisions, resource allocation or interventions. Furthermore, while we have employed a multi-stage cluster sampling design, the mobility of the population might have introduced sampling bias (i.e., some groups moved away before data collection). This may have led to sampling bias, under-representing nomadic and transhumant populations and limiting the generalizability of our findings. The high mobility of these populations presents inherent challenges in ensuring representative sampling. Finally, insecurity in the study site prevented the research team from reaching all target locations, including nomadic and transhumance camps. This may lead to sampling bias, under-representing these groups, thus limiting the generalizability of our results.

Conclusion

This study emphasizes how social, economic, geographic, and informational factors interact in a multifaceted way that shape participation in MDA among mobile populations in Mali. The main barriers identified include lack of information as the most frequently cited barrier to participation, with mobile populations often disconnected from mainstream communication channels. Subsequently, mobility-related factors, such as long travel distances, lack of transportation, and seasonal movement of livestock (e.g. cattle, sheep, or goats) significantly influenced non-participation. In addition, male gender, occupational status (e.g., livestock breeding and mining), suggesting that risk perception and competing economic priorities may reduce engagement in preventive health campaigns. The results show significant variation in participation among mobile populations, likely due to differing lifestyles, access to information, and confidence in health programs. Addressing this variability will be crucial in improving coverage and achieving equitable treatment access, which requires tailored strategies that consider the specific needs and barriers of each group. For instance, targeted sensitization campaigns can increase participation by enhancing information dissemination and fostering confidence among IDPs, migrants and nomads.

Abbreviations

aOR	adjusted Odds Ratio
bOR	unadjusted Odds Ratio
BTI	Bertelsmann Transformation Index
CI	Confidence Interval
COR-NTD	Coalition for Operational Research on Neglected Tropical Diseases
COVID-19	Coronavirus Disease 2019
IDPs	Internally Displaced Person
MDA	Mass Drug Administration
NTDs	Neglected Tropical Diseases
PC-NTDs	preventive chemotherapy NTDs
WHO	World Health Organization

Supplementary Information

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Supplementary Material 1.

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Author's contributions

MS, YIC, MS, MAK, TBN and AK designed and conceived the study. MS, AFD, DD, DT, HD, MMK, CD, and YIC collected, processed and analyzed the data. MS, AFD, HD, CD, YIC drafted the manuscript. MS, HD, MS, YIC, MD, MAK, TBN and AK approved the final version of the manuscript and helped with the analysis and drafting of the manuscript; all authors read and approved the final manuscript.

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Data availability

The data that support the findings of this study are available from the authors but restrictions apply to the availability of these data, and so are not publicly available. Data are, however, available from the authors upon reasonable request.

Declarations

Ethics approval and consent to participate

In accordance with the declaration of Helsinki, the protocol was reviewed and approved by the Ethical Review Committee of the University of Sciences, Techniques and Technologies of Bamako (Mali) [Approval No. 2019/173/CE/FMOS/FAPH]. Subsequent approval was provided by the University of Ottawa for additional analysis [Approval No. H- 02- 23- 8759]. Written informed consent was obtained from all participants before data collection.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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