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REACHING MOBILE POPULATIONS IN MASS DRUG ADMINISTRATION FOR NEGLECTED TROPICAL DISEASES: EVIDENCE FROM MALI AND BROADER IMPLICATIONS FOR AFRICA

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Thesis submitted to the University of Ottawa
in partial Fulfillment of the requirements for the
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PREFACE

This thesis is submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy in Population Health at University of Ottawa. The thesis follows a manuscript-based format and includes four scientific articles. Research (chapters 3 and 4) presented here was conducted between 2020 and 2023 with funding from two research grants NTDSC # 200D and 250G. Chapters 3 and 4 present original empirical research conducted in Mali, while Chapter 5 presents a scoping review of African studies. I am the first author of all manuscripts, and I contributed to study design, data collection, analysis, and writing. Co-authors provided input on methodology, data interpretation, and manuscript writing and revision.

Ethical approval to conduct the research

This research was conducted following approval from the relevant ethics committee. The research described in Chapters 3 and 4 (articles 1 and 2) received ethical approval from the institutional review board of the University of Sciences, Techniques and Technologies of Bamako (Approval No. 2023/11/CE/USTTB and Approval No. 2019/173/CE/FMOS/FAPH), Bamako, Mali, while Chapter 3 (article 1) and the entire research received formal approval from the institutional review board of the Faculty of Health Sciences, University of Ottawa under the Approval No. H-02-23-8759. Ethical approval was not required for the scoping review presented in Chapter 5. DeepL (https://www.deepl.com) was used to assist with selected French-to-English translations in the background and discussion sections.

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Article 1: 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

Neglected Tropical Diseases (NTDs) affect over a billion people globally, with mass drug administration (MDA) being one of the cornerstone strategies for control and elimination. However, mobile populations such as nomads, internally displaced persons (IDPs), migrants, and seasonal workers are frequently missed during MDA campaigns. This gap threatens progress toward the global targets for NTDs outlined in the WHO Roadmap 2021–2030, particularly in endemic regions like Mali and across Africa. Understanding the barriers to MDA participation among these groups is essential for designing equitable and effective interventions.

Three complementary studies were conducted to explore MDA access among mobile populations. A cross-sectional study in Mali (2020–2021) used structured questionnaires and multivariable regression to identify factors associated with non-participation in schistosomiasis MDA. A qualitative study in Mali (2023) used in-depth interviews and focus group discussions to explore reasons for never being treated during MDA among mobile groups. Finally, a scoping review (2024/2025) followed PRISMA-ScR guidelines, synthesized evidence from 20 studies across Africa on mobility-related barriers to MDA.

The following results present the main findings of our research. MDA coverage among mobile populations was consistently below the recommended 75% threshold. In Mali, only 40.8% of internally displaced people (IDPs) and 3.62% of migrants participated in the last MDA round. Key barriers included: lack of information (64.5%), geographic inaccessibility, mobility patterns (e.g., transhumance, seasonal work), low income and occupations such as mining, fear of side effects and rumors, and inflexible campaign schedules. Our findings also revealed that males, those facing physical or geographic barriers, and nomadic groups were significantly more likely to miss MDA. The scoping review highlighted additional systemic issues such as limited cross-border coordination and insufficient community engagement. Identified promising strategies included mobility-informed microplanning, flexible delivery models, and integrated health services. Mobile populations are systematically excluded from MDA programs, undermining efforts to eliminate NTDs. Addressing these disparities requires context-specific, adaptive, and participatory approaches. To ensure no one is left behind, MDA programs must move beyond one-size-fits-all models. Tailored strategies that account for mobility patterns, livelihood contexts, and local barriers are urgently needed.

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LIST OF ABBREVIATIONS

ABS: Australian Bureau of Statistics

COR-NTD: Coalition for Operational Research on Neglected Tropical Diseases

COREQ: Consolidated Criteria for Reporting Qualitative Research

COVID-19: Coronavirus Disease 2019

ESPEN: Expanded Special Project for Elimination of Neglected Tropical Diseases (WHO-AFRO)

IDI: In-Depth Interview

FGD: Focus Group Discussion

GIS: Geographic Information System

GPELF: Global Programme to Eliminate Lymphatic Filariasis

GPS: Global Positioning System

IDMC: Internal Displacement Monitoring Centre

HIV/AIDS: Human Immunodeficiency Virus / Acquired Immunodeficiency Syndrome

IOM: International Organization for Migration

JBI: Joanna Briggs Institute

LF: Lymphatic Filariasis

MDA: Mass Drug Administration

MMDP: Morbidity Management and Disability Prevention

MMPs: Mobile and Migrant Populations

MPH: Master of Public Health

MSc: Master of Science

NGO: Non-Governmental Organization

NIH: National Institutes of Health

NTD: Neglected Tropical Disease

NTDSC: Neglected Tropical Disease Support Center

ORCID: Open Researcher and Contributor ID

OTZ: Operational Transmission Zones

PC-NTDs: Preventive Chemotherapy Neglected Tropical Diseases

PRISMA: Preferred Reporting Items for Systematic Reviews and Meta-Analyses

PRISMA-P: Preferred Reporting Items for Systematic Review and Meta-Analysis Protocols

RGPH: Recensement Général de la Population et de l'Habitat (General Population and Housing Census)

SAC: School-Aged Children

SAFE: Surgery, Antibiotics, Facial Cleanliness and Environmental Improvement (Trachoma strategy)

STH: Soil-Transmitted Helminths

STHs: Soil-Transmitted Helminthiases

STPH: Swiss Tropical and Public Health Institute (often abbreviated Swiss TPH)

TAS: Transmission Assessment Survey

TB: Tuberculosis

UHC: Universal Health Coverage

UK: United Kingdom

UNHCR: United Nations High Commissioner for Refugees

US: United States

USA: United States of America

USAID: United States Agency for International Development

USTTB: Université des Sciences, des Techniques et des Technologies de Bamako

WAHO: West African Health Organization

WHO: World Health Organization

CHAPTER 1: INTRODUCTION

1.1 Rationale

Neglected tropical diseases (NTDs) are a group of infectious diseases or conditions that predominantly affect populations living in tropical and subtropical regions, particularly in low- and middle-income countries where inadequate sanitation and limited health services are common (WHO, 2021). They cause illness, physical and mental suffering, disability, stigma, reduced productivity, and can negatively affect children's education (Alvarez-Hernandez et al., 2020). For example, lymphatic filariasis (LF) causes elephantiasis and hydrocele, which can result in lifelong disability (Medeiros et al., 2021).

The five most prevalent NTDs worldwide include LF, onchocerciasis, schistosomiasis, soil-transmitted helminths (STHs), and trachoma. All are targeted by the World Health Organization (WHO) through preventive chemotherapy delivered via mass drug administration (MDA) (Lenk et al., 2016; Peeling et al., 2017), and are collectively referred to as PC-NTDs. The global fight against NTDs has achieved substantial success, reducing morbidity and mortality (Hietanen et al., 2025). According to the latest WHO Global Report on NTDs (2025), in 2023, approximately 1.495 billion people required interventions against at least one NTD, 122 million fewer than in 2022. Globally, this represents a 32 % reduction compared with 2010 levels. That same year, about 867 million individuals received treatment through preventive chemotherapy programs. The overall disease burden declined substantially, with NTD-related deaths dropping from 139,000 in 2015 to 119,000 in 2021, and disability-adjusted life years (DALYs) falling from 17.2 million to 14.1 million over the same period. By the end of 2023, 50 countries had successfully eliminated at least one NTD reaching the halfway point toward WHO's 2030 target of 100 countries (WHO, 2025).

Despite these global achievements, significant gaps remain. Mobile populations such as nomadic communities, seasonal migrants, internally displaced persons and communities in remote and hard-to-reach areas remain unreached by MDA interventions, thereby contributing to health inequities and threatening elimination goals (Dean et al., 2019; Jacobson & Bush, 2018; Masong et al., 2021). In Mali, where such mobile populations are numerous, elimination goals are in danger when these at-risk groups routinely miss MDA, possibly constituting hotspots that could lead to

disease persistence or re-emergence. Addressing this gap is therefore essential to achieving and sustaining NTD elimination targets.

1.2 Problem statement

Neglected tropical diseases (NTDs) continue to affect more than 600 million people in poor and marginalized communities in Africa. NTDs lead to significant morbidity, including physical and visual disabilities, stigma and mental health issues, and a heavy socioeconomic burden. Republic of Mali, located in West Africa, has historically had a high prevalence of NTDs across its population, including those NTDs addressed through the mass administration of preventive chemotherapy (Dembélé et al., 2012). Through the combined efforts of the Malian Government and its technical and financial partners to ensure MDA coverage in endemic regions, significant progress has been made. Mali has eliminated trachoma as a public health problem in 2023 (WHO, 2023), stopped the MDA campaigns for LF, and is preparing an elimination dossier for WHO certification in 2026. For STH, the latest evaluations indicate that treatment is no longer required. For onchocerciasis, stop-MDA surveys are underway, However, some operational transmission zones (OTZs) in Sikasso and Kayes regions still require treatment. Schistosomiasis remains a major concern in Mali, with considerable work still needed to reach elimination.

The control and elimination of NTDs require the treatment of all population groups. No one should be left behind from a social justice, equity or epidemiological perspective. Mobile populations (including IDPs and refugees, nomadic pastoralists, seasonal migrants/workers, among others) are particularly at risk of missing out on NTDs related interventions. These groups represent a significant proportion of the population in Africa, including Mali (Camlin et al., 2018). Over the past decade, climate change, armed conflicts, terrorism, poverty, violence, and growing insecurity have all contributed to an increased influx of people on the move in Africa (IOM, 2022). This situation has disrupted public health interventions including MDA for NTDs and increased the risk of persistence or re-emergence of diseases (Bigna, 2016). Consequently, the country risks losing the progress achieved so far.

Currently, there remains insufficient evidence to fully understand the patterns of mobility and their impact on MDA coverage, posing a challenge to achieving national elimination goals by 2030. The formal Malian health system does not appear to be adapted to the lifestyle of mobile

populations. Addressing these gaps is critical to ensuring equitable health interventions and accelerating progress toward disease elimination.

Therefore, this thesis aims to fill this gap by developing the evidence to support equity-oriented guidance and recommendations to support an efficient, integrated, and comprehensive approach tailored to the realities of mobile populations, thereby contributing to stronger and more inclusive strategies for achieving the sustainable elimination of NTDs in Mali and globally.

1.3 Research questions

1. What are the factors associated with low MDA coverage for schistosomiasis among mobile populations in Mali?
2. What are the factors including barriers and facilitators to treatment that lead to never treatment for PC-NTDs among mobile populations?
3. What is the impact of mobile populations on MDA coverage and effectiveness in Mali and other countries across Africa?
4. What recommendations can be made to inform approaches that support access to NTD-related health services for mobile populations?

1.4 Thesis objectives and hypotheses

General objective

To investigate the factors influencing MDA coverage and effectiveness of MDA for PC-NTDs among mobile populations in Mali and across Africa, and to generate evidence-based recommendations for improving access, equity, and program effectiveness.

Specific objective 1: To identify factors associated with low MDA coverage for schistosomiasis among mobile populations in Mali.

Hypothesis 1*: Mobile populations in Mali have lower MDA coverage for schistosomiasis compared to non-mobile populations due to structural, social, and mobility barriers.*

Specific objective 2: To understand the barriers and facilitators leading to never treatment for PC-NTDs among mobile and migrant populations in Mali.

Hypothesis 2*: Mobile populations in Mali experience never treatment during MDA due to specific individual, social, and programmatic barriers, and understanding these reasons can inform the development of an effective, standardized, and evidence-based programmatic response to improve treatment coverage.*

Specific objective 3: To assess the impact of mobile populations on MDA coverage and program effectiveness in Mali and in other countries across Africa.
Hypothesis 3*: Population mobility has a negative impact on MDA coverage and program effectiveness, leading to pockets of persistent transmission in Mali and in other countries across Africa.*

Specific objective 4: To develop recommendations for interventions and strategies that enhance access to NTD-related health services for mobile populations.
Hypothesis 4*: Tailored, context-specific interventions and delivery strategies can significantly improve access to NTD-related health services among mobile populations.*

1.5 Significance of the thesis

The research conducted as part of this thesis is highly relevant to the Malian context. First, it fills gaps in the available data on the effect of population mobility on the effectiveness of MDA for PC-NTDs in Mali and accross Africa. While national NTD control programs have made considerable progress, mobile populations remain underserved and at risk of being left behind. Understanding the barriers and enablers to treatment within these groups is essential to ensuring equity in NTD-related health interventions, particularly MDA.

Second, the thesis provides evidence on the factors associated with lack of treatment and low coverage among mobile populations. This knowledge is essential for developing tailored, equity-oriented strategies that can be integrated into national programs. By focusing on the realities of mobile communities, including nomadic pastoralists, seasonal migrants/workers, IDPs, and refugees, the research highlights the social determinants that threaten elimination goals if not addressed.

Third, the findings will not only contribute to Mali's efforts to achieve and sustain PC-NTDs elimination but will also be relevant to other African countries facing similar mobility

dynamics. People are moving in historic numbers due to economic, political and climate-related reasons. Other countries in the region will benefit from understanding the context in Mali as it relates to mobile populations.

Finally, the findings of this research have practical implications for policy development, planning, and implementation. The study aligns with the WHO Roadmap 2021-2030 for NTDs, which emphasizes leaving no one or no people behind in order to achieve universal access to essential healthcare. By formulating recommendations for innovative, integrated, and mobility-adapted approaches, this study has the potential to strengthen health systems, reduce inequalities, and accelerate progress toward the sustainable elimination of NTDs in Mali and efforts towards universal healthcare.

1.6 Thesis structure

This thesis follows an article-based format and is structured as follows:

Chapter 1 presents the study's rationale, problem statement, research questions, objectives, hypotheses, and significance. It highlights the burden of NTDs in Mali, gaps in MDA coverage among mobile populations, and the importance of equity-oriented strategies to improve program effectiveness.

Chapter 2 provides the background and literature review for the study. It presents a comprehensive overview of neglected tropical diseases (NTDs) in Africa, with a focus on preventive chemotherapy-targeted NTDs (PC-NTDs) and mass drug administration (MDA) strategies. The chapter examines the epidemiology, burden, and social and economic impacts of NTDs, as well as global and national efforts toward disease control and elimination. It also reviews existing evidence on population mobility, barriers to MDA participation, and the influence of mobile and migrant populations on program coverage and effectiveness. Finally, the chapter identifies research gaps and frames the rationale for the current study, situating it within the broader literature on equity, health systems, and NTD elimination.

Chapter 3 describes empirical fieldwork conducted in Mali to identify the factors associated with low MDA coverage among mobile communities. The study explores individual, social, health system organization, and programmatic factors that influence treatment uptake, with a focus on barriers and facilitators of involvement. The findings provide essential evidence on equity inequalities in access to schistosomiasis control programs, as well as practical

recommendations for strengthening national elimination strategies. The study was published in *BMC Infectious Diseases*.

Chapter 4 presents article 2. In this study we explore why some mobile and migrant populations consistently miss MDA interventions, identifying individual, social, and structural factors that influence never treatment. The findings provide context-specific insights to inform strategies for improving inclusion in NTD programs. The article was published in *BMJ Global Health*.

Chapter 5 presents articles 3 and 4, which focus on the scoping review conducted to explore the impact of mobile and migrant populations on MDA coverage and effectiveness in Africa. Article 3 (the protocol) is published in *PLOS One* and article 4 (the completed review) is in *BMC Infectious Diseases of Poverty*. Together, these 2 articles highlight the evidence base on how mobility influences NTD control and elimination efforts, while also identifying research gaps and practical implications for policy and programs.

Chapter 6, is a comprehensive discussion that integrates the findings of the three studies. As previously outlined in Section 2.9, the Levesque framework for healthcare access (Levesque et al., 2013) provides the conceptual basis for interpreting these findings. The Levesque framework conceptualises access as the interaction between the characteristics of health services and the abilities of individuals and communities to seek, reach, pay for, and engage with care. It outlines five dimensions on the supply side (approachability, acceptability, availability and accommodation, affordability, and appropriateness) and five corresponding abilities on the demand side (ability to perceive, seek, reach, pay, and engage). This chapter situates the results within the broader literature. It concludes the thesis by discussing how the three studies collectively advance understanding of persistent gaps in schistosomiasis control, highlighting areas where current approaches may be strengthened. It also identifies intervention points suggested by the Levesque framework, and outlines recommendations for future research.

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CHAPTER 2: BACKGROUND AND LITERATURE REVIEW

Overview

Neglected tropical diseases (NTDs) targeted by preventive chemotherapy (PC-NTDs) represent a major public health challenge, particularly in endemic countries such as Mali. The main strategy for controlling and eliminating these diseases is mass drug administration (MDA), which aims to achieve high treatment coverage in at-risk populations. However, a critical obstacle to achieving elimination goals is ensuring equitable access to these interventions for all population subgroups. Mobile populations, including refugees, internally displaced persons (IDPs), nomadic pastoralists, seasonal workers, and economic migrants, face important barriers that prevent them from accessing MDA. Their constant movement, often driven by conflict, environmental factors, social and cultural activities or the search for resources, disrupts health service delivery, excludes them from censuses, and places them beyond the reach of standard health interventions campaigns. This leads to low treatment uptake, potential establishment of reservoirs of infection that may sustain transmission and undermine progress towards elimination goals. This thesis, therefore, seeks to investigate the specific challenges and barriers that prevent mobile and migrant populations in Mali from accessing PC-NTDs MDA campaigns, employing Levesque's conceptual framework for healthcare access to analyze both health system and population-level factors.

This chapter presents a review of the literature, defining neglected tropical diseases, the current situation in the fight against NTDs worldwide, in Africa, and in Mali, and the programmatic implications for the national program to combat NTDs in Mali.

1.8 Neglected Tropical Diseases

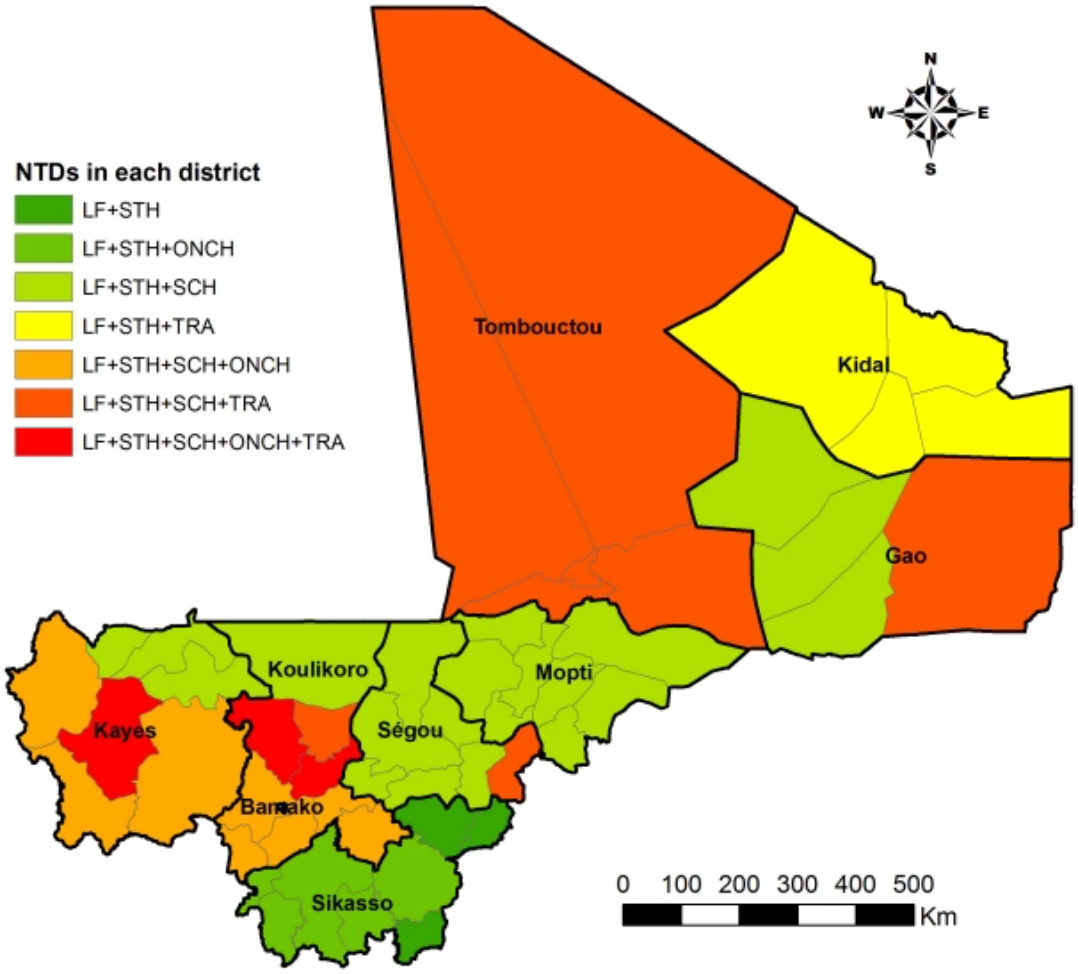
NTDs are a group of 21 preventable and treatable diseases or conditions that predominantly affect populations in tropical and subtropical regions and thrive in areas with poor sanitation, limited access to clean water, and inadequate healthcare infrastructure (Brindley et al., 2025; WHO, 2024b). These diseases disproportionately affect rural and poor populations, contributing to chronic disability, reduced productivity, and social stigma.

1.9 Global burden and distribution

NTDs are a group of 21 preventable and treatable diseases or conditions that predominantly affect populations in tropical and subtropical regions and thrive in areas with poor sanitation, limited access to clean water, and inadequate healthcare infrastructure (Brindley et al., 2025; WHO, 2024b). Globally, over one billion people are affected by at least one NTD, with economic losses in endemic countries estimated in the tens of billions of dollars annually due to lost productivity, disability, and healthcare costs (Hietanen et al., 2025; WHO, 2024b). NTDs disproportionately affect marginalized populations, reinforcing cycles of poverty and inequity. For example, lymphatic filariasis can lead to elephantiasis, which results in stigma and reduced economic productivity; onchocerciasis patients can develop eye lesions which can lead to visual impairment and permanent blindness; while schistosomiasis can impair growth and cognitive development in children (Alvarez-Hernandez et al., 2020; Hotez & Kamath, 2009). The health impacts are profound, but beyond health, these diseases perpetuate poverty by reducing productivity, increasing healthcare costs, and contributing to social exclusion within affected communities. Despite their impact, NTDs have historically received less attention and funding than infectious diseases like HIV/AIDS, tuberculosis, and malaria which have a higher mortality burden (Hotez & Kamath, 2009).

1.9.1 Mali: burden and distribution of PC-NTDs

Mali, a West African country with a population of about 25 million (United Nations, 2024), has historically been heavily affected by PC-NTDs. These include lymphatic filariasis, onchocerciasis, schistosomiasis, soil-transmitted helminthiases, and trachoma, all of which were endemic in the country (Dembélé et al., 2012). Integrated treatment of NTDs with PC in Mali began in 2007, as the country was one of the first to benefit from the Fast-Track strategy of the United States Agency for International Development (USAID). By 2009, the country had a complete map of all PC-NTDs.



LF: lymphatic filariasis; ONCH: onchocerciasis; SCH: schistosomiasis; STH: soil-transmitted helminthiasis; TRA: trachoma. Source: doi: [10.1371/journal.pntd.0001574](https://doi.org/10.1371/journal.pntd.0001574)

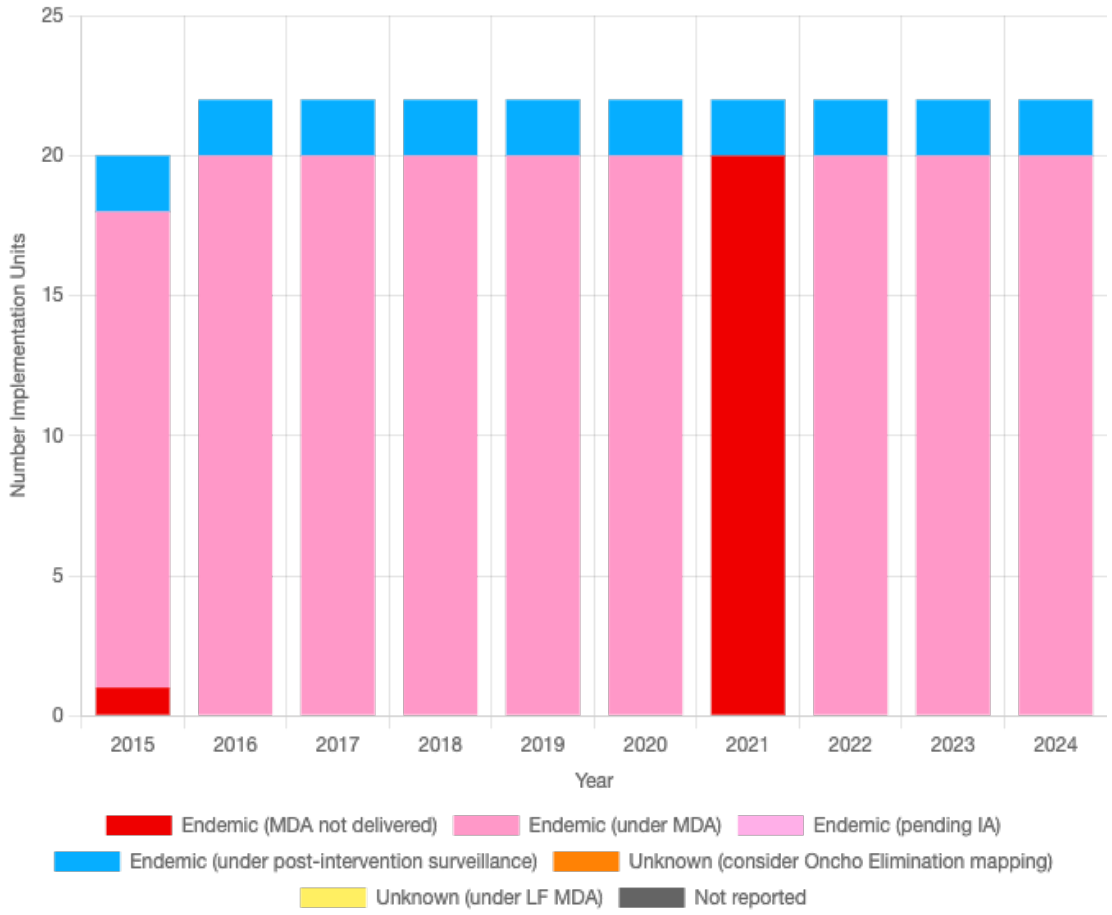
Figure 1. Endemic situation shown as number of major target NTDs in each district in Mali

Many districts experienced co-endemicity of two or more diseases, which complicated control and elimination efforts. Table 1 presents the burden of the five preventive chemotherapy neglected tropical diseases (PC-NTDs) in Mali, based on data from ESPEN (2024).

Table 1. Burden of the five PC-NTDs in Mali (ESPEN, 2024)

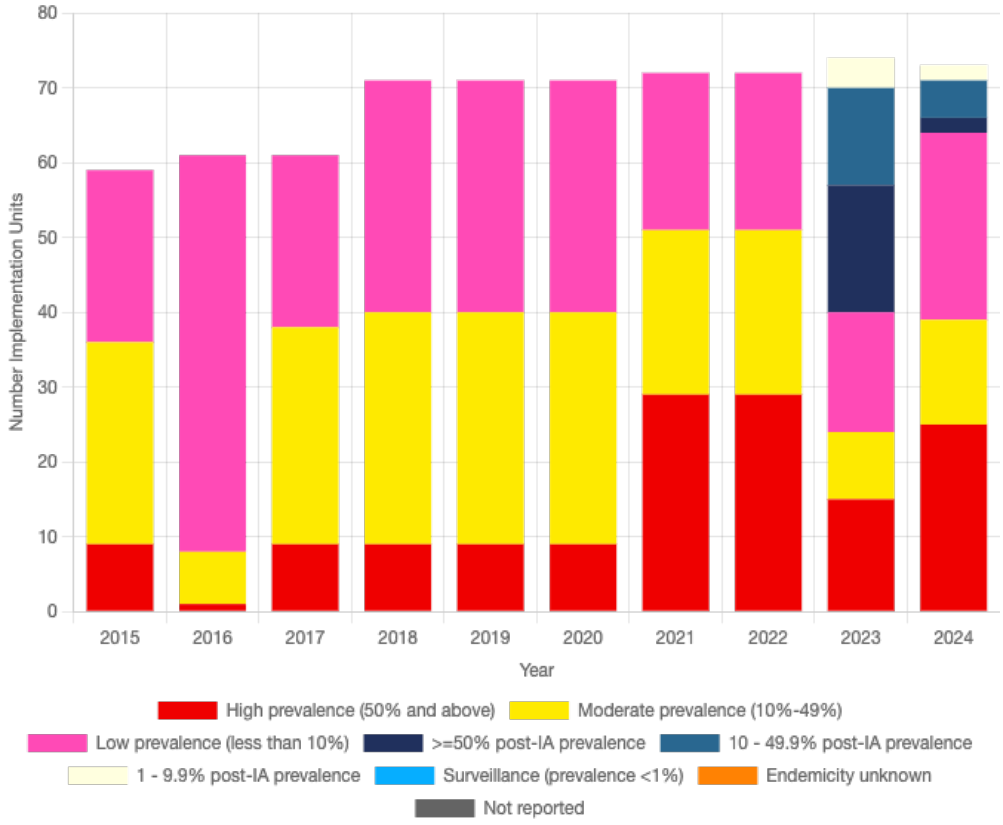
PC-NTDs	Start date	Historical burden before the initiation of MDA	Current state of the burden
Lymphatic filariasis (LF)	**2004**	The whole country was endemic: 1-18% from north to south depending on the evaluation units; overall prevalence was 7.07%.	All units of assessment have stopped processing. Certification of elimination in progress.
Onchocerciasis	**1986**	35 health districts were endemic: 20 of them are under treatment with ivermectin and 15 are under surveillance; 13 others health districts are hypo-endemic that were only treated from 2004 to 2019 as part of LF targeted MDA.	The country has passed Pre-stop except 2 operational transmission zones (OTZ). Currently Stop treatment surveys are ongoing in all OTZ which passed pre-stop surveys. MDA is ongoing in all OTZ.
Trachoma	**1998**	Baseline mapping revealed a prevalence of active trachoma ranging from 23.1% to 46.7% and 2.5% for trachomatous trichiasis.	Validated by WHO in May 2023 as having eliminated trachoma as a public health problem (WHO, 2023)
Schistosomiasis	**1982**	A schistosomiasis control project set up in 1979 with financial support from the German Cooperation became a national program in 1982. Prevalence varies widely among districts: from <20% to over 70% in some areas.	Data from 2021 showed that, out of a total of 1,510 health sub-districts, 210 are non-endemic (0%), 586 have low prevalence, 403 have moderate prevalence, and 311 have high prevalence (>50%).

Soil-transmitted helminths	**1982**	From 2004-2006 mapping, results revealed that the whole country was endemic.	Data from 2021 showed that STHs no longer constitute a public health problem in Mali. MDA has been stopped in all health districts.



Source: https://espen.afro.who.int/maps-data/countries/mali#onc

Figure 2. Onchocerciasis endemicity status across all endemic implementation units in Mali, (Mali 2024)



Source: https://espen.afro.who.int/maps-data/countries/mali#sch

Figure 3. Schistosomiasis endemicity status across all endemic implementation Unit in Mali, (Mali 2024)

1.10 Approaches of control and elimination

1.10.1 The WHO NTD Roadmap 2030

The WHO NTD Roadmap 2021–2030 emphasizes integrated approaches combining preventive chemotherapy, vector control, morbidity management, and cross-sectoral interventions (Casulli, 2021). The roadmap highlights the global commitment to "leave no one behind" and achieve equitable access to healthcare, aiming to eliminate at least one NTD in 100 countries and eradicate dracunculiasis and yaws by 2030 (WHO, 2021). As of March 2024, half of the target had been achieved, with 50 countries successfully eliminating at least one NTD. These successes offer valuable lessons that can guide elimination strategies in other settings (Hietanen et al., 2025).

With the 2030 agenda, WHO pledged to ensure “no one will be left behind” and to “endeavor to reach the furthest behind first.” As such, we need to ensure that people living in vulnerable circumstances (youth, IDPs, refugees, and migrants; mobile populations, and indigenous populations) have special attention in the elimination phase (Ehrenberg et al., 2021; Engels & Zhou, 2020).

1.10.2 Mass drug administration and morbidity management and disability prevention

Mass Drug Administration (MDA) is a key strategy recommended by WHO for controlling and eliminating several NTDs, including lymphatic filariasis, onchocerciasis, soil-transmitted helminthiases, trachoma, and schistosomiasis. MDA involves the periodic provision of safe, effective medications to entire at-risk populations, irrespective of individual infection status, aiming to prevent transmission at the community level or reduce morbidity among affected individuals (Hotez et al., 2007; WHO, 2017). High coverage (geographical and epidemiological) and uptake are critical for MDA success. The WHO recommends achieving ≥65–80% epidemiological coverage, depending on the disease, to interrupt transmission cycles in all endemic areas (WHO, 2021).

In addition to MDA, the control and elimination of NTDs must include morbidity management and disability prevention (MMDP) care for affected individuals, delivered through existing health systems. MMDP is a critical component of the WHO’s elimination strategies, particularly for addressing chronic and persistent disabilities such as lymphoedema/elephantiasis, hydrocele, disfigurement, and blindness (Banda et al., 2021; Bush et al., 2020; Mushi et al., 2024).

Global targets and milestones for 2030 have been defined to track progress in disease-specific control and elimination efforts (see Table 3 for PC-NTDs) (WHO, 2024).

Table 2. WHO target for 2030, milestone and achievement

Disease	Indicators	Target (2030) n/N (%)	Milestone (2023) n/N (%)	Achieved (2023) n/N (%)
Onchocerciasis	Number of countries verified for interruption of transmission	12/38 (31%)	5/38 (13%)	4/38 (11%)
Lymphatic filariasis	Number of countries validated for elimination as a public health problem	58/72 (81%)	23/72 (32%)	19/72 (26%)
Soil-transmitted helminthiases*	Number of countries validated for elimination as a public health problem	96/101 (96%)	60/101 (60%)	0
Schistosomiasis	Number of countries validated for elimination as a public health problem	78/78 (100%)	49/78 (63%)	0
Trachoma	Number of countries validated for elimination as a public health problem	66/66 (100%)	28/66 (42%)	18/66 (27%)

* *Ascaris lumbricoides, Trichuris trichiura, Necator americanus and Ancylostoma duodenale*

N= number of countries targeted, n= number of countries validated by WHO for the disease

1.10.3 Mali NTD national programs

In Mali, the fight against neglected tropical diseases (NTDs) is a national priority. Through its dedicated programs, the country is committed to protecting the most at-risk communities, strengthening health systems, and achieving the elimination targets set by the WHO. In accordance with World Health Assembly resolutions, Mali has implemented programs to combat the five PC-NTDs. Starting with schistosomiasis and STHs in 1982, onchocerciasis in 1986, trachoma in 1998, and finally lymphatic filariasis in 2004. In 2007, the programs were integrated, and mapping of all PC-NTDs was completed in 2009 across the entire country. Thus, since 2007, successive strategic plans for 2007-2011, 2012-2016, 2017-2021, and 2022-2026 have been implemented by the Malian government through the Ministry of Health.

1.11 Progress toward control and elimination of NTDs

1.11.1 Global progress and milestones: overview of achievements under WHO's 2030 NTD Roadmap

The WHO Roadmap for NTDs 2021 - 2030 sets ambitious global targets to prevent, control, eliminate, and eradicate a diverse group of 21 diseases that disproportionately affect the world's most vulnerable populations (WHO, 2021). The overarching goal is to reduce by 90% the number of people requiring NTD interventions, reduce NTD-related DALYs by 75%, achieve elimination of at least one NTD in 100 countries, and eradicate dracunculiasis and yaws by 2030 (Casulli, 2021).

The approach outlined in the Roadmap shifted from a disease-specific focus to a cross-cutting strategy centered on country ownership, integration, and universal health coverage (UHC). In 2022 alone, over 1 billion people were reached with treatment for at least one NTD through mass drug administration (MDA). For instance, the elimination of trachoma, the world's leading infectious cause of blindness, has been validated in 18 countries, with two countries (Morocco and Oman) having eliminated trachoma as a public health problem. For lymphatic filariasis, 19 countries have been validated as having eliminated LF as a public health problem.

1.11.2 Regional achievements in Africa: Success stories

African nations are achieving historic milestones in the fight against NTDs and have celebrated remarkable victories. Togo stands out as a global leader, becoming the first country to eliminate four different NTDs, including dracunculiasis (Guinea-worm disease) in 2011, lymphatic filariasis in 2017, trachoma in 2022, and human African trypanosomiasis (sleeping sickness) in 2022. Furthermore, nations like Mali, Benin, Ghana, and Malawi have successfully eliminated trachoma as a public health problem, protecting millions from blindness. These successes are the result of sustained political will, effective partnerships, and the dedication of community health workers. These proven strategies provide a powerful blueprint for other endemic countries to follow.

1.11.3 Progress in Mali: Trends in prevalence, MDA coverage, and elimination targets achieved

Mali has been a key player in the fight against NTDs in West Africa. The implementation of the 2007-2011, 2012-2016, 2017-2021 and 2022- 2026 strategic plans has yielded satisfactory results. Trachoma has recently been eliminated in Mali as a public health problem (WHO, 2023). The dossier for the elimination of LF is currently being prepared. The country has stopped MDA for STHs, and the elimination dossier is planned for 2026. Surveys for MDA stopping criteria meeting are underway for onchocerciasis in endemic regions of the country. Today, only schistosomiasis remains the major challenge for control and elimination (ESPEN, 2024).

Mali's health system operates at multiple community levels: primary health center, regional, and national. It faces persistent challenges including limited financial and human resources, geographic barriers, political instability, and ongoing security threats in northern and central regions. Notwithstanding these challenges, Mali has realized substantial advancements (ESPEN, 2024). The remaining gaps in MDA coverage are largely associated with populations that are difficult to reach due to mobility or marginalization. These "last mile" populations are critical to address if Mali is to meet its 2030 NTD elimination targets in alignment with the WHO Roadmap.

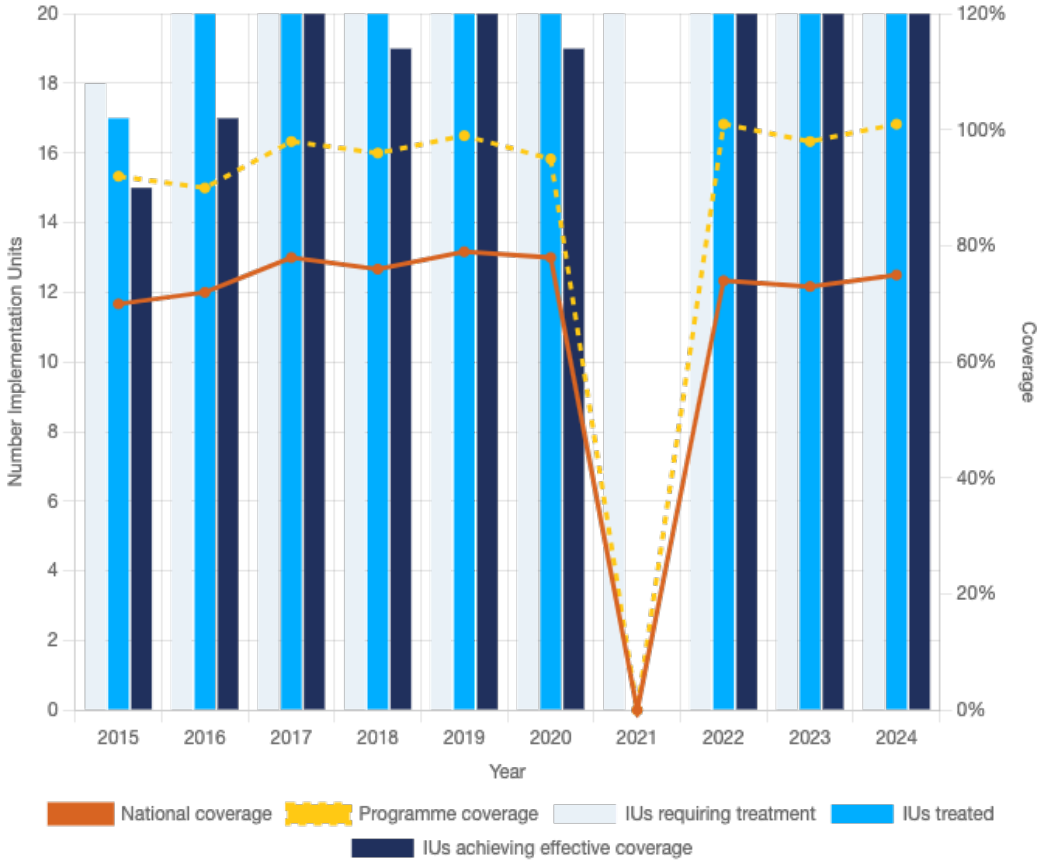
1.11.4 Mass drug administration (MDA) status in Mali in 2024 (data from ESPEN)

Table 3 summarizes Mali's 2024 MDA coverage against national targets, disaggregated by disease. It highlights areas that are meeting targets and those requiring targeted follow-up to sustain progress toward elimination goals.

Table 3. Coverage of MDA in Mali in 2024 compared with national targets, showing progress toward elimination goals

Disease	National Target (%)	Geographic Coverage (%)	National coverage (%)	Current state
Lymphatic filariasis	65%	-	Treatment is not required	Elimination dossier in preparation
Onchocerciasis	65%	100	75% of individuals requiring PC in the country were treated	Endemic requiring PC
Schistosomiasis	75% SAC*	92%	88% of SAC and 0% of adults requiring PC in the country were treated	Endemic requiring PC
STH	5% SAC	-	Treatment is not required	Meet criteria to stop MDA
Trachoma	80%	-	-	Certified eliminated in 2023 by WHO
*SAC=school Aged Children; STH= Soil-Transmitted Helminthiasis				
Source: https://espen.afro.who.int/maps-data/countries/mali#overview--drug-packages				

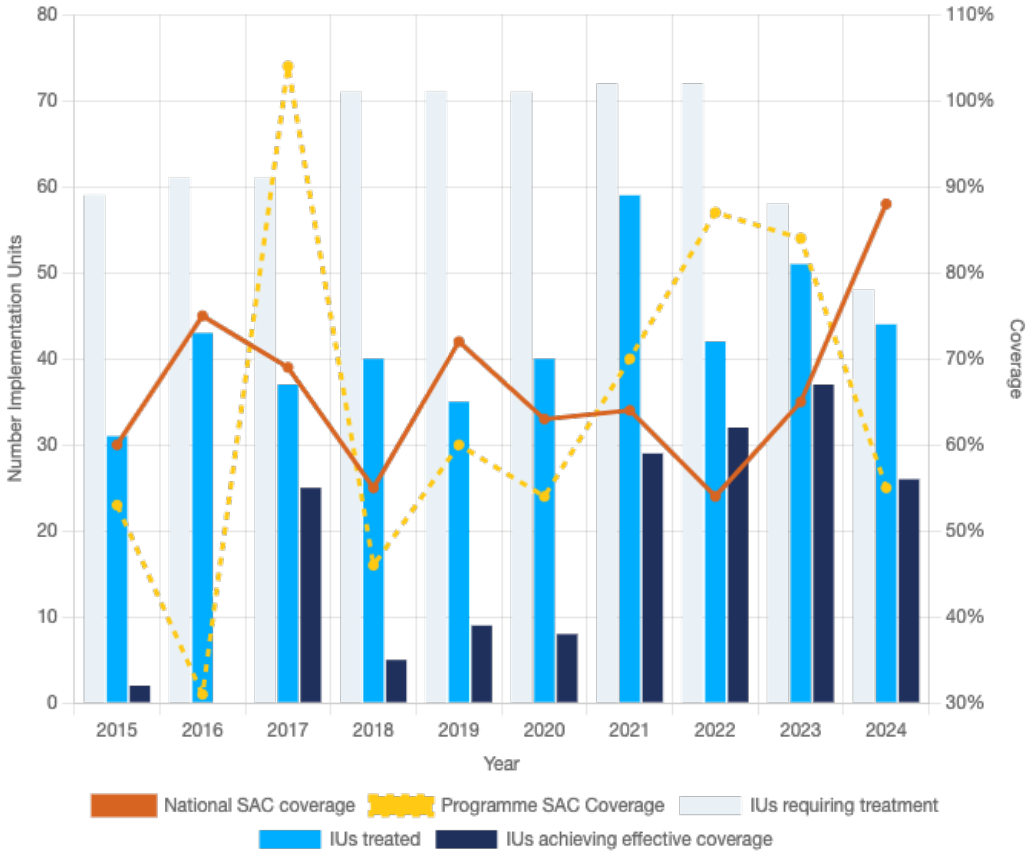
These figures below show the current MDA coverage trends over time of the 2 endemic (onchocerciasis and schistosomiasis) national programs in Mali in 2024.



SAC= school age children, IUs=implementation Units, PC= preventive chemotherapy

Source: https://espen.afro.who.int/maps-data/countries/mali#onc

Figure 4. PC Coverage trends over time in Mali for Onchocerciasis program (2024)



SAC= school age children, IUs=implementation Units, PC= preventive chemotherapy

Source: https://espen.afro.who.int/maps-data/countries/mali#sch

Figure 5. PC Coverage trends over time in Mali for Schistosomiasis program (2024)

Compliance/uptake: is defined as the proportion of eligible individuals swallowing the treatment during MDA campaigns out of the total number of eligible people (WHO, 2021). To strengthen coverage and uptake (or compliance), distribution of the medicines alone is not enough; programs must also ensure that people are swallowing the tablets through directly observed administration. Reaching all population groups, especially mobile or hard-to-reach peoples, will be crucial for achieving elimination.

Coverage compliance gap: The "coverage–compliance gap" refers to the difference between the proportion of eligible individuals who receive the drugs (coverage) and the proportion of those who actually ingest them (compliance) (Babu & Babu, 2014). A systematic review in India found coverage rates ranging from 48.8% to 98.8% and compliance from 20.8% to 93.7%, revealing an average gap of about 22% (Babu & Babu, 2014). Similar patterns have

been reported in Africa: in Ethiopia, 81.5% of residents were offered treatment but many did not swallow the tablets (Teshome et al., 2021). Determinants of this gap include fear of side effects, inadequate awareness of the disease or treatment benefits, low trust in drug distributors, poor timing of campaigns, and weak community engagement (Silumbwe et al., 2017). Population mobility further widens this gap as migrants, seasonal workers, and nomadic pastoralists often miss MDA rounds because of absence or shifting residence. A study among nomadic Peuhl groups in Togo showed persistently high antigen prevalence (11.9%) post-MDA for LF, underscoring that mobile populations are systematically under-served by conventional distribution approaches (Dorkenoo et al., 2021). From a programmatic perspective, these findings imply that simply reaching people with tablets is insufficient. Effective elimination programmes must ensure uptake via better communication, directly-observed treatment, community mobilization, and robust monitoring of actual ingestion rather than only delivery.

Never treatment and infection: People who are systematically missed, and who self-report never to have taken any medicines during an MDA campaign have been called never treated [Brady paper]. The percentage of people never treated during MDA is expected to be very high among mobile populations in Mali. Understanding the reasons some people have never been treated is a crucial step in the elimination framework (Adams et al., 2022) as untreated individuals may constitute a potential parasite reservoir (Abou-El-Naga, 2015; Faust et al., 2020). Reasons for never treatment often include absence during campaigns, lack of information, fear of side effects, or mistrust of health workers (Brady et al., 2023).

Studies show a persistent association between individuals who have never participated in MDA and higher infection prevalence in endemic communities. Coverage surveys have shown that never treated groups frequently overlap with high-risk occupational or mobile populations, contributing to continued disease transmission even where overall programme coverage exceeds WHO thresholds (Brady et al., 2023; Krentel et al., 2013). Similar patterns have been reported in other endemic settings: in Indonesia, nearly half of surveyed individuals had never received preventive chemotherapy for lymphatic filariasis, mainly due to fear of side effects and limited awareness (Titaley et al., 2022). In Ghana, persistent *Onchocerca volvulus* infection was strongly associated with a small but consistent group who had never taken ivermectin despite years of MDA (Otabil et al., 2023); and modeling studies on *Schistosoma mansoni* demonstrate that even a modest proportion of never-treated individuals can significantly delay elimination targets (Kura

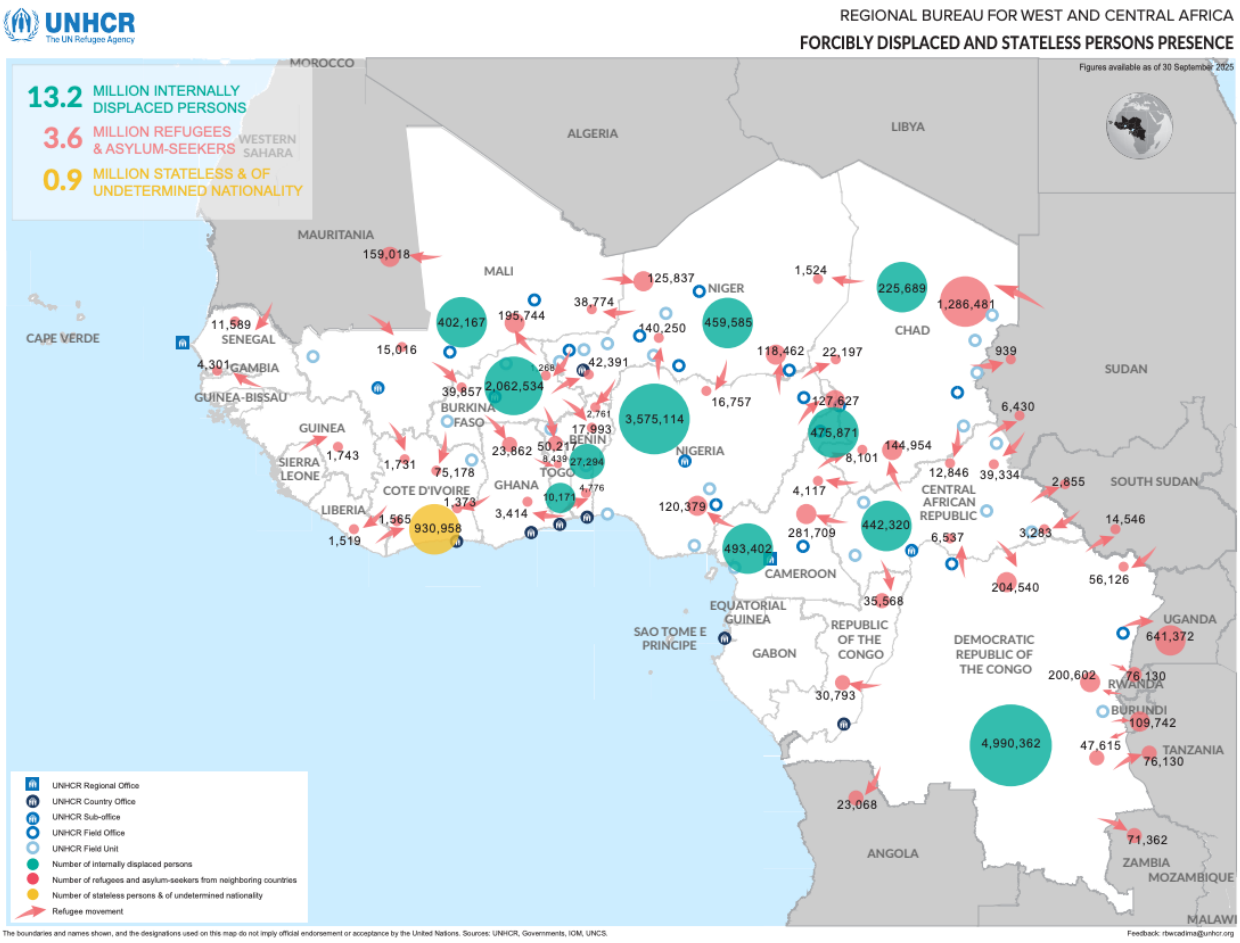
et al., 2024). Collectively, these findings emphasize that never treated populations constitute a critical reservoir for ongoing transmission. Understanding the behavioral and structural factors that lead to persistent non-participation is therefore essential to achieving national elimination goals.

1.12 Population mobility

Population mobility is defined as the geographic movement of people from their usual place of residence to another place looking for better opportunities, to escape disasters and unrest, or safer places (ABS, 2009). This movement can be done from one country to another, from one region to another, or between rural and urban areas depending on the reasons that motivate people to move. Mobile populations include refugees, IDPs, nomad pastoralists and livestock breeders (STPH, 2022). Mobile and migrant populations are highly vulnerable and face major barriers/obstacles to accessing public health interventions. They also can be key drivers of both vulnerability and infectious diseases transmission. If a person infected with NTDs migrates to an area where MDA has stopped, that person could contribute to the transmission cycle, hence reigniting disease transmission and posing a threat to elimination efforts (Vegvari et al., 2019).

1.12.1 Population movement: an African regional perspective

The number of Africans living in internal displacement as a result of conflict and violence has more than tripled over the past 15 years, rising from 10.2 million in 2009 to 32.5 million in 2023 (IDMC, 2025)**.** According to UNHCR's Regional Bureau for West and Central Africa (RBWCA), the total number of refugees, IDPs, and stateless individuals in Africa reached record levels as of August 2025, reflecting the cumulative impact of protracted conflicts, insecurity, and climate-related shocks (https://data.unhcr.org/). This sharp increase highlights the growing scale and persistence of displacement crises across the continent (IDMC, 2025).



Principal refugees, IDPs and stateless persons

Source: https://data.unhcr.org/en/documents/details/119287

Figure 6. Overview of key mixed movements trends reported in West and Central Africa (October 2025)

1.12.2 Why people are moving

Population mobility in West Africa including Mali, is a common phenomenon but is increasingly shaped by contemporary and complex drivers. It is deeply rooted in traditional agro-pastoral practices such as transhumance among Fulani and Dogon herders cross-border trade, and seasonal agricultural migration (Schürmann et al., 2022). These days, this structural mobility is further intensified by a convergence of crises (Kelly-Hope et al., 2023).

Impact of climate change on NTDs*:* Climate change is emerging as a critical factor influencing the epidemiology and transmission dynamics of vector-borne and waterborne diseases including NTDs (Kelly-Hope et al., 2023; Tidman et al., 2021). Some of the NTDs are expected to undergo shifts in both their transmission seasons and geographic distribution, potentially spreading into areas and affecting populations that were previously unaffected (Tidman et al., 2021). National disease control/elimination, or eradication programs are increasingly at risk from complex issues like population displacement, climate change, and political instability (Kelly-Hope et al., 2023). Many key factors affect the spread and severity of human diseases, including mobility of people, animals, and goods; control measures in place; availability of effective drugs; quality of public health services; human behavior; and political stability and conflicts (Kelly-Hope et al., 2023; Manyazewal et al., 2024; Rahamtalla et al., 2025). Climate change is expected to significantly increase schistosomiasis infection risk in eastern Africa by 20% over the next 20–50 years (Asare et al., 2025; McCreesh et al., 2015).

Conflict and insecurity**:** ongoing conflict in central and northern Mali has displaced large populations, creating groups of IDPs with unpredictable movement patterns. Many people settle in peri-urban zones that are underserved by the health system (Diallo, 2017). Sociopolitical instability affects millions worldwide and hinders advancement toward global health goals. The 2024 report of the United Nations High Commissioner for Refugees (UNHCR) notes that in 2023, 117.3 million people were forcibly displaced. Such large-scale displacement disrupts health initiatives across the globe, especially those already underfunded and politically overlooked, such as programs targeting neglected tropical diseases (NTDs) (Manyazewal et al., 2024; UNHCR, 2023). The healthcare system in Sudan has been severely weakened by the conflict, leading to serious public health issues. Infrastructure was destroyed, medical supplies were in low supply, and healthcare workers were displaced as a result of the violence. These events disrupted essential health services, increased the risk of infectious diseases, and exacerbated malnutrition and mental health (Rahamtalla et al., 2025). Access to widespread treatment delivery is frequently hindered by inadequate health infrastructure, and it is still particularly challenging to maintain high coverage in MDA programs in remote or conflict-affected areas (Branda et al., 2024).

Economic dynamics: The search for employment opportunities in mining zones and large urban centers drives labor-related mobility (Farnham et al., 2022). Recent research

indicates that the nature of work in remote areas, patterns of population mobility, and health status are closely interconnected (Lokotola et al., 2024). These economic dynamics contribute directly to seasonal agricultural migration, as families and individuals temporarily relocate to pursue employment opportunities tied to harvest cycles and regional agricultural demands (Moreda, 2025). This underscores the need for an evidence-based approach to protect the health of both migrant and mobile populations, as well as the communities of origin and the host communities with which they interact (Carney & Gushulak, 2016).

***Nomadisme/transhumance*:** Nomads are usually categorized as hunters, gatherers and pastoralists. Pastoralists can be classified as transhumant, who migrate regularly between two grazing areas according to clearly established routes and maintained each year, and as pastoralists, whose economy is primarily based on migration and herding (Muhammad-Baba & Amzat, 2012; Sheik-Mohamed & Velema, 1999). The difficulty of including nomadic and transhumant populations in public-health interventions has been documented in many settings. For example, in Mali, a study found that the constant mobility of nomadic populations precluded regular access to health services, which contributed to low uptake of preventive care in those communities (Sangare et al., 2021). Research document lower health-service uptake among nomadic pastoralists and identify mobility as a recurrent reason for never treated status in MDA campaigns (Adams et al., 2022; Afari-Asiedu et al., 2024; Gammino et al., 2020). Similarly, in Nigeria, outreach-based efforts among nomads significantly improved detection and treatment outcomes for diseases such as tuberculosis (TB), showing that standard, static health-service delivery models are often inadequate for mobile populations (John et al., 2024).

Furthermore, climate change, particularly declining rainfall, disrupts traditional transhumance patterns in Africa by forcing pastoralists to migrate earlier toward farming areas in search of grazing land for animals, which increases the risk of conflict with sedentary agriculturalists (McGuirk & Nunn, 2025). This climate-driven displacement of herders highlights how environmental stress can trigger both mobility and social instability among transhumant populations, emphasizing the need for adaptive governance and inclusive resource management. For programmes this means adapting timing, cross-border coordination, mobile delivery teams, and community-led strategies to ensure MDA reaches and is ingested by transhumant groups.

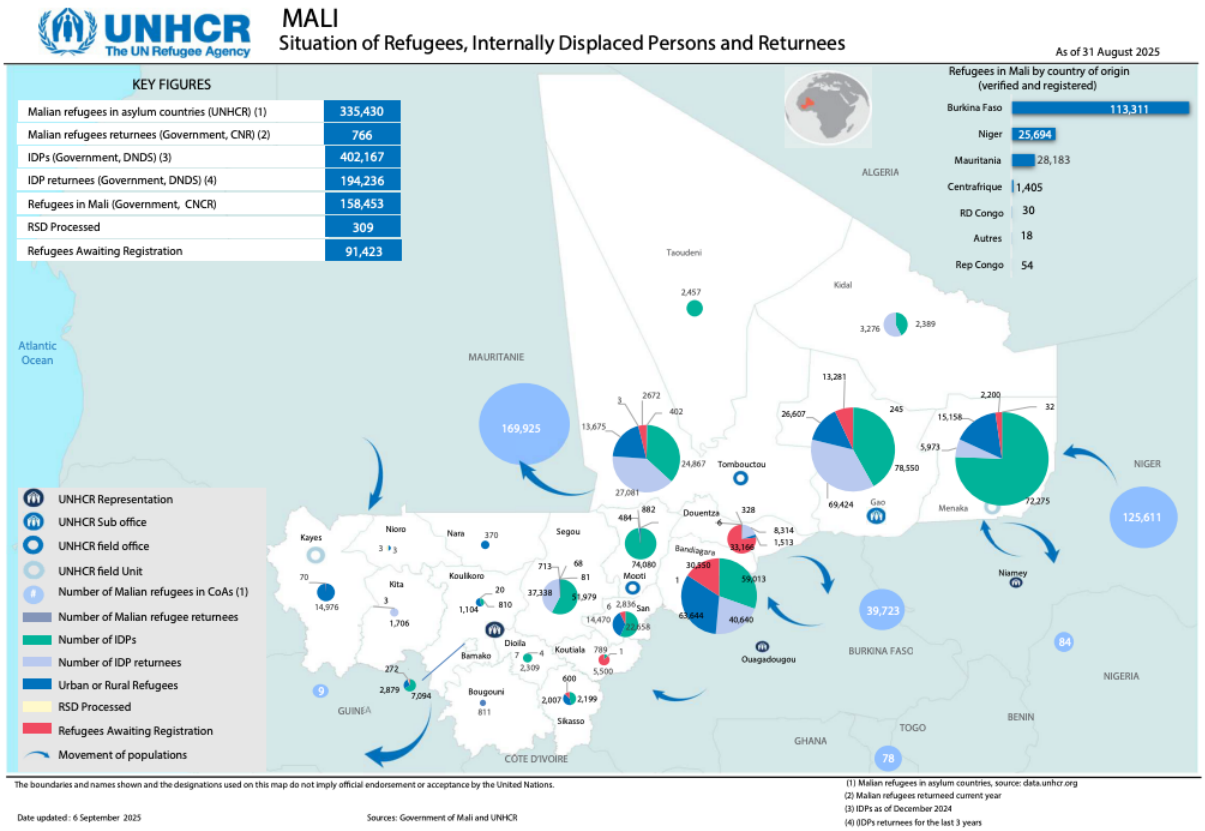
Internally displaced persons, and refugees: Populations living in conflict-affected areas or displaced by violence are among the most vulnerable to NTDs. Their constant movement

increases the risk of infection for both themselves and host communities, while also limiting their access to essential health services. For example, in South Sudan, ongoing conflict has forced large populations to move across regions, complicating mass drug administration campaigns for onchocerciasis and schistosomiasis (Elsaeed Elhag et al., 2025). Similarly, in Nigeria's northeastern states, displacement due to insurgency has disrupted routine NTD interventions, leaving both displaced and host populations at higher risk of infection (Olanrewaju et al., 2025).

Cross-border population movement: Movement across borders poses a risk of spreading NTDs and reintroducing diseases that neighboring endemic areas/countries have previously eliminated. (Ramaiah, 2013). People who are highly mobile across borders include traders, nomadic or transhumant populations, and individuals displaced by conflict or insecurity, who may spend extended periods away from home communities. While these groups are not homogenous, they share a common characteristic: their mobility makes them difficult to locate, track, and include in standard, place-based health interventions, such as MDA campaigns. This presents significant challenges for achieving equitable coverage and ensuring the effectiveness of public health programs targeting mobile populations (Adams et al., 2022; Baayenda et al., 2023; Gustavsen et al., 2016). Research indicates that, despite progress in Uganda, onchocerciasis continues to be reintroduced from endemic cross-border areas in the DRC and South Sudan, challenging elimination efforts (Bush et al., 2018). A comparable issue of cross-border onchocerciasis transmission has been documented in Malawi and Guinea-Bissau, likely stemming from adjacent areas in Mozambique and Guinea (Boakye et al., 2018). Moreover, uncoordinated cross-border elimination efforts exacerbate these challenges, as differences in national strategies and timing of interventions can allow transmission to persist or diseases to be reintroduced across borders (Gebrezgabiher et al., 2019).

***Mali-specific context*:** Mali's recent history shows that multiple groups of people are moving because of conflict, climate change, better economic opportunities, informal mining and political instability. These many circumstances have led to thousands of individuals being displaced as well as youth migration from their communities to much more stable and promising places. The humanitarian context in Mali remains complex and fluid, marked by ongoing insecurity and population movements across several regions. As of 31 August 2025, an estimated 335,430 individuals, including refugees, IDPs, and returnees were documented by UNHCR,

underscoring the magnitude of the displacement crisis in Mali (see Figure 7) (https://data.unhcr.org). As a result, mobility becomes a structural barrier that contributes to persistent gaps in NTD coverage and inequitable access to preventive treatment in Mali.



Source: https://data.unhcr.org/en/documents/details/118464?utm_source=chatgpt.com

Figure 7. Mali situation of refugees internally displaced persons and returnees (31 August 2025)

1.13 Health implications of population mobility

Population mobility poses major challenges for health systems in Africa, particularly those structured around fixed facilities and sedentary populations. According to the International Organization for Migration (IOM), more than 43 million people in Africa require humanitarian assistance, with a significant proportion being mobile or displaced populations (*Global Migration Data Portal*, 2024). These groups frequently fall outside the reach of routine health delivery platforms, including national programs for NTDs (Adams et al., 2022). Mobile and displaced populations often face disruptions in continuity of care, weak disease surveillance, and limited integration into community health structures (Cantor et al., 2021; Manyazewal et al.,

2024). Health systems rarely have mechanisms to track mobile individuals across borders or regions, leading to persistent service gaps in prevention and treatment (Buback et al., 2025; Manyazewal et al., 2024). Furthermore, insecurity, limited workforce mobility, and poor data systems constrain adaptive responses. Strengthening cross-border coordination, mobile health services, and community-based delivery models is therefore critical to ensure equitable access and sustain disease elimination efforts among migrant and nomadic populations.

1.14 Facilitators of access and coverage among mobile populations

Despite these challenges, the literature highlights several promising strategies to overcome barriers to improve awareness and uptake of MDA for NTDs elimination among mobile populations. These strategies include:

***Community engagement and health education*:** Respected pastoralists who have received training to distribute medications during transhumance are examples of peer distributors who are being trained from within the mobile communities themselves. This method expands on preexisting trust and movement pattern understanding (Gammino et al., 2020).
Mobile pastoralists are one of the last populations to be reached by health services and are frequently missed by health campaigns. Studies indicate that some of the most common facilitators of intervention success were cultural sensitivity, community engagement and service mobility (Wild et al., 2020).

Intersectoral integration: Interventions that adopt a One Health approach by integrating human and veterinary services and prioritizing community-engaged design align with the use of trusted peer distributors within mobile populations (Gammino et al., 2020).

Human medicines can be distributed during livestock vaccination campaigns (e.g., against contagious bovine pleuropneumonia), ensuring higher coverage. Research in Chad emphasized how integrating **human and animal vaccination** and planning around the periodic presence of pastoralist groups supports trust-building strategies, an important context in which **training respected pastoralists as peer distributors** would be effective (Abakar et al., 2018). Digital innovations offer new opportunities to enhance schistosomiasis control by improving data collection, monitoring treatment coverage, and facilitating targeted interventions (Manyazewal et al., 2024).

Mobile mapping applications can track transhumance routes, identify gathering points (water sources, weekly markets), and optimize health team deployment (Carrasco-Escobar et al., 2019). Short message service (SMS) or voice-based systems can be used to disseminate messages in appropriate languages about the timing and location of drug distribution. Innovative approaches such as mobile platforms and SMS have shown potential to coordinate mass drug administration campaigns in real time, by informing communities about the timing and location of distribution while also facilitating drug stock management (Stanton et al., 2016). In West Africa, the use of phone-based text messages by community health workers proved feasible to support lymphatic filariasis morbidity surveillance, highlighting that SMS can also serve to remind communities about treatment dates and locations (Kalinga et al., 2022).

Cross-border coordination is essential for addressing health issues that transcend national boundaries, ensuring synchronized strategies, resource sharing, and continuity of interventions among neighboring countries. Lessons from cross-border collaboration for onchocerciasis elimination across Liberia, Sierra Leone, Guinea, and Côte d'Ivoire, demonstrated how coordinated efforts improved joint planning and interventions (Gustavsen et al., 2016), highlighted the establishment of cross-border committees, synchronized mass treatment campaigns, and enhanced coordination at local and regional levels for malaria and NTD control (WAHO, 2018).

1.15 Impact of mobility on the effectiveness and equity of MDA

Failing to include mobile and migrant populations in MDA campaigns is unfair and strategically risky for the global goals to eliminate NTDs. When untreated, these groups become potential sources of infection, sustaining the cycle of transmission. This creates a dangerous circumstance where diseases can be reintroduced into settled communities that have already successfully eliminated them, thereby wasting years of investment and gains (Toor et al., 2018; Vegvari et al., 2019). From an equity standpoint, the failure to reach mobile populations deepens health inequalities. In the conflict-affected province of Cabo Delgado, Mozambique, disruption of MDA for IDPs has been directly linked to the continued transmission of lymphatic filariasis and schistosomiasis, threatening national elimination goals (Badia-Rius et al., 2024). Computer modeling further supports this, showing that movement from untreated areas can slash the chance of eliminating soil-transmitted helminths by 30% in high-risk regions, highlighting how

deeply mobility influences disease spread (Vegvari et al., 2019). Research demonstrates that population movement, especially cross-village or cross-region migration, dramatically reduces the success rate of helminth elimination even where high coverage of MDA is achieved. For instance, a 2023 study in Kenya showed that spatial mobility of people led to bounce-back of hookworm infections years after treatment campaigns, emphasizing the need to integrate mobility data in the design and evaluation of MDA programs (Collyer et al., 2023).

Mobile and migrant populations, such as nomadic pastoralists, seasonal workers, refugees, and IDPs, are often some of the most vulnerable groups. They are repeatedly missed by simple, low-cost, and life-saving public health measures (Adams et al., 2022). Research from Cameroon and Mali shows that inflexible, census-dependent planning routinely fails to account for these communities, which only makes them more vulnerable and traps them in a cycle of sickness and poverty (Masong et al., 2021; Sangare et al., 2024). Leaving mobile and migrant populations behind goes against the core idea of Universal Health Coverage (UHC) and breaks the WHO NTD Roadmap 2030's and Sustainable Development Goals' promise to "leave no one behind" (Casulli, 2021; Rajan et al., 2020).

Understanding the impact of these population movements and the related social dynamics is crucial to change strategy, and use more appropriate approaches designed to align with movement patterns. Ultimately, achieving elimination goals will also depend on maintaining a focus on the hardest-to-reach groups, thereby transforming a critical weakness into the foundation for lasting success.

1.16 Conclusion

Mali has made substantial and commendable progress in its fight against PC-NTDs, achieving milestones such as the elimination of trachoma as a public health problem and advancing towards the elimination of lymphatic filariasis and soil-transmitted helminthiases. However, the final phase of this journey, the "endgame", presents formidable challenges, mainly driven by the dynamic and complex nature of population mobility in the country.

A large numbers of people in Mali including internally displaced persons, refugees, nomadic pastoralists, seasonal workers, and cross-border migrants are constantly on the move due to conflict and insecurity, climate change, economic pressures, and traditional livelihoods. This mobility of population creates significant gaps in MDA coverage, fosters potential

reservoirs of infection, and threatens to undermine decades of progress. The coverage-compliance gap and pockets of never treated populations further exacerbate these challenges, highlighting that current strategies may not sufficiently reach or engage these mobile groups.

To secure the gains made to date and to achieve the 2030 NTD elimination targets, the next critical steps must include adaptive and targeted strategies, enhanced community engagement, integration and innovation, as well as strengthened health systems. Ultimately, overcoming the "last mile" challenge in Mali's NTD elimination journey requires a deliberate shift in strategy. The focus must now be on understanding and responding to the patterns and needs of mobile populations. By translating the general strategies identified in the literature into concrete, operational actions tailored to the Malian context, the program can transform its greatest vulnerability into the foundation for lasting, equitable success. The promise to "leave no one behind" depends on it.

1.17 Theoretical and conceptual framework

Healthcare access has been conceptualized by numerous theoretical models, each with its own advantages and limitations. One theory is the Penchansky and Thomas model, published in 1981, which describes access between community needs and the health system’s capacity to provide care services (Penchansky & Thomas, 1981). It conceptualizes access through five key dimensions known as the Five A’s: availability, accessibility, accommodation, affordability, and acceptability, with a focus on how systemic and social barriers create disparities for marginalized groups. For people to access a service effectively, it must be organized appropriately, be acceptable to the community, be affordable, be adequately supplied, and be located within practical geographic reach.

Subsequently, the Five A's model was revised by Saurman in 2016 to introduce a sixth dimension, awareness, emphasizing the importance of communication and information (Saurman, 2016). While Saurman's addition improves consideration of communication gaps affecting mobile groups, the framework remains largely service-oriented and assumes relatively fixed communities, making it less suitable for our study. Moreover, it does not fully account for individual abilities, decision-making, and the active role of individuals in accessing care.

The health care access barriers (HCAB) model, originally developed by Carrillo et al. (2011) is a comprehensive framework for categorizing barriers faced by vulnerable communities

when attempting to access care. It organizes barriers into three domains: financial (direct and indirect costs of care, no health insurance), structural (transportation, limited services availability or organizational constraints), and cognitive (low health literacy, and limited awareness of services), providing a practical perspective for identifying specific leverage points of intervention. (Carrillo et al., 2011). However, while the HCAB framework is useful for understanding barriers in relatively stable or settled populations, it is less suited for contexts where mobility itself is the central determinant of access, as is the case for nomadic, pastoralist, displaced, and cross-border groups in the Sahel. The model does not fully account for how seasonal movements and the temporality of mobility directly influence access to preventive services such as MDA. Nor does it sufficiently account for the fact that health systems organized around fixed structures, static populations, and annual campaign schedules consistently fail to reach mobile communities, regardless of individual structural and psychosocial barriers. For this reason, it does not adequately capture barriers inherent to highly mobile populations.

Andersen's behavioral model of health services use defines access as a condition of susceptibility to use health services, the perceived need for health care, and the presence of factors that facilitate or impede service use (Babitsch et al., 2012). This model highlights that both personal characteristics and external conditions jointly shape whether and how people seek and receive health care. Andersen's model primarily focused on relatively stable populations and formal health service utilization. It does not explicitly capture dynamic mobility, cross-border movements, or systematic non-reach that characterize nomadic pastoralists, seasonal workers, IDPs, and refugees. Additionally, it does not integrate structural or systemic barriers such as MDA campaign timing, which are important in understanding gaps in MDA coverage among highly mobile populations.

The integrated framework for access to medicines moves beyond clinical care to focus on a critical aspect of treatment. It posits that access is achieved through the simultaneous consideration of a medicine's availability, accessibility, affordability, and acceptability, while emphasizing on the often-overlooked dimension of quality for a comprehensive assessment (Afzali et al., 2019). This framework is valuable for evaluating pharmaceutical supply and service quality, but it does not capture mobility, patient the active role of individuals, or structural determinants, making it less suitable for understanding barriers to MDA compliance/uptake among mobile populations.

Several other explanations and frameworks of healthcare access exist; however, Levesque's conceptual framework for healthcare access is arguably the most comprehensive and fitting framework to explain why mobile populations miss MDA (Levesque et al., 2013).

Levesque's conceptual framework of access to health care

Levesque's framework published in 2013, was developed from a comprehensive review of the existing literature on access to health care. It defines access to health care as "the opportunity to identify, seek, reach, obtain, or use healthcare and to ensure the fulfillment of the needs for these services, page 2" (Levesque et al., 2013). It implies a multidimensional aspect with five dimensions of accessibility, (acceptability, availability and accommodation, affordability, and appropriateness) and five corresponding patient abilities (ability to perceive, ability to seek, ability to reach, ability to pay, and ability to engage), emphasizing the patient's journey to care. This framework examines barriers to accessing care that result from people's ability to perceive, seek, reach, pay, or engage, in addition to health system failures. It also considers the socioeconomic determinants of the population. It has been used to guide the design of interventions to improve healthcare access and service coverage in patients with various diseases (Cu et al., 2021; Latif et al., 2020; Tschirhart et al., 2016).

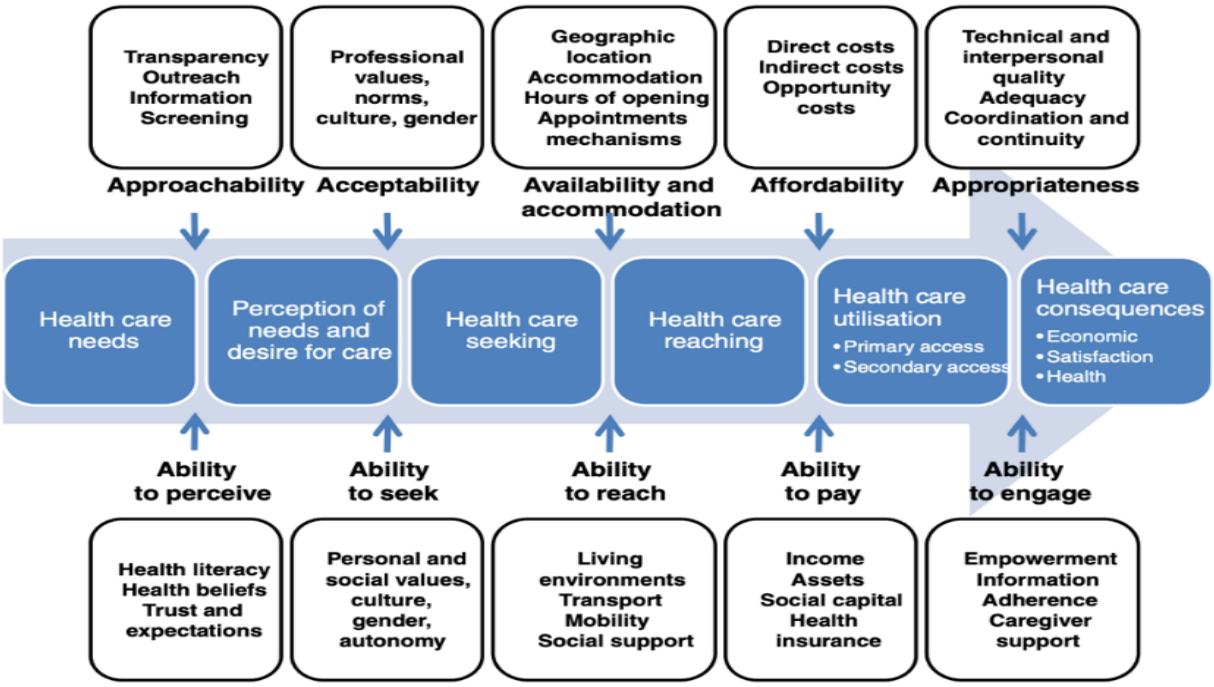
In the context of mobile populations (nomadic, pastoralist, and other mobile Sahelian populations) in Mali and other countries in the region, Levesque's conceptual framework offers a particularly relevant lens for understanding why these groups are repeatedly excluded from MDA campaigns. Their ability to perceive the need for preventive chemotherapy is influenced by priorities related to their mode of mobility or basic needs; their ability to seek health services is limited by long distances, seasonal migrations, and the limited number of points of contact with the health system; and their ability to reach or travel to fixed distribution points is often incompatible with the timing of campaigns or their geographical location. Similarly, the ability to pay, not for the MDA itself, but for the opportunity costs associated with travel and time, is an often-overlooked barrier.

Finally, their ability to engage depends on their trust in public institutions, their past experiences with health interventions, and the social organization of mobile communities. At the health system level, the availability, accommodation, appropriateness, and acceptability of MDA services are often out of step with the mobility patterns and sociocultural realities of these

populations. Levesque's model therefore helps clarify how structural and individual factors intersect to produce systematic non-coverage in MDA campaigns, making it a valuable conceptual basis for analyzing, and ultimately rethinking, strategies to equitably include mobile populations in NTD elimination efforts.

Levesque's conceptual framework of access to health care

Figure 8: Levesque's conceptual framework of access to health care (Levesque et al., 2013)



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CHAPTER 3: ARTCLE 1. Factors associated with low coverage in mass drug administration for schistosomiasis in mobile populations in Mali: a cross-sectional study

Overview

Chapter 3 presents the first article of this dissertation, which investigates the determinants of low mass drug administration coverage for schistosomiasis among mobile populations in Mali. This cross-sectional study provides essential insights into the structural and behavioral factors that limit treatment reach in highly mobile settings. The manuscript was published in BMC Infectious Diseases: https://doi.org/10.1186/s12879-025-11626-7

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1.19 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 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

1.20 Background

Neglected tropical diseases (NTDs) are a diverse group of 21 diseases and conditions that prevail in tropical and subtropical areas (Molyneux et al., 2017). They affect more than one billion people and cost developing economies billions of dollars every year (Hotez et al., 2014). 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 (WHO, 2023).

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 (WHO, 2024), 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% to 50.83% for urinary schistosomiasis and intestinal schistosomiasis respectively, and Tominian/San reporting 5.5% to 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 (Mutombo et al., 2019). A recent study reported 50.2% urinary schistosomiasis prevalence with 36 eggs/10 ml

urine average (Agniwo et al., 2023). 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 (Adams et al., 2022; Sangare et al., 2024). 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 (Forson et al., 2023; Kusi et al., 2020; Njomo et al., 2020). 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 (Bhutta et al., 2014; Kura et al., 2024). It is therefore hypothesized that mobile populations could harbor pathogens and may introduce transmission when they move to other regions (Castelli, 2018). 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 (Acosta et al., 2024; Eboreime et al., 2025; TDM/IOM-Mali, 2024).

Given the increased numbers of people in movement, there is also a paucity of information on how to best provide mobile people living in vulnerable circumstances with essential health care (Bhutta et al., 2014b; Kuper, 2019). 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 (Adams et al., 2022).

Previous studies, including our own, had established strong evidence of the vulnerability of mobile populations to missed MDA (Adams et al., 2022; Masong et al., 2021; Sangare et al.,

2024, 2025). 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.

1.21 Methods

Defining mobile populations in Mali

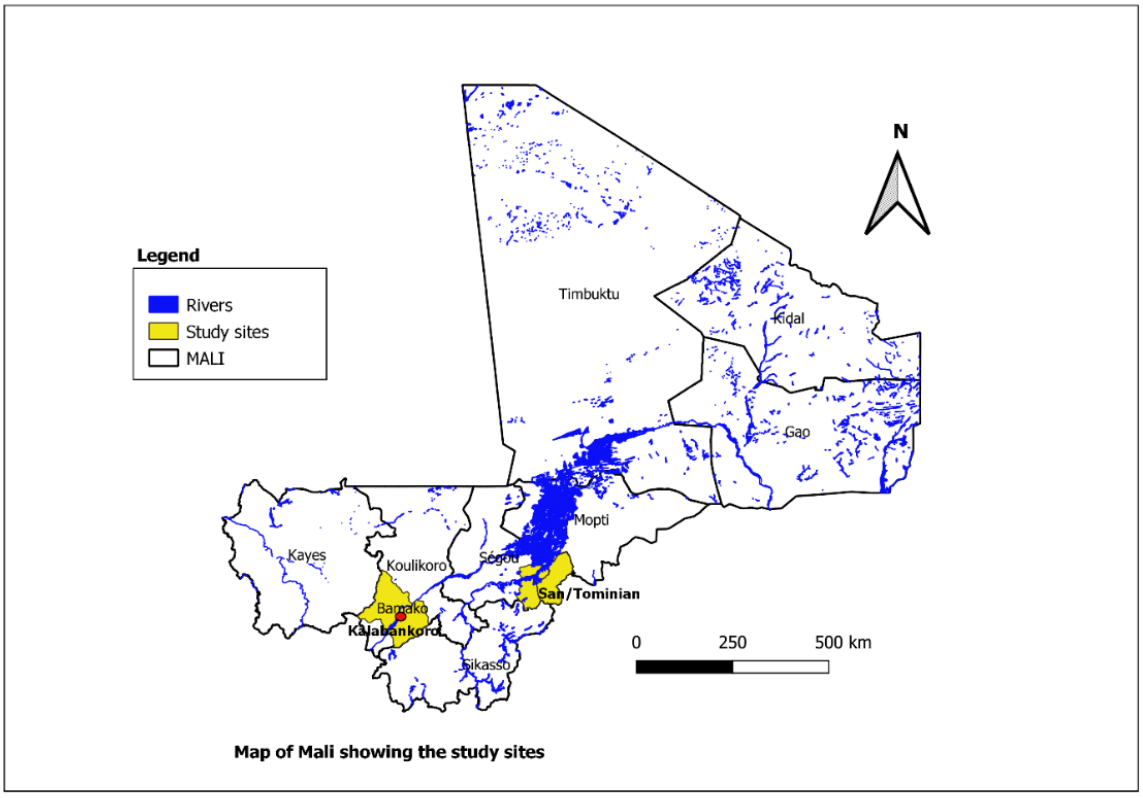
For this paper, the term "mobile populations" encompasses diverse groups whose movement patterns vary based on economic, environmental, and sociopolitical factors. These include: ***Internally displaced persons (IDPs)****:* This term refers to people forced to flee their homes due to conflict, violence, insecurity, persecution, or disasters but who remain within Mali's borders. IDPs are considered some of the most vulnerable groups globally (UNHCR, 2025). As of September 2024 there were 378,363 IDPs in Mali according to the International Organization for Migration Displacement Tracking Matrix (DTM Mali) (TDM/IOM-Mali, 2024). ***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 (Sheik-Mohamed & Velema, 1999). ***Economic migrants, (eg. 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 (European Commission, 2025). Additionally, in our study, ***residence*** referred to the participant's current place of stay at the time of the survey, regardless of duration (Adams et al., 2022b; Guyant et al., 2015).

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 (see Figure 1: map of Mali showing the study health districts): 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 (Umutoni & Ayantunde, 2018). 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 (Maïga et al., 2022). 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.



Source: NTDs Lab/ICER-Mali/USTTB 2023

Figure 9. Supplementary file 1: Map of Mali showing the study health districts

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 $N_0 = Z^2pq/e^2$ (Heinisch, 1965), 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 $N_0 = (1.96)^2 \times (0.20) \times (1- 0.20) / (0.03)^2 = 683$ +10% of nonresponse (68.30) = 752 community members for both health districts.

Sampling methods:The study employed multi-stage cluster sampling (Carlin & Hocking, 1999) 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 and 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 file 2: 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 (Wickham et al., 2014, 2023). 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 (Bates et al., 2015). Multicollinearity was assessed using the vif() function *(variance inflation factor)*. A variance inflation factor of 2.5 or greater was considered multicollinear (Johnston et al., 2018). 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 (Bates et al., 2015) in RStudio was used to build mixed models tailored to our dataset. Model results were presented in tabular form using gtsummary (Sjoberg et al., 2021), which enables informative formatting of results. Graphs were generated with the ggplot2 package (Wickham, 2016), 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 (Sutherland et al., 2023).

1.22 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.

1.23 Results

Socio-demographic characteristics of participants

Data were collected from 1,067 participants: 529 IDPs, 414 migrants, and 124 nomads (Table 4).

Table 4: 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

Characteristic	Health district			p-value[2]
	Overall, N = 1 067[1]	**Kalabancoro**, N = 520[1]	**Tominian/San**, N = 547[1]	
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	

Characteristic	Health district			
	Overall, N = 1 067[1]	**Kalabancoro**, N = 520[1]	**Tominian/San**, N = 547[1]	**p-value**[2]

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

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 4).

Table 5: 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 (%)

Among non-participants in MDA (N = 327), nearly half of the IDP (48.5% (66/136)) were under the age of 30 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 5).

Figure 2 shows the frequency of participation in the last schistosomiasis MDA by the different mobile populations studied (IDPs, migrants and nomads/transhumants).

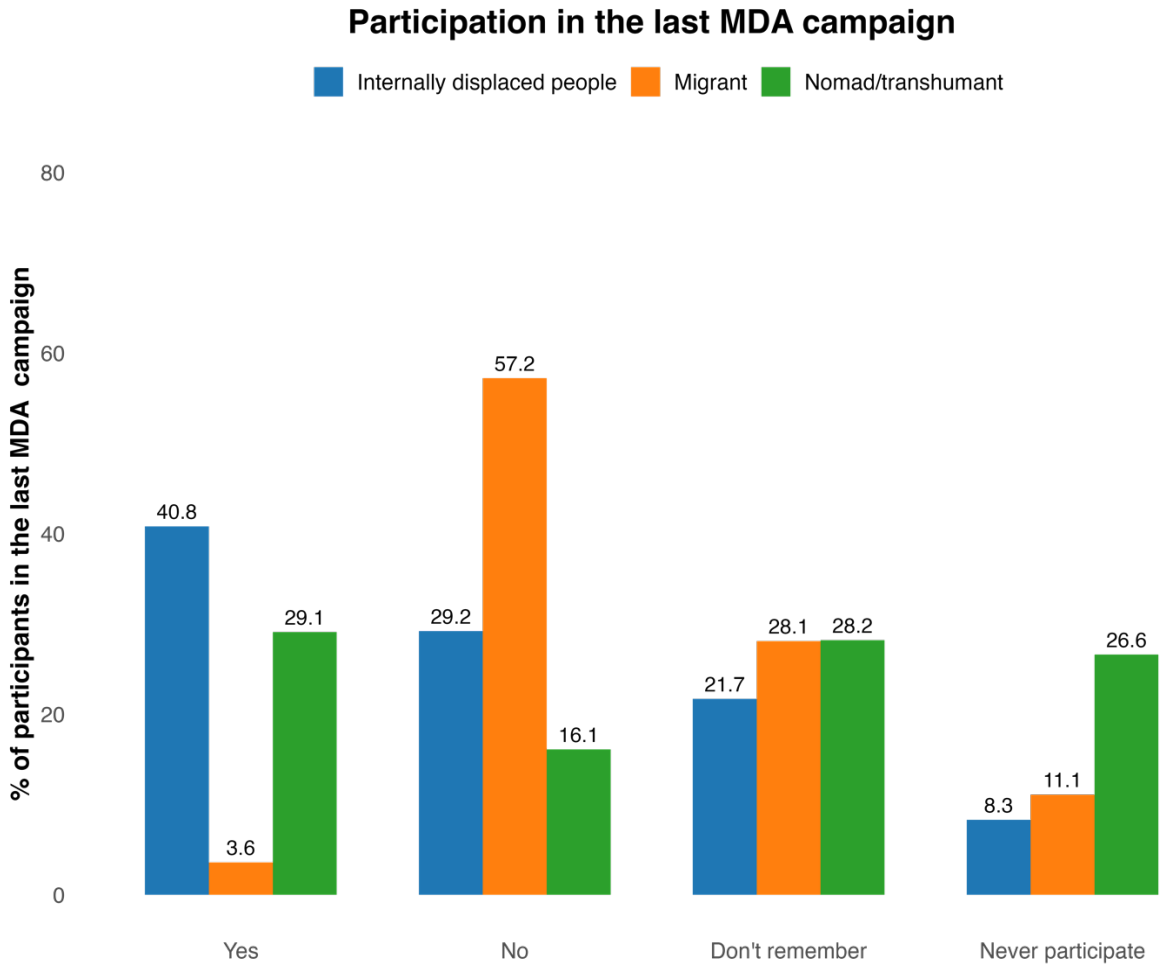


Figure 10. Frequency of participation in the last schistosomiasis MDA within IDPs, migrants and nomads/transhumants

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 (Figure 10).

Frequency of the most cited barriers to taking part in the most recent MDA campaign targeting schistosomiasis using praziquantel (Figure 11)

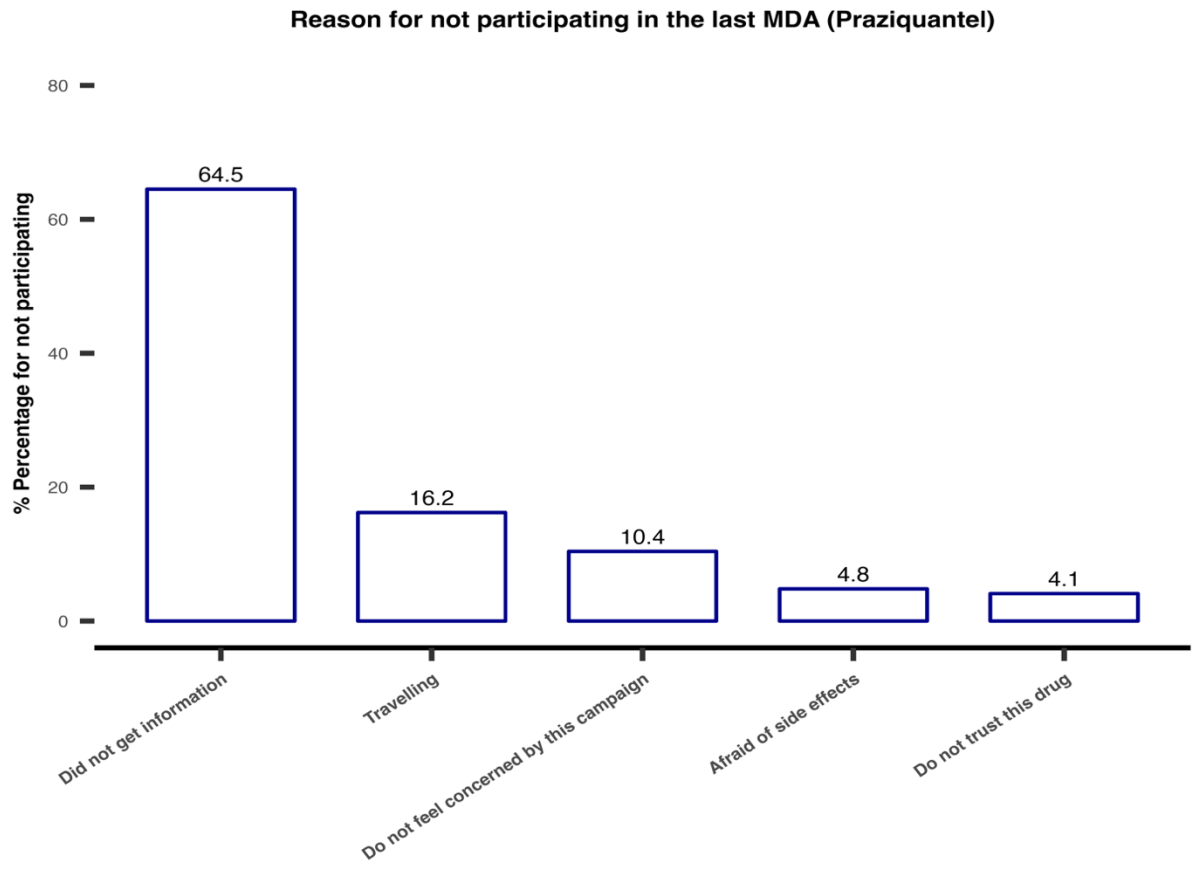


Figure 11. Frequency of reasons for non-participation in last schistosomiasis MDA among everyone (praziquantel distribution)

The reasons for not attending the last MDA using praziquantel for schistosomiasis control are shown in Figure 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) (Figure 11).

Table 6. Characteristics of participants missing the MDA campaigns

	Participation to the last schistosomiasis MDA			
Characteristics	**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)	

	Participation to the last schistosomiasis MDA			
Characteristics	**Overall**,	**Yes**,	**No**,	**p-value**[2]
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

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 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 6).

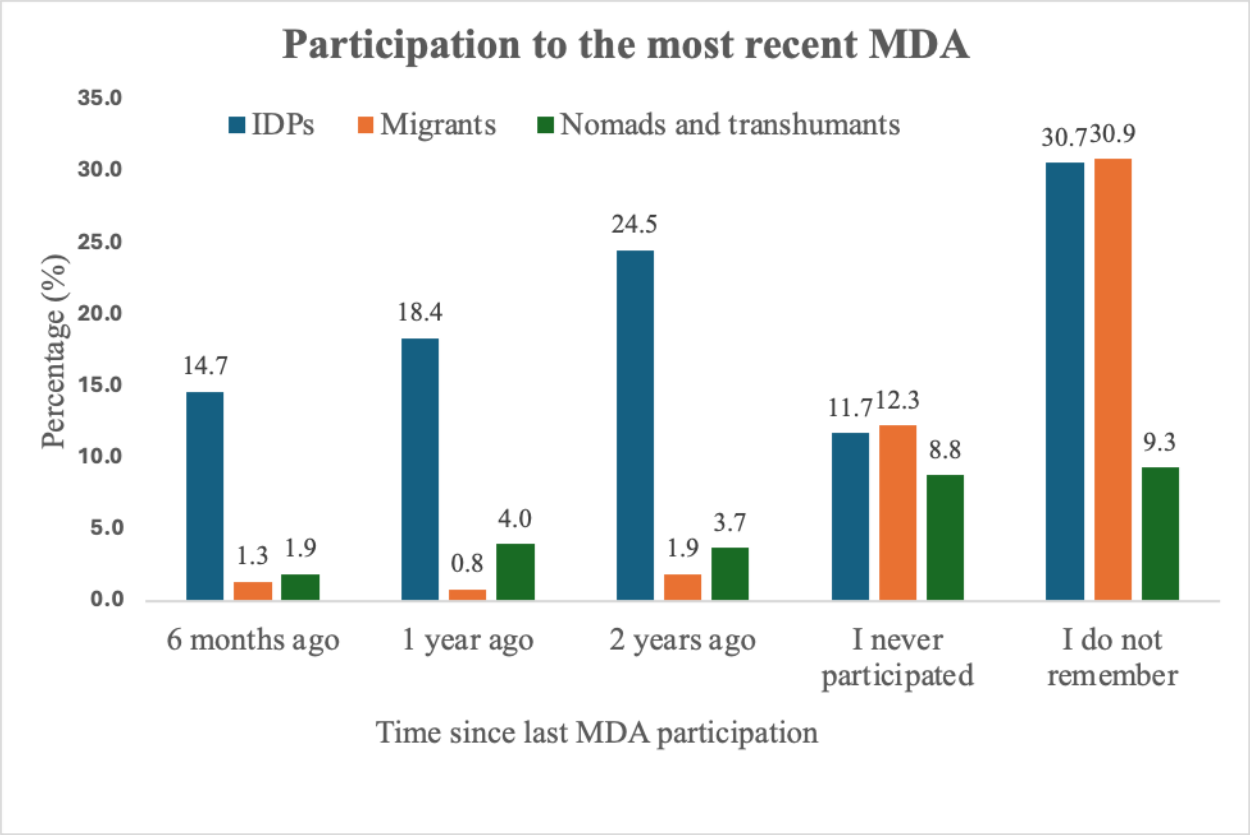


Figure 12. Distribution of respondents by their most recent participation in MDA campaigns

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 (Figure 12).

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

Table 7. 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

Non-participation to the last schistosomiasis MDA							
Characteristics	**%**	**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	—	

Non-participation to the last schistosomiasis MDA							
Characteristics	**%**	**OR**[1]	**95% CI**[1]	**p-value**	**aOR**[12]	**95% CI**[1]	**p-value**
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	—	

Non-participation to the last schistosomiasis MDA							
Characteristics	**%**	**OR**[1]	**95% CI**[1]	**p-value**	**aOR**[12]	**95% CI**[1]	**p-value**
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 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 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 7).

1.24 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).

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 (Kraft & Kraft, 2021).

The study participants mainly consist of young people (defined by the World Health Organization as 10-24 years) (WHO, 2025), reflecting Mali's demography in which 65% of the population is under 25 years according to the Bertelsmann Transformation Index (BTI) (BTI, 2024; RGPH-5, 2022). 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) (Schwartz et al., 2021), 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 (Kalinda et al., 2020). Adam et al. (2022), in their scoping review, also identified that most mobile populations are youth seeking economic opportunities and safety (Adams et al., 2022). 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.

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 (Muchiri et al., 2023). 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 (Bowleg, 2012; Davis, 2008). These adolescents are economically vulnerable, which influences their mobility and their likelihood of missing 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 (Marou et al., 2024; Toothong et al., 2015). 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 (Kebu et al., 2023). 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 (Aya Pastrana et al., 2020; Engels & Zhou, 2020; Hudu et al., 2024). 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. (COR-NTD, 2021; Fitzpatrick, 2023; Materia et al., 2023). 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 (Xie et al., 2024). Integrating feedback methods as part of a stakeholder communication plan is also essential, as they help assess and adapt the strategy's effectiveness (Hardavella et al., 2017). 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 (Boehnke & Rutherford, 2021; Cifra et al., 2021). 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 been also 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 (Titaley et al., 2022). 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 (Brady et al., 2023; Kura et al., 2024). 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 (Krentel et al., 2016, 2021). 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 (Sangare et al., 2021). 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 (Masong et al., 2021; Odoi et al., 2024). 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 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.

1.25 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 lead 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 have led to sampling bias, under-representing these groups, thus limiting the generalizability of our results.

1.26 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.

List of 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.

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.
- ***Clinical trial number***

  Not applicable.
- ***Availability of data and materials***

  The anonymized data or key summary tables (not already included in the manuscript) used in the current study may be made available by the corresponding author upon reasonable request.
- ***Competing interests***

The authors declare that they have no competing interests.

- ***Funding***

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- ***Authors' 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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- ***Footnotes***

Not applicable

1.27 References

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Appendices

Appendix 1. Questionnaire

I.	**GPS coordinates**	
1	Longitude	
2	Latitude	
3	Altitude	
4	Precision (≤ 5 meters)	
II. Respondent identification		
1	ID of participant	
2	Date of interview (JJ/MM/AA)	
3	Name of the interviewer	
4	Heath district	
5	Sub-district	
6	Village/quartier	
7	Interview results	1=Complete 2= Incomplete

III.	**Knowledge of neglected tropical diseases (1=Schistosomiasis (Sougounè bleni/Sorri sorri/Grochien/Damadiala) 2=Onchocerciasis (Mara) 3=Géo-helminthes (Konona toumouni) 4= lymphatic filariasis (Sen ba), 5=Trachoma (Gnè diallan dimi) and MDA campaigns (djama je foura di)**		
Q01	Tell us, what is/are the most common health problems in your community?	1. …… 2. …… 3……...	
Q02-a	Today we're going to talk about neglected tropical diseases. Have	Yes……..1 No……..2	if no to Q02 ----->Q20

	you heard of onchocerciasis? (*Mara)*		
Q02-b	Have you heard of lymphatic filariasis? (*Sen ba*) ?	Yes……..1 No……..2	
Q02-c	Have you heard of schistosomiasis? (*Sougounè bleni*)	Yes……..1 No……..2	
Q02-d	Have you heard of trachoma? (*gnè diallan dimi*)	Yes……..1 No……..2	
Q03-a	If yes to any of these diseases, which MDA did you participate in?	Ivermectin /Albendazole Yes /--/ No /--/ Praziquantel Yes /--/ No /--/ Azithromycin Yes /--/ No /--/	
Q03-b	If yes to any of these diseases, then in relation to MDA, when did you last take part in an MDA ?	6 months ago ……..……..……...1 1 year ……..……..……..…….2 2 years…….……3 I don't remember ……..…..… …….4 I never participate in ……..…….5 Other ……...……6	
Q04-a	What was the most memorable event at the during the campaign?	…….. …….. ……..	
Q04-b	Who do you think was the most important person involved in this event?	Community health worker…….1 Health personnel……2 Family/friend/neighbor ……..3 Myself ……..……4 village chief ……...5 imam/priest ……...6	

		Other……...7	
Q05	How did you feel about the MDA campaign?	Sad……..……..…..1 Angry/ nervous ……..2 Happy…….3 Very happy ……4 Indifferent (showing no interest) ……...5 Other……..……..6	
Q06	Have you ever seen a schistosomiasis awareness campaign (radio, TV, health center, etc.)?	Never…….…….....1 Radio…….…….…….....2 TV…….……..…….3 Health center……..…..……..……4 Other…….…….....5	
Q07	In your opinion, what is the primary cause of schistosomiasis?	Worms.....1 Molluscs.....2 Mosquitoes.....3 Dirt.....4 Heredity.....5 Dirty water.....6 I don't know.....7 Other.....8	Do not read answers
Q08	What factors do you think contribute to exposure to schistosomiasis?	Mosquitoes.....….....1 Mud .....…..... ....2 In water .....3 I don't know.....4 Other.....5	Do not read answers
Q09	Can we prevent schistosomiasis?	Yes…….……..1 No……2 I don’t know…….....3	
Q11	If so, what is the basis for preventing schistosomiasis?	Water evacuation.....1 Taking praziquantel during MDA……...2 See the marabout/traditional healer.....3	Do not read answers

		Sleep under mosquito net.....4 I don't know.....5 Other.....6	
Q12-a	If someone has schistosomiasis, what signs/symptoms do you notice in that person?	Hematuria (blood in the urine) …..…….1 Dysuria (urinary burning) ……..…2 Blood in stools ……..…..…3 Abdominal pain ……..….4 Other to be specified …….……..5	Do not read answers
Q12-b	Has anyone in your family had signs of schistosomiasis?	Yes……..1 No…….……...2 I don't know.…….……..3	
Q13	If so, what was your attitude?	Take him to the health center.....1 Take him to the marabout/trained therapist……2 I didn't do anything.....3 Self-medication.....4 Heals itself.....5 I don't remember, I don't know.....6	
Q14	Have you heard about the mass treatment campaigns against schistosomiasis?	Yes……..1 No…….……..2	
Q15	If yes, have you ever received medication against schistosomiasis during mass campaigns?	Yes……1 No…….……2	
Q16	If you participated in an MDA campaign against schistosomiasis, why did you agree to take these drugs? Or why did you	Treating schistosomiasis.....1 Prevent schistosomiasis.....2 Making distributors happy.....3 Because everyone has taken.....4 I don't know..... 5	Do not read answers

	agree to have your child/family member take praziquantel?	Other (please specify) 6	
Q17	Has anyone in your family or close circle ever received schistosomiasis medication during mass treatment campaigns?	Yes……. ……..1 No……...……..2 I don't know.……. ……3	
Q18	Did you know that there has been a campaign to distribute anti-schistosomiasis drugs over the last 6 months?	Yes……. ……..1 No……...……...2 I don't know.……. ……3	
Q19	Are you willing to take praziquantel or give it to your child during future TDM?	Yes…….……..1 No……..……..2 I don't know.……..……..3	
IV.	**Mapping the movement of mobile and migrant populations**		
Q20	What is your original residence (health district and sub-district)?	Village …….……..1 Health area……..2 District…….....3	
Q21	What time of year do you move? Or does your fraction/tribe move? (only for transhumant and seasonal workers)	Rainy season (July - October).....1 Cool season (November - February).....2 Hot and dry season (March - May).....3 Beginning of wintering.....4 After harvest time.....5 Any time of year.....6	Do not read answers

Q22	Why are you (or your fraction/tribe) moving? In other words, what's motivating your move? direction?	Looking for work.....1 Going to pastures .....2 Taking refuge from insecurity.....3 Looking for wedding trousseau.....4 To change environment.....5 Other (please specify) 6	
Q23	Does your family move with you (or with your fraction/tribe)?	Yes……..1 No……..2	
Q24	Do you move every year?	Yes……..1 No……..2	
Q25	Do you always move to the same places?	Yes……..1 No……..2	
Q26	What do you do (work occupation) during your move?	Small business.....1 Laborer.....2 Bringing animals to pasture.....3 Unemployed.....4 I don't know.....5 Other (please specify) 6	Do not read answers
Q27	What do you do for your day-to-day health needs during your move?	Go to health center.....1 See traditional healer/marabout.....2 Buy street medicines.....3 Other (please specify) 4	
V.	**Sociodemographic characteristics of participants**		
Q28	Can you please tell me how old you are?	…… ……	(year completed)

Q29	Sex	Male……1 Female……..2	Do not read answers
Q30	What is your current residence	Village .....1 Health area ….....2 District.....3	
Q31	How long have you lived here?	Less than 6 months.....1 Between 7-12 months.....2 Between 1-2 years.....3 Over 2 years.....4	
Q32-a	Do you live here all year round?	Yes……..1 No……..2	If yes ---->Q33
Q32-b	If not, how would you classify your movement?	Rainy season (July - October).....1 Cool season (November - February).....2 Hot and dry season (March - May). .....3 Beginning of wintering.....4 After harvest time.....5 Any time of year.....6	Do not read answers
Q33	Level of education	Out of school.....1 Primary.....2 Secondary.....3 Higher.....4 Medersa/ Koranic school 5	
Q34	What is your main occupation?	Farmer ..... ……..1 Livestock herder..... …….....2 Laborer .... .3 Housewife..... ...4 Merchant..... .5 Civil servant..... 6 Artisan..... .7	

		Other (please specify)……..……..…….8	
Q35	What is your occupation during the trip?	Farmer ..... ……..1 Livestock herder..... …….....2 Laborer .... .3 Housewife..... ...4 Merchant..... .5 Civil servant..... 6 Artisan..... .7 Other (please specify)…..……..……..8	
Q36	What is your marital status?	Married ....1 Single ....2 Divorced ....3 Widowed 4	
Q37	What is your average monthly household income? (SMIG=40000F CFA)	Less than SMIG..... 1 The same or more than the minimum wage.....2 I don't know .....……...3	
VI.	**Participation in MDA campaigns (experience with MDA)**		
Q38	Have you or anyone in your family ever taken part in mass treatment campaigns against schistosomiasis?	Yes……..1 No…….……..2	If yes, refer to Q02) If no Q44
Q39	How did you (or your child) feel when you took praziquantel?	No feeling..... ....1 nausea..... ....2 headaches..... ....3 Fevers..... ....4 Dizziness..... ….....5 Stomachache 6	

		Other to specify..... 5	
Q40	Do you know anyone who has reported side effects from mass treatment?	Yes……..1 No…….……..2	
Q41	Who was the distributor of the drugs (praziquantel)?	Community health worker/relay.....1 A family member..... .....2 CSCOM staff..... .....3 I don't know..... .....4 Other to be specified.....5 CSCOM= Community Health Center	
Q42	Did anyone influence you (or your child) to take this schistosomiasis medication?	Yes..... .....1 No..... .....2 I don't remember..... 3	
Q43	In your community, who has the most influence in encouraging people to take the drugs (praziquantel) for schistosomiasis?	Village Chief.....1 Health center staff..... .....2 The community health worker.....3 Husband/wife/family member/friends…....4 Myself.....5 The mayor/commander.....6 Other.....7	Read the answers
Q44	In relation to question Q38, why didn't you receive the schistosomiasis drugs (praziquantel)? Or Why didn't you allow your child to swallow	I didn't get the information.....1 I was out of town..... .....2 I was afraid of side effects.....3 I don't trust the drug..... .....4 Rumors .....5 I don't know why I must take this medication…….6 I don't believe in the government's and its partners' free medicines.....7	Do not read answers

	praziquantel to prevent schistosomiasis?	It doesn't concern me at all.....8 I didn't like the attitude of the distributors....9 Other (please specify) 10	
VII.	**Population access to MDA for schistosomiasis**		
Q45	In relation to the last MDA for schistosomiasis you or your child attended, where did you or your child receive the tablets?	At home ....1 At school ..... ….....2 In the village square..... .....3 At the health center.....4 At the neighborhood market.....5 I don't remember.....6	
Q46	Do you know the people who gave the medication to you or your child?	I know him very well (neighbor, friend, family member) .....1 It's someone I know.....2 It's someone I knew before..... .....3 I've never seen this people before,.....4 I don't know them.....5	
Q47	Can you describe your level of trust in the people who give you this medication?	I trust him a lot.....1 Neutral (no idea) …….....2 I don't trust him a lot.....3 I don't remember the situation.....4 I was scared.....5	Read the answers
Q48	Can you take Praziquantel or give it to your child whenever you want?	Yes.....1 No.....2 I don't know.....3	
Q49	How accessible do you consider these campaigns to be for your communities?	Very accessible..... .....1 Accessible.....2 Moderately accessible.....3 Not accessible.....5 Don't know.....6	Read the answers

Q50	What could be the reasons why some people don't have access to schistosomiasis medication?	Long distance to distribution site.....1 Difficult-to-reach village, ...2 Side effects, ...3 Drug shortages, ...4 Absence on the day of distribution,.....5 Lack of information about the campaign….....6 Not seeing the distributors.....7 Other 8	Do not read the answers
Q51	In your opinion, is the distribution time sufficient?	More than sufficient……..1 Sufficient ……..…..2 Somewhat sufficient……..……3 Very insufficient…….……4 Not at all sufficient …….……5 Don't know ……..6	Read the answers
Q52	How do members of your community receive information (news, health, community)?	TV…….....1 Radio .....2 Telephone .....3 Internet .....4 Interpersonal, place of worship (Mosque & Church) .....5 Other to specify.....6	
VIII.	**Factors that affect or improve the coverage of mass treatments for schistosomiasis among nomadic and migrant populations**		
Q53	What do you think of the importance to your health of the medicines distributed during mass treatment campaigns against schistosomiasis (or other NTDs)?	Very important for my health..... .....1 Important for my health..... .....2 Neutral..... .....3 Not important for my health..... .....4 Not at all important for my health..... 5	Read the answers

Q54a	What do you think of the safety of these drugs?	Very safe……..…….1 Safe …….....2 Neutral…….....……..3 Too many side effects …….....4 Dangerous……...….5 Very dangerous…….6	Read the answers
Q54b	What do you think about free medicines?	It's a good thing.....1 I don't think it's good medicine..... .....2 We don't trust them too much..... .....3 Other.....4	
Q55	Who do you trust for health information?	Family / friend / neighbor.....1 Community health worker..... .....2 Nurse / midwife..... ....3 Doctor..... .....4 Town crier.....5 Community leader..... .....6 Imam / priest / religious leader.....7 Others 8	
Q55-a	Do you think that your current situation (migrant/transhumant) means that you do not benefit fully from TDM campaigns?	Yes…….……..1 No…….……...2	
Q55-b	Do you think that your current situation (migrant/transhumant) means that your child does not benefit fully from MDA campaigns?	Yes……1 No…….....2	

Q56	How does your current living situation affect your ability to participate in the schistosomiasis MDA?	Distribution takes place in my absence.....1 The campaign takes place only once a year..2 We are not considered here.....3 I have never seen the distributors here.....4 We have no information on campaign..... 5 I'm not concerned.....6 Other 7	Do not read the answers
Q57	How does your current living situation affect your child's ability to participate in schistosomiasis MDA?	Distribution takes place in my absence.....1 The campaign takes place only once a year.....2 We are not considered here.....3 I've never seen the distributors here .....4 We have no information about the campaign.....….....5 I'm not concerned.....6 Other 7	Do not read the answers
Q58	What do you suggest for effective participation in MDA campaigns against schistosomiasis or other NTD-CP in your village or community?	Awareness.....1 Change of distribution strategy.....2 Changing distributors (I don't want relays) ....3 Change season.....4 Other (please specify) 5	Do not read the answers
Q59	What are your suggestions for improving access to mass treatment?	……. ……. ……	

Appendix 2. Certificate of ethics approval for study 1

UNIVERSITE DES SCIENCES,
DES TECHNIQUES ET DES TECHNOLOGIES DE BAMAKO

FACULTE DE MEDECINE ET D'ODONTO-STOMATOLOGIE
FACULTE DE PHARMACIE/ BP 1805, *BAMAKO – MALI*

☎ : (223) 20 22 52 77 — 🖷 : (223) 20 22 96 58

N°2019/ 173 /CE/FMOS/FAPH

Le Président du Comité
D'Ethique de la FMOS/FAPH

Bamako, le 19 décembre 2019

/-)u **Docteur Moussa SANGARE**

Cher Docteur,

J'ai le plaisir de vous informer que le Comité d'Ethique des Facultés de Médecine/d'Odontostomatologie et de Pharmacie (FMOS/FAPH) approuve définitivement votre projet de recherche intitulé **«Intégration de l'analyse spatiale dans l'approche des méthodes mixtes pour améliorer l'accès aux MDA en touchant les populations mal desservies et vulnérables dans le cadre de l'élimination des Maladies Tropicales Négligées au Mali»** ayant constaté l'effectivité de la prise en compte des différentes recommandations faites et vous souhaite plein succès dans vos recherches.

Cette approbation est valable du **19 décembre 2019 au 18 décembre 2020**. Elle sera renouvelée après le dépôt du rapport annuel.

LE PRESIDENT

UNIVERSITE DES SCIENCES,
DES TECHNIQUES ET DES TECHNOLOGIES DE BAMAKO

FACULTE DE MEDECINE ET D'ODONTO-STOMATOLOGIE
FACULTE DE PHARMACIE/ BP 1805, *BAMAKO – MALI*

☎ : (223) 20 22 52 77 **🖷 : (223) 20 22 96 58**

N°2020/ 278 /CE/FMOS/FAPH

Bamako, le 07 décembre 2020

Le Président du Comité
D'Ethique de la FMOS/FAPH

Docteur Moussa SANGARE

Cher Docteur,

Le Comité d'Ethique de la FMPOS accuse réception de votre courrier du 30 novembre 2020 informant le comité d'éthique de l'évolution de l'étude intitulée **«Intégration de l'analyse spatiale dans l'approche des méthodes mixtes pour améliorer l'accès aux MDA en touchant les populations mal desservies et vulnérables dans le cadre de l'élimination des Maladies Tropicales Négligées au Mali» version 1. 0 décembre 2019.**

Après analyse, le comité d'éthique approuve le rapport annuel d'activité et par conséquent vous donne son accord pour continuer cette étude.

Cette autorisation prend effet à compter du 07 décembre 2020 et reste valable jusqu'au 06 décembre 2021.

Le Comité d'Ethique de la FMOS/FAPH, vous souhaite bonne continuation et plein succès dans vos recherches.

P/LE PRESIDENT P.O
LE VICE- PRESIDENT

CHAPTER 4: ARTICLE 2. Understanding the barriers and facilitators related to never treatment during mass drug administration among mobile and migrant populations in Mali, a qualitative exploratory study

Overview

Chapter 4 presents the second article of this dissertation, which explores the factors influencing persistent non-treatment during mass drug administration among mobile and migrant populations in Mali. Published in BMJ Global Health, this qualitative exploratory study examines both the structural and individual determinants that shape access to and uptake of preventive chemotherapy. Building on the insights generated in the previous chapter, the findings presented here contribute to a deeper understanding of why certain groups remain unreached and highlight opportunities to strengthen MDA strategies in highly mobile settings.

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4.1. Abstract

Introduction

Five of the neglected tropical diseases use a strategy of preventative chemotherapy distributed via mass drug administration (MDA) for all eligible people living in endemic areas. To be successful, high coverage must be sustained over multiple rounds. Therefore, it will be difficult to reach elimination as a public health problem using MDA if there remain clusters of people who have never been treated. The study aims to explore the reasons why people with high mobility report being never treated during MDA and to provide evidence to support the development of standardized questions for data collection using qualitative research tools.

Methods

We conducted an exploratory study using qualitative methods among displaced people, nomads/transhumants, and economic migrants who self-reported that they had never been treated during MDA in the health districts of Tominian and Kalabancoro in Mali. Data were collected through in-depth individual interviews and focus group discussions. Nvivo 14 software was used for data management and analysis.

Results

The main reasons reported for never treatment included: geographical mobility, lack of awareness/information, negative rumors, fear of side effects, conflict and insecurity, and logistical difficulties faced in reaching these populations. Proposed solutions included involving communities in the MDA, increasing awareness and information campaigns, effectively managing side effects, and designing and implementing flexible and effective interventions.

Conclusion

This study highlights that there are people with high mobility who may never have been treated during any round of MDA. The reasons for never treatment highlight the challenges faced when reaching particular groups during MDA activities/interventions. Suggested remedies will require programmes to implement more flexible and tailored interventions. Customized approaches based on the context are essential to guarantee fair access to preventive chemotherapy. Effective interventions must consider the supply and demand side in crafting interventions. This research adds to the evidence base to understand never treatment, particularly among highly mobile population groups and in schistosomiasis elimination programmes.

Key words: mass drug administration, displaced people, hard-to-reach, never treated, Mali

Key messages

WHAT IS ALREADY KNOWN ON THIS TOPIC ?

One of the largest global public health interventions is the mass drug administration of preventive chemotherapy for the control and elimination of neglected tropical diseases (NTDs), carried out in endemic countries across the globe. Even though this strategy has shown itself to be successful, as programmes reach the endgame towards elimination of certain NTDs, it has become evident that elimination may not be achieved if certain populations remain never treated.

WHAT DOES THIS STUDY ADD ?

This is one of the first papers that describes the reasons why mobile populations may remain untreated during MDA for NTD control and elimination. Analyzed using Levesque's framework for access to healthcare, the reasons leading to never treatment highlight entry points to reach particular groups during MDA interventions.

HOW MIGHT THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY ?

The study highlights the impact of significant geographic mobility of certain populations in Mali on the success of MDA efforts. This research provides insight towards the creation of a standardized and successful programmatic response. A universal strategy may not be adequate, and customized approaches are needed to address the contextual differences of highly mobile populations. The use of Levesque's framework provides guidance to assess the supply and demand sides of MDA in order to improve access for mobile populations.

4.2. Introduction

In sub-Saharan Africa, neglected tropical diseases (NTDs) are common, contributing to approximately 40% of the global burden of NTDs, with about 600 million individuals still requiring preventive chemotherapy (PC) treatment [1]. An essential part of the strategy for some NTDs uses preventive chemotherapy administered through mass drug administration (MDA) without individual diagnosis. MDA is a safe and affordable public health intervention, in part due to the provision of donated medicines [2]. The World Health Organisation (WHO) recommends PC for five NTDs (PC-NTDs): trachoma, lymphatic filariasis (LF), onchocerciasis, schistosomiasis, and soil-transmitted helminthiases (STH) [3].

The global fight against NTDs has achieved substantial success, reducing morbidity and mortality, and improving health and well-being for millions of people [4]. As of 2024, 19 countries in the WHO African region have eliminated at least one NTD [5]. Trachoma has been eliminated in the Gambia, Ghana, Malawi, Togo, Benin, and Mali, while LF has been eliminated in Togo and Malawi [6]. To date, Togo has eliminated four NTDs: Guinea worm (2011), lymphatic filariasis (2017), human African trypanosomiasis (2020), and trachoma (2022) [7]. Mali has had a historically high prevalence of NTDs, yet the national programme has made significant progress using MDA interventions, eliminating trachoma in 2023 and submitting a dossier for LF elimination certification in 2026 [8,9]. MDA for LF and STH ceased in 2019, and Mali is on track to eliminate onchocerciasis, however schistosomiasis remains a challenge, with all districts considered as endemic [10,11].

As many countries move towards the endgame of a particular NTD, new strategies are needed to meet the targets outlined in the WHO 2030 NTD Roadmap [12]. Increasingly, the importance of never treatment has been raised as a potential risk to elimination goals for PC-NTDs [13]. Never treatment is defined as a self-reported statement of never taking the preventive chemotherapy offered during any round of MDA [14–17]. This group of people are termed as ‘never treated’ and are estimated to be more than 25% of the eligible population in some locations[18]. Untreated individuals risk being reservoirs for parasites, leading to disease re-emergence [19]. Research has suggested that never treated individuals may be at greater risk for infection with LF [20–22]. Recent modeling suggests that increased proportions of never treatment can result in increased MDA rounds and delay elimination for LF [23]. Similar modeling for STH and schistosomiasis MDA programmes suggests that never treatment impacts

the potential for elimination of both parasites [18,24,25]. As part of the challenges facing the NTD community, never treatment has become a critical aspect that must be addressed if elimination goals are to be reached.

Despite Mali's notable progress in MDA campaigns against PC-NTDs, there is a concern that clusters of never treated people could risk the programmatic gains made in the last decade particularly given the recent geopolitical shifts and history of population mobility within the country. From 2008 – 2022, Mali has seen 380,000 internally displaced people (IDPs), representing an important increase in total IDPs within the country [26]. Nomads and transhumants move seasonally to find food and water for animals, however due to an increasingly volatile security situation in some parts of the country and the impacts of climate change, their internal migration has also increased. In the context of this study we have defined nomads or nomadic populations as groups of people who temporarily or permanently move their residence and work activities from one place to another. Nomads encompass 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 further categorized as a) transhumants (nomadic groups regularly migrating between two grazing areas along established routes), b) pastoralists migrating along traditional routes but also exploring different areas annually, and c) semi-pastoralists exhibiting semi-sedentary living and movement patterns [27].

Mobile populations, including IDPs, nomadic/transhumant herders, refugees, and migrants, often have limited access to public health interventions due to their mobility [28,29]. Studies have shown that MDA and routine healthcare delivery among mobile populations are difficult to achieve and result in missed treatments [30,31]. It is therefore expected that some people will miss annual MDA treatment and some will never be treated during any MDA round. Never treatment is particulary important for Mali PC-NTD programmes because Mali has stopped MDA for trachoma, STH and LF with the Stop MDA surveys in progress for onchocerciasis. There are concerns that the intersection of highly mobile populations and never treatment could be a risk for re-emergence of some NTDs in Mali. The reasons for missed treatment vary over time but may include ignorance, fear of side effects, cultural beliefs, lack of risk perception, absence, ineligibility such as pregnancy, CDD profile or attitude [32–35].

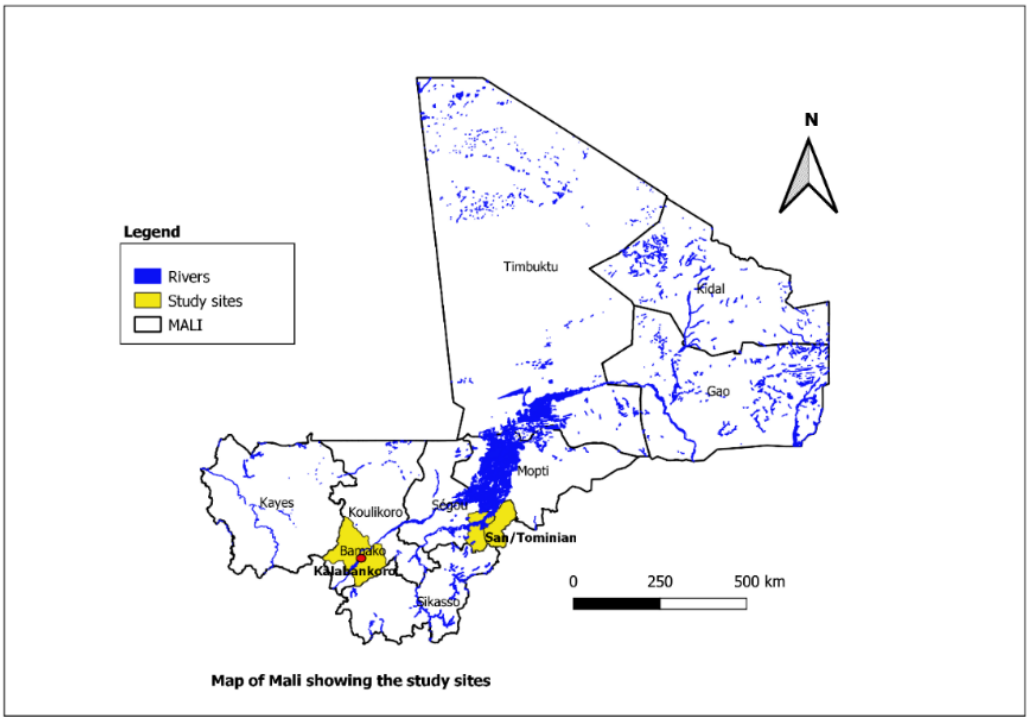
To address never treatment, special attention for mobile populations is needed. Numerous studies indicate that population movement plays an important role in the spread and control/elimination of NTDs [36–38]. In the context of NTD elimination, understanding why some members of mobile populations are never treated and identifying ways to reach them will be useful in achieving sustainable elimination goals in Mali. This study aims to understand the barriers and facilitators related to never treatment during MDA for one of the PC-NTDs, schistosomiasis, among mobile and migrant populations in Mali; to explore how programmes may broaden their reach. Finally, we aim to make recommendations for an operational response to never treatment issues based on the study outcomes.

4.3. Methods

Study setting

The study was carried out in the health districts of Tominian and Kalabancoro. These two districts were selected in collaboration with the national NTD programme according to the following criteria: presence of diverse highly mobile population groups, MDA for schistosomiasis has been completed recently and an acceptable security situation that allows the research team to travel.

Tominian's health district is a rural area in the Segou region, 465 kilometers from the capital city of Bamako. This district is known to have significant transhumance movements, internally displaced persons (IDPs), nomads, and economic migrants between the Bourgou (a geographical area within the Health District of Koro), the Djenné health district in Mopti region at the center of the country, and the bordering districts with Burkina Faso. The main economic activities of people living in the district include farming, cattle breeding, and trading. Most people in this region originate from northern and central Mali, and because of insecurity there, many have brought their grazing animals to this region where there is more security and grass. Kalabancoro district is an suburban environment, where the population is characterized by economic migrants and informal gold and sand miners, and IDPs from the northern part of the Mali. With a population of 166,722 inhabitants, the city, which is the third most populous in the country, is situated on the southern bank of the Niger River. The commune has been included into Bamako’s suburbs, which is the capital of Mali. (Figure 13. Map of Mali with study site).



(Source: NTDs Research Unit, ICER-Mali, 2024)

Figure 13. Map of Mali showing the main study health districts

MDA history and coverage for both districts.

MDA interventions started in Mali with schistosomiasis control in 1979, which became a national programme in 1982 (including STH). In 1986, ivermectin was introduced for onchocerciasis in endemic districts; followed by MDA for trachoma (1998) and for LF (2004). In 2007, MDA activities were integrated for all five NTDs as a pilot implementation in three regions (Kayes, Koulikoro and Sikasso) which included 24 districts. Over the years, the programme expanded gradually, achieving nationwide coverage for the 5 PC-NTDs by 2009. Coverage rates range from 76% to 100%, and have remained consistently high since 2009 [39]. In some health subdistricts, the number of people treated was even higher than expected, due to unforeseen population movements and the fact that the census is not regularly updated before each treatment. Currently, in both study districts, only praziquantel distribution for schistosomiasis is ongoing. Since 2022, MDA for schistosomiasis has been carried out by sub-district, with distribution taking place both in the community and at schools.

In Tominian, the last MDA in 2023 distributed praziquantel. Originally the programme targeted 89,230 children for treatment, and managed to treat, 97,608, approximately 9% more. This excess is likely due to the inclusion of IDP populations and migration from other areas. In Kalabancoro, praziquantel was distributed for schistosomiasis in 2023. They achieved 97.46% therapeutic coverage, treating 56,886 out of a planned 58,367 children according to the National Schistosomiasis Control Programme. This study followed the last round of MDA for schistosomiasis in both areas.

Study design and data collection

This study employed an exploratory design using qualitative research methods, specifically in-depth interviews (IDIs) and focus group discussions (FGDs). A purposive sampling frame was used to identify participants amongst the different mobile groups [40]. Participants were recruited across mobility, gender, and age ranges (18 years and above). Initially, health records and MDA data identified areas with low treatment coverage. To identify never treated individuals to participate in the IDIs, we met with community leaders and community drug distributors (CDD) to explain the study and the concept of "never treatment." Collaborations with local community leaders, and health workers facilitated access to potential informants. Direct outreach and community meetings were employed to explain the study's goals and ensure confidentiality. They directed us to individuals uninterested in MDA and newcomers like IDPs and nomads. The team informally approached potential participants and gauged their interest in participating. In compliance with the principles of research ethics, we decided not to include those who did not volunteer to take part in our study. At this level, we had planned 24 IDIs with community members (never treated), i.e. 12 per district. IDIs were also planned with key informants including healthcare professionals including CDD living in both districts. The planned sampling frame for these IDIs included 4 CDDs and 4 healthcare professionals.

A total of 8 FGD were planned with community members who identified as never treated and who lived in the study districts. IDI participants were identified according to population subgroups of interest and invited to participate in the IDIs on the basis of their characteristics of interest, their level of involvement in the MDA process and their availability and willingness to participate in this research. For these FGDs, males and females were split into different groups. Every FGD had a target of between six and eight participants and was led by a note-taker and an

interviewer using a structured topic guide. IDIs and FGD were audio-recorded and had an average duration of thirty to forty-five minutes. The topic guide ensured that the intended field of inquiry was covered and facilitated the comparison of information gathered from respondents. The development of the topic guide was guided by known themes related to never treatment and healthcare access, and incorporated data collection sheets and seasonal calendars. The guide was iteratively refined throughout the IDIs and FGDs to better address emerging themes and insights. Specific questions were designed to extract details regarding the unique attributes of every MDA, such as target demographics, and implementation methods. We also showed medicines and empty medicine boxes to participants as a memory aid. The FGDs incorporated seasonal calendars, which are a participatory tool that seeks to understand the broader community experiences regarding their movement and activities throughout different seasons [41]. A template was designed which allowed participants to outline their different activities throughout the year (seasons, movements, harvest, among others). All data collection materials (FGDs and IDIs guides, and seasonal calendar) were tested in Bamako prior to fieldwork.

All FGDs and IDIs were conducted in either Bambara or French at the preferred time and location of the participant(s). Interviews were conducted until data saturation was reached. Individuals conducting the IDIs and FGDs had prior experience and received additional training prior to the study's commencement to ensure a thorough understanding of the research objectives and methodologies.

Data management and analysis

Recorded IDIs and FGDs were transcribed and translated into French. To ensure an accurate translation, the investigators exchanged their files and listened again, comparing what was written and what was said in the audio file. If necessary, a third person was called in to reconcile any discrepancies. We did not returned Transcripts to participants for review or correction to preserve the integrity of the original data as collected.

Analysis was conducted using thematic analysis [42], which is a systematic approach that allowed the research team to identify and interpret recurring themes and patterns in the data. The analysis team co-coded a selected number of transcripts to develop a pre-established codebook. Once agreed upon by the coders, this pre-codebook was used to initiate coding using Nvivo 14. This process was iterative and inductive, i.e. each time a member of the coding team found a new

theme, he or she communicated with the others to take it into account. At the end of coding, the Nvivo 14 files were combined to perform the final analysis. The transcripts were analyzed using a process of open and axial coding [43]. Initial open coding involved breaking down the data into smaller segments, and these segments were assigned codes that captured the essence of the content. Axial coding followed to establish connections between codes and to develop broader categories.

Nvivo 14 software facilitated coding and data management. Coding and analysis were iterative, with constant comparison and refinement of categories. Two team members collaborated to analyze data, ensuring coding process reliability and validity. Through co-coding, team members individually analyzed qualitative data using the codebook with established or emergent codes. Subsequently, they compared their findings, resolving any discrepancies to reach consensus. Seasonal calendar data underwent a thorough examination to identify patterns and trends in participant experiences and activities throughout the year. To analyze seasonal calendar data, we used various methods [44]. These included organizing data on weather, illness, labor activities, food scarcity, education, human mobility and other NTD programme activities. Additionally, calendars drawn up by different population groups were compared to explore differences in responsibilities and perceptions. The seasonal calendars help to understand how seasonal changes affect population mobility, NTD programme activities, and other community indicators.

Community engagement strategies conducted prior to implementation

Before beginning the fieldwork, the research team identified relevant stakeholders including partnering NGOs in NTDs, local community leaders, and NTD control/elimination programme managers. We presented the protocol to the NTD programme managers and asked for their agreement to use the study data. Prior to travelling to the study sites, we contacted the physicians, healthcare providers and administrators of relevant community health centers. The research team also met with village leaders and CDDs at the community level to introduce the study and gain permission to carry out the activities. We also had meetings to discuss the study's objectives with community leaders at the gold-panning sites. This process was carried out over the course of the study. To carry out the IDI and FGD, we put in place a very good team of interviewers, made up of male and female public health doctors with extensive experience in the

social sciences. The team was supervised by senior researchers from the University of Science, Technology and Technologies of Bamako in Mali, the University of Ottawa in Canada and the National Institutes of Health in the United States. While conducting this work, we acknowledged the significance of reflexivity, recognizing our position as the researchers and any potential biases that might affect the results of the study (see the reflexivity statement in Supplementary file 1).

4.4. Ethical approval and considerations

We received ethical clearance from the University of Sciences, Techniques, and Technologies of Bamako's Ethical Review Committee (Approval No.2023/11/CE/USTTB), Mali, and from the Health Sciences and Sciences Research Ethics Board of the University of Ottawa (Approval No.H-02-23-8759). Furthermore, we received approval from the relevant administrative bodies for the study districts and villages. Study participation was voluntary, and we ensured informed consent by thoroughly explaining all procedures to participants. We obtained written consent from all participants prior to beginning IDIs or FGDs.

Patient and public involvement statement

The research's design, methodology, reporting, and dissemination plans did not involve input from participants or the general public. However, we would like to thank all the participants for their willingness and cooperation in taking part in this study. We would also like to thank all the administrative and local leaders for their support and consent to conduct this study.

4.5. Results

A total of 31 IDIs and 10 FGDs (with 4-5 individuals in each FGD) were included in the final analysis. In Kalabancoro health district, the 6 FGDs were conducted with 3 groups of women and 3 groups of men, the 12 IDIs with CM were conducted with 6 women and 6 men, the 5 IDIs with health professionals (HP) were conducted with 1 woman and 4 men. In Tominian health district, the 4 FGDs were conducted with 2 groups of women and 2 groups of men, the 12 IDIs of CM were conducted with 6 women and 6 men and the 2 IDIs with HP were conducted with men.

Participants' characteristics

The demographic characteristics of the participants in this study are presented in Table 8.

Table 8. Characteristics of the overall study population

Type of Data collection	Health district	Health sub-district	Gender		Total
			Female	Male	
FGD	Kalaban-coro	Baguinéda	5	6	11
		Tourela	8	10	18
	Tominian	Fangasso	0	4	4
		San	10	5	15
IDI	Kalaban-coro	Dialakorobougou	0	2	2
		Kalabancoro central	3	3	6
		Kassela	0	2	2
		Tourela	4	3	7
	Tominian	Fangasso	0	1	1
		Monikoro	0	1	1
		Monisso	1	1	2
		San	5	5	10
Average age of participants by health district					
	Health district	**Minimum**	**Maximum**	**Median**	**Q1 - Q3**
FGD	Kalaban-coro	24	53	40	28 - 46
	Tominian	24	44	34	27 - 41

IDI	Kalaban-coro	19	57	33	27.5 - 45
	Tominian	17	76	34.5	25.5 – 49.25

Study sites	**FGD**	**IDI (CM)**	**IDI (HP)**	**Seasonal calendar**	**Total**
Kalaban-coro					
Female	3	6	1	2	12
Male	3	6	4	2	15
Tominian					
Female	2	6	2	2	12
Male	2	6	0	3	11

In-depth Interview (IDI); Focus Group Discussion (FGD) ; Community Member (CM) ; Health Professional (HP)

Overall, there were more male than female participants for both FGD and IDI. Results are reported according to the Levesque framework [45] which outlines the supply and demand sides for health care access. Levesque and colleagues conceptualized access to health care in five keys dimensions: 1) Approachability; 2) Acceptability; 3) Availability and Accommodation; 4) Affordability; and 5) Appropriateness. Additionally, the Levesque model highlights five corresponding abilities of the patients or population: 1) Ability to perceive; 2) Ability to seek; 3) Ability to reach; 4) Ability to pay; and 5) Ability to engage [45] (Figure 14).

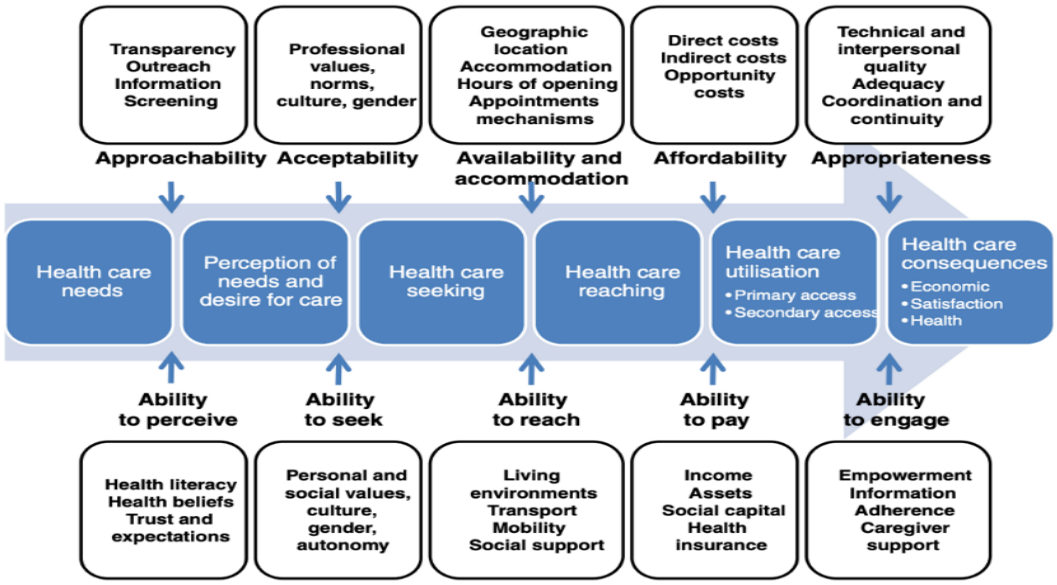


Figure 14. Levesque's conceptual framework of access to health care (Levesque et al., 2013)

The research findings are mapped along the parameters of this framework to identify barriers and facilitators relating to never treatment during mass drug administration among mobile and migrant populations in Mali (Table 9).

Table 9. Barriers and facilitators of access to MDA identified by participants in IDIs and FGDs using Levesque et al.'s framework

Supply -side dimension of accessibility	**Themes and their respective barriers (B) and facilitators (F)**	**Corresponding demand-side dimension of ability to access**	**Themes and their respective barriers (B) and facilitators (F)**
Approachability	▪ Lack of communication channels and low education levels in rural	*Ability to perceive*	▪ Beliefs, cultural barriers, and misconceptions (B)

	and mobile populations (B) ▪ Educational campaigns (F)		▪ Lack of communication channels and low education levels in rural and mobile populations (B)
Acceptability	▪ Lack of appropriate training and knowledge of CDD (B) ▪ Community health workers' role (F)	*Ability to seek*	▪ Lack of appropriate training and knowledge of CDD (B) ▪ Discrimination and stigmatization (B)
Availability and accommodation	▪ Geographic mobility (B) ▪ Seasonal observations on population shifts (B) ▪ Role of security in the movement (B) ▪ Accessible and flexible services (F)	*Ability to reach*	▪ Geographic mobility (B) ▪ Seasonal observations on population shifts (B) ▪ Role of security in the movement (B)
Affordability	▪ Economic constraints (B)	*Ability to pay*	▪ Economic constraints (B)

Appropriateness	▪ Culturally tailored interventions (F)	*Ability to engage*	▪ Culturally tailored interventions (F)

Furthermore, to ensure a comprehensive reporting on qualitative research methods in the study, the manuscript benefited from the use of the Consolidated criteria for reporting qualitative research (COREQ): a 32-item checklist for interviews and focus groups [46]. A checklist of items has been included for this paper (Supplementary file 2).

1) Approachability and the ability to perceive

Approachability and the ability to perceive healthcare services are crucial supply-side components of the Levesque framework. These elements emphasize the importance of clear communication and the dissemination of information to ensure that individuals are aware of available health services and its benefits. While implementing MDA campaigns in areas where there are high numbers of mobile populations, it is essential to efficiently disseminate information about the dates, times, locations, and benefits related to MDA so as to overcome barriers such as misconceptions and language barriers. The study highlighted important barriers and facilitators with respect to approachability and the ability to perceive dimensions such as educational campaigns, lack of communication channels and low education levels in rural and mobile populations, beliefs, cultural barriers, and misconceptions.

Educational campaigns

Educational campaigns designed to dispel myths, clarify misconceptions, and inform migrants about the benefits of MDA can have a positive impact on improving coverage. Results from this research demonstrated that visual aids, such as posters and videos, were particularly helpful in conveying information despite language barriers. In one IDI, one adult male sand miner in Kalabancoro said:

"*When distributing medicines, advance notice about MDA dates and locations, along with their benefits, should be provided through radio or television. Without information, encountering CDD without advance information becomes difficult to accept.* (II_HA_NT_ES_KAL).

Lack of communication channels and low education levels in rural and mobile populations

The study revealed a poor standard of living and low level of education for people living in endemic rural areas including the mobile populations. These factors are overlooked in planning MDA for Mali's rural and mobile populations. As a result, there may not be sufficient communication avenues to reach these individuals. During a focus group discussion, a man stated: "*I also think there is a lack of communication. Most people here rarely listen to radios, so we need town criers to carry the message"* (FGD_FJ_NT_ES_KAL). "*So, if that is the way it is going to be, we need to make sure we share information with all these internally displaced people to raise their awareness. These internally displaced people often do not receive enough information about the campaigns*." (II_AS_HJ_KAS_KAL).

Beliefs, cultural barriers, and misconceptions

Cultural conceptions can affect how people see medical treatments such as MDA. Some cultures have traditional beliefs that oppose taking biomedical or Western medication, or they may harbor misgivings about modern medicine. Without sufficient communication and outreach, community members may not perceive the benefit of MDA to address the health needs in their household, or their community and preferences for traditional medicines may persist. One young male community member stated:
"I don't like tablets and haven't taken one since childhood. I prefer traditional concoctions to tablets and needles. The last time I was treated with tablets and injections was a very long time ago. *I just don't like it*." (II_HJ_NT_SIA_TOM)

Another female participant said: *"Imagine when you go to the hospital even lacking ten (10) CFA francs they deprive you of your medicine. So, in this context, if someone comes to give you these medicines for free you can be afraid and create rumors about these medicines. Some people say that these drugs even make you sterile." (II_FJ_NT_MED_TOM).*

Participants from mobile populations interviewed for this research expressed their preference for traditional healers and cultural practices over modern medical treatment due to

deeply ingrained beliefs. Lower costs and the perceived ability to treat various diseases further drive their reliance on traditional medicine.

A young male from Tominian said, *"Even when I left Abidjan to come here, I didn't accept to be vaccinated, because I don't tolerate this kind of treatment. When I go to the hospital for a consultation, I do not tolerate the smell of medicine circulating there, so if the consultation is going to take a long time, I give up. I prefer traditional medicine." (II_HJ_NT_SIA_TOM).*

2) Acceptability and the ability to seek health care

Acceptability and the ability to seek health care are the second dimension of access to health care in the Levesque framework, referring to cultural and social factiors that impact health services such as MDA. The Levesque framework emphasizes the importance of acceptability and the ability to seek health care in ensuring effective health interventions, such as MDA. Stigma and discrimination, the lack of training and knowledge of CDDs, and the role of the community health worker were identified as key factors with respect to these dimensions.

Lack of approprate training and knowledge of community drug distributors (CDDs)

Research participants expressed their reluctance to participate in MDA. If the CDD is not able to convincingly explain the rationale for taking the treatment, then individuals may not see value in MDA participation and may refuse the tablets. One of the community members said: *"Well, we don't really understand what they're doing, they just say take it, it's good for you, but we're not sick so I prefer to hold back"* (II_HJ_NT_SIA_KAL). An adult man said, "*Normally when drugs are dispensed, information should be given in advance about when and where they are dispensed, as well as their usefulness. Distributors need to make more effort to tell us about the drugs. If this isn't done and you come across the distributors without having received enough information beforehand, it's hard to accept in this case. But if you inform them in advance, they will share the information and they will be more than happy to participate and take the drug.*" (II_HA_NT_ES_KAL)

Discrimination and stigmatization

Mobile populations, particularly migrants and internally displaced individuals can face discrimination and stigmatization from the local population and/or healthcare providers. This can

discourage them from seeking medical attention due to fears of mistreatment or negative social interactions, illustrated by a participant in a FGD: "*Sometimes, the distributors do not consider us unless they are done with serving all the local people in the village. Also, some people put themselves aside, they do not want to participate in such activities because they think they are foreigners here and that they are not concerned.*" (II_AS_HJ_FAN_TOM).

Community health workers' role

Community health workers emerged as key facilitators of MDA acceptance. Participants highlighted the importance of trusted individuals within their communities who could explain the benefits of MDA, address concerns, and provide information in local languages. During a FGD, a young man said, "*I will never agree to take these medicines unless they go through our village distributors that we know."* (FGD_HJ_NT_TOU_KAL).

Some people are reluctant to take medicines unless they know the distributor. It's important that the distributor is trusted by the villagers, and that he or she is one of them. Another young man in Tominian, stated : "*There is also the problem of choosing distributors, i.e. you have to use well-known agents, known by the villagers, for reasons of trust*." (II_AS_HJ_MON_TOM).

3) Availability, accommodation and the ability to reach

The third dimension of access to health care is the availability and accommodation of services. Services are considered available and accommodating if they are physically accessible, timely, and have adequate capacity to meet demand. Geographic mobility and insecurity issues were identified as barriers by the participants while observation of seasonal trends and accessible and flexible services were identified as facilitators.

Geographic mobility/ population movements according to seasons

Geographical mobility influences the implementation of MDA within these populations as they move and miss community-based interventions. Population mobility varies according to seasons and activities. This is illustrated during an IDI with a sand miner who said: "*There are more people moving during the rainy season because at that time the river is full, but as soon as the rains stop and the river starts getting empty, people return to their original community*

location. The work here during the dry season doesn't bring in enough, it's during the rainy season that there is a lot of work and movements." (IDI_AS_NT_ES_KAL).
"*There's a lot of movement here. During the dry season, a lot of women travel with their children to Bamako, Ségou, and so on. They go there to work and come back to the village during the rainy season to carry out their regular activities. There are also small movements during the harvest. When the rice fields in a particular village are harvested, there's an influx of women. Some of these women earn enough money in the countryside. Even now we have children who are in Burkina Faso, they go back and forth."* (II_AS_HJ_MON_TOM).

However, in the case of traditional gold miners, movement was also reported but in the opposite direction. As noted in one FGD, a young man stated: "*Yes, it's during the dry season that the farmers come here before going back when the rainy season is about to start.*"(FGD_HJ_NT_TOU_KAL).

For groups who are constantly moving, conventional communication techniques such as posters and flyers might not be as successful, and the usual MDA procedures may not be effective as illustrated by health personnel in Tominian: *"In July and August, most residents are on-site carrying out their activities. The problem is that they are no longer at home during the door-to-door campaign. The campaign is organized in July-August, this is the time for fieldwork. They usually don't come home until evening. There is no campaigning at night. " (II_AS_HJ_MON_TOM).*

Role of security in mobility (especially in the case of IDPs)

MDA programmes in Mali face obstacles in treating NTDs, especially among IDPs, due to security and transportation issues. Displacement from insecure regions has caused urban overpopulation, which has resulted in a lack of medications as these additional populations were not accounted for in initial MDA planning. Moreover, armed bandits hinder access to some regions, impeding the delivery of treatments and supplies. A female IDP said: *"We moved here because of growing insecurity in central Mali."* (IC_FJ_LAF_TOM). A health worker said in response to a question about low coverage: "*For me, this low coverage is due to the numerous movements of these people because of the insecurity.*" (II_AS_HJ_FAN_TOM).

During a focus group discussion, a young man was asked about the difficulties they currently face in terms of public health needs, said: *"As for diarrhea, it's all the same with the*

lack of hygiene. Malnutrition, onchocerciasis, and the other diseases you mentioned are the result of poverty. Many people here have become poor because of insecurity. Furthermore, the health workers are afraid to come to us for treatment because of the insecurity. So, we don't benefit from the drug distributed during your campaigns." (II_AS_HJ_MON_TOM).

Seasonal observations on population shifts: insights from the seasonal calendar

The data from the seasonal calendars provided some explanations and reasons for the population movements studied in the two health districts. The flow of young people to Kalabancoro is more important after the harvest period (October-December). They usually return to their respective villages around the beginning of the rainy season, i.e. May-June. People can still move at any time of the year in this district because of its proximity to Bamako and the availability of several means of transportation including buses (Supplemental figure 1).

In the Tominian area, there are IDPs, either Fulani nomads/transhumants or farmers who have fled their villages or grazing areas due to insecurity in northern and central Mali. In addition, there are people seeking to make money because there are no jobs in their communities of origin. Many have settled down and are starting to integrate with the native population. As a result, they turn to farming in the villages they settle in during the rainy season to feed themselves. Because of insecurity, activity characterized as nomadism/transhumance is lessening in Tominian and San health districts (Supplemental figure 2).

Accessible and flexible services

Providing accessible MDA services which take the mobility of the population into account was expressed by participants as a facilitator for participation. Setting up mobile clinics or temporary treatment points at locations frequently visited by migrants may increase the likelihood of participation. Increasing the number of distributors in these areas would also help to increase therapeutic coverage as illustrated by this quote by a community health center director: *"I think that if we increase the number of distributor teams and the number of annual treatment rounds, that could be a solution for increasing the number of treated people."* (II_AS_HJ_FAN_TOM).

Another man (Kalabancoro) said, "*In the beginning, the health workers who came here had enough means to meet our needs, they came with a lot of medicines. Now they can continue*

to do so, and take advantage of the opportunity to give us medicines for MDA." (FGD_FA_NT_BAN_KAL).

4) Affordability and the ability to pay

In Levesque et al.'s framework, affordability and the ability to pay is the fourth dimension affecting access to care. In this dimension, economic constraints were cited as the main factor leading to disparities in healthcare access and outcomes among different population groups. These financial barriers can exacerbate inequalities.

Economic constraints

MDA interventions in Mali are funded by the Malian government and partners such as the World Health Organization and bilaterial donors and use donated medicines. As a result, the treatments are free for people living in endemic communities. However, individuals still perceive opportunity costs in terms of time and effort spent waiting or traveling to distribution points, which can interfere with work and other essential activities. Economic constraints create scarcity of resources (time, money, energy) and impact decision-making. Many participants expressed a desire for treatment but delayed taking action due to extreme poverty and the need to prioritize their basic needs.

People living in distress are most concerned about their basic needs (shelter, food, security). As a result, preventive health services for NTDs may not be perceived as a priority area. This is illustrated by a young man participant, who said: "*Life is really hard here, what we need now is food. We didn't harvest this year, we came here without harvesting. Our biggest worry is food, if we have enough to eat, the rest will come too, InshaAllah. To be in good health, you need to have enough to eat, and vice versa."* (II_HJ_NT_MED_TOM).

Another man said: "*I was in Cameroon looking for a better life. I spent a lot of time there, but unfortunately, I didn't have enough money, so I decided to come back to Mali. Life is very hard here in our village, so maybe I'll go back to Cameroon or another country.*" (II_HJ_NT_TOU_KAL).

5) Appropriateness and the ability to engage

Culturally appropriate community interventions are a main facilitator in the Levesque framework's "appropriateness and ability to engage" feature. Culturally tailored interventions consider the cultural norms, beliefs, and values of the target population, which increases trust, relevance, and accessibility. It can also improve communication, enhancing access to health and addressing specific health needs or risk factors that may face some particular communities. These types of interventions often involve local leaders, giving them ownership in their own health improvement which can increase community and people's ability to engage in health programmes.

Culturally tailored interventions

Research results showed that culturally sensitive MDA campaigns, especially for mobile and migrant populations, could benefit greatly from such approaches. Engaging community leaders is crucial for increasing participation and improving health outcomes. Cultural competence is thus vital in ensuring that public health initiatives are both relevant and effective, as illustrated by this young man during a one-to-one interview: *"It's essential to get the local population involved. Anecdotally, during vaccinations, we've noticed that before people agree to be vaccinated, they take the advice of certain community leaders, and these leaders advise them to take the drug. The intervention and involvement of community leaders is essential to the smooth running of campaigns."* (II_AS_HJ_MON_TOM).

4.6. Discussion

This research aimed to understand the reasons why people with high mobility were never treated over multiple rounds of community-based MDA for schistosomiasis elimination in two districts in Mali. Few studies have explored why people are never treated over multiple years of MDA of preventive chemotherapy for NTDs. Much of the published research on MDA coverage and compliance tends to explore the various factors associated with people not receiving or not taking treatment during the last cycle of MDA (e.g., absence during MDA, fear of side effects, perception of not being at risk) [14,47,48], rather than never treatment over multiple rounds. Consequently, there is a lack of understanding about the contributing factors associated with never treatment and how they may change over time. Some of the known factors associated with never treatment in the literature include lack of information, fear of side effects, and lack of risk perception [16,35,49,50]. However, the current published research on never treatment does not explore this concept within mobile populations. This research explored how subgroups who exhibit unique mobility patterns (e.g. nomads, internally displaced persons (IDPs), sand miners, and traditional gold miners) experience complications during the implementation of MDA which can contribute to never treatment. Our research showed that economic migration, nomadism, and seasonal or daily travel were identified as critical factors that intersect with commonly known factors for never treatment, such as lack of information, fear of side effects, and low risk perception [51].

Seasonal and economic variations in travel patterns pose obstacles to both the supply side and demand side of MDA. Study results demonstrated how these characteristics are dynamic, implying that conventional MDA approaches may not adequately address the demands of these mobile populations and sufficiently provide access to the healthcare delivered during MDA. Given these dynamics and the nature of mobile people, how can health programmes adapt? The Levesque framework on healthcare access provided a guide to categorise the research findings for interpretation and action. The findings imply that it is critical to consider the varied and intricate mobility patterns that define different populations to enhance MDA coverage (demand side) and offer mobile populations high-quality healthcare (supply side) that is adapted to their unique situation. This strategy can lead to a more effective and equitable MDA campaigns, guaranteeing that even the most mobile and historically marginalized people obtain preventive chemotherapy during MDA for NTDs, and in this research, schistosimasis.

Movements Dynamic: Mobile populations and geographical shifts

The findings highlight Mali's significant population mobility, identifying obstacles that may hinder MDA success and explaining untreated cases. Tailoring MDA strategies to address subgroup barriers is essential for improved healthcare access, emphasizing the need to adapt public health approaches for Mali's increasingly dynamic population. Similar findings were reported by Vegvari et al in 2019 in a study exploring how human movement complicates the elimination of STH in areas where disparities in MDA coverage exist [52]. Moreover, population mobility and geographical shifts have implications for public health planners for MDA implementation in Mali. Infected individuals moving between regions may introduce or re-emerge infectious diseases [53]. Mobile populations are difficult to track by an already under-resourced health system, hindering preventive and curative health efforts. Understanding and even anticipating population movement patterns can help to identify and target high-risk areas for NTDs. Thus, MDA strategies in Mali should adapt to temporal and spatial population dynamics, optimizing intervention timing and locations (Figure 2). This supply-side intervention has the potential to improve all elements of the demand side of the Levesque framework, the ability to seek, to perceive, to reach, to engage and to pay (in terms of opportunity costs).

Overlap of multiple groups in movement

Our study population includes an overlap of multiple groups in movement simultaneously. Some of these movements are predictable, such as those related to seasonal changes, while others, like IDPs, are unpredictable (Figure 3). This diversity of population movements has significant implications for the implementation of an effective and equitable MDA. MDA works most effectively in stable communities where people are familiar with one another and tend to stay in the same location for most of the year. It is well-recognized that delivering even basic routine healthcare to mobile populations can be particularly challenging [54,55]. Consequently, it is reasonable to anticipate that some individuals may be considered as never treated across multiple MDA campaigns, given the dynamic and transient nature of the populations under study in Mali. This emphasizes the need for innovative strategies and targeted approaches to reach and serve these diverse and often underserved groups effectively [56]. This has the potential to improve both the demand and supply sides of the Levesque framework. On

the demand side, addressing social and gender norms, geographic barriers and raising awareness, and tailoring services to the living conditions of mobile populations can increase their ability to seek and access healthcare. On the supply side, ensuring service availability and accommodation through mobile teams and more flexible delivery models can better align with the diverse needs of these populations. This holistic approach improves MDA access for mobile groups.

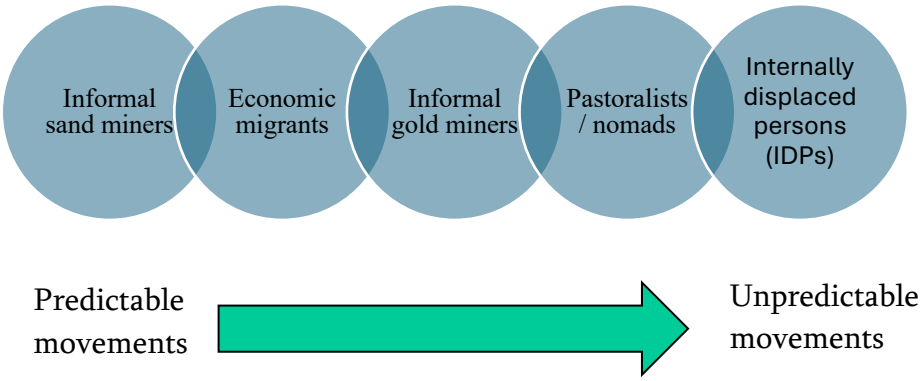


Figure 15. Navigating population dynamics: challenges and innovations in mass drug administration for diverse and mobile communities

Security, conflicts issues, and access to healthcare

Insecurity and conflict significantly hinder treatment access to healthcare, including MDA. When people flee for safety, they often miss essential treatments. Host districts also face drug shortages, isolation, and distrust, further contributing to treatment gaps. Conflict zones frequently report interruptions in MDA introducing potential gaps contributing to NTD elimination goals [57]. Similar patterns are seen in immunization programmes where children miss multiple doses or remain zero-dose in conflict areas [58,59]. Our research findings align with Peprah et al. 2016 reported non-acceptance of oral cholera vaccination campaigns among IDPs in Juba, South-Sudan during a humanitarian crisis [60]. Similarly, the research in Mali showed that geographic mobility, conflict and insecurity, economic migration, fear of side effects, lack of information / communication, language and cultural barriers and luck of trust in healthcare workers were described as reasons for non-participation in the MDA. Future strategies in Mali where mobile populations are present should consider this phenomenon.

Strategies should extend beyond physical security, and relate to the realities experienced by the different kinds of mobile populations [61,62]. Additionally, the timing of distribution needs careful consideration. In conflict areas, aligning MDA and vaccination campaigns with periods of relative stability can improve participation and coverage [63]. Tackling these challenges requires a multi-faceted strategy including cross-sectoral collaboration, data sharing, mobile health technologies, flexible healthcare delivery models, CDD teams to target specific groups, and community engagement among others. Programmes should consider the complexity of security issues while prioritizing population well-being [61,62,64,65]. NTD programmes need to work closely with mobile populations, local leaders and army as well as populations in insecure and conflict zones to overcome these obstacles. They can also work with organizations with experience working in conflict and insecurity zones.

This study emphasizes the need for innovative, context-specific solutions that can adapt to the challenges posed by conflict and insecurity, ensuring no one is left behind in MDA delivery. This approach will improve access according to the supply side of the Levesque framework, in particular approachability, availability and accommodation. In addition, by intervening at the supply side, measures might also enhance the demand side of the Levesque framework, specifically the search, the ability to reach (e.g., mobility), ability to seek (e.g., autonomy) and ability to engage (e.g., information and adherence) as mobile populations will have better access to MDA.

Cultural barriers, beliefs, and socioeconomic factors influencing MDA participation

The study reveals that cultural beliefs, misconceptions, and rumors impact mobile populations' MDA participation leaving some people untreated. Our research showed that the fear of drug side effects deterred many people from taking treatment. This has been shown across the schistosomiasis literature on coverage and compliance [66,67]. Research participants also reported that they do not feel the need to take the treatment during MDA as the risk of infection is not perceived. They do not feel sick or see the illness in their community. This is also a research finding on community uptake of schistosomiasis MDA in other sites [68].

Mobile populations, particularly for IDPs, face difficulty meeting their basic needs, as this study has shown. This reduces the importance of preventive treatments and actions. Furthermore, NTDs receive less attention than other medical issues [69,70] such as HIV/AIDS,

malaria, and tuberculosis [71]. Ng'etich et al. 2021 found that health professionals in Kenya were only prepared to participate in surveillance efforts for diseases that they deemed to be of priority such as immunization [72]. Because many NTDs, like schistosomiasis, are associated with morbidity instead of mortality, they may be considered as a lower priority [73,74]. This is particularly true in situations where people are living in circumstances of high vulnerability due to lack of basic needs. Future interventions must include culturally tailored interventions and educational campaigns to enhance community engagement and promote the value of preventive chemotherapy.

By focusing on educational campaigns, we can address low health literacy by offering easily available information that align with community health attitudes and expectations, hence improving the acceptability of the supply side under the Levesque framework. This can also foster trust to healthcare professionals ensuring that schistosomiasis and other NTDs are considered as a priority for preventive healthcare actions. On the demand side, these interventions empower individuals with the knowledge to perceive risks and seek care, supported by caregivers who provide information and encouragement.

Innovative strategies for MDA

As described in the results discussed above, this research highlights the necessity for innovative strategies to reach mobile populations. Adaptable MDA campaigns are essential to enhance access for these groups. Customizing community engagement to the characteristics of Mali's diverse mobile populations is vital. Given the dynamic nature of mobile populations, flexible mini-campaigns are recommended to effectively reach these populations. Collyer et al. 2019 found that integrating a catch-up campaign in the first year of MDA for schistosomiasis, rapidly reduced prevalence and heavy-intensity infections [75]. Mancarella et al. 2022 demonstrated that the COVID-19 vaccine was effective using catch-up strategies in Italy [76]. A similar study reported that catch-up campaigns have been successful in increasing routine vaccine coverage in Malawi [77]. Innovative operational and implementation research can help to understand how to implement flexible interventions based on population-specific characteristics.

4.7. Limitations

The study involved a purposive sample of mobile populations who claimed no prior treatment during MDA. This sample does not represent all mobile communities in Mali, thus limiting the generalizability of the study's findings. It is possible that never-treated individuals may struggle to recall past experiences and emotions related to their condition more frequently than other social groups [78]. Respondents may not provide all their reasons for never treatment, or they may report only recent reasons. They may be ashamed to give certain reasons, so as not to appear unrealistic or uncompliant to the interviewers. Brown et al. 2022, have shown that social reactions can induce shame, leading to feelings of rejection, embarrassment, and isolation, along with fear of exposure and judgment [79]. To mitigate this effect in our study, we instructed interviewers to avoid judging participants' words, to be culturally sensitive and to do everything possible to put participants at ease. Furthermore, questions surrounding never treatment had been previously validated in earlier studies [15,35,49,80].

Standardized questions allow for the collection of qualitative data collection and analysis approach

These results contribute to the existing research on never treatment and provide input into the development of qualitative research questions to understand never treatment within programmatic evaluation responses and operational research. Questions should be carefully crafted to capture key barriers and facilitators for never treatment. Findings can help design programmatic responses and initiatives that aim to increase the engagement of IDPs, as well as nomadic and migrating groups in Mali and in other similar settings. Some recommendations for questions within cross-sectional surveys, qualitative research (IDIs and FGDs) and programmatic evaluation include :

1) Have you ever declined to participate in MDA for [specific disease] in the past? If yes, please explain the main reasons or factors that influenced your decision.
2) What are the reasons why you are never treated during MDA for NTDs? (an open question followed by: Of that list, what is the primary reason (cite one only))
3) What needs to change for you to agree to take treatment in the next MDA round offered to you?

4) In your opinion, what contributes to people never taking treatment in your community?
5) In your opinion, what will make it easier for everyone in your community to access MDA for schistosomiasis? Foronchocerciasis ? For lymphatic filariasis? For other PC-NTDs?
6) What can be done to ensure that everyone participates in MDA targeting NTDs, including those who are never treated?
7) What roles can health workers, other authorities, and community members play in ensuring that everyone participates in MDA targeting NTDs?
8) Do you participate to any other community-based health interventions? Why? Why not

4.8. Conclusion

This study highlights the challenges of never treatment in Mali's schistosomiasis MDA programme among diverse mobile populations. The geographic mobility of populations poses a significant hurdle to the elimination of schistosomiasis as well as other PC-NTDS, demanding innovative strategies, such as flexible treatment methods (e.g., mini-campaigns, specific CDD teams to target and treat mobile populations in their settlements, tailored educational campaigns and awareness, cross-sectoral collaboration) informed by subgroup-specific nuances. Levesque et al.'s framework helps to conceptualize the elements of accessibility and availability of NTD treatment. By applying the Levesque framework, the study reveals that addressing these barriers requires a multifaceted approach that addresses both the supply side and the demand side, e.g., improving MDA programmes by including community leaders to strengthen cultural acceptability (acceptability and ability to seek), ensuring the delivery processes are suited to the population's needs (availability and accommodation and ability to reach), and creating tailored communication strategies that promote awareness and engagement (appropriateness and ability to engage). The results highlight the need for more flexible and context-specific approaches to achieve equitable access to MDA, hence contributing to the overall goal of disease elimination in Mali.

Patient consent for publication

We obtained consent from all participant to publish the data.

Provenance and peer review

Not commissioned; externally peer reviewed.

Data availability statement

All data relevant to the study are included in the manuscript and its supporting supplementary files. Additional information can be obtained from the corresponding authors on reasonable request.

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Competing interests

The authors have declared no competing interests.

Reflexivity statement

We have also attached a reflexivity statement in Supplementary file 1.

Contributions

Contributors: MS, AFD, YIC, SD, MK, TBN and AK conceived and designed the study. MS, AFD, YIC, DT, SOT, HD, ID, OC, BS, FT, SD were involved in the acquisition of data. MS, AFD, ID, SOT, DT, FT, and BS conducted the in-depth interviews and focus group of discussion. MS, AFD, YIC, AK, DT, SOT, HD, ID, OC, BS, DT developed the analysis plan, conducted the analysis and interpreted the data. MS, AFD, DT, BS, YIC and AK drafted the

manuscript. All authors edited, contributed to the manuscript and approved the final version submitted. AK is the guarantor.

Abbreviations

CDD (Community Drug Distributor); COR-NTD (Coalition for Operational Research on Neglected Tropical Diseases); FGD (Focus Group Discussions); HIV (Human Immunodeficiency Virus); AIDS: (Acquired Immunodeficiency Syndrome); IDI (In-Depth Interview); IDP (Internally Displaced Persons); LF (Lymphatic Filariasis); MDA (Mass Drug Administration); MD (Doctor of Medicine); (MPSH) Master of Science in Public Health; (MPH) Master of Public Health; NGO (Non-Governmental Organization); NT (Never Treated); NTDs (Neglected Tropical Diseases); PC (Preventive Chemotherapy); Doctor of Philosophy (PhD); SCH (Schistosomiasis); STH (Soil-Transmitted Helminthiases); USTTB (University of Sciences, Techniques and Technologies of Bamako); WHO (World Health Organization).

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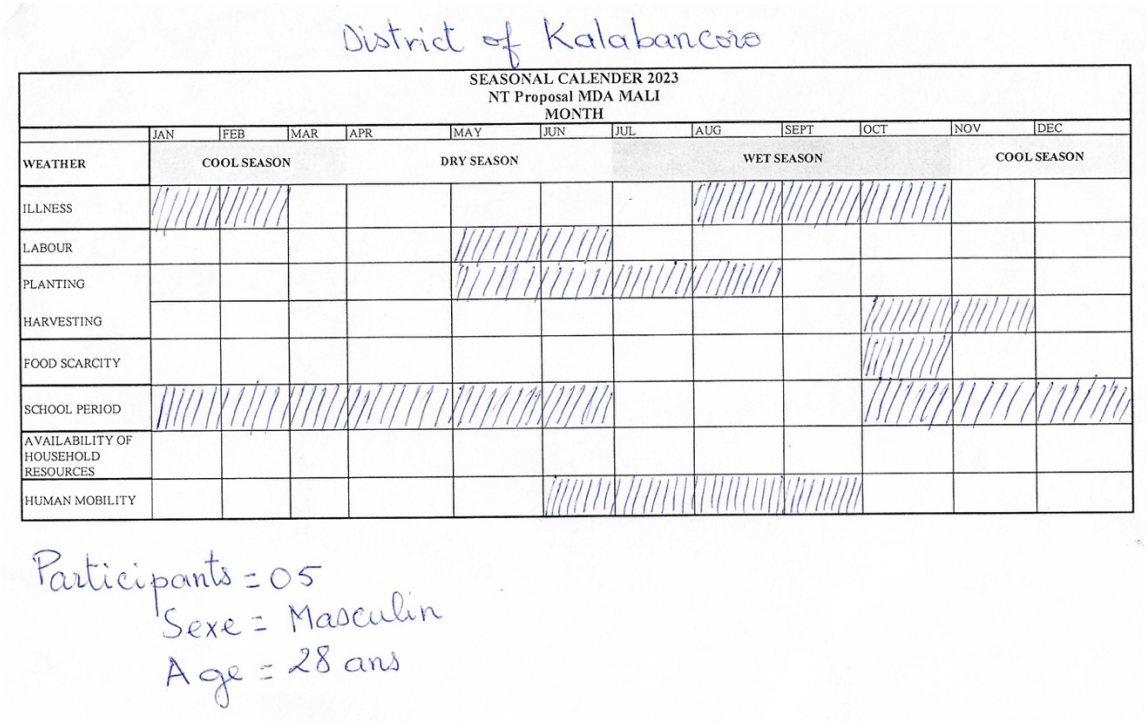
Appendices

Appendix 3. Supplemental figure 1: Seasonal calendar district of Kalabancoro



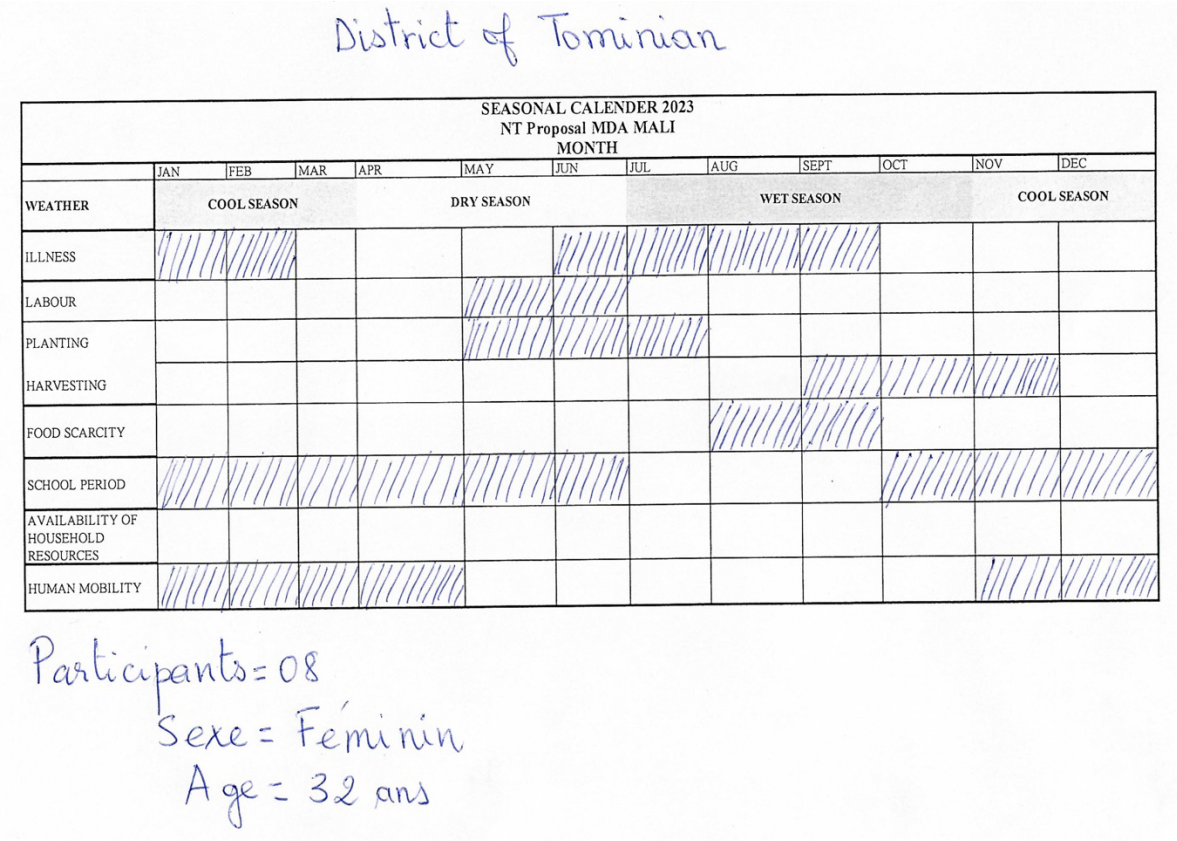
District of Kalabancoro

SEASONAL CALENDER 2023
NT Proposal MDA MALI
MONTH

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC
WEATHER	COOL SEASON				DRY SEASON			WET SEASON			COOL SEASON	
ILLNESS												
LABOUR												
PLANTING												
HARVESTING												
FOOD SCARCITY												
SCHOOL PERIOD												
AVAILABILITY OF HOUSEHOLD RESOURCES												
HUMAN MOBILITY												

Participants = 05
Sexe = Masculin
Age = 28 ans

Appendix 4. Supplemental figure 2: Seasonal calendar district of Tominian



District of Tominian

SEASONAL CALENDER 2023
NT Proposal MDA MALI
MONTH

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC
WEATHER	COOL SEASON			DRY SEASON				WET SEASON			COOL SEASON	
ILLNESS												
LABOUR												
PLANTING												
HARVESTING												
FOOD SCARCITY												
SCHOOL PERIOD												
AVAILABILITY OF HOUSEHOLD RESOURCES												
HUMAN MOBILITY												

Participants = 08
Sexe = Féminin
Age = 32 ans

Appendix 5. Reflexivity statement

As the primary researcher, I recognize that the methodology of this study has been influenced by my experiences and background. I am a man, Malian citizen, medical doctor and a PhD candidate in population health in Canada, with a professional focus on healthcare access among underserved populations. My personal experiences growing up in a rural community in Mali, where healthcare resources were often limited, have influenced my interest in this topic.

MS, AFD, ID, SOT, DT, FT, and BS conducted all the in-depth interviews and focus group of discussion. MS, AFD, YIC, SD, MK, TBN and AK conceived and conceptualized this study. Most of the investigators held a background in medicine, social epidemiology, and public health. It was important to us to have a team made up of both men and women to consider socio-cultural aspects and language barriers. Additionally, the interviewers' background in public health allowed them to develop a codebook that was informed by their prior knowledge of organizations' cultures and people in vulnerable circumstances access to mass drug administration against neglected tropical diseases allowed to highlight themes and sub-themes. This benefited the data collection as well as analysis as it shaped the thematic scope of the research, complementing the themes of the conceptual framework.

Throughout the research process, we remained aware of the potential for our own experiences and assumptions to influence data collection and interpretation. To mitigate this, we employed member-checking and peer debriefing, ensuring that participant voices were accurately represented and not overshadowed by our own perspectives. Moreover, we maintained a reflexive journal during fieldwork to track and reflect on any emerging biases or preconceptions. We aimed to remain as transparent and open as possible about our influence on the research process.

Our study requires a careful examination of power dynamics between the researcher and participants. If the researcher is perceived as an outsider, participants may withhold information due to distrust or fear of judgment, limiting the researchers' access to crucial insights. Power imbalances may arise from differences in education, socio-economic status, or cultural backgrounds, further influencing the openness of participants. We acknowledge that these dynamics could affect the authenticity of the data. Therefore, we set out to mitigate this effect by ensuring a non-judgmental environment for honest dialogue during IDIs and FGDs. We started

each interview with general conversation, to allow the participant to become comfortable with the research team and answering questions.

We also recognize that our data might also be limited by information bias such as social desirability, recall and self-reporting bias in the responses of participants. We recognized these limitations, and we took appropriate measures such as validating the topic guides before data collection, ensuring the confidentiality and anonymity of participants, reviewing the known characteristics of the population, reviewing the duration of the interview, checking the recall period and providing memory aids. During the piloting and review, in cases where the content of the interview was unclear or ambiguous due to the use of terminology, the team met to discuss it and find a consensus.

The strengths of this study lie in its relevance to the challenges of people living in vulnerable circumstances especially as NTD programs approach elimination. The study was conducted in collaboration with the NTD program in Mali, thus, the recommendations from the study can be used directly by the NTD program.

Appendix 6. Certificate of ethics approval for study 2

UNIVERSITE DES SCIENCES,
DES TECHNIQUES ET DES TECHNOLOGIES DE BAMAKO

FACULTE DE MEDECINE ET D'ODONTO-STOMATOLOGIE
FACULTE DE PHARMACIE/ BP 1805, *BAMAKO – MALI*

☎ : (223) 20 22 52 77 🖷 : (223) 20 22 96 58

N°2023/ 11 /CE/USTTB

Bamako, le 10 janvier 2023

Le Président du Comité d'Ethique de l'USTTB

(-)w

Docteur Moussa SANGARE

Cher Docteur,

J'ai le plaisir de vous informer que le comité d'Ethique de l'USTTB approuve définitivement votre protocole de recherche intitulé «**Une exploration qualitative pour comprendre les obstacles et les facilitateurs liés à l'absence de traitement lors de l'administration massive de médicaments parmi les populations migrantes et mobiles au Mali» version 3.0 du 07 décembre 2022** ayant constaté l'effectivité de la prise en compte des différentes recommandations faites.

Cette approbation est valable du **10 janvier 2023 au 09 janvier 2024**. Elle sera renouvelée après le dépôt du rapport annuel.

Le Comité d'Ethique de l'USTTB vous souhaite plein succès dans vos recherches.

LE PRESIDENT
DU COMITE D'ETHIQUE

04/05/2023

Université d'Ottawa
Bureau d'éthique et d'intégrité de la recherche

University of Ottawa
Office of Research Ethics and Integrity

CERTIFICAT D'APPROBATION ÉTHIQUE I CERTIFICATE OF ETHICS APPROVAL

Numéro du dossier / Ethics File Number	H-02-23-8759
Titre du projet / Project Title	Improving coverage in mass drug administration in Mali for the elimination of neglected tropical diseases by reaching mobile populations, a mixed method study.
Type de projet / Project Type	Thèse de doctorat / Doctoral thesis
Statut du projet / Project Status	Approuvé / Approved
Date d'approbation (jj/mm/aaaa) / Approval Date (dd/mm/yyyy)	04/05/2023
Date d'expiration (jj/mm/aaaa) / Expiry Date (dd/mm/yyyy)	03/05/2024

Équipe de recherche / Research Team

Chercheur / Researcher	Affiliation	Role
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Le Comité d'éthique de la recherche (CÉR) de l'Université d'Ottawa, opérant conformément à l'*Énoncé de politique des Trois conseils* (2014) et toutes autres lois et tous règlements applicables, a examiné et approuvé la demande d'éthique du projet de recherche ci-nommé.

L'approbation est valide pour la durée indiquée plus haut et est sujette aux conditions énumérées dans la section intitulée "Conditions Spéciales ou Commentaires". Le formulaire « Renouvellement ou Fermeture de Projet » doit être complété quatre semaines avant la date d'échéance indiquée ci-haut afin de demander un renouvellement de cette approbation éthique ou afin de fermer le dossier.

Toutes modifications apportées au projet doivent être approuvées par le CÉR avant leur mise en place, sauf si le participant doit être retiré en raison d'un danger immédiat ou s'il s'agit d'un changement ayant trait à des éléments administratifs ou logistiques du projet. Les chercheurs doivent aviser le CÉR dans les plus brefs délais de tout changement pouvant augmenter le niveau de risque aux participants ou pouvant affecter considérablement le déroulement du projet, rapporter tout évènement imprévu ou indésirable et soumettre toute nouvelle information pouvant nuire à la conduite du projet ou à la sécurité des participants.

The University of Ottawa Research Ethics Board, which operates in accordance with the *Tri-Council Policy Statement* (2014) and other applicable laws and regulations, has examined and approved the ethics application for the above-named research project.

Ethics approval is valid for the period indicated above and is subject to the conditions listed in the section entitled "Special Conditions or Comments". The "Renewal/Project Closure" form must be completedfour weeks before the above-referenced expiry date to request a renewal of this ethics approval or closure of the file.

Any changes made to the project must be approved by the REB before being implemented, except when necessary to remove participants from immediate endangerment or when the modification(s) only pertain to administrative or logistical components of the project. Investigators must also promptly alert the REB of any changes that increase the risk to participant(s), any changes that considerably affect the conduct of the project, all unanticipated and harmful events that occur, and new information that may negatively affect the conduct of the project or the safety of the participant(s).

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Responsable d'éthique en recherche / Protocol Officer
Pour/For **Daniel LAGAREC** Président(e) du/ Chair of the **Comité d'éthique de la recherche en sciences de la santé et sciences / Health Sciences and Sciences Research Ethics Board**

CHAPTER 5: ARTCLE 3. Exploring the impact of mobile and migrant populations on mass drug administration coverage and effectiveness in Africa: a scoping review protocol

Overview

Chapter 5 presents the third article of this dissertation, which outlines a scoping review protocol examining how mobile and migrant populations influence mass drug administration coverage and effectiveness across Africa. This chapter defines the methodological framework guiding the review and clarifies its relevance for understanding persistent gaps in NTD control efforts. The protocol was published in *PLOS One*: **https://doi.org/10.1371/journal.pone.0324949**.

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5.1. Abstract

Background

Neglected tropical diseases (NTDs) affect populations in tropical regions, particularly low- and middle-income countries with limited economic and health resources. Mass drug administration (MDA) is a strategy for controlling and eliminating NTDs by treating entire at-risk populations to reduce parasite loads, interrupt transmission, and prevent reinfection. It is cost-effective and promotes equity by reaching underserved communities. MDA is a critical approach to controlling and eliminating NTDs. Mobile populations in Africa such as nomadic groups and internally displaced persons, may lack access to MDA, which poses challenges to NTD elimination. This study aims to explore the influence of population mobility on the implementation, effectiveness, and sustainability of MDA in Africa.

Materials and methods

This scoping review adheres to the PRISMA extension for scoping reviews and Joanna Briggs Institute (JBI) methodology. PCC (Population, Concept, Context) serves as the foundation for the study. Relevant papers published after 2000 will be identified through a comprehensive search of Medline Ovid, Embase, Web of Science, and gray literature. Studies addressing challenges to MDA in Africa's and related to mobile populations will be included. An Excel spreadsheet modified from the JBI will be used for data extraction and analysis.

Conclusion

The results of this review will shed light on how MDA coverage is affected by the phenomenon of mobile and migrant populations and what effective approaches, if any, have been used to address this problem and improve overall population access to MDA.

Keywords: NTDs, mobile and migrant populations, mass drug administration, impact, Africa, scoping review

5.2. Introduction

Background and rationale

Neglected tropical diseases (NTDs) are a group of diseases and conditions that prevail in tropical and subtropical areas mainly in low- and middle-income countries, where inadequate sanitation and poor health services are common (WHO, 2024a). NTDs can cause illness, physical and mental suffering, disability, and stigma, decrease productivity and negatively affect children's education (Alvarez-Hernandez et al., 2020). Several clinical manifestations are associated with NTDs. For example, lymphatic filariasis (LF) may cause elephantiasis and hydrocele which are highly disfiguring and painful conditions for those affected (Medeiros et al., 2021). Leprosy and leishmaniasis cause disfiguring, and stigmatizing scars and can lead to mental distress in affected patients (Gomez et al., 2020) while urogenital schistosomiasis causes male and female genital lesions causing immeasurable suffering and shame, especially in Africa (Orish et al., 2022; Vlassoff et al., 2022). Other NTDs, such as onchocerciasis, can remain asymptomatic for years before complications emerge, resulting in a delayed diagnosis and more severe outcomes like river blindness (Alvarez-Hernandez et al., 2020).

The five most prevalent NTDs worldwide are LF, onchocerciasis, schistosomiasis, soil-transmitted helminth infections (ascariasis, trichuriasis, and hookworm), and trachoma. These diseases can be controlled by preventive chemotherapy (PC-NTDs) delivered through mass drug administration (MDA) (Lenk et al., 2016). MDA is a safe and inexpensive means of delivery of essential drugs based on the principles of preventive chemotherapy, where populations or sub-populations are offered treatment regardless of their disease status (Peeling et al., 2017). These recommendations are based on the epidemiology of NTDs, host-parasite interaction, patient acceptability and drug effect (King & Li, 2018; Krentel et al., 2021).

Significant progress has been made in reducing the transmission and burden of NTDs worldwide through PC-NTDs (WHO, 2023a). In Africa, MDA and other control efforts have recently led to certification of national elimination of LF in Malawi (Chiphwanya et al., 2024) and Togo (WHO, 2017) bringing the total number of countries globally with LF elimination status to nineteen (19) (WHO, 2024b). In Mali, trachoma was eliminated in 2023 (WHO, 2023b) and for onchocerciasis, Mali was successful at the pre-stop MDA survey in 2019 (Dolo et al.,

2023). The pre-stop MDA survey assesses key epidemiological and entomological indicators to determine if treatment can be safely stopped without risking disease resurgence.

Despite these achievements, there remain many population groups or geographic areas that have not been reached with MDA interventions (Jacobson et al., 2022). Not only does this contribute to inequity for those left untreated, but it also compromises the achievement of NTD elimination. Elimination goals remain in danger if at-risk groups like mobile and migrant populations (MMPs) (including nomadic pastoralist communities, internally displaced persons (IDPs) routinely miss MDA, potentially contributing to hotspots that could lead to disease re-emergence (Dean et al., 2019)

The control and elimination of NTDs requires the treatment of all eligible individuals in all population groups, following the principle that no one should be left behind. Over the past decade, the risks and vulnerabilities faced by migrant and mobile populations in Africa have been compounded. For example, in the Sahel region, armed conflict, terrorism, poverty, violence, and growing insecurity have all contributed to an increased influx of people on the move (IOM, 2024). MMPs are a significant proportion of the population in the African region (Camlin et al., 2018a; Camlin et al., 2018b). Insecurity and exacerbated poverty are responsible for mobility that involves IDPs, nomadic pastoralists, refugees, migrants, among others. These individuals have been shown to have the least access to MDA when compared to the general population (Sangare et al., 2024). Climate change and severe weather events such as droughts, floods, and extreme heat are driving increased mobility as communities are forced to migrate/move in search of water, arable land, and livelihood opportunities. These movements often heighten vulnerabilities by disrupting access to essential health services particularly through interruptions in continuity of care. These movements also create health challenges in both the home and host communities that people leave and those they move to as mobile populations may miss essential preventative health measures, such as immunizations or antenatal care, due to constant movement in the home and host districts. In the host district, an influx of people can overwhelm local health facilities, resulting in longer wait times, shortages of medical supplies, and pressure on healthcare personnel (McMichael, 2015).

Today, little is known about how best to provide essential health care to mobile and migrant populations. The constant mobility of populations marginalizes them or even excludes them from health services. To address this issue among mobile populations living in vulnerable

circumstances, it is essential to understand the context in which interventions can be effective in responding to these specific situations. What are the barriers and facilitators to accessing MDA for PC-NTDs among MMPs (nomadic pastoralists, migrant laborers, IDPs, and refugees) in Africa; Why are these populations moving? Where are these populations coming from or going to? What challenges are associated with the capacity and willingness of stakeholders, including the beneficiary populations, to successfully implement MDA to effectively control/eliminate NTDs and other infectious diseases?

5.3. Objectives

To address these questions, we will conduct a scoping review to explore the influence of population mobility on the implementation of mass drug administration (MDA) for preventive chemotherapy neglected tropical diseases (PC-NTDs) in Africa. This review aims to explore the factors driving population movement and assess their consequences on health outcomes, particularly in relation to the implementation and effectiveness of MDA programs in Africa. We seek to explore three primary questions:

1. **Reasons for movement and patterns:** to understand the key factors driving the movement patterns of MMPs in sub-Saharan Africa that impact the implementation of MDA for PC-NTDs, including seasonal work, conflict, insecurity, and nomadic lifestyles.
2. **Consequences on MDA programs:** To determine the health-related impacts of these movements on MDA programs, including how mobile populations might miss treatments, the challenge of re-administering drugs, potential increased transmission of diseases, and the strain on health systems in Africa.
3. **Successful approaches documented**: to compile evidence of successful approaches shown to effectively improve MDA coverage among mobile populations in sub-Saharan Africa, with a focus on impact and outcome data.

5.4. Expected anticipated results

Mobility patterns and barriers to MDA access

- MMPs, including nomadic pastoralists, migrant laborers, IDPs, and refugees, will have lower MDA coverage compared to settled populations due to their movement patterns.

- Seasonal migration related to work, climate variability, or conflict will contribute to missed treatment opportunities and inconsistent MDA access.

Health impacts of population mobility

- High population mobility will lead to lower adherence to MDA schedules, increasing the risk of sustained transmission of PC-NTDs among these populations.
- Inadequate adaptation of MDA delivery models to mobile populations will result in suboptimal health outcomes compared to more stable populations.

Stakeholder engagement and implementation challenges

- Limited coordination among health authorities, community leaders, and mobile populations will hamper effective MDA implementation.
- MDA strategies that fail to account for mobility patterns will show reduced effectiveness, leading to gaps in NTD control and elimination efforts.

Successful MDA approaches and coverage improvement

- Community-driven, flexible, and appropriate MDA delivery models will be more effective in reaching and treating mobile populations.
- Integrating MDA with other essential health services (e.g., vaccination campaigns, maternal health) will improve accessibility and coverage.
- The use of digital tools (e.g., mobile tracking, SMS reminders) will enhance MDA follow-up and retention among mobile groups.

Operational Definitions of Concepts

Mass drug administration (MDA). MDA is a campaign strategy in which all eligible people in an area are given preventive chemotherapy regardless of their infection status. MDA is recommended by the WHO and involves periodically treating at-risk populations depending on the level of infection in the community. MDAs are essential for assisting in the control and elimination of NTDs. Achieving WHO-established threshold coverage levels ((1) LF: ≥65% of the total population at risk (targeting the entire eligible population); (2) onchocerciasis: ≥80% of the eligible population (usually individuals aged 5 years and above in endemic areas); (3) schistosomiasis: ≥75% of school-age children (and at-risk adults in some settings); (4) soil-transmitted helminthiases (STH): ≥75% of preschool- and school-age children; trachoma: ≥80% of the total population in endemic areas (as part of the SAFE strategy, focusing on MDA with

azithromycin) for NTDs elimination is crucial, as success is only guaranteed if the drug reaches the target populations (WHO, 2017a, 2024a)

Mobile populations. Population mobility is defined as the geographic movement of people from their usual place of residence to another place for different reasons, including looking for better opportunities, to escape disasters and unrest, or safer places (ABS, 2009). Depending on the rationale for movement, it can be from one country to another, from one region to another, or between rural and urban areas. Mobile populations include refugees, IDPs, informal economic migrants, nomadic pastoralists and livestock breeders, among others (Scheel & Tazzioli, 2022; STPH, 2024). Mobile populations are highly vulnerable because they often lack consistent access to essential services such as healthcare, education, and social protection and hence they face major barriers/obstacles to accessing public health interventions. In the context of this study, we will focus on IDPs, informal economic migrants, nomadic pastoralists including livestock breeders.

The concept of "effectiveness of MDA". In this study, we aim to explore the impact of mobility on MDA implementation. Unlike a systematic review or meta-analysis, we do not intend to conduct our own measurements. Instead, we will summarize existing findings from the literature in a descriptive manner. Based on these findings, we will assess whether a systematic review and meta-analysis are necessary for objective measurement. The primary goal is to map the existing literature on this topic.

5.5. Materials and methods

Protocol Design

We will use the Joanna Briggs Institute methodology (JBI) guidance for scoping reviews to conduct the study (Peters et al., 2020) and the Preferred Reporting Items for Systematic Review and Meta-Analysis Protocols (PRISMA-P) (Shamseer et al., 2015) for writing the protocol (Supplemental 1). The review protocol will not be registered within the International Prospective Register of Systematic Reviews (PROSPERO) because scoping reviews are not currently accepted. We will utilize the PRISMA extension for scoping reviews (PRISMA-ScR) as the reporting guidelines for the scoping review manuscript (Tricco et al., 2018).

Eligibility Criteria

Methodological framework for conducting the scoping study: In this paper we will use PCC (Population (or participants)/concept/context) framework to guide the research question and inform the search strategy for our scoping review (Pollock et al., 2023).

Population: Our population will include mobile populations, such as those defined above, in regions where MDA for PC-NTDs is being implemented. We will include basic characteristics of participants, such as age, gender, education, economic status.

Concept/Intervention: The concept we will be examining in this scoping review is the implementation of MDA for preventive chemotherapy NTDs (PC-NTDs). Health outcomes will include MDA coverage rates, treatment adherence, disease transmission rates, and progress toward NTD elimination. Impact outcomes will include the overall success, measured by coverage rate, of MDA programs, and challenges, such as delays or setbacks in disease control due to missed treatments and reinfection risks.

Context: In Sub-Saharan Africa, population mobility severely hampers public health interventions, particularly MDA programs targeting NTDs including lymphatic filariasis, onchocerciasis, trachoma, schistosomiasis, and soil-transmitted helminths (Merrill et al., 2021). To accomplish the goal of disease elimination, these programs mostly depend on high levels of drug coverage throughout populations (Silumbwe et al., 2019). However, in regions where communities are highly mobile due to nomadic lifestyles, seasonal migration, labor migration, or displacement due to conflict or climate change, MDA coverage can be severely impacted (Muchiri et al., 2023; Sangare et al., 2024; Zimmerman et al., 2011). Geographically, many of these areas in Africa are characterized by remote, hard to reach, rural locations with inadequate health infrastructure and limited access to health care. Efforts to ensure continuity of care along with consistent use of drugs are complicated by the temporary and unpredictable nature of mobile populations, which frequently cross borders internationally (Adams et al., 2022). Culturally, some of these populations may have beliefs that can influence their willingness to participate in MDA campaigns. Factors such as language barriers, trust in health systems, and knowledge about NTDs may further exacerbate the challenge. Additionally, this scoping review may also examine how certain sub-groups within these mobile populations such as women, children, or ethnic minorities are differently affected by MDA campaigns (George et al., 2023).

Inclusion/Exclusion Criteria

We will include studies conducted from 2000 until 2024 because, since the 2000s, global efforts to eliminate NTDs such as lymphatic filariasis and onchocerciasis have intensified. International initiatives such as the Global Program for the Elimination of Lymphatic Filariasis (GPELF), launched by WHO in 2000, have marked a turning point in strategies to combat these diseases (Turner et al., 2022). The collection of more accurate data on MDA campaigns and population movements has also been enhanced using technological advances, such as Geographic Information Systems (GIS) and health surveillance tools (molecular xenomonitoring) (Fletcher-Lartey & Caprarelli, 2016; Riches et al., 2020). Cross-border migration, humanitarian crises, and refugee and internally displaced person flows have increased, especially after 2000 because of wars in the Middle East and Africa (Zimmerman et al., 2011). This study will involve all study designs including randomized controlled trials, non-randomized controlled studies, quasi-experimental, observational studies, and evaluation studies of MDA. Studies published in peer-review journals and found in grey literature will be included. The references cited in the reviewed literature will be searched to identify additional relevant studies. Only studies focusing on Africa will be included. We will include only papers and documents published in English and French. We will exclude studies that (1) are conducted outside Africa, (2) are prior to the year 2000, (3) are not in French or English, (4) focus on topics unrelated to MDA campaigns, preventive chemotherapy NTD elimination efforts or mobile populations as defined in this protocol.

Information Sources and Search Strategy

The search strategy will be developed under the guidance of a research librarian of Health Sciences from the University of Ottawa. A comprehensive search strategy using subject headings and keywords will be used to search for potentially eligible published studies in Medline (Ovid), Embase, and Web of Science. An initial search through the Medline (Ovid) database will be conducted using an analysis of text words found in the title and abstract, and the index terms used in describing the article (See a preliminary Medline search: Supplemental 3). Secondly, keywords and index terms shall be identified to search for studies in selected databases. Finally,

additional studies not found in the databases shall be searched from the reference lists of the selected studies from the first and second searches.

Additional searches will be conducted on the WHO, World Bank websites and the Centers for Disease Control and Prevention (CDC), The International Organization for Migration (IOM), The International Labour Organization (ILO) and the United Nations High Commissioner for Refugees (UNHCR) to search for unpublished studies. Search terms will include mobile, nomadic populations, migrant, internally displaced person, access to healthcare, neglected tropical diseases, NTDs, Africa, mass drug administration, MDA, care, movement, strategy. For grey literature search we will conduct manual searches by reviewing relevant reports, policy briefs, and technical documents available on institutional websites. This will involve navigating organizational repositories and identifying relevant grey literature that may not be indexed in standard databases.

Zotero software will be used for citation management in this scoping review. The PRESS (Peer Review of Electronic Search Strategies) checklist will be used to ensure the rigor and accuracy of the search strategy for this scoping review. The search strategy will specifically target the five WHO preventive chemotherapy NTDs of interest using relevant search terms that include but not limited to:

1. **Lymphatic filariasis** or *elephantiasis or filarial or Wuchereria bancrofti or Brugia malayi or Brugia timori or microfilaria AND*
2. **Onchocerciasis or** *onchocerca volvulus* **or** *river blindness* **or** *onchocerciasis* **or** *volvulus AND*
3. **Schistosomiasis or** *Schistosoma haematobium,* **or** *Schistosoma intercalatum,or Schistosoma guineensis* **or** *Schistosoma mansoni,* **or** *bilharzia,* **or** *Katayama fever,* **or** *snail fever AND*
4. **Soil-transmitted helminthiasis (STH) or** *Ascaris lumbricoides* **or** *Trichuris trichiura* **or** *Ancylostoma* **or** *Necator americanus* **or** *roundworm* **or** *whipworm* **or** *hookworm AND*
5. **Trachoma or** *Chlamydia trachomatis* **or** *trachoma* **or** *granular conjunctivitis AND*

Moreover, population mobility-related terms such *refugee, pastoralist, cross-border, internally displaced persons (IDPs), economic migrant, transhumance, nomad, migrant*

population, migrant worker, and population dynamics will be included to further focus and refine the search.

Study Selection and Screening Process

Prior to the study's commencement we will ensure that all team members have a shared interpretation of the inclusion and exclusion criteria, as well as how unclear information will be assessed by multiple team members. In some cases where questions remain concerning a particular study, efforts will be made to contact the authors for clarification to resolve ambiguities.

Studies will be identified in searched databases and saved in Zotero and exported to Covidence for screening. After importing references and inclusion/exclusion criteria into Covidence, two independent reviewers will screen titles and abstracts of included studies. All conflicts between the two reviewers will be resolved by a third reviewer. Once potentially eligible studies have been selected, this same procedure will be applied for full text screening. We will hold a briefing session with all reviewers on the screening process and the steering of inclusion/exclusion criteria and conflict resolution. We will be meeting regularly to discuss progress, address any difficulties, and explore ways to collaborate effectively.

Assessment of Study Quality

Unlike systematic reviews, a formal quality assessment is optional in scoping reviews, which are intended to map the extent and nature of evidence on a broad topic. However, the team will assess and discuss the quality of the studies informally, to avoid giving undue weight to the results of what we consider to be a lower quality study. For example, if a study is purely descriptive of only a few people or does not describe aspects of the study in a way considered rigorous by the team, we will highlight this when reporting on that study

Data Charting, Collection and Extraction Procedures

Two independent reviewers will extract data using a Microsoft Excel spreadsheet adopted from the Joanna Briggs Institute's template for data extraction (Supplemental 2) (JBI, 2024; M. D. Peters et al., 2024). The template will be piloted on three articles before use. The following information will be gathered: (i) study characteristics, such as the name of the first authors, the

year of publication, the country, and the study design; (ii) details about interventions that were put into place, such as implementation strategies, factors that helped or hindered the implementation of rural pipeline programs, and the results or impacts of those programs; (iii) reasons for movement and patterns of movement of mobile populations, the consequences on health outcomes and the approaches being developed to overcome these issues among mobile and migrant populations. In line with our review questions, both quantitative and qualitative data will be collected and analyzed. We will resolve discrepancies by consensus, or a third reviewer will be required. The rules for data extraction will be documented and stored with the protocol and template at the research data storage facility of ICERMali at the University of Sciences, Techniques and technologies of Bamako (USTTB) in Mali.

We will include specific data extraction fields focusing on mobile populations, MDA interventions, and effectiveness outcomes. For mobile populations, fields will capture demographic data (e.g., age, gender, socio-economic status), migration patterns (e.g., seasonal, nomadic, cross-border movement), and risk factors (e.g., exposure to disease vectors, access to healthcare). For MDA interventions, we will document intervention types (e.g., mass drug administration, targeted treatment), delivery methods (e.g., door-to-door, fixed-site, mobile teams), coverage rates (e.g., proportion of population reached), and community engagement strategies (e.g., awareness campaigns, local health worker involvement). Effectiveness outcomes will include treatment compliance rates, disease prevalence reduction, and any reported adverse effects or treatment failures.

Synthesis and Presentation of Results

Extracted data will be reported in tables and/or figures. Further formats can be considered at the time of analysis. The results of this scoping review will be descriptive, including an explanation of their study characteristics with reference to study population on which they focus. We will summarize the characteristics of included studies in a descriptive way. With an emphasis on mapping important concepts, populations, and features, we will compile and display the extracted data descriptively according to JBI recommendations (Aromataris et al., 2024). We will report the results in text, tables and graphs following PRISMA-ScR guidelines.

5.4. Expected Outcomes of the Study

It is expected that the results of this study will reveal a low proportion of non-compliance and access to MDA among mobile and migrant populations. It is also expected that the results will reveal a relationship between the socio-demographic/structural characteristics of participants and MDA participation among mobile populations in Africa. We also anticipate that this study will determine why some people missed treatment and what recommendations are needed to improve MDA coverage rates in MMPs in Africa We will attempt to highlight evidence from the literature on the health status of mobile populations and to assess the best ways to provide them with MDA campaigns.

5.5. Potential Limitations

This review may have limitations related to the search strategy. The inclusion of only studies published in French and/or English, as well as the specific search terms used, may reduce the sensitivity in identifying relevant studies. This study may also suffer from publication bias. We will work with stakeholders and experts, if necessary, to find unpublished studies and incorporate studies in English and French to capture the most relevant content in order to reduce publication and language bias. The inclusion of studies in English and French is justified by the fact that these languages are frequently used in worldwide research, especially in the study's target regions, like West Africa, guaranteeing thorough coverage of important studies. Furthermore, the writers' fluency in both languages enables proper literature interpretation and analysis.

5.6. Ethics Statement and Dissemination of Results

This protocol is part of a thesis protocol. We received ethical clearance from the University of Sciences, Techniques, and Technologies of Bamako’s Ethical Review Committee (Approval No. 2023/11/CE/USTTB), Mali, and from the Health Sciences and Sciences Research Ethics Board of the University of Ottawa (Approval No. H- 02- 23- 8759). This specific scoping review relies on studies already published or in the public domain and therefore does not require ethical approval. However, all measures will be taken to respect the procedures of scientific integrity.

The results of this study will be used in collaboration with program managers to strengthen the elimination or control of NTDs in Africa. The dissemination of the results of the scoping review will be done through peer review publication, presentation at conferences and other relevant stakeholder fora.

Status and Timeline of the Study

The scoping review will be conducted over a six-month period, from February to July 2025 (Table 10).

Table 10. Activities and Timeline of the Study

Activities	**February 2025**	**March 2025**	**April 2025**	**May 2025**	**June 2025**	**July 2025**
Search strategy developpement						
Screening of studies and analysis of titles and abstracts						
Selection of studies and analysis of studies in full texts						
Data extraction						
Data analysis and discussion						
Presentation of results						
Scope review submission						

5.7. Conclusion

Our review attempts to address the social inequalities faced by populations in Africa. Mass treatment is an effective way to prevent disease, but to be effective it is necessary that they be implemented and adapted to different contexts and population groups, especially those most hard to reach. The aim of this review is to explore the influences of population mobility on the implementation of MDA in Africa, and to examine the evidence of factors influencing movement and approaches that have proven effective in improving MDA coverage among them. Our review will answer these questions across Africa, thus helping to improve mass treatments and increase health equity for all. Further, other disease control and elimination programs in Africa and elsewhere that are using mass treatment methods will potentially benefit from our results. Similarly, the information generated will contribute to reaching the global elimination targets.

Supporting information

- Supplemental file 1: Completed PRISMA-P 2015 checklist
- Supplemental file 2: Data extraction sheet information
- Supplemental file 3: Preliminary search from Medline

List of abbreviations

Australian Bureau of Statistics (ABS); Centers for Disease Control and Prevention (CDC); Geographic Information Systems (GIS); Global Program for the Elimination of Lymphatic Filariasis (GPELF); Internally Displaced Persons (IDPs); Joanna Briggs Institute methodology (JBI); Lymphatic Filariasis (LF); Mass Drug Administration (MDA); Mobile and Migrant Populations (MMPs); Neglected Tropical Diseases (NTDs); Peer Review of Electronic Search Strategies (PRESS); Preferred Reporting Items for Systematic Reviews and Meta-Analysis Protocols (PRISMA-P); Preventive Chemotherapy NTDs (PC-NTDs); PRISMA Extension for Scoping Reviews (PRISMA-ScR); Swiss Tropical And Public Health Institute (STPH); The International Labour Organization (ILO); The International Organization for Migration (IOM); The International Prospective Register of Systematic reviews (PROSPERO); The United States Agency for International Development (USAID); United Nations High Commissioner for Refugees (UNHCR); Université des Sciences, des Techniques et des Technologies de Bamako (USTTB); World Health Organization (WHO).

DECLARATIONS

Consent for publication

Not applicable

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5.8. References

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Appendix 7. Supplemental 1. PRISMA-P 2015 checklist

Section and topic	Item No	Checklist item	REPORTED ON PAGE #
Administrative information			
Title:			
Identification	1a	Identify the report as a protocol of a systematic review	The study is identified in the title as a scoping review protocol
Update	1b	If the protocol is for an update of a previous systematic review, identify as such	This is not an update to a previous review
Registration	2	If registered, provide the name of the registry (such as PROSPERO) and registration number	No. The protocol was not registered
Authors:			
Contact	3a	Provide name, institutional affiliation, e-mail address of all protocol authors; provide physical mailing address of corresponding author	This information is on page 1 and 15.
Contributions	3b	Describe contributions of protocol authors and identify the guarantor of the review	Author contributions and funding are included in the manuscript on page 15 and 16.

Section and topic	Item No	Checklist item	REPORTED ON PAGE #
Amendments	4	If the protocol represents an amendment of a previously completed or published protocol, identify as such and list changes; otherwise, state plan for documenting important protocol amendments	The protocol does not represent an amendment to a previously completed or published protocol.
Support:			
Sources	5a	Indicate sources of financial or other support for the review	This review is part of a PhD thesis protocol and received no funding.
Sponsor	5b	Provide name for the review funder and/or sponsor	This review is part of a PhD thesis protocol and received no funding.
Role of sponsor or funder	5c	Describe roles of funder(s), sponsor(s), and/or institution(s), if any, in developing the protocol	Not applicable
Introduction			
Rationale	6	Describe the rationale for the review in the context of what is already known	Yes. The review rationale is on pages 3 to 6 of the manuscript.

Section and topic	Item No	Checklist item	REPORTED ON PAGE #
Objectives	7	Provide an explicit statement of the question(s) the review will address with reference to participants, interventions, comparators, and outcomes (PICO)	The review questions/objectives are on pages 5 and 6. Yes. The key elements (population or participants, concepts, and context) are on pages 7 and 8 of the manuscript.
Methods			
Eligibility criteria	8	Specify the study characteristics (such as PICO, study design, setting, time frame) and report characteristics (such as years considered, language, publication status) to be used as criteria for eligibility for the review	Yes. The eligibility criteria is on pages 7, 8 and 9 of the manuscript.
Information sources	9	Describe all intended information sources (such as electronic databases, contact with study authors, trial registers or other grey literature sources) with planned dates of coverage	Yes, this information is included on page 10 of the manuscript.
Search strategy	10	Present draft of search strategy to be used for at least one electronic database, including planned limits, such that it could be repeated	Yes, this information is included on page 10 of the manuscript.
Study records:			

Section and topic	Item No	Checklist item	REPORTED ON PAGE #
Data management	11a	Describe the mechanism(s) that will be used to manage records and data throughout the review	Yes. The mechanism(s) that will be used to manage records and data during the review are presented on page 11 and 12 of the manuscript.
Selection process	11b	State the process that will be used for selecting studies (such as two independent reviewers) through each phase of the review (that is, screening, eligibility and inclusion in meta-analysis)	The process for selecting sources of evidence is on page 11.
Data collection process	11c	Describe planned method of extracting data from reports (such as piloting forms, done independently, in duplicate), any processes for obtaining and confirming data from investigators	Yes, the methods of collection process data are on pages 11 and 12.
Data items	12	List and define all variables for which data will be sought (such as PICO items, funding sources), any pre-planned data assumptions and simplifications	Yes. The list and definition are on supplemetal table 2.
Outcomes and prioritization	13	List and define all outcomes for which data will be sought, including prioritization of main and additional outcomes, with rationale	Yes, this information is included on page 12 of the manuscript.

Section and topic	Item No	Checklist item	REPORTED ON PAGE #
Risk of bias in individual studies	14	Describe anticipated methods for assessing risk of bias of individual studies, including whether this will be done at the outcome or study level, or both; state how this information will be used in data synthesis	Not applicable to this study
Data synthesis	15a	Describe criteria under which study data will be quantitatively synthesized	Not applicable to this study
	15b	If data are appropriate for quantitative synthesis, describe planned summary measures, methods of handling data and methods of combining data from studies, including any planned exploration of consistency (such as I^2, Kendall's τ)	Not applicable to this study
	15c	Describe any proposed additional analyses (such as sensitivity or subgroup analyses, meta-regression)	Not applicable to this study
	15d	If quantitative synthesis is not appropriate, describe the type of summary planned	Yes, this information can be found on page 12 of the manuscript.
Meta-bias(es)	16	Specify any planned assessment of meta-bias(es) (such as publication bias across studies, selective reporting within studies)	Not applicable

Section and topic	Item No	Checklist item	REPORTED ON PAGE #
Confidence in cumulative evidence	17	Describe how the strength of the body of evidence will be assessed (such as GRADE)	Not applicable

From: Shamseer L, Moher D, Clarke M, Ghersi D, Liberati A, Petticrew M, Shekelle P, Stewart L, PRISMA-P Group. Preferred reporting items for systematic review and meta-analysis protocols (PRISMA-P) 2015: elaboration and explanation. BMJ. 2015 Jan 2;349(jan02 1):g7647. (**https://www.bmj.com/content/349/bmj.g7647.long**)

Supplemental 2. Appendix 10.1 Modified JBI template source of evidence details, characteristics and results extraction instrument

Appendix 8. Supplemental 2. Modified JBI template source of evidence details, characteristics and results extraction instrument

Scoping review details	
Scoping Review title:	
Review objective/s:	
Review question/s:	
Inclusion/Exclusion Criteria	
Population	
Concept	
Context	
Types of evidence source	
Evidence source Details and Characteristics	
Citation details (e.g. author/s, date, title, journal, volume, issue, pages)	
Country	
Context	
Participant details (e.g. ID, age, sex, education, country)	
Details/Results extracted from source of evidence (in relation to the concept of the scoping review)	
E.g. Quality of Life Domains assessed	
E.g. Number of items in tool	
E.g. details of psychometric validation of tool	

CHAPTER 5: ARTICLE 4. The influence of human population movement on mass drug administration for neglected tropical diseases: a scoping review

Overview

Chapter 5 presents the fourth article of this dissertation, which reports the main findings of a scoping review examining how human population movement shapes mass drug administration coverage and outcomes for neglected tropical diseases. This article synthesizes evidence across diverse settings in Africa to highlight critical gaps and opportunities for improving NTD programming in mobile populations. This manuscript is published in *BMC Infectious Diseases of Poverty*: **https://doi.org/10.1186/s40249-026-01433-w**.

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5.6. Abstract

Background: Neglected tropical diseases (NTDs), including but not limited to lymphatic filariasis, onchocerciasis, trachoma, schistosomiasis, and soil-transmitted helminths, remain a major public health challenge in Africa. Mass drug administration (MDA) is a key strategy for NTD control and elimination. However, mobile populations such as internally displaced persons (IDPs), nomadic groups, and seasonal workers often face major constraints that reduce MDA effectiveness defined by coverage. Understanding how mobility and its underlying drivers affect MDA implementation is therefore critical to designing inclusive, effective, and equitable intervention strategies. In this review, we aim to map existing evidence on how human population movement influences the outcomes of MDA programmes in Africa.

Methods: Following PRISMA-ScR guidelines, we searched using electronic databases Medline (Ovid), Embase, Web of Science, and manually screened additional sources for studies published in English or French between January 2000 and February 19, 2025. Two authors independently extracted data, resolving discrepancies through discussion, or with a third reviewer. We included studies reporting on MDA interventions and mobile or migrant populations in Africa. Data were extracted using a standardized template and synthesized thematically to describe mobility patterns, barriers to access, implementation gaps, and strategies used to improve MDA reach among mobile groups. The thematic synthesis consisted of organizing the extracted data into recurring themes, comparing trends across studies, and grouping similar observations to develop broader themes that reflect common challenges and approaches related to mobile populations.

Results: From 6814 studies identified, twenty (20) met the inclusion criteria. The review identified multiple challenges likely to affect MDA equity and effectiveness. Mobility, particularly among nomad pastoralists, seasonal workers, IDPs, and cross-border populations leads to systematic exclusion from MDA campaigns. Barriers included geographic inaccessibility, limited tailored communication, lack of cross-border collaboration/coordination, and rigid campaign schedules. Promising strategies documented were mobility-informed microplanning, cross-border collaboration/coordination, flexible delivery models, enhanced community engagement and integration with other health interventions. The evidence emphasizes the need for adaptive, equity-focused MDA approaches to effectively reach mobile populations. From 6814 studies identified, twenty (20) met the inclusion criteria. The review identified multiple challenges likely to affect MDA equity and effectiveness. Mobility,

particularly among nomad pastoralists, seasonal workers, IDPs, and cross-border populations leads to systematic exclusion from MDA campaigns. Barriers included geographic inaccessibility, limited tailored communication, lack of cross-border collaboration/coordination, and rigid campaign schedules. Promising strategies documented were mobility-informed microplanning, cross-border collaboration/coordination, flexible delivery models, enhanced community engagement and integration with other health interventions. The evidence emphasizes the need for adaptive, equity-focused MDA approaches to effectively reach mobile populations.

Conclusion: Population mobility has a significant impact on equitable MDA delivery and can hinder progress toward NTD elimination targets in Africa. Tailored, flexible, and inclusive strategies are urgently needed to ensure mobile populations are reached. Future efforts should focus on developing mobility indicators, pilot-testing adaptive MDA delivery models aligned with movement patterns and strengthening partnerships with neighboring countries and humanitarian organizations.

Keys word: Population mobility, Mass drug administration, Neglected tropical diseases, Africa, Coverage, Scoping review

5.7. Background

Neglected tropical diseases (NTDs) comprise a group of 21 diseases and conditions that disproportionately affect people living in vulnerable circumstances, particularly in underserved and hard-to-reach areas (WHO-ESPEN, 2025). Among these, five diseases including lymphatic filariasis, onchocerciasis, schistosomiasis, soil-transmitted helminthiases, and trachoma are classified as NTDs that can be addressed by the use of preventive chemotherapy (PC-NTDs) because they can be controlled or eliminated through large-scale mass drug administration (MDA). The African region carries a disproportionately high burden of these PC-NTDs, with the majority of global cases occurring on the continent (WHO, 2021; WHO-ESPEN, 2025). Overall, Africa bears 39% of the total global NTD burden. However, PC-NTDs are preventable, treatable, and through sustained interventions, have the potential to be eliminated. Global efforts against NTDs have seen significant progress. The number of people globally needing interventions for NTDs fell by 32% from 2010 to 2023, and by May 2025 a major milestone was reached with 56 nations worldwide having eliminated at least one NTD (WHO, 2025). This progress aligns with

WHO's global target of achieving elimination of at least one NTD in 100 countries by 2030 (WHO, 2025a). These achievements highlight the feasibility of NTD elimination when appropriate strategies are implemented effectively and are sustained.

Mass drug administration (MDA) has been a cornerstone of global and regional strategies to eliminate the PC-NTDs as public health problems. MDA is a safe and inexpensive means of delivery of essential drugs based on the principles of preventive chemotherapy, whereby populations or sub-populations are offered treatment regardless of their disease status (Peeling et al., 2017). However, despite the scale-up of MDA programs across the continent, persistent coverage gaps remain, especially among mobile and migrant populations (MMPs) who often temporarily reside or move across endemic regions (Adams et al., 2022; Forson et al., 2023; Sangare et al., 2024). There is growing evidence that population growth and mobility are impeding PC-NTDs elimination (Aagaard-Hansen et al., 2010). In the context of this paper, 'mobile populations' refer to groups with limited fixed residence whose movements are driven by livelihood, socio-economic, or security factors. Examples include nomadic pastoralists, internally displaced persons (IDPs), seasonal agricultural and mining workers, refugees, seasonal migrants, and those engaged in cross-border movements. This raises the possibility that NTDs could re-establish in areas where they have been eliminated. For example, NTD-affected mobile populations, such as nomadic pastoralist communities, IDPs, seasonal workers (e.g. agricultural, mining), refugees, migrants and cross-border movement groups, may migrate to areas where MDA has stopped, based on achieving target prevalence or where disease prevalence is so low that transmission is no longer a concern.

NTD initiatives often face challenges to reach mobile populations. These population groups have limited geographic access to general health services including NTDs, and may experience poor quality of care, interruptions in treatment delivery, and high costs associated with travel and care-seeking (Gammino et al., 2020). These challenges are compounded by linguistic barriers, low awareness of NTDs, and alternative health beliefs, which hinder uptake of prevention and treatment strategies (Raimundo-Silva et al., 2024; Taylor & Kazembe, 2024; Ukwaja et al., 2020). Barriers also include geographic inaccessibility, population movement and related professions, sociopolitical marginalization, conflict and insecurity, limited integration in national health systems, and weak surveillance and follow-up mechanisms. Cultural norms, language diversity, and irregular documentation status can further complicate service provision.

(Adams et al., 2022; Manyazewal et al., 2024; Sangare et al., 2024). These barriers to prevention and treatment may contribute to transmission hotspots, putting hard won progress at risk and potentially leading to disease re-emergence (Dean et al., 2019). These barriers highlight a critical need to better tailor MDA approaches to populations on the move.

While global NTD strategies recognize the importance of equity and inclusivity in disease elimination, there remains a limited understanding of how population mobility impacts MDA delivery, uptake, and effectiveness in African contexts. Existing research is fragmented and often focuses on fixed communities, overlooking the complex realities of population movement and health service delivery at the margins. Mobility involving IDPs, nomadic pastoralists, refugees, migrants, among others is caused by insecurity, climate change and worsened poverty. It has been demonstrated that, in comparison to the general population, these people have the least access to MDA (Sangare et al., 2024a). In the African context, where mobile groups are frequently under -represented in standard health data systems, this gap in the research highlights the urgent need to thoroughly map the nature, magnitude, and impact of population movement on NTD interventions of MDA.

We conducted a scoping review to synthesize the available evidence of population mobility effect on the implementation of MDA for PC-NTDs in Africa. This review aimed to explore the factors driving population movement and to assess their consequences on health outcomes, with a particular focus on the implementation of MDA programs in Africa. The overall goal was to inform more inclusive, equity-driven strategies for NTDs elimination that are responsive to the needs of mobile and migrant populations. Specifically, this review sought to address the following questions: Why are these populations moving? Where are these populations coming from or going to? What challenges are associated with the ability and willingness of stakeholders, including the beneficiary populations, to successfully implement MDA to effectively control/eliminate NTDs and other infectious diseases?

Operational definitions of concepts.

Mobile populations. We defined population mobility as the geographic movement of people from their usual place of residence to another location for reasons that include seeking better economic or agricultural opportunities, escaping natural disasters or conflict, or finding safer living conditions. It may be from one country to another, from one region to another, or

from rural to metropolitan areas, depending on the reason for the relocation. Nomadic pastoralists, livestock breeders, refugees, IDPs, and migrants for informal economic purposes are examples of mobile populations. They frequently lack uninterrupted access to basic services like healthcare, education, and social security, making them vulnerable (Scheel & Tazzioli, 2022; STPH, 2024). IDPs, refugees, informal economic migrants, and nomadic pastoralists, especially livestock producers, were the MMP included in the focus for this study.

Mass drug administration (MDA). is a campaign approach that provides preventive chemotherapy to all eligible individuals in a disease endemic region, irrespective of their infection status. The WHO advises MDA on a periodic basis according on the community's infection level. Reaching the WHO-recommended threshold coverage levels is essential to control and eliminate NTDs: (1) LF: > 65% of the entire population at risk, focusing on all eligible individuals; (2) schistosomiasis: > 75% of school-age children (and at-risk adults in certain situations); (3) onchocerciasis: ≥ 80% of the eligible population (typically people aged 5 and older in endemic areas); (4) soil-transmitted helminthiases (STH): ≥ 75% of preschool- and school-age children; (5) trachoma: ≥ 80% of the population is required in endemic areas (as part of the SAFE (Surgery for trichiasis, Antibiotics to treat infection, Facial cleanliness, and Environmental improvement) strategy, emphasizing on MDA with azithromycin) (WHO, 2017, 2024).

5.8. Methods

Study design

This scoping review followed a previously published protocol (Sangare et al., 2025) in accordance with the Joanna Briggs Institute methodology (JBI) guidance for scoping reviews (Peters et al., 2020) and the Preferred Reporting Items for Systematic Review and Meta-Analysis Protocols (PRISMA-P) for writing the protocol (Shamseer et al., 2015). To guide the reporting of our scoping review, we used the PRISMA Extension for Scoping Reviews (PRISMA-ScR) (Supplementary file 1. PRISMA-ScR Checklist) (Tricco et al., 2018).

Eligibility criteria

We used the PCC (Population, Concept, Context) framework (Pollock et al., 2023) to guide the research question and guide our search strategy: (1) **Population:** We included studies involving mobile and migrant populations in Africa, as defined in our methodological framework, including nomadic groups, seasonal workers, refugees, IDPs, cross-border migrants; (2) **Concept:** We focused on studies reporting data on MDA coverage, treatment compliance, transmission indicators, progress toward elimination targets, barriers to MDA access, or strategies to improve coverage and adherence among mobile populations; (**3) Context:** We limited our review to studies reporting specifically the five PC-NTD diseases (lymphatic filariasis, onchocerciasis, schistosomiasis, soil-transmitted helminthiases, and trachoma). Only studies conducted in African countries endemic for at least one of the targeted diseases were included.

Inclusion and exclusion criteria

We included studies published between January 2000 and February 2025 in English or French. This period corresponds with intensified global NTD elimination efforts (e.g., WHO's Global Programme to Eliminate Lymphatic Filariasis launched in 2000) (Turner et al., 2022), improved monitoring tools such as GIS and molecular xenomonitoring (Fletcher-Lartey & Caprarelli, 2016; Riches et al., 2020), and increasing population movements driven by migration and humanitarian crises (Zimmerman et al., 2011).

Studies were excluded if they were literature reviews, conference abstracts, protocols, editorials, or commentaries; did not directly focus on mobile or migrant populations and MDA or PC-NTDs; or lacked primary data relevant to the review objectives. We recognize that these restrictions may constitute limitations of our review. A summary of all eligibility, inclusion, and exclusion criteria is provided in Table 11.

Table 11. Inclusion, exclusion, and data extraction criteria

Key Theme	Screening Phase 1 (Title/Abstract)	Screening Phase 2 (Full-Text)	Extraction (Data to Collect)
Mass Drug Administration	Studies mentioning MDA for neglected tropical diseases in any population	Studies explicitly focusing on MDA implementation, challenges, or outcomes in mobile populations.	• Target disease(s): PC-NTDs • MDA strategy (e.g., fixed-point, mobile teams) • Coverage metrics (e.g., %, denominators)
Mobile Population	Studies involving migrants, refugees, nomads, or temporally displaced groups (e.g., seasonal workers).	Detailed analysis of mobility's impact on MDA access, coverage, or adherence.	• Population type (e.g., seasonal workers and migrants, internally displaced people, nomads and transhumants) • Mobility patterns (cyclical, one-way)
Reasons for Movement	Any mention of migration drivers (e.g., conflict, livelihoods, environmental factors).	Clear linkage between movement patterns and MDA delivery (e.g., logistical barriers, coverage gaps).	• Primary drivers (economic, conflict, environmental) • Impact on MDA participation

Key Theme	Screening Phase 1 (Title/Abstract)	Screening Phase 2 (Full-Text)	Extraction (Data to Collect)
Consequences on MDA	Studies discussing health program challenges (e.g., low coverage, inequities) in mobile groups.	Evidence of how mobility affects MDA success (e.g., • Coverage gaps • Logistical issues • Disease resurgence).	• Quantified gaps (e.g., 30% missed doses) • Program adaptations • Logistical issues • Disease resurgence
Successful Approaches	Interventions or strategies (e.g., community engagement, mobile clinics) to improve MDA in mobile populations.	Evidence of effectiveness: • Community engagement • Cross-border coordination	• Strategy details • Outcome metrics (e.g., • coverage improvement) Documented outcomes (e.g., increased coverage, reduced prevalence)
Study Type	—	Primary research/program evaluations only. 1. Primary research, evaluations, reports 2. Excludes lab-based or animal studies	• Study design (e.g., cohort, RCT) • Data collection methods • Exclude studies NOT relevant to mobile population or MDA

Key Theme	Screening Phase 1 (Title/Abstract)	Screening Phase 2 (Full-Text)	Extraction (Data to Collect)
Language	—	Published in English or French.	—
Year	Published from 2000–2024	—	• Publication year

Search strategy and information sources

Database searches

Under the guidance of a research librarian of Health Sciences from the University of Ottawa, the study team (MS, OC, CD and AK) devised a comprehensive search strategy using subject headings and keywords was developed to search for eligible published studies in Medline (Ovid), Embase, and Web of Science databases. The searches were constructed by combining search terms as indicated in the Supplementary file 2 (Supplementary file 2. Database final strategy search). Search terms included mobile, nomadic populations, migrant, internally displaced person, access to healthcare, neglected tropical diseases, NTDs, Africa, mass drug administration, MDA, care, movement, strategy and infectious agent and vector of NTDs. Search concepts were combined with "AND", and words within a word group or with a concept were combined with "OR". Practical screening assessed the title of the publication as well as date of publication. Using pertinent search terms, the search strategy was restricted to the five WHO preventive chemotherapy NTDs of interest: 1) lymphatic filariasis (or elephantiasis or filarial or *Wuchereria bancrofti* or *Brugia malayi* or *Brugia timori* or microfilaria AND); 2) onchocerciasis (or *Onchocerca volvulus* or river blindness or onchocerciasis or *volvulus* AND); 3) schistosomiasis (or *Schistosoma haematobium* or *Schistosoma intercalatum* or *Schistosoma guineensis* or *Schistosoma mansoni* or *bilharzia* or snail fever AND); 4) soil-transmitted helminthiasis (or *Ascaris lumbricoides* or *Trichuris trichiura* or *Ancylostoma* or *Necator americanus* or roundworm or whipworm or hookworm AND); 5) trachoma (or *Chlamydia trachomatis* or trachoma or granular conjunctivitis AND). Supplementary file 2. Although *Wuchereria bancrofti* is the only causative agent of lymphatic filariasis in Africa, we included *Brugia malayi and Brugia timori* in the initial search strategy to ensure sensitivity and comprehensiveness. African studies may reference *Brugia spp*. in broader discussions of lymphatic filariasis or in reviews comparing global species distribution.

Hand searches

Additional searches were conducted on the WHO, World Bank websites and the Centers for Disease Control and Prevention (CDC), The International Organization for Migration (IOM),

The International Labour Organization (ILO) and the United Nations High Commissioner for Refugees (UNHCR) for unpublished studies. The manual search included the same terms as the database search. We also conducted a hand search of gray literature by reviewing references identified during manual searches and other external sources / websites, although no formal gray literature search strategy or predefined repository was used.

Study selection and screening process

We imported all the references/citations we found as well as inclusion/exclusion criteria into Covidence, an online tool that helps manage systematic reviews (https://www.covidence.org/). The platform automatically flagged and removed any duplicate studies. From there, the studies selection process was done in two phases:

Title and abstract screening. Two independent reviewers screened each study's title and abstract against our pre-set criteria, guided by the PCC framework (Pollock et al., 2023). If a study did not focus on mobile populations, MDA, or was not conducted in Africa, we excluded it. Whenever the reviewers disagreed, they discussed until they reached a consensus. All other conflicts between the two reviewers were resolved by a third reviewer.

Full-text review. For studies that passed the initial screening (Title and abstract), we obtained and carefully read the full articles to confirm whether they fit our criteria. Reasons for exclusion at this stage were documented, and the remaining studies were retained for data extraction.

We documented each step of the process and summarized it in a PRISMA-ScR flow diagram, showing how many records we started with, how many were screened, included, or excluded along with the reasons for exclusion when applicable. This process ensures that only the most relevant studies made were included in our final selection.

Data charting, collection and extraction procedures

Two independent reviewers extracted the data using a Microsoft Excel spreadsheet (Supplementary file 3. Data extraction sheet.xlsx). adapted from the Joanna Briggs Institute's data extraction template. The template was piloted on three studies and refined before full application to ensure consistency and relevance. The piloting process was done independently by 2 reviewers followed by a discussion to agree on the final template. The extracted information included: (i) Study characteristics such as the first author's name, year of publication, country of

study, and study design; (ii) Intervention details including MDA implementation strategies, facilitators and barriers to delivery, and reported outcomes or impacts; (iii) Population mobility or reasons for movement, patterns of migration (e.g., seasonal, nomadic, cross-border), and health-related consequences among mobile populations; (iv) Strategies to reach mobile populations including tailored approaches used to overcome mobility-related barriers.

In line with the review objectives, both qualitative and quantitative data were extracted and analyzed. Specific data fields focused on mobile populations (e.g., demographic details, socio-economic status, healthcare access), MDA interventions (e.g., delivery methods, coverage rates, community engagement strategies, period), and effectiveness outcomes (e.g., treatment compliance, reduction in disease prevalence or adverse effects). Discrepancies between reviewers were resolved through discussion or by consulting a third reviewer when necessary. All procedures and rules for data extraction were documented and securely stored with the protocol and extraction datasheet at the research data storage facility of ICER-Mali, based at the University of Sciences, Techniques and Technologies of Bamako (USTTB), Mali.

Assessment of study quality

Following the methodological framework for scoping reviews by Arksey & O'Malley (2005), we did not conduct a formal critical appraisal of the included studies, as our objective was to map the extent, range, and nature of the existing evidence rather than attempt to assess certainty in these results or synthesize these in such a way as we would in systematic reviews (Arksey & O'Malley, 2005). Although a formal critical appraisal was not conducted, reviewers noted basic methodological characteristics (e.g., study design, clarity of objectives, and relevance to the review question) during data extraction to support interpretation of the findings.

Synthesis and presentation of results

Extracted data were summarized using tables and descriptive text. The findings were presented descriptively, highlighting the key characteristics of the included studies, particularly in relation to the populations they examined. Study characteristics were synthesized in a descriptive manner, with a focus on mapping key concepts, populations, and contextual features. Data were organized and displayed following the JBI guidance. We reported data using the PRISMA-ScR guidelines (Tricco et al., 2018), through narrative descriptions and tables.

5.9. Ethics statement

Ethical clearance was obtained from the University of Sciences, Techniques, and Technologies of Bamako's Ethical Review Committee (Approval No. 2023/11/CE/USTTB), Mali, and from the Health Sciences and Sciences Research Ethics Board of the University of Ottawa (Approval No. H- 02- 23- 8759). This review was conducted as part of a PhD research project. The data included in this review rely on studies already published or in the public domain and therefore do not require ethical approval. The study team respected all procedures of scientific integrity of conducting a scoping review, as mentioned above.

5.10. Results

Characteristics and summary of included studies

Our search across multiple databases identified a total of 6814 potential studies. Electronic searches were conducted in Medline (Ovid) (n = 2303), EMBASE (n = 3013), Web of Sciences (n = 1498), google search (n = 16), the WHO search engine (n =5), NGO and technical/financial websites. (see Fig. 1: PRISMA-P Flow Chart). After title and abstract screening, only 84 studies met the criteria for full text review. Next, we conducted a comprehensive review of those articles (that met the first step criteria), which resulted in the selection of 20 studies for this scoping review. A detailed overview of the included studies is presented in Table 12. Data from the included studies were extracted into an Excel file created for this purpose. The included articles are summarized in Table 13.

Table 12. Characteristics of included studies

Author (Year)	Title	Country/ Region	Study design	Age of study population	Target NTDs	Type of mobility	Citation
Adams et al (2022)	Leaving no one behind: targeting mobile and migrant populations with health interventions for disease elimination-a descriptive systematic review	Africa (multiple regions)	Descriptive systematic review	Both sexes (Youth and adult)	PC-NTDs malaria, trypanosomiasis, polio, smallpox & rinderpest.	Cross-border, seasonal, occupational, displacement	(Adams et al., 2022 b)
Ajakaye et al (2022)	Contrasting epidemiology of urogenital schistosomiasis among pastoral communities surrounding three Ramsar wetland in Nigeria.	Nigeria (pastoral communities around Ramsar wetlands)	Cross-sectional study	Both sexes, ages (≤ 10 and ≥ 20)	Schistosomiasis (*S. haematobium*)	Transhumant and seasonal movement with livestock	(Ajakaye et al., 2022 a)
Baayenda et al (2023)	'Follow the cattle': a joint cross-border trachoma MDA perspective	Tanzania, Kenya and Uganda	Descriptive case study	Sex: not reported, Age: Children	Trachoma	seasonal and Transhumant cross-border movement following cattle	(Baayenda et al.,

		(East Africa)		aged 1–9, Adults ≥ 15 years			2023)
Badia-Rius *et al.* (2024)	Impact of conflict on the elimination targets of lymphatic filariasis, schistosomiasis and soil-transmitted helminths in Cabo Delgado province, Mozambique.	Mozambique (Cabo Delgado province)	Desk-based secondary data analysis	Sex: all genders Age: children and adults	Lymphatic filariasis, schistosomiasis and soil-transmitted helminths	The focus is on forced mobility population and Internal displacement	(Badia-Rius et al., 2024a)
Sangare *et al.* (2024)	Understanding the barriers and facilitators related to never treatment during mass drug administration among mobile and migrant populations in Mali: a qualitative exploratory study	Mali (Tominian, Kalabancoro)	Qualitative exploratory study (in-depth interviews and focus group discussions)	Both sexes (Youth and adult)	Schistosomiasis (context of MDA)	Seasonal migration for agriculture, circular migration for periodic urban work, & displaced migration due to conflict within the same year	(Sangare et al., 2024b)
Masong *et al.* (2021)	Achieving equity in UHC interventions: who is left behind by neglected tropical	Cameroon	Qualitative study applying	Both sexes (adults	Schistosomiasis	Seasonal and cross-border Mobility, Labour/Economic	(Christine

	disease programmes in Cameroon?		ethnographic observations	eligible for MDA)		Migration, short-term mobility Rural/urban migration,	Masong et al., 2021)
Dorkeno *et al.* (2021)	Monitoring migrant groups as a post-validation surveillance approach to contain the potential reemergence of lymphatic filariasis in Togo.	Togo (national; border points)	Cross-sectional: Programmatic surveillance evaluation (post-validation)	Both sexes (Youth and adult)	Lymphatic filariasis	Cross-border movement of migrants and traders	(Dorkeno et al., 2021a)
Silumbwe *et al.* (2017)	A systematic review of factors that shape implementation of mass drug administration for lymphatic filariasis in sub-Saharan Africa	Sub-Saharan Africa (multiple countries)	Systematic review	Both sexes, age not specified	This paper reviews the literature on Lymphatic filariasis elimination	Varied (seasonal, remote, peri-urban)	(Silumbwe et al., 2017a)
Vegvari *et al.* (2019)	Human population movement can impede the elimination of soil-transmitted helminth	Sub-Saharan Africa	Metapopulation transmission	Children (0–15 years-old)	Soil-transmitted helminths	Seasonal mobility, Inter-village human movement	(Vegvari et

	transmission in regions with heterogeneity in mass drug administration coverage and transmission potential between villages: a metapopulation analysis.	(multiple countries)	modeling analysis	Young adults (15–35 years-old) Sex is not explicitly mentioned			al., 2019 a)
Durrans *et al.* (2019)	"Moving like birds": A qualitative study of population mobility and health implications in the Bijagos Islands, Guinea Bissau.	Guinea-Bissau (Bijagós Islands)	Qualitative study (interviews and focus group discussions)	Both sexes, age not specified	Lymphatic filariasis, scabies, soil transmitted helminths	Seasonal and circular mobility between islands and mainland	(Durrans et al., 2019 a)
Gichuki *et al.* (2024)	Using community-based participatory approaches to improve access to mass drug administration for trachoma elimination in a pastoral conflict area of Kenya	Kenya (Baringo): pastoral conflict area	Mixed methods: Community-based participatory research with operational	Both sexes, age not specified	Trachoma	Seasonal mobility, Transhumant and security-driven movement	(Gichuki et al., 2024 a)

			implementation				
Nditanchou *et al.* (2023)	Ivermectin and doxycycline treatments against Onchocerciasis: Adaptations and impact among semi-nomadic population in Massangam Health District, Cameroon	Cameroon (Massangam Health District)	quasi-experimental design: Program adaptation evaluation	Both sexes, ages [9–40 et plus]	Onchocerciasis	Seasonal and circular movement	(Nditanchou et al., 2023a)
Mtuy *et al.* (2021)	Understanding hard-to-reach communities: local perspectives and experiences of trachoma control among the pastoralist Maasai in northern Tanzania.	Tanzania (northern Maasai areas)	Qualitative study (Ethnographic research)	Both sexes, age [15– 50]	Trachoma (ocular infection caused by *Chlamydia trachomatis*)	Seasonal mobility: transhumant within and across districts	(Mtuy et al., 2021a)
West *et al.* (2015)	Risk of Infection with Chlamydia trachomatis from Migrants to Communities Undergoing Mass Drug Administration for Trachoma Control.	Tanzania	Longitudinal study (Epidemiological risk analysis)	Children under 10 years old (both sexes)	Trachoma	In-migration from endemic areas	(West et al., 2015a)

Harvey *et al.* (2022)	How can the neglected tropical disease community be inclusive and equitable in programme delivery? Reaching refugees and internally displaced people through integrating a 'leave no one behind' approach	Sub-Saharan Africa (multiple countries: (humanitarian/refugee settings)	Cross-sectional study Programmatic perspective (Leave No One Behind)	Age/sex not reported, interventions targeted "eligible children & adults at risk of NTDs).	PC-NTDs: trachoma, lymphatic filariasis, schistosomiasis, and soil-transmitted helminths,	Forced displacement and camp-based mobility	(D. Harvey et al., 2022a)
Bush *et al.* (2018)	Cross-border issues: an important component of onchocerciasis elimination programmes.	Cross-border onchocerciasis zones (West and Central Africa)	Programmatic review/commentary	Both sexes, age not specified	Onchocerciasis	Cross-border daily and seasonal movement	(Bush et al., 2018a)
Sanders *et al.* (2019)	Prevalence of trachoma within refugee camps serving South Sudanese refugees in White Nile State, Sudan:	Sudan (White Nile State refugee camps)	Cross-sectional: Population-based	Both sexes, ages [1–70 et plus]	Trachoma	Forced displacement; camp-to-host movement	(Sanders et al.,

	Results from population-based surveys.		prevalence surveys				2019 a)
Seck *et al.* (2023)	Pastoralists residing in northern Senegal.	Senegal	Cross-sectional study:	Both sexes, ages [0–50 et plus	Schistosomiasis	Transhumant and seasonal movement	(Seck et al., 2023 a)
Perez-Saez *et al.* (2015)	A Theoretical analysis of the geography of schistosomiasis in Burkina Faso highlights the roles of human mobility and water resources development in disease transmission	Burkina Faso	Secondary analysis: Geospatial analysis (quantitative techniques)	Not mentioned	Schistosomiasis	Seasonal, circular migration, and local movement between villages and water bodies	(Perez-Saez et al., 2015 a)
Ervin *et al.* (2016)	Surveillance and azithromycin treatment for newcomers and travelers' evaluation (ASANTE) Trial: Design and baseline characteristics	Tanzania	Cluster-randomized community trial (baseline survey and intervention design)	Both sexes, ages [1–9]	Trachoma	In-migration, seasonal mobility, short-term travel	(Ervin et al., 2016 a)

Table 13. Summary of results of all included studies

Author (Year)	Population and setting	Type of intervention	Reasons for mobility	Impact of mobility on MDA coverage and effectiveness	Barriers identified	Facilitators / enabling factors	Key findings relevant to mobility & MDA
Adams *et al.* (2022)	Mobile and migrant populations (MMP) across elimination programs (Nomadic pastoralists, Migrant laborers, Internally Displaced Persons (IDPs) and refugees)	Mass Drug Administration (MDA) for neglected tropical diseases (NTDs), Vaccination campaigns Vector control interventions, Health education Cross-border coordination for synchronized MDA and surveillance Community health worker mobilizations	Livelihood, conflict, environmental change, labor migration	MMPs are missed by conventional campaigns due to their absence during fixed MDA periods, leading to gaps in coverage and persistent transmission. Campaigns timed outside of peak settlement periods may miss entire subgroups; for instance, livestock herders, forest workers, or miners may only be present in certain seasons. Movement between countries can result in "importation" or re-introduction of	Geographic mobility/remoteness, Population enumeration/sampling/timing: seasonal or occupational migration leads to absence during campaigns. Language and cultural barriers, mistrust of health systems, misinformation, lower health literacy.Lack of tailored intervention/delivery strategies; most are designed for stable populations.	Community engagement; tailored awareness campaigns; side-effect management; flexibility in implementation	The review found that MMP are consistently underserved by elimination programs, with structural, linguistic, and legal barriers driving lower coverage; programs that mapped mobility, synchronized activities across borders, adapted delivery modalities, and engaged trusted

				disease into areas that had achieved control/elimination.			intermediaries achieved better reach and equity.
Ajakaye *et al.* (2022)	Pastoralist communities living around three Ramsar wetlands (nomadic livestock herders)	Study focused on epidemiological survey and diagnosis (urine filtration/microscopy for Schistosoma eggs). No recent mass drug administration (MDA) of praziquantel reported in some communities (e.g., no functional health center in Dagona Sanctuary community)	Livelihood (pastoralism), seasonal grazing and water access	Disrupted planning and reduced effectiveness Transhumant mobility around wetlands increases exposure and leads to missed fixed-site activities; scheduling MDA around pastoral routes and seasons is required to reach these groups.	Lack of functional health facilities and recent mass drug administration programs in some communities (Dagona Sanctuary). Insecurity and conflict in some regions affect delivery of interventions. Lack of inclusion of pastoral communities in control programs Ecological factors affecting snail vectors (variation between wetlands)	Targeted case finding and MDA scheduling around pastoral calendars; water, sanitation and behavior change interventions	The study reported contrasting, often high, urogenital schistosomiasis prevalence linked to pastoral mobility and water contact patterns, underscoring the need to align MDA and health education with transhumance schedules and to improve access to safe water.
Baayenda *et al.* (2023)	Nomadic pastoralist communities and mobile cattle herders	Synchronized MDA: Cross-border coordination: Simultaneous	Pasture and water availability; seasonal movement	Missed populations: Cross-border pastoral mobility can undermine isolated national campaigns.	Asynchronous national schedules; population flux; weak cross-border	Binational coordination; aligning MDA timing/routes to transhumance	The paper argues that synchronizing trachoma MDA along

	in cross border areas: Ateker ethnic groups along the Uganda-Kenya border. Maasai pastoralists al ong the Kenya-Tanzania border	MDA campaigns in Kenya, Uganda, and Tanzania. Community engagement: Involvement of cultural/ kraal leaders for mobilization. Joint planning/ supervision: Shared data, resources, and timelines.		Recrudescence: Uncoordinated MDA allows reinfection across borders. Binational/coordinat ed MDA scheduling along cattle routes sustains coverage among mobile herders	data sharing. Uncoordinated MDA efforts risk perpetuating trachoma and other NTDs due to gaps in coverage, particularly affecting nomadic populations. Additionally, limited focus on cross-border MDAs and funding restrictions imposed by partners hinders efforts to reach vulnerable groups	corridors; joint microplanning	transhumance routes and sharing data across borders increases access for mobile pastoralists and reduces missed populations.
Badia-Rius *et al.* (2024)	Conflict-affected resident and internally displaced populations	Standard MDA with adapted delivery	Armed conflict and insecurity: Forced mobility from conflict fragments catchment populations and lowers MDA reach unless flexible,	IDPs and nomadic groups were excluded from MDA. Displacement may reintroduce parasites to cleared areas. Transmission Assessment Surveys (TAS) postponed due to insecurity	Population displacement: Internally displaced persons (IDPs) are often missed during MDA campaigns due to their constant movement. Geographic inaccessibility:	Adaptive delivery with partners; integrating with humanitarian services; flexible timing and microplanning	Conflict substantially disrupted preventive chemotherapy, displacing communities and lowering coverage, and the authors recommend flexible, risk-

					Approximately 41% of districts are classified as "hard-to-reach," limiting program coverage. Funding gaps: Reduced international support has weakened the sustainability of NTD programs.		informed MDA jointly planned with humanitarian actors to protect elimination timelines.
Sangare *et al.* (2024)	Internally Displaced Persons (IDPs), nomads/transhumants, economic migrants, Seasonal migrants	Mass Drug Administration (MDA) for schistosomiasis, using praziquantel. The study explored qualitative insights into barriers and facilitators of MDA participation rather than implementing a new intervention.	Livelihood, conflict, migration	MDA campaigns often coincide with periods of high mobility (e.g., rainy season for farming or dry season for mining), leading to missed treatments. Mobility contributed to "never-treated" clusters, risking disease resurgence and hindering elimination goals. Static MDA strategies failed to adapt to dynamic population movements,	Lack of communication channels and low education levels in rural and mobile populations, Lack of appropriate training and knowledge of CDD, Discrimination, Economic constraints. Seasonal observations on population shifts	Community engagement; tailored awareness campaigns; side-effect management; flexibility in implementation	Identified why highly mobile populations remained untreated and proposed tailored, flexible strategies using Levesque's framework to improve equitable MDA access.

				resulting in coverage gaps			
Masong *et al.* (2021)	Populations underserved by NTD programs (including urban poor, migrants, nomads, people with disabilities)	Mass Drug Administration (MDA) for schistosomiasis, using praziquantel. The study evaluated both school-based (targeting children) and community-based (door-to-door) distribution strategies.	Livelihood change, displacement, service-seeking	MDA campaigns often coincided with peak farming seasons (e.g., July for planting, December for holidays), when migrant populations were absent. Mobile groups (e.g., Nigerian laborers) were consistently missed, creating reservoirs for disease transmission. Static MDA schedules failed to adapt to dynamic migration patterns, reducing effectiveness.	Inadequate sensitization campaigns, limits in CDD training around pregnancy and reproductive health; lack of alignment between distribution and community availability and the exclusion of existing formal and informal governance structures	Inclusive planning; disability-sensitive delivery; outreach in informal settlements; multilingual communication	The study identified who is left behind by NTD programs in Cameroon—particularly migrants, urban poor and people with disabilities—and recommends equity-oriented adaptations, including multilingual communication and service design that addresses mobility and accessibility needs.
Dorkenoo *et al.* (2021)	Nomadic Peuhls', refugees because of conflict. Migrant groups	Specific delivery	Work, trade, and travel	Timing Mismatch: Migrants were often absent during MDA campaigns. Cross-border movement can	Mobility: Nomadic Peuhls' transient presence complicates surveillance and treatment.	Border collaboration and targeted rapid tests; integration with port-of-entry screening	Monitoring migrant groups after LF validation was feasible and helped mitigate

	entering from neighboring endemic areas			reintroduce LF into validated areas;			reintroduction risk, supporting targeted surveillance of cross-border entrants and migrants from endemic areas helps sustain post-MDA gains
Silumbwe *et al.* (2017)	Migrants and mobile populations targeted for lymphatic filariasis (LF), MDA across SSA	Mass Drug Administration (MDA) for lymphatic filariasis (LF), primarily using albendazole, ivermectin, or diethylcarbamazine citrate (DEC).	Programmatic and contextual factors	Mobility and unregistered migrations made it difficult to estimate target populations, leading to under- or over-supply of drugs. Rapid urbanization and population movements resulted in "hard-to-reach" areas with low MDA coverage.	Lack of geographical demarcations and unregistered migrations into rapidly urbanizing areas, delayed drug deliveries at both country and community levels, inappropriate drug delivery strategies, limited number of drug distributors	Strong community engagement and supervision; tailored timing; responsive AE management; incentives for CDDs	Across SSA, MDA performance depended on context-sensitive delivery: programs that engaged community-directed strategies, aligned timing with local calendars, and ensured strong supervision achieved higher coverage.

Vegvari *et al.* (2019)	Populations across borders, (interconnected villages)	Standard MDA with adapted delivery	Work, trade, social links	Movement from untreated villages reduces the probability of elimination, especially in high-prevalence settings.	Human mobility	Coordinated, high-coverage, synchronized rounds, targeting high-mobility links	The model shows that human movement between communities with uneven coverage can sustain transmission and impede elimination, highlighting the value of synchronized, high-coverage MDA and attention to highly connected locations.
Durrans *et al.* (2019)	Displaced populations (due to disaster or conflict); emigrants and immigrants; visitors; education travel; and	Standard MDA with adapted delivery	Livelihoods (fishing, farming), caregiving, social obligations	Migrants absent during MDA rounds reduce treatment coverage Mobile individuals bring infections from untreated areas. MDA schedules are not aligned with seasonal return periods.	Migrants missing MDA campaigns due to absence during distribution. Distrust of health programs or traditional beliefs. Hard-to-reach islands with limited health infrastructure.	Community-led scheduling; mobile outreach; integrating services with travel calendars	Participants described mobility as a way of life that complicates fixed-schedule services; health interventions should adapt to seasonal calendars and

	circulatory movement						transport realities to avoid missing mobile households.
Gichuki *et al.* (2024)	Pastoralists, internally displaced people (IDPs)	Standard MDA with LNOB approach	Pasture, water access, insecurity	Refugees may reside in isolated areas with limited access to public health facilities, and include various at-risk groups such as children, women, older people, and people with disabilities	Treatment rejection, Refugees may reside in isolated areas with limited access to public health facilities and include various at-risk groups such as children, women, older people and people with disabilities	Co-design with elders; security coordination; gender-sensitive messaging	Using CBPR, the team co-created trachoma MDA strategies with pastoralist communities, strengthening trust and access despite insecurity and distance, and improving local participation.
Nditanchou *et al*. (2023)	Semi-nomadic populations in onchocerciasis foci	Standard MDA with a systematic approach	Pastoralism and trade	Disrupted planning and reduced effectiveness	Mobility, lack of awareness	Tailored timing, bivouac delivery, and combined treatment strategies	Program adaptations for semi-nomadic groups—including flexible timing and combined ivermectin–doxycycline strategies—were feasible and improved

							participation and impact indicators.
Mtuy *et al.* (2021)	Pastoralist Maasai communities	Mass Drug Administration (MDA) of azithromycin (*Zithromax*) for trachoma control, part of the SAFE strategy (Surgery, Antibiotics, Facial cleanliness, Environmental improvement).	Livestock care, seasonal grazing	MDA coincided with seasonal migration (dry season), leading to absences of men and some women.	Limited community engagement, lack of trust in government programs, and misaligned priorities such as water access and human-animal conflicts hindered MDA responses. Political-economic factors and top-down resource allocation further reduced effectiveness.	Engaging traditional leaders; flexible hours and locations; gender-sensitive approaches	Local perspectives highlighted that trachoma control must align with Maasai mobility patterns and social structures; flexible, leader-endorsed delivery is essential to reach remote manyattas.
West *et al.* (2015)	Communities undergoing trachoma MDA with incoming migrants	Standard MDA with adapted delivery	Work and family movement	Re-emergent infection due to migration may slow progress toward elimination.	Some migrant families may have been missing if they moved in and out between censuses	Enhanced surveillance; screening/targeting for new arrivals; synchronized coverage across adjacent areas	The study found that migrants from endemic areas posed a measurable risk of reintroducing C. trachomatis into communities

							undergoing MDA, suggesting the value of monitoring and targeted strategies for newcomers.
Harvey *et al.* (2022)	Refugees (e.g., Cameroonians fleeing conflict into Nigeria). Internally displaced persons (IDPs) within Nigeria and Niger due to conflict, violence, and natural disasters.	Standard MDA with adapted delivery	Conflict, disasters, persecution	Mobile populations are often missed in standard MDA rounds due to transient residence. Fluctuating camp populations complicate census-taking and coverage estimates.	Lack of data on displaced populations' locations and sizes. Insecurity in conflict zones limiting access.	Joint planning with humanitarian clusters; inclusion in essential service packages; flexible supply chains	The paper recommends integrating NTD programming into humanitarian response to reach refugees and IDPs, emphasizing joint planning, protection-sensitive delivery, and equitable access.
Bush *et al.* (2018)	Cross-border communities with ongoing transmission	Standard MDA with adapted delivery	Trade, social ties, pastoralism	Disrupted planning, MDA coverage reduced and reduced effectiveness	Language differences, Lack of coordination in MDA schedules, the lack of availability or non-release of funds by	Binational agreements; joint microplanning; shared entomological/xenomonitoring data	Cross-border movement is a critical driver of persistent onchocerciasis transmission; coordinated binational

					governments for CB activities, the lack to date of including CB issues in programmatic planning		MDA and data sharing are necessary to achieve elimination.
Sanders *et al.* (2019)	South Sudanese refugees living in camp in White Nile state	Standard MDA with adapted delivery	Conflict and insecurity	Refugees may reside in isolated areas with limited access to public health facilities and include various at-risk groups such as children, women, older people and people with disabilities	not reported	Camp-specific microplanning; integration with WASH and case management	Refugee camps hosted substantial trachoma prevalence, supporting the need for camp-tailored SAFE implementation, including MDA and improved WASH services.
Seck *et al.* (2023)	Nomadic pastoralist	Standard MDA with adapted delivery	Pastoral livelihoods and water access	Disrupted planning and reduced effectiveness	not reported	Mobile outreach and timing with transhumance; targeted screening	Seroprevalence to Schistosoma soluble egg antigen among nomadic pastoralists indicated ongoing exposure, highlighting the need for targeted

							surveillance and MDA strategies aligned with transhumance patterns.
Perez-Saez *et al.* (2015)	Human mobility in general	N/A	Agricultural activities, fishing, labor migration, seasonal transhumance	Interestingly, intense human mobility was also shown to exacerbate the impact of the building of the dams in the case of high levels of urban contamination and exposure rates. Mobility patterns created spatial heterogeneity in exposure and transmission, which would reduce the effectiveness of MDA if programs do not account for seasonal and occupational migration.	High spatial heterogeneity of exposure due to mobility; uneven access to preventive chemotherapy if programs are not adapted to movement patterns	Integration of spatial mobility data into program design and resource allocation could optimize targeting to achieve sustainable interruption of transmission.	The study demonstrated that both human mobility and water resource development play critical roles in shaping schistosomiasis transmission in Burkina Faso. Seasonal and occupational mobility patterns significantly affect exposure risk, creating hotspots of persistent transmission.
Ervin *et al.* (2016)	Newcomers and Travelers	Standard MDA with	Resettlement, temporary labor,	Disrupted planning and reduced effectiveness,	High turnover of population; difficulty	Incorporating surveillance for new arrivals and	The ASANTE trial highlighted

		adapted delivery	visiting relatives, trade	newcomers and travelers were frequently missed by routine MDA,	identifying and treating newcomers in time; risk of untreated individuals sustaining transmission	systematic outreach helped ensure higher treatment equity.	that newcomers and travelers were frequently missed by standard community-wide azithromycin MDA, undermining elimination goals for trachoma.

Characteristics and thematic focus of included studies

The articles focused on mobile populations of all ages in Africa, including children and adults eligible for MDA of PC-NTDs. Interventions were delivered in various settings, such as schools, health centers, communities. The selected studies examined four key themes: 1) mobility drivers and challenges of delivering MDA to mobile populations; 2) impact of mobility on MDA coverage; 3) successful strategies for improving MDAs; and 4) key recommendations including gaps and proposed solutions for future MDA research.

Drivers of mobility, patterns and barriers to MDA delivery

Dynamic mobility patterns amongst the populations in the papers were found to be driven by a range of factors. Livelihood-related movements, such as seasonal migration for agricultural or construction work, traditional gold and mining, and transhumance among pastoralist communities, cause frequent and often unpredictable population shifts in many settings (Baayenda et al., 2023; Nditanchou et al., 2023). Studies included in this review found that mobility patterns often fall outside of the fixed timelines and geographic boundaries of planned MDA campaigns, reducing the likelihood that these populations are reached at the necessary time and place.

Mobile populations including nomadic pastoralists, migrant laborers, IDPs, and refugees experience lower MDA coverage compared to settled populations due to their movement patterns as documented by existing studies (Adams et al., 2022; Harvey et al., 2022). Seasonal migration, driven by work opportunities, climate variability, or conflict, further contributes to missed treatments and inconsistent MDA access (Durrans et al., 2019; Sangare et al., 2024) For example, pastoralist communities face exclusion due to their reliance on cattle movements, which rarely align with fixed MDA campaign schedules (Gichuki et al., 2024; Mtuy et al., 2019).

In Cameroon, static MDA schedules failed to adapt to the cyclical migration of Nigerian laborers, creating reservoirs for schistosomiasis transmission (Masong et al., 2021). In Nigeria, a study by Ajakaye et al. (2022) found that pastoralists migrating between Ramsar wetlands exhibited significantly higher schistosomiasis prevalence due to missed MDA opportunities. This study also emphasized the difficulty of reaching these mobile populations with MDA targeting

schistosomiasis (Ajakaye et al., 2022). Similarly, in Burkina Faso, intense human mobility linked to dam construction exacerbated schistosomiasis transmission (Perez-Saez et al., 2015).

Environmental pressures including recurrent droughts, floods, and resource scarcity, particularly in areas that are ecologically vulnerable, force communities to relocate in search of water, grazing lands, or food security (Ajakaye et al., 2022; Vegvari et al., 2019). Such movements can be sudden and unexpected, making MDA and other health services delivery even more difficult.

Finally, studies indicate that **conflict, insecurity, and forced displacement** driven by armed conflicts and political instability contribute to irregular population movements, particularly in border regions and areas of crisis (Badia-Rius et al., 2024; Dorkenoo et al., 2021; Durrans et al., 2019; Harvey et al., 2022). Displaced populations may reside in informal settlements, refugee camps, or move across districts or national boundaries, making it difficult for NTD programs to identify, register, and follow up with eligible individuals (Badia-Rius et al., 2024; Sanders et al., 2019). In Togo, Dorkenoo et al. (2021) identified that the cross-border movement of nomadic Peuhls posed a risk of reintroducing lymphatic filariasis into areas that had achieved validation of elimination, as these mobile groups were frequently missed by surveillance and treatment campaigns (Dorkenoo et al., 2021). In Mozambique's Cabo Delgado province, a desk analysis conducted by Badia-Rius et al. (2024) highlighted that conflicts and forced displacement have systematically excluded IDPs from MDA, thereby disrupting the elimination timelines (Badia-Rius et al., 2024). Similarly, refugee camps in Sudan reported persistent trachoma transmission due to cross-border mobility (Bush et al., 2018; Sanders et al., 2019).

Because of these movement patterns, MDA programs can have significant operational challenges in delivering MDA consistently to mobile and migrant populations. These include logistical barriers such as difficulties in timely drug distribution or tracking eligible individuals across borders or informal settlements (Dorkenoo et al., 2021; Silumbwe et al., 2017). In addition, inadequate awareness about MDA campaigns due to limited community engagement and limited health education among transient groups were reported in a few studies (Masong et al., 2021; Mhiche et al., 2025; Rusike et al., 2025; Silumbwe et al., 2019). In Mali, low education levels and discrimination reduced participation amongst mobile populations, and instances of never treatment were reported due to exclusion from community-based drug distribution

(Sangare et al., 2024). Additional barriers to MDA delivery also included the presence of language and cultural differences, which hindered communication and trust in health programs (Bush et al., 2018). A systematic review identified the lack of tailored intervention strategies for mobile groups (Silumbwe et al., 2017)**.**

Impact of population mobility on MDA coverage and effectiveness

Population movement significantly hinders the success of MDA initiatives targeting the elimination of NTDs in Africa, as measured by reported coverage and epidemiological coverage (WHO, 2025). As highlighted by several studies, mobile populations such as nomadic pastoralists, refugees, IDPs, seasonal laborers/workers, and cross-border populations are frequently missed by national MDA programs, leading to inconsistent coverage, ongoing or re-introduction of transmission, and diminished program effectiveness (Adams et al., 2022; Ajakaye et al., 2022; Dorkenoo et al., 2021; Mtuy et al., 2021; Nditanchou et al., 2023; Sangare et al., 2024; Seck et al., 2023; Baayenda et al., 2023). In pastoralist and nomadic settings, research from Nigeria, Senegal, and Tanzania have documented direct links between **mobility and limited MDA reach** (Ajakaye et al., 2022; Mtuy et al., 2021; Seck et al., 2023). These studies show that pastoralist populations exhibit elevated disease burden and lower MDA participation due to constant movements, remote locations, and cultural barriers. Mtuy et *al*. (2021) in Tanzania, research emphasized how geographic isolation and mistrust created operational hurdles in mobile population groups (Mtuy et al., 2021).

Multiple works highlight how **mobile groups are structurally excluded** due to inadequate planning, poor community engagement, and health system inflexibility (Adams et al., 2022; Masong et al., 2021; Sangare et al., 2024). In Mali, seasonal migration for farming and mining led to clusters of never treated individuals, perpetuating schistosomiasis transmission (Sangare et al., 2024). Similarly, in Cameroon, Nigerian migrant laborers were consistently missed during MDA rounds, creating reservoirs for schistosomiasis (Masong et al., 2021). Reaching mobile populations is not only a matter of equity and social justice (which is essential), but also of absolute necessity to protect the gains that have been made. With the failure to treat mobile and migrant groups, programs risk persistent reservoirs of infection that can undermine overall progress.

Beyond routine mobility, **conflict-driven displacements** exacerbated the strain to MDA efforts (Badia-Rius et al., 2024; Harvey et al., 2022; Sanders et al., 2019). For example, Badia-Rius et al. (2024) documented disrupted MDA activities in Mozambique's conflict zones, while Sanders et al. (2019) reported that South Sudanese refugees in Sudan were not included in national treatment registers (Sanders et al., 2019). In Niger, refugees in isolated settlements faced limited access to MDA due to security threats and logistical gaps (Harvey et al., 2022).

Cross-border movement is another major factor that further impedes MDA success (Bush et al., 2018; Nditanchou et al., 2023; Baayenda et al., 2023). These papers emphasized those transhumant pastoralists who cross national borders and create gaps in coordination between countries, risking reintroduction of infections into treated zones and delaying regional elimination efforts' positive impacts. The transhumance of nomadic Peuhls across districts of Togo, coupled with conflicts with local farmers, frequently led to their absence during MDA campaigns, thereby sustaining lymphatic filariasis transmission (Dorkenoo et al., 2021). Similarly, in West and Central Africa, uncoordinated cross-border MDA schedules resulted in untreated mobile populations (Bush et al., 2018). Baayenda et al. (2023) described how uncoordinated national MDA campaigns in Uganda, Kenya, and Tanzania for trachoma were undermined by cross-border mobility of pastoralists, which allowed for reinfection and sustained transmission (Baayenda et al., 2023).

The consequence of these operational challenges is **the persistence of NTD transmission** in both mobile and host communities. For instance, Adams et al. (2022) found that these populations are often missed during fixed campaign periods, resulting in pockets of untreated individuals who sustain transmission cycles (Adams et al., 2022). Other studies from Tanzania and Kenya found that migrants were 2.5 times more likely to be infected with trachoma than resident populations, directly contributing to re-emergent infections in communities undergoing MDA (Gichuki et al., 2024; West et al., 2015). Furthermore, uncoordinated MDA efforts led to re-emergent trachoma infections via migrant reintroduction (Ervin et al., 2016; West et al., 2015). Finally, in sub-Saharan Africa, movement from untreated villages appeared to reduce the probability of elimination by 30% in some high-prevalence settings (Vegvari et al., 2019).

Studies recommended adapting interventions to the respective cultural and geographical contexts. Gichuki et *al*. (2024) found that participatory approaches of campaigns improved MDA

uptake in Kenya's conflict areas (Gichuki et al., 2024). Sangare et *al*. (2024) emphasized aligning MDA campaigns with local movement patterns (Sangare et al., 2024). Synchronized cross-border MDA in Tanzania, Kenya, and Uganda has been reported to increase access and decrease the number of populations missed (Baayenda et al., 2023). Modeling studies also support the disruptive effect of mobility (Ajakaye et al., 2022; Durrans et al., 2019; Vegvari et al., 2019) demonstrating how untreated mobile individuals sustain transmission of soil-transmitted helminths, urging dynamic MDA strategies. These findings emphasize the need for flexible MDA delivery strategies that align with mobility patterns, rather than relying solely on fixed geographical targets. In line with this, the flexible delivery in our discussion explicitly includes integrated drug delivery strategies to optimize coverage and minimize parallel, uncoordinated efforts.

Successful strategies documented and proposed solutions for future effective MDA

Key strategies have emerged from the evidence to improve MDA outcomes among mobile populations:

i] ***Integrate mobility mapping into MDA microplanning.***

The paths taken by migrating populations and their settlement patterns should be accurately identified. Multiple studies recommend incorporating real-time mobility data into national MDA policies to better capture missed populations and guide adaptive delivery strategies (Adams et al., 2022; Dorkenoo et al., 2021; Vegvari et al., 2019). For instance, a study documented how cross-border trachoma programs in Uganda, Kenya, and Tanzania mapped pastoralist cattle-migration routes to align MDA campaigns with seasonal population movements (Baayenda et al., 2023). Health teams coordinated between districts and across borders, using local knowledge of cattle camps and migration calendars to ensure that mobile pastoralists received treatment. This approach directly improved MDA reach among highly mobile pastoralist groups, reducing systematic exclusion due to seasonal mobility. This demonstrated the use of field-validated mobility mapping as a microplanning tool (Baayenda et al., 2023).

Similarly, Nditanchou et al. (2024) implemented mobility mapping in MDA microplanning, to better improve coverage in hard-to-reach mobile groups. The program adapted treatment delivery to semi-nomadic Fulani herders by mapping seasonal transhumance patterns (where and when herders move with cattle). Community distributors and health workers planned

flexible treatment points along migration routes, and timed ivermectin + doxycycline delivery with seasonal presence of nomads. Reported uptake improved, showing that mobility-informed planning can reduce systematic non-treatment. (Nditanchou et al., 2024).

ii] ***Enhance cross-border and regional collaboration.***

Given the transboundary nature of many mobile populations, studies emphasized the importance of harmonized MDA campaigns between neighboring countries, shared surveillance data, and coordinated health policies to prevent reinfection across borders (Bush et al., 2018; Nditanchou et al., 2023; Baayenda et al., 2023); For example, to work together to eliminate trachoma among cross-border nomadic populations, Kenya, Tanzania, and Uganda have adopted a strategy known as "synchronized MDA." The initiative intends to control *Chlamydia trachomatis* infections by administering antibiotics to the entire population in endemic areas across borders during the same treatment period. The implementation of MDA and TT surgery in April 2019 reached an additional 40,000 people in eight nomadic border regions with MDA thanks to collaborative planning meetings that resulted in successful social mobilization, team selection, and unanimous support from local leaders (Baayenda et al., 2023).

A similar collaboration in Tanzania and Kenya MDA in July and December 2022 targeted nomadic Maasai communities along their shared border. Through joint planning, community mobilization, and coordinated supervision, the campaign reached about one million people in five days. This approach overcame the limitations of isolated interventions and marked a shift toward a more coordinated regional strategy for trachoma elimination (Baayenda et al., 2023).

iii] ***Adopt flexible and decentralized delivery models*****.**

Adapting MDA timing and methods to seasonal and cultural calendars is critical. Evidence from Mtuy et *al.* (2019, 2021), Ajakaye et *al.* (2022), and Seck et al. (2023) supported using mobile outreach teams, integration with routine services, and alignment with community events to increase participation (Ajakaye et al., 2022; Mtuy et al., 2019, 2021; Seck et al., 2023). In Baringo County, Kenya, a conflict-affected pastoral area, MDA coverage for trachoma remained low (around 68%), below the WHO recommended threshold (80%). The authors implemented a participatory community approach in several phases (pre-intervention, intervention, post-intervention), involving the community in identifying barriers to participation and access to MDA. This approach aimed at adapting mobilization and treatment delivery

methods to reflect the realities of the local population, including mobility patterns and specific constraints. As a result, the overall MDA coverage in the area increased from 67.6% in 2021 to 87% in 2023 thus meeting the WHO threshold of 80%. MDA coverage of trachoma and other neglected tropical diseases has improved as a result of the application of community-based, participatory methodologies in the development and implementation of data-driven strategies. (Gichuki et al., 2024). Masong et al. (2021) further emphasize that migrant farmers, seasonal workers, out-of-school children, and women of childbearing age were regularly overlooked. They recommend stronger collaboration with local governance and more flexible planning to ensure no population groups are left behind. (Masong et al., 2021).

iv] ***Prioritize inclusion and community engagement.***

Meaningful participation of mobile groups in program design fosters trust and ownership. Kenya's synchronized MDA approach exemplifies the strong involvement of community leaders (Baayenda et al., 2023). Similarly, studies recommend engaging traditional leaders, local health actors, and community representatives to design culturally appropriate and context specific interventions (Adams et al., 2022; Gichuki et al., 2024; Sangare et al., 2024).

v] ***Monitor migrant populations in elimination and post-elimination settings*****.**

Continuous monitoring is essential to prevent re-emergence. Research in Togo after LF elimination shows the value of migrant-focused surveillance, where seasonal workers, nomadic Peulhs, traders, and cross-border migrants were actively screened to prevent resurgence. This approach complemented Transmission Assessment Surveys (TAS), which primarily focus on resident populations (Dorkenoo et al., 2021)**.**

vi] ***Address structural inequities in program design*****.**

To ensure equity, NTD programs must explicitly target those at risk of being left behind. Integrating equity frameworks into national NTD policies and strategies can close access gaps for some mobile populations, as demonstrated by some studies (Adams et al., 2022; Badia-Rius et al., 2024). The review by Adams et al. (2022), highlights that although most programs still rely on census-based planning which excludes mobile populations, some projects have adapted through the use of participatory mapping of migration routes, use of GPS/GIS tools, and time-location sampling to reach mobile populations. These remain exceptions rather than standard practice, showing progress but not yet systemic change (Adams et al., 2022).

5.11. Discussion

We conducted a scoping review to explore current evidence of the impact of mobility on MDA delivery, coverage and effectiveness for NTDs in Africa. The review found that mobility particularly among nomad pastoralists, seasonal workers, IDPs, and cross-border populations leads to systematic exclusion from MDA campaigns. While some barriers appear universal, effective and documented solutions vary considerably across geographic contexts and types of mobility. The following discussion summarizes these findings, examines their implications for policy and practice, identifies limitations in the existing literature, and proposes directions for future research.

Our analysis identified four main themes: challenges related to mobility, impact on MDA coverage, effective strategies, and policy recommendations. The reviewed studies consistently indicate that mobile populations have lower MDA coverage than sedentary populations. This exclusion is explained by complex mobility patterns, often driven by economic, environmental, and political factors (Adams et al., 2022; Durrans et al., 2019; Harvey et al., 2022; Sangare et al., 2024). For example, transhumant herders are frequently absent during fixed campaigns (Gichuki et al., 2024), while those displaced by conflict escape health registries in their districts of origin and are not taken into account in the registrations in their host districts (Badia-Rius et al., 2024). Similarly to MDA campaigns, studies show that mobile populations experience significantly lower immunization rates compared to settled communities (Masong et al., 2021; Nditanchou et al., 2023; Onigbogi et al., 2025; Sanders et al., 2019). Seasonal migrants frequently miss scheduled immunizations (Wang-Lu et al., 2025), while conflict-displaced populations fall through gaps between home and host regions (Swartz et al., 2025). In Kenya, Gamino *et al.* (2016) reported significantly lower vaccination rates among nomadic children (28%) compared to settled populations (85%) (Gammino et al., 2016) . These disparities in coverage stem from complex mobility dynamics influenced by factors such as economic hardship, environmental stressors, and political instability (Mishra et al., 2020; Swartz et al., 2025; Wang-Lu et al., 2025). Although these examples come from the literature on vaccination rather than NTD-specific MDA, they offer relevant parallels. These findings highlight the weakness of health campaigns (including vaccinations and NTDs programs) in reaching highly mobile population groups.

The impact of these mobility patterns on MDA campaigns also varies depending on their nature of mobility. Pastoral populations, such as transhumant herders in the Sahel, mainly suffer

from a temporal misalignment with fixed campaigns (Mtuy et al., 2021). Mobile populations often remain invisible to health systems due to poor enumeration. Many MDA failures are rooted in the systemic lack of data on these groups. These challenges are not unique to MDA campaigns; similar challenges have been documented in measles supplemental immunizations in Chad, Ghana and northern Kenya, where nomadic and pastoralist groups were repeatedly missed during campaigns due to their mobility (Abakar et al., 2018; Afari-Asiedu et al., 2024; Pertet et al., 2018). Moreover, similar operational barriers have also been observed in seasonal malaria chemoprevention campaigns, where mobile nomadic populations where missed because they were often excluded in the enumeration data, reducing the overall effectiveness of the interventions (Moukénet, Donovan, et al., 2022; Moukénet, Honoré, et al., 2022).

Implications for policy, practice, and strengthening health systems

The results from this review are more applicable to operational research settings, and have relevant policy and public health implications. The pattern of barriers and enablers suggests that the main challenge in reaching these populations is largely systemic and not technical, reflecting failures in the implementation of well-known solutions rather than gaps in technical knowledge. First, addressing the loss of valuable health information, is critical: national programs should adopt innovative enumeration strategies such as mobile phone data analysis, satellite imagery, time-location sampling, and integration with refugee/IDP registries to make mobile populations visible to health systems. Second, national programs should incorporate mobility data into their microplanning to strengthen their planning systems. Third, using real-time mapping tools to track mobile groups could reduce omissions in reaching these mobile groups. Fourth, cross-border partnerships should be institutionalized, with harmonized protocols, dedicated funding, and permanent health committees to reduce dependence on individual leaders. As well, pre - post-elimination surveillance systems should be adapted to include mobile and migrant groups. In summary, the evidence suggests the need for targeted or integrated strategies to ensure that mobile populations are not overlooked in MDA and other public health services. The evidence presented here indicates that such approaches could significantly improve MDA services. These findings underscore the need for flexible integrated drug delivery, mobile, and community-tailored strategies that can be adapted across disease control programs.

Intersectionality of vulnerability. Mobility interacts with other forms of marginalization, such as language barriers, gender, socioeconomic status, and cultural norms, increasing the health vulnerabilities of these communities. Framing the issue as "mobile vs. sedentary" risks oversimplifying the problem: some settled populations experience exclusion due to similarly intersecting vulnerabilities. Effective strategies, including the use of trusted intermediaries, multilingual communications, and culturally appropriate services, are relevant not only for mobile populations but also for a broader set of hard-to-reach groups. Adopting an intersectional lens expands the relevance of MDA solutions beyond mobility alone. Integrating these considerations into planning and implementation can increase the relevance and equity impact of MDA campaigns. This suggests that programs need to adopt a much more systemic approach.

Institutionalizing innovation. The study also highlights successful cases of MDA implementation where exceptional leadership and efficient problem solving have overcome bureaucratic and/or financial obstacles (Baayenda et al., 2023; Silumbwe et al., 2017). These successes are fragile and may be unsustainable, especially given high turnover of health personnel. Future policy recommendations should focus on institutionalizing innovations that include permanent cross-border committees, professional incentives for healthcare workers during campaigns, and integrated flexible funding mechanisms to reduce reliance on temporary funding support.

5.12. Limitations and future research directions

This review has some limitations in both the evidence extracted from the search and in the analysis. We deliberately limited our search to mobile populations and NTDs for which the WHO recommends MDA for control and elimination, and to English and French literature published after the year 2000 to February 2025. Excluding related programs such as vaccination and seasonal malaria chemoprevention likely narrowed the scope of relevant insights and reduced opportunities for cross-disease program learning. Most of the studies included were qualitative or descriptive, with limited use of rigorous quantitative or comparative methods. A limitation of this review is the lack of a structured search of gray literature, which may have resulted in the omission of relevant reports or evaluations that were not captured through our informal approach. As this is a scoping review, no formal quality assessment was performed,

which limits our ability to comment on the robustness of the included evidence. Very few studies provided clear figures comparing MDA coverage between mobile and sedentary populations, which restricts our ability to draw generalizable conclusions and suggests potential publication bias. More importantly, no study has yet evaluated the cost-effectiveness of adaptive MDA program strategies, nor quantified the relative contribution of mobility versus other intersecting vulnerabilities. Future research should prioritize rigorous comparative studies to evaluate adaptive MDA strategies and inform policy.

5.13. Conclusion

This review reveals the critical importance of including mobile populations in NTD elimination efforts. While challenges remain significant, the evidence supports a shift from rigid and fixed approaches to more flexible, dynamic, and context-specific strategies for mobile communities. Future steps should include the development of mobility and enumeration indicators, testing flexible and integrated MDA delivery tailored to movement patterns, and establishing partnerships with other health campaigns such as immunization. Achieving equitable MDA coverage will require multisectoral coordination, dedicated funding, and political will to balance standardized protocols with locally adapted delivery models. Filling data gaps and addressing the intersectional vulnerabilities of mobile and marginalized populations is vital to achieving the goal of eliminating NTDs. In the same way, institutionalizing innovative approaches to service delivery ensures that successes are sustainable and scalable. Failure to reach these groups could reverse decades of progress. Ensuring that elimination strategies explicitly integrate mobility considerations, intersectional vulnerability, and sustainable innovations will help secure irreversible interruption of transmission.

Abbreviations

ABS: Australian Bureau of Statistics; CDC: Centers for Disease Control and Prevention; GIS: Geographic Information Systems; GPELF: Global Program for the Elimination of Lymphatic Filariasis; IDPs: Internally Displaced Persons; JBI: Joanna Briggs Institute methodology; LF: Lymphatic Filariasis; MDA: Mass Drug Administration; MMPs: Mobile and Migrant Populations; NTDs: Neglected Tropical Diseases; PRESS: Peer Review of Electronic Search Strategies; PRISMA-P: Preferred Reporting Items for Systematic Reviews and Meta-

Analysis Protocols; PC-NTDs: Preventive Chemotherapy NTDs; PRISMA-ScR: PRISMA Extension for Scoping Reviews; STPH: Swiss Tropical And Public Health Institute; ILO: The International Labour Organization; IOM: The International Organization for Migration; PROSPERO: The International Prospective Register of Systematic reviews; USAID: The United States Agency for International Development; UNHCR: United Nations High Commissioner for Refugees; USTTB: Université des Sciences, des Techniques et des Technologies de Bamako; WHO: World Health Organization.

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Data availability

The datasets generated and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

- **Ethics approval and consent to participate.** As this review used only published or publicly available data, no ethical approval was required. All procedures followed principles of scientific integrity for scoping reviews.
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Appendices

Appendix 9. Medline (Ovid) database final strategy search

	Ovid MEDLINE(R) ALL <1946 to February 19, 2025>	
#	**Query**	**Results from 20 Feb 2025**
1	exp Population Dynamics/	86,319
2	population dynamic*.ti,ab,kf.	42,190
3	exp "Emigration and Immigration"/ or exp "Emigrants and Immigrants"/ or exp "Transients and Migrants"/	53,462
4	(Migrant? or migration? or Transient? or Emigrant? or Immigrant? or refugee?).ti,ab,kf.	769,316
5	exp Human Migration/	28,352
6	Refugees/ or Refugee Camps/	14,614
7	Cross-border population*.ti,ab,kf.	29
8	(Internally displaced adj2 (person* or people or population)).ti,ab,kf.	863
9	(pastoral* or nomad* or transhum*).ti,ab,kf.	7,918
10	Travel pattern*.ti,ab,kf.	469
11	("no one behind" or ("no one" adj2 "left behind")).ti,ab,kf.	403
12	or/1-11	868,090
13	exp Filariasis/ or exp Elephantiasis, Filarial/ or exp Mass Drug Administration/ or exp Albendazole/	21,599
14	(Drug distribution campaign or community-based treatment or (mass adj2 (administration* or treatment)) or NTD program* or MDA adherence or MDA uptake or MDA coverage).ti,ab,kf.	6,447
15	exp Trachoma/ or exp Ivermectin/ or exp Onchocerciasis/ or exp Schistosomiasis/ or exp Anthelmintics/	99,921

16	(Mass Chemotherap* or Preventive chemotherap*).ti,ab,kf.	1,051
17	(Health adj2 (intervention* or system?)).ti,ab,kf.	201,341
18	(Health equity or (access adj1 healthcare) or healthcare barrier* or (health adj2 system strengthening) or implementation).ti,ab,kf.	430,360
19	exp Neglected Diseases/ or exp Helminthiasis/ or exp Schistosomiasis/ or exp Tropical Medicine/	145,504
20	(Disease? adj2 (elimination or control or eradication)).ti,ab,kf.	87,970
21	Neglected Tropical disease?.ti,ab,kf.	6,485
22	(Lymphatic filariasis* or Bancroftian filariasis or Brugia malayi or Brugia timori or Filarial lymphedema or Wuchereria bancrofti).ti,ab,kf.	6,506
23	(Onchocerciasis* or river blindness or onchocerca volvulus).ti,ab,kf.	5,290
24	(Schistosomiasis* or Bilharziasis or Snail fever or Schistosome or Schistosoma haematobium or (Schistosoma adj2 (mansoni or japonicum or mekongi or intercalatum))).ti,ab,kf.	33,328
25	(Soil-transmitted helminth* or Geohelminths or Intestinal helminths or Hookworm infection or Ankylostomose or Ancylostoma duodenale or Necator americanus or Ascariasis or Ascaris lumbricoides or Trichuriasis or Trichuris trichiura or Roundworm infection).ti,ab,kf.	11,871
26	(Trachoma* or ("Chronic conjunctivitis" and "Chlamydia trachomatis")).ti,ab,kf.	20,114
27	Parasitic infection*.ti,ab,kf.	11,226
28	Vector-borne disease*.ti,ab,kf.	6,100
29	or/13-28	925,872
30	Africa/ or exp Africa South of the Sahara/	308,626
31	(africa or Angola or Congo or Ghana or Mauritius or Sierra Leone or Benin or Cote d'Ivoire or Guinea or Somalia or Botswana or Guinea-Bissau or Mozambique or South Africa or Burkina Faso or Djibouti or Kenya or Namibia or Sudan or Burundi or Equatorial Guinea or Lesotho or Niger or Cabo Verde or Eritrea or Liberia or Nigeria or Togo or Cameroon or	500,552

	Eswatini or Madagascar or Rwanda or Tanzania or Central African or Ethiopia or Malawi or Sao Tome or Uganda or Chad or Gabon or Mali or Senegal or Zambia or Comoros or Gambia or Mauritania or Seychelles or Zimbabwe).ti,ab,kf.	
32	30 or 31	574,619
33	12 and 29 and 32	3,108
34	limit 33 to (english or french)	2,973
35	limit 34 to yr="2000 -Current"	2,293

exp Population Dynamics/
population dynamic*.ti,ab,kf.
exp "Emigration and Immigration"/ or exp "Emigrants and Immigrants"/ or exp "Transients and Migrants"/
(Migrant? or migration? or Transient? or Emigrant? or Immigrant? or refugee?).ti,ab,kf.
exp Human Migration/
Refugees/ or Refugee Camps/
Cross-border population*.ti,ab,kf.
(Internally displaced adj2 (person* or people or population)).ti,ab,kf.
(pastoral* or nomad* or transhum*).ti,ab,kf.
Travel pattern*.ti,ab,kf.
("no one behind" or ("no one" adj2 "left behind")).ti,ab,kf.
or/1-11
exp Filariasis/ or exp Elephantiasis, Filarial/ or exp Mass Drug Administration/ or exp Albendazole/
(Drug distribution campaign or community-based treatment or (mass adj2 (administration* or treatment)) or NTD program* or MDA adherence or MDA uptake or MDA coverage).ti,ab,kf.
exp Trachoma/ or exp Ivermectin/ or exp Onchocerciasis/ or exp Schistosomiasis/ or exp Anthelmintics/
(Mass Chemotherap* or Preventive chemotherap*).ti,ab,kf.
(Health adj2 (intervention* or system?)).ti,ab,kf.
(Health equity or (access adj1 healthcare) or healthcare barrier* or (health adj2 system

strengthening) or implementation).ti,ab,kf.
exp Neglected Diseases/ or exp Helminthiasis/ or exp Schistosomiasis/ or exp Tropical Medicine/
(Disease? adj2 (elimination or control or eradication)).ti,ab,kf.
Neglected Tropical disease?.ti,ab,kf.
(Lymphatic filariasis* or Bancroftian filariasis or Brugia malayi or Brugia timori or Filarial lymphedema or Wuchereria bancrofti).ti,ab,kf.
(Onchocerciasis* or river blindness or onchocerca volvulus).ti,ab,kf.
(Schistosomiasis* or Bilharziasis or Snail fever or Schistosome or Schistosoma haematobium or (Schistosoma adj2 (mansoni or japonicum or mekongi or intercalatum))).ti,ab,kf.
(Soil-transmitted helminth* or Geohelminths or Intestinal helminths or Hookworm infection or Ankylostomose or Ancylostoma duodenale or Necator americanus or Ascariasis or Ascaris lumbricoides or Trichuriasis or Trichuris trichiura or Roundworm infection).ti,ab,kf.
(Trachoma* or ("Chronic conjunctivitis" and "Chlamydia trachomatis")).ti,ab,kf.
Parasitic infection*.ti,ab,kf.
Vector-borne disease*.ti,ab,kf.
or/13-28
Africa/ or exp Africa South of the Sahara/
(africa or Angola or Congo or Ghana or Mauritius or Sierra Leone or Benin or Cote d'Ivoire or Guinea or Somalia or Botswana or Guinea-Bissau or Mozambique or South Africa or Burkina Faso or Djibouti or Kenya or Namibia or Sudan or Burundi or Equatorial Guinea or Lesotho or Niger or Cabo Verde or Eritrea or Liberia or Nigeria or Togo or Cameroon or Eswatini or Madagascar or Rwanda or Tanzania or Central African or Ethiopia or Malawi or Sao Tome or Uganda or Chad or Gabon or Mali or Senegal or Zambia or Comoros or Gambia or Mauritania or Seychelles or Zimbabwe).ti,ab,kf.
30 or 31
12 and 29 and 32
limit 33 to (english or french)
limit 34 to yr="2000 -Current"
https://login.proxy.bib.uottawa.ca/login?url=http://ovidsp.ovid.com/ovidweb.cgi?T=JS&NEWS=

N&PAGE=main&SHAREDSEARCHID=1CqcoPrieOK5CrW85VooEwRjvdfs9zSJqQVhEEhOgpenAiaV5qPijFk7088xHgKuk

Appendix 10. EMBASE database final strategy search

	Embase Classic+Embase <1947 to 2025 February 19>	
#	**Query**	**Results from 20 Feb 2025**
1	population dynamics/	60,175
2	population dynamic*.ti,ab,kf.	18,680
3	migration/ or forced migration/ or immigration/ or exp migrant/	104,166
4	(Migrant? or migration? or Transient? or Emigrant? or Immigrant? or refugee?).ti,ab,kf.	975,600
5	refugee/ or asylum seeker/ or refugee camp/	20,748
6	Cross-border population*.ti,ab,kf.	36
7	(Internally displaced adj2 (person* or people or population)).ti,ab,kf.	929
8	(pastoral* or nomad* or transhum*).ti,ab,kf.	8,681
9	Travel pattern*.ti,ab,kf.	498
10	("no one behind" or ("no one" adj2 "left behind")).ti,ab,kf.	437
11	or/1-10	1,074,514
12	exp filariasis/ or exp lymphatic filariasis/ or exp onchocerciasis/ or elephantiasis/ or albendazole/ or mass drug administration/	43,706
13	(Drug distribution campaign or community-based treatment or (mass adj2 (administration* or treatment)) or NTD program* or MDA adherence or MDA uptake or MDA coverage).ti,ab,kf.	9,045
14	trachoma/ or ivermectin/ or exp schistosomiasis/ or exp onchocerciasis/	62,096
15	(Mass Chemotherap* or Preventive chemotherap*).ti,ab,kf.	1,368
16	(Health adj2 (intervention* or system?)).ti,ab,kf.	258,940
17	(Health equity or (access adj1 healthcare) or healthcare barrier* or (health adj2 system strengthening) or implementation).ti,ab,kf.	555,839

18	neglected disease/ or tropical medicine/ or helminthiasis/	37,548
19	(Disease? adj2 (elimination or control or eradication)).ti,ab,kf.	125,979
20	Neglected Tropical disease?.ti,ab,kf.	7,913
21	(Lymphatic filariasis* or Bancroftian filariasis or Brugia malayi or Brugia timori or Filarial lymphedema or Wuchereria bancrofti).ti,ab,kf.	8,130
22	(Onchocerciasis* or river blindness or onchocerca volvulus).ti,ab,kf.	6,217
23	(Schistosomiasis* or Bilharziasis or Snail fever or Schistosome or Schistosoma haematobium or (Schistosoma adj2 (mansoni or japonicum or mekongi or intercalatum))).ti,ab,kf.	39,667
24	(Soil-transmitted helminth* or Geohelminths or Intestinal helminths or Hookworm infection or Ankylostomose or Ancylostoma duodenale or Necator americanus or Ascariasis or Ascaris lumbricoides or Trichuriasis or Trichuris trichiura or Roundworm infection).ti,ab,kf.	14,192
25	(Trachoma* or ("Chronic conjunctivitis" and "Chlamydia trachomatis")).ti,ab,kf.	26,074
26	Parasitic infection*.ti,ab,kf.	14,495
27	Vector-borne disease*.ti,ab,kf.	6,905
28	or/12-27	1,084,982
29	africa/ or exp "africa south of the sahara"/	416,819
30	(africa or Angola or Congo or Ghana or Mauritius or Sierra Leone or Benin or Cote d'Ivoire or Guinea or Somalia or Botswana or Guinea-Bissau or Mozambique or South Africa or Burkina Faso or Djibouti or Kenya or Namibia or Sudan or Burundi or Equatorial Guinea or Lesotho or Niger or Cabo Verde or Eritrea or Liberia or Nigeria or Togo or Cameroon or Eswatini or Madagascar or Rwanda or Tanzania or Central African or Ethiopia or Malawi or Sao Tome or Uganda or Chad or Gabon or Mali or Senegal or Zambia or Comoros or Gambia or Mauritania or Seychelles or Zimbabwe).ti,ab,kf.	609,944
31	29 or 30	692,212

32	11 and 28 and 31	3,495
33	limit 32 to (english or french)	3,383
34	limit 33 to yr="2000 -Current"	2,986

population dynamics/
population dynamic*.ti,ab,kf.
migration/ or forced migration/ or immigration/ or exp migrant/
(Migrant? or migration? or Transient? or Emigrant? or Immigrant? or refugee?).ti,ab,kf.
refugee/ or asylum seeker/ or refugee camp/
Cross-border population*.ti,ab,kf.
(Internally displaced adj2 (person* or people or population)).ti,ab,kf.
(pastoral* or nomad* or transhum*).ti,ab,kf.
Travel pattern*.ti,ab,kf.
("no one behind" or ("no one" adj2 "left behind")).ti,ab,kf.
or/1-10
exp filariasis/ or exp lymphatic filariasis/ or exp onchocerciasis/ or elephantiasis/ or albendazole/ or mass drug administration/
(Drug distribution campaign or community-based treatment or (mass adj2 (administration* or treatment)) or NTD program* or MDA adherence or MDA uptake or MDA coverage).ti,ab,kf.
trachoma/ or ivermectin/ or exp schistosomiasis/ or exp onchocerciasis/
(Mass Chemotherap* or Preventive chemotherap*).ti,ab,kf.
(Health adj2 (intervention* or system?)).ti,ab,kf.
(Health equity or (access adj1 healthcare) or healthcare barrier* or (health adj2 system strengthening) or implementation).ti,ab,kf.
neglected disease/ or tropical medicine/ or helminthiasis/
(Disease? adj2 (elimination or control or eradication)).ti,ab,kf.
Neglected Tropical disease?.ti,ab,kf.
(Lymphatic filariasis* or Bancroftian filariasis or Brugia malayi or Brugia timori or Filarial lymphedema or Wuchereria bancrofti).ti,ab,kf.
(Onchocerciasis* or river blindness or onchocerca volvulus).ti,ab,kf.
(Schistosomiasis* or Bilharziasis or Snail fever or Schistosome or Schistosoma haematobium or

(Schistosoma adj2 (mansoni or japonicum or mekongi or intercalatum))).ti,ab,kf.
(Soil-transmitted helminth* or Geohelminths or Intestinal helminths or Hookworm infection or Ankylostomose or Ancylostoma duodenale or Necator americanus or Ascariasis or Ascaris lumbricoides or Trichuriasis or Trichuris trichiura or Roundworm infection).ti,ab,kf.
(Trachoma* or ("Chronic conjunctivitis" and "Chlamydia trachomatis")).ti,ab,kf.
Parasitic infection*.ti,ab,kf.
Vector-borne disease*.ti,ab,kf.
or/12-27
africa/ or exp "africa south of the sahara"/
(africa or Angola or Congo or Ghana or Mauritius or Sierra Leone or Benin or Cote d'Ivoire or Guinea or Somalia or Botswana or Guinea-Bissau or Mozambique or South Africa or Burkina Faso or Djibouti or Kenya or Namibia or Sudan or Burundi or Equatorial Guinea or Lesotho or Niger or Cabo Verde or Eritrea or Liberia or Nigeria or Togo or Cameroon or Eswatini or Madagascar or Rwanda or Tanzania or Central African or Ethiopia or Malawi or Sao Tome or Uganda or Chad or Gabon or Mali or Senegal or Zambia or Comoros or Gambia or Mauritania or Seychelles or Zimbabwe).ti,ab,kf.
29 or 30
11 and 28 and 31
limit 32 to (english or french)
limit 33 to yr="2000 -Current"
https://login.proxy.bib.uottawa.ca/login?url=http://ovidsp.ovid.com/ovidweb.cgi?T=JS&NEWS=N&PAGE=main&SHAREDSEARCHID=4kev5FfddXrQB4UnxSVlz0WLHneBX7LjbIH8PSvou1CJgdk4gj6ZE7Gc5MWpxCtqy

Appendix 11. WEB OF SCIENCE database final strategy search

Link to launch the search in Web of Science: obtain 1,487 articles to export
https://www.webofscience.com/wos/woscc/summary/a06a0336-ffbb-4946-a4ee-85c2e7c90bce-014c4d95f9/relevance/1

TS=((((population$ NEAR/1 dynamic*) or migrant* or migration? or transient? or emigrant* or immigrant* or refugee$ or (Cross-border NEAR/1 population$) or ("Internally displaced" NEAR/2 (person* or people or population$)) or pastoral* or nomad* or transhum* or travel NEAR/1 pattern* or "no one behind" or ("no one" NEAR/2 "left behind")))) AND ((("Drug distribution campaign" or "community-based treatment" or (mass NEAR/2 (administration* or treatment)) or NTD program* or MDA adherence or MDA uptake or MDA coverage or ((mass or preventive) NEAR/1 chemotherap*) or (Health NEAR/2 (intervention* or system?)) or "Health equity" or (access NEAR/1 healthcare) or (healthcare NEAR/1 barrier*) or (health NEAR/2 ("system strengthening" or implementation)))) OR ((((Disease$ NEAR/2 (elimination or control or eradication)) or ((Neglected or Tropical) NEAR/1 disease$) or "Lymphatic filariasis" or "Bancroftian filariasis" or "Brugia malayi" or "Brugia timori" or "Filarial lymphedema" or "wuchereria bancrofti" or Onchocerciasis* or "river blindness" or "onchocerca volvulus" or trachoma or Ivermectin or onchocerciasis or anthelmintics or Filariasis or Filarial or Elephantiasis or Albendazole or Helminthiasis or Schistosom* or Bilharziasis or "Snail fever" or (Schistosoma NEAR/2 (mansoni or japonicum or mekongi or intercalatum or haematobium))))) OR (((Soil-transmitted NEAR/1 helminth*) or Geohelminths or "Intestinal helminths" or "Hookworm infection" or Ankylostomose or "Ancylostoma duodenale" or "Necator americanus" or Ascariasis or "Ascaris lumbricoides" or Trichuriasis or "Trichuris trichiura" or "Roundworm infection" or Trachoma* or "Chronic conjunctivitis" and "Chlamydia trachomatis" or (Parasitic* NEAR/1 infection*) or (Vector-borne NEAR/1 disease*)))) AND ((africa or Angola or Congo or Ghana or Mauritius or Sierra Leone or Benin or Cote d'Ivoire or Guinea or Somalia or Botswana or Guinea-Bissau or Mozambique or South Africa or Burkina Faso or Djibouti or Kenya or Namibia or Sudan or Burundi or Equatorial Guinea or Lesotho or Niger or Cabo Verde or Eritrea or Liberia or Nigeria or Togo or Cameroon or Eswatini or Madagascar or Rwanda or Tanzania or Central African or Ethiopia or Malawi or Sao Tome or Uganda or Chad or Gabon or Mali or Senegal or Zambia or Comoros or Gambia or Mauritania or Seychelles or Zimbabwe)) AND (LA==("ENGLISH" OR "FRENCH"))) AND

(PY==("2025" OR "2024" OR "2023" OR "2022" OR "2021" OR "2020" OR "2019" OR "2018" OR "2017" OR "2016" OR "2015" OR "2014" OR "2008" OR "2007" OR "2006" OR "2005" OR "2004" OR "2003" OR "2002" OR "2001" OR "2000" OR "2013" OR "2012" OR "2011" OR "2010" OR "2009"))

Appendix 12. Supplemental 2. Modified JBI template source of evidence details, characteristics and results extraction instrument

Scoping review details	
Scoping Review title:	
Review objective/s:	
Review question/s:	
Inclusion/Exclusion Criteria	
Population	
Concept	
Context	
Types of evidence source	
Evidence source Details and Characteristics	
Citation details (e.g. author/s, date, title, journal, volume, issue, pages)	
Country	
Context	
Participant details (e.g. ID, age, sex, education, country)	
Details/Results extracted from source of evidence (in relation to the concept of the scoping review)	
E.g. Quality of Life Domains assessed	
E.g. Number of items in tool	
E.g. details of psychometric validation of tool	

CHAPTER 6: DISCUSSION, LIMITATIONS AND CONCLUSION

Overview

This chapter serves as a synthesis of the findings from two research articles and scoping review, integrating their insights into a unified discussion. It finalizes the thesis by examining the broader practical and scholarly implications of the work and outlines directions for future inquiry. This chapter also highlights how the collective results contribute to advancing knowledge in the field.

6.1. Summary of key findings

The research presented in this thesis reveals substantial and persistent gaps in MDA coverage among mobile populations, based on empirical evidence from Mali and a broader scoping review across Africa. Together, the findings emphasize the complex and interrelated barriers that contribute to inequitable access to preventive chemotherapy for NTDs among populations on the move.

First, this research found that participation in MDA targeting schistosomiasis among mobile populations in Mali was consistently below the World Health Organization's recommended 75% threshold (Sangare et al., 2024, 2025). Only 40.8% of internally displaced persons (IDPs) and 3.62% of migrants reported participation, indicating a significant equity gap in Mali. By contrast, a school-based MDA campaign in Mali reported much higher coverage among non-mobile populations, with 93.51% for praziquantel and 95.25% for albendazole (Sangare et al., 2021). Key determinants of this low participation included lack of awareness or information about MDA, high geographic mobility, occupational constraints, low socioeconomic status, and gender disparities, with men nearly three times more likely to miss MDA than women.

Second, this research also found that physical and logistical barriers played a central role in exclusion. Long distances to distribution points, poor accessibility, and the transient nature of nomadic pastoralist and transhumant groups significantly limited participation. These groups were over three times more likely to be missed than IDPs, reflecting a clear intersection between livelihood patterns and health service delivery.

Furthermore, this research revealed through the scoping review, that similar systemic constraints were evident across African settings (Sangare et al., 2026). These included rigid campaign schedules misaligned with migration patterns, insufficient cross-border collaboration, weak integration with other community-based health services, and limited community engagement. Collectively, these barriers can be understood through the lens of healthcare access frameworks, which highlight failures across multiple dimensions: from the lack of approachable information and culturally acceptable delivery to the fundamental unavailability of services where mobile populations live and work. However, the review also identified promising strategies that can inform program redesign: mobility-informed microplanning, flexible and decentralized delivery models, integration with other community health interventions (e.g., immunization programs), and stronger cross-border coordination mechanisms.

Finally, the qualitative study provided deeper contextual understanding of "never-treated" populations, uncovering factors such as lack of information/awareness, negative rumours, fear of side effects, mistrust of health workers, and perceived program inflexibility. The study emphasized that participatory, context-specific, and adaptive implementation approaches involving trusted community leaders and tailored communication are critical to overcoming these persistent barriers.

Taken together, the three independent studies demonstrate that standardized, one-size-fits-all MDA delivery models are insufficient to achieve equitable and sustained coverage particularly in areas or populations with increased complexity. Without programmatic adaptation to population mobility and local contexts, large pockets of untreated individuals will persist, maintaining residual reservoirs of infection and threatening the achievement of national and global NTD elimination goals.

Overall, the research highlights the need for a paradigm shift toward tailored, adaptive, and equity-focused MDA strategies that explicitly account for population mobility, livelihood patterns, and the social determinants of access. Achieving this will require concerted efforts to strengthen local engagement, enhance cross-border collaboration, and integrate MDA within broader community health systems. In doing so, NTD programs can move closer to ensuring that no population, however mobile or marginalized, is left behind in the path toward elimination.

6.2. Interpretation and implications

The findings from these three studies conducted in Mali and across Africa reveal a consistent and concerning pattern: conventional MDA strategies are structurally misaligned with the mobility dynamics of key population groups. This misalignment reflects a deeper programmatic rigidity, in which standard campaign frameworks are designed primarily for fixed, sedentary communities. The very low coverage levels observed, 3.62% among migrants and 40.8% among IDPs, demonstrate the scale of this gap (Sangare et al., 2025).

Applying Levesque's access to healthcare framework (Levesque et al., 2013) provides a powerful, structured explanation for these coverage gaps. Levesque framework investigates healthcare access across the supply (healthcare services) and demand (individuals and communities) sides, illustrating the factors that are associated with access. In this study, we focus specifically on the demand side, exploring factors that shape individuals' abilities to perceive, seek, reach, pay for, and engage with care within the community. Future research could extend this work by examining access from the supply side, investigating how health system characteristics influence service delivery and utilization. The barriers identified across our studies operate simultaneously across multiple dimensions of this framework:

- ***Approachability***: In the Levesque et al. (2013) framework, "approachability" is defined as the extent to which people can perceive that a service exists, can be reached, and is relevant to them. This is particularly important for mobile populations, who often have low awareness and ability to perceive MDA as needed. This was the primary barrier identified in our research (Sangare et al., 2025), with 64.5% of non-participants citing a lack of information. Health campaigns that do not actively seek out mobile groups through tailored communication (e.g., via local radio, community leaders) remain invisible to them. Addressing this barrier requires proactive engagement strategies that consider mobility patterns and communication preferences to ensure equitable access to MDA and related interventions such as LF morbidity disabilities management and disability prevention.
- ***Acceptability***: refers to the cultural and social factors that influence whether people are willing to use a health service. It reflects how well services align with individuals' values, norms, beliefs, and expectations. The cultural and social appropriateness of MDA was

demonstrated in our research and other studies (Adams et al., 2022; Gammino et al., 2020; Krentel et al., 2016; Sangare et al., 2024, 2025) to be low for mobile groups. Factors such as mistrust of health workers, fear of side effects, negative rumours, and a perception of program inflexibility directly undermine the acceptability of the intervention, as highlighted in the qualitative study (Sangare et al., 2024). Certain professions are often linked to population mobility, such as taking animals to pasture. In Mali, it is mostly men who take animals to pasture, go to the fields early in the morning, or travel frequently in search of daily sustenance for their families. This would explain the 3.62% coverage rate seen in our study for praziquantel MDA (Sangare et al., 2025). Because they move around a lot, they have less access to information and are less likely to accept interventions. They will not perceive the distribution of praziquantel to be relevant to their own situation. People on the move will not become aware or may not be confronted with a health situation in a community in the same way that someone living there would be. Research indicates that compliance and acceptability vary widely and are influenced by a combination of personal, social, community, and health system factors (Niles et al., 2021).

- ***Availability and accommodation***: refer to whether health services are physically reachable and organized in a way that allows people to use them. This includes service location, opening hours, frequency of delivery, scheduling, and the flexibility of service delivery. For mobile populations, the physical accessibility of services remains a critical gap. Fixed-post distribution at health centers will be unavailable to those who are living in geographically remote areas. This was a key operational barrier, with the cross-sectional study in Mali revealing that nomadic pastoralist and transhumant groups were over three times more likely to be missed by MDA than IDPs, primarily due to their remote location and mobility (Sangare et al., 2025). The scoping review synthesized evidence from multiple African countries, identifying rigid campaign schedules and fixed-post delivery models as primary drivers of exclusion for nomadic and transhumant populations (Sangare et al., 2026). Long distances, transient nature of pastoralist and tranhumant groups, and occupational constraints mean that the place, time, and appointment systems of MDA are fundamentally misaligned with their livelihoods. As a result, these populations are systematically left out of routine MDA campaigns, and may

contribute to persistent pockets of transmission. Furthermore, in many settings including Mali, primary health care systems do not explicitly account for mobile populations in their procurement or service delivery plans, which can leave these groups underserved and difficult to reach during interventions such as MDA (Adams et al., 2022; Wild et al., 2020).

- ***Affordability***: The Levesque et al. (2013) framework defines affordability as the the economic capacity of individuals or households to spend resources (money, time, effort) to access health services. This includes direct costs (fees for drugs or services) and indirect costs (transportation, lost income, or time away from work). All of which can influence whether individuals are able to participate in interventions such as MDA. Even when MDA is provided free of charge, mobile populations may still face high indirect costs limiting treatment uptake. For day labourers or livestock farmers, taking the time to travel to a distant distribution location can result in a significant loss of income, or even risk their livelihood. This was reflected in the Malian cross-sectional study, where a key reason for non-participation cited by respondents was being "away for work" at the time of the MDA campaign (Sangare et al., 2025). Such circumstances often make health interventions less accessible, particularly when distribution schedules do not align with work or migration patterns. As a result, many mobile individuals prioritize immediate survival needs over disease preventive measures such as MDA.
- ***Ability to reach*****:** This dimension includes the population's ability to physically reach distribution posts. High geographic mobility, location of temporary settlements or traditional mining sites far from health infrastructure, and insecurity in regions such as central and northern Mali directly compromise the ability of mobile and migrant populations to reach distribution posts. Seasonal factors such as heavy rains or poor road conditions can further limit movement and prevent access to MDA services. In addition, limited transportation options and insufficient awareness of distribution schedules remain major obstacles, as reflected by 64.5% of non-participants who reported not being informed about the campaign (Sangare et al., 2025).

These interpretations, structured by Levesque's framework, align with findings from other African contexts. For example, studies in Tanzania, South Sudan, and Ethiopia have reported similarly low coverage among mobile and pastoralist groups, primarily due to the static

nature of campaign delivery and limited adaptation to migration cycles (Buda et al., 2025; Gammino et al., 2020; Mtuy et al., 2021; Muchiri et al., 2023). In each of these cases, mobility acted as a key determinant of inequitable access to MDA. The convergence of evidence across the present studies, quantitative, qualitative, and scoping review, further underscores that mobility itself functions as a structural determinant of healthcare access, interacting with other social factors such as gender, occupation, and economic vulnerability to create persistent inequities across all five dimensions of access.

Importantly, women may also face unique access barriers. For example, when male household members are away, women may lack the autonomy, resources, or social support to travel long distances to healthcare facilities or participate in MDA. These gendered mobility and access constraints highlight the importance of considering both men's and women's specific circumstances when planning health interventions in mobile populations (Gammino et al., 2020; Jebena et al., 2022).

6.3. Programmatic implications

In Mali, multiple MDA campaigns are ongoing, such as schistosomiasis MDA nationwide and onchocerciasis MDA in select endemic OTZ. Recognizing the differences in target populations, geographic coverage, and delivery strategies adds an important layer of complexity. From a programmatic perspective, these findings, interpreted through Levesque's framework, point to the need for a transition from uniform to context-responsive MDA models that address specific access dimensions.

- ***To improve approachability and acceptability***: Communication and community engagement must be tailored. The primary barrier identified (limited awareness 64.5%) indicates the need for a contextually grounded communication approach (Sangare et al., 2025). Local radio, traditional leaders, and community health workers can serve as trusted intermediaries to enhance perceived need and trust. This approach is supported by studies in Senegal and Niger (Aremu et al., 2025), and many other countries in Africa (Idriss-Wheeler et al., 2024; Werner et al., 2023), where early involvement of local leadership significantly improved community trust and uptake. In recent research in Mali, the use of community leaders in mining sites improved the acceptability of MDA for

onchocerciasis (manuscript in preparation). This involved social research to understand population dynamics, and tailor messages according to need.

- ***To improve availability and accommodation***: In the Malian context, fixed-post distribution at health centers does not accommodate populations who live or work far from settlements. Hence, flexible and decentralized delivery mechanisms are required. Deploying mobile MDA teams (to grazing areas, markets, or border zones), engaging pastorilist leaders as drug distributors, and aligning campaigns with migration patterns could directly address this gap. Similar approaches used in Kenya, Tanzania, South Sudan and northern Nigeria have shown measurable gains in both reach and community participation (Eshitemi et al., 2025; Gichuki et al., 2024; Muchiri et al., 2023; Okeibunor et al., 2013).
- ***To improve affordability and ability to reach***: Mobility-informed microplanning is essential. By aligning campaigns with mobility patterns (such as seasonal migration routes, pastoralist corridors, or mining sites into microplans) and bringing services to where people are, programs drastically reduce the indirect costs and physical barriers to access. Evidence from cross-border trachoma programs in Kenya and Tanzania demonstrates that adapting MDA timing to local migration calendars can substantially increase coverage (Baayenda et al., 2023; Eshitemi et al., 2025).

6.4. Policy and strategic implications

At the policy level, these results support a more deliberate institutional recognition of mobile populations as a priority group in national NTD and infectious disease control strategies. Applying an access lens helps to reveal critical policy gaps. To sustainably address the dimensions of availability and ability to engage, policy must evolve. Cross-border collaboration is a key element. The scoping review revealed that uncoordinated national campaigns leave untreated zones along borders, which can serve as persistent transmission reservoirs (Sangare et al., 2026). Experiences from the Maasai trachoma initiative in East Africa have shown that synchronizing campaign schedules across national boundaries can close these epidemiological gaps (Baayenda et al., 2023; Gebre & Sankar, 2015). The Sahel Malaria and NTDs project serves as a strong example of cross-border partnership. It aims to improve access to and use of harmonized community-level services for the control and prevention of malaria and preventive

chemotherapy NTDs in targeted cross-border areas across participating Sahelian countries (Mali, Niger, and Burkina Faso) (WAHO, 2018).

Equally important is the integration of equity-focused indicators into national monitoring frameworks. As highlighted by the WHO NTDs Roadmap (2021–2030) (Casulli, 2021), success must be measured not only by national coverage averages but also by the extent to which programs reach marginalized populations. Thus, disaggregating MDA data by mobility status, gender, and geography is essential to capture the true performance of NTDs programs. Novel indicators, like capturing never treatment in routine data collection (Brady et al.,2024) can provide regular updates on levels of people who may be excluded from public health campaigns. Programs can follow up on signals of never treatment using a tailored approach.

Finally, in conflict-affected and insecure settings such as central and north Mali, adaptive MDA delivery models, like micro-campaigns during periods of stability or integration with humanitarian aid operations, are needed to sustain service delivery (Sangare et al., 2024, 2025). This mirrors successful health interventions implemented in fragile regions of many countries in Africa including South Sudan and Nigeria, where flexibility and local partnerships were central to maintaining continuity (Idriss-Wheeler et al., 2024; Okeibunor et al., 2013; Werner et al., 2023).

6.5. Research and surveillance implications

The limitations in measuring 'never-treated' populations (Brady et al., 2023; Kura et al., 2024; Sangare et al., 2024) highlight a critical gap in our understanding of access, particularly regarding 'approachability' and 'ability to perceive' need. Developing standardized mobility indicators should be a research priority. Incorporating simple measures of population movement, such as migration season, duration, and purpose into health management information systems would make surveillance more sensitive to the realities of population dynamics. This approach has already proven effective in malaria surveillance systems that account for human movement patterns (Abdul-Rahman et al., 2025; Buckee et al., 2017; Tam et al., 2021). Similar evidence was also reported in immunization program (Ateudjieu et al., 2022). This must be done at the district level because as we move toward elimination, it is important to conduct local monitoring to identify pockets of infection and people who have never been treated and who may continue to transmit the disease.

Further, operational research should explore the feasibility of using GPS-enabled tracking of community drug distributors (CDDs), digital mapping of temporary settlements, and integrated health service delivery (e.g., combining MDA with vaccination or malaria chemoprevention) to improve availability and accommodation. In studies in Tanzania in 2014, the Ministry of Health integrated a measles-rubella vaccination campaign, MDA of ivermectin + albendazole, and Vitamin A into a single community-based delivery platform (Mwingira et al., 2016). Similarly, research by Mandrosovololona et al. in Madagascar successfully integrated MDA targeting LF into polio vaccination campaigns to improve financial efficiency, effectiveness and therapeutic coverage of MDA targeting lymphatic filariasis (Mandrosovololona et al., 2024).

Finally, research focusing on never-treated populations, those persistently excluded from MDA, should continue using longitudinal and mixed-methods designs. Comparable studies have revealed that these groups often remain untreated due to social marginalization and migration, fear of side-effects, treatment not offered or eligible for treatment rather than resistance or refusal (Brady et al., 2023; Duguay et al., 2024; Krentel et al., 2016; Kura et al., 2024). Not taking that into account, and leaving too many individuals going untreated could make it more difficult to meet the WHO 2030 goals.

6.6. Social and community implications

Health interventions operate at the interface of supply and demand, where social factors critically influence an individual's ability to seek, reach, and pay for care. Our findings demonstrated that men were less likely to take part in MDA, and that trust in drug distributors varied by origin, and that rumours influenced participation. These suggest that social cohesion and cultural understanding of disease and intervention are central to a successful MDA implementation. Building social and cultural competence among health workers, community leaders, and CDDs, including sensitivity to local norms and language, can directly improve the acceptability of MDA services and individuals' ability to seek them. In Ghana and Uganda, for example, training CDDs to engage respectfully with nomadic groups was found to significantly enhance coverage and uptake (Adams et al., 2022; Amazigo et al., 2021). Addressing disparities in access due to gender is also essential. The association between male gender and non-participation may relate to occupational mobility, risk perception, or gendered communication

patterns (Sangare et al., 2025). Future interventions could include male-targeted outreach during market days or community gatherings, strategies that have been effective in Tanzania (Mtuy et al., 2019, 2021). Although our study did not identify specific association with female gender and access to healthcare, this does not mean that there was no data. Rather, it suggests that a gendered approach to data collection and tailoring interventions is needed.

Finally, genuine community leadership and involvement, beyond symbolic consultation, is key. As participants emphasized in this study, "the intervention and involvement of community leaders is essential" (Sangare et al., 2024). Evidence from literature shows that campaigns co-led by local leaders not only achieved higher coverage but also sustained participation over multiple rounds (Idriss-Wheeler et al., 2024; Werner et al., 2023).

6.7. Global health and equity implications

The persistent exclusion of mobile populations from MDA reflects a broader equity gap in global health programming. These populations, often displaced by conflict, pursuing seasonal livelihoods, or maintaining traditional pastoralist lifestyles are simultaneously among the most vulnerable and least visible in health statistics. Their systematic exclusion undermines both the ethical principle of equity and the technical feasibility of disease elimination. As the WHO NTD Roadmap (2021–2030) emphasizes, achieving elimination targets depends on closing these coverage gaps. Reaching mobile and displaced populations is therefore not only a moral imperative but also a practical necessity for sustaining global NTD elimination gains. Addressing these inequities requires sustained investment in surveillance, adaptive delivery models, and multisectoral collaboration that spans health, migration, and security sectors.

6.8. Implications for implementation and considerations for intersectoral collaboration and governance

These findings place increased emphasis on the influence of broader contextual factors on the implementation of the proposed recommendations. In particular, the discussion explicitly acknowledges that the intersection of armed conflict, climate change, and economic instability represents a complex implementation environment that can substantially shape feasibility across diverse settings. These structural and environmental determinants are critical, as they can constrain, delay, or substantially modify implementation pathways, thereby influencing the

translation of evidence into effective practice. They also underscore the need for coordinated, cross-sectoral responses involving health, environmental, and socio-economic actors. In addition, these factors often interact with existing health system vulnerabilities, further compounding implementation challenges in already resource-constrained contexts, highlighting the importance of adaptive governance mechanisms capable of responding to dynamic and uncertain conditions.

At the same time, the proposed recommendations are intended to be adaptable and context-sensitive, with the potential to be integrated into existing health systems and adjusted according to local operational realities. This includes leveraging flexible delivery approaches, strengthening coordination with community-based actors, and building on established platforms operating in fragile and resource-limited settings. Effective implementation will depend on strong intersectoral collaboration, including partnerships across the health, agriculture, water and sanitation, environmental, education, and social protection sectors, as well as non-governmental organizations and community stakeholders. Such collaboration is particularly important in settings affected by climate variability and insecurity, where determinants of health outcomes extend beyond the health sector alone. Their successful operationalization will require strong partnerships with national programmes and local stakeholders to ensure feasibility, relevance, acceptability, and sustainability in real-world conditions, as well as clear governance structures to support accountability, coordination, and decision-making across sectors.

While this thesis focuses on identifying practical and relevant strategies, future research should further examine implementation pathways at pilot level and subsequent scale-up. This includes a detailed assessment of operational requirements, resource implications, and integration within existing health systems. It further involves evaluating governance arrangements and intersectoral coordination mechanisms to support effective and sustainable implementation at scale.

6.9. Limitations

This research is subject to several limitations. It is likely that many of the themes identified in the Mali research could be tested, measured or further explored in other regions where the same phenomena exist (Sangare et al., 2024, 2025). The high mobility of the populations themselves introduced a potential sampling bias, as the most transient groups may have been absent during data collection.

In the cross-sectional study, a high percentage of participants reported that they "did not remember" whether they had participated in schistosomiasis MDA, introducing recall bias and complicating accurate measurement of coverage and never-treatment (Sangare et al., 2025). This phenomenon is more complex than simple forgetfulness: it may also reflect social desirability bias, where participants are reluctant to admit non-participation. Such biases can lead to overestimation of coverage or underestimation of gaps in treatment. Budge et al. (2016) in Togo have highlighted these challenges in coverage surveys, emphasizing that memory limitations and social pressures can affect self-reported data (Budge et al., 2016). However, other researchers have demonstrated that recall bias (Worrell & Mathieu, 2012) in similarly administered coverage surveys did not affect reliability of the coverage indicator. Furthermore, the never treatment question has been used and validated in multiple settings (Brady et al., 2023; Duguay et al., 2024; Niles et al., 2021; Titaley et al., 2022). Therefore although there are potential limitations, the research has used validated measures where recall bias was not shown to be an issue.

For the qualitative study, social desirability bias may have led participants to underreport certain reasons for non-participation, such as distrust or cultural aversion (Sangare et al., 2024). As stated in the manuscript, to reduce the impact of this bias, community health workers were involved in the data collection so to enable community members to trust the study team and to encourage their participation in the research.

The scoping review, while comprehensive, was limited to English and French literature and excluded parallel lessons from vaccination or malaria campaigns, potentially missing transferable insights (Sangare et al., 2026). This limitation was not however highlighted as a limitation by the peer reviewers.

Finally, a key limitation across all studies is the lack of cost-effectiveness data on the proposed adaptive strategies, which is crucial for persuading policymakers and donors to reallocate often-scarce resources to reach hard to reach populations. This was not part of the original thesis proposal but would be an important follow-up for the research. As elimination programmes reach the last mile, the cost of campaigns will likely increase as new adaptations are introduced to ensure that the hard to reach are included.

6.10. Directions for future research

Future studies should focus on the following areas:

1. **Implementation and cost-effectiveness analyses**: There is an urgent need to pilot and rigorously evaluate the proposed adaptive strategies (e.g., mobility-informed microplanning, flexible delivery models) in diverse settings. Such studies should include detailed cost-effectiveness analyses to provide a compelling evidence base for scaling up these approaches. Comparing the cost per person treated in a standard campaign to a mobility-tailored campaign is essential.
2. **Development and validation of mobility metrics** for inclusion in national NTDs and health surveillance systems.
3. **Gender-responsive research** to understand and address the specific factors contributing to male under-participation in MDA. Such studies should explore the underlying reasons linked with occupation, social norms, and risk perception to design and test gender-responsive communication and delivery strategies to improve uptake among men.
4. **Integration studies** to investigate the feasibility and impact of integrating MDA with other community-based health interventions such as routine immunization, seasonal malaria chemoprevention, affects both efficiency and equity. This could improve efficiency and increase the value proposition for both supply and demand sides.
5. **Longitudinal research on persistently untreated populations** to capture evolving social and behavioral dynamics across successive MDA rounds. This would provide dynamic insights that cross-sectional surveys cannot capture.

6.11. Conclusion

The journey towards the elimination of NTDs has reached a decisive phase. This dissertation demonstrates that achieving NTD elimination will depend on the capacity of health systems to adapt to the realities of human mobility and systematically address the multiple dimensions of access (approachability, acceptability, availability, affordability, and ability to reach) as defined by the Levesque et al. framework. The gaps in MDA coverage among nomads, migrants, seasonal workers and IDPs are not an intractable problem but a solvable one, rooted in a mismatch between rigid programmatic delivery and dynamic human realities. By adopting a

paradigm shift from standardized campaigns to flexible, equity-focused, and context-specific strategies, NTD control and elimination programs can bridge this gap. This requires programmatic innovation grounded in mobility-informed microplanning, policy reform that institutionalizes cross-border collaboration and equity, and community engagement that builds trust and cultural relevance. The imperative is clear: reaching the unreached is not merely an act of equity but a fundamental prerequisite for achieving and sustaining the elimination of NTDs. Ensuring that mobile populations are no longer left behind is the definitive next step in the global fight against these diseases of poverty.

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