

THE IMPACT OF INSECTICIDE RESISTANCE ON THE EFFICACY OF IRS AND LLINS IN MALI :

Findings for Policy Makers – Draft Document



Summary

Indoor residual spraying (IRS) and long-lasting insecticidal nets (LLINs) are the two main methods of malaria vector control. Both methods are insecticide-based. However, mosquitoes in certain areas have become resistant to these insecticides; this resistance phenomenon seems to threaten the efficacy of these malaria vector control tools.

This research analysed the effects of insecticide-resistance mechanisms on malaria vector control tools in three West African countries, namely, Mali, Benin and Nigeria. This policy brief focuses on the research carried out in Mali.

The research involved identifying appropriate study sites, characterising malaria vectors in the identified study sites, and understanding communities' behaviours and perceptions of LLIN/IRS utilisation and efficacy.

Key findings:

- *An. gambiae* s.l. was the main malaria vector in the study sites.
- In areas with IRS and LLINs, *An. gambiae* s.l. densities per house were lower than in areas where only LLINs were used.
- LLINs coverage for pregnant women was 53% and 91% for children < 1 year.
- At Dalabani, the presumed susceptible locality, the resistance level had recently increased.
- There were a number of weaknesses in the implementation of LLINs for malaria vectors control.
- It is unclear when and how often IRS is implemented, and data to monitor changes in vector population and transmission is lacking.
- There was widespread and increasing resistance of malaria vectors to insecticides, especially pyrethroids, with multiple resistance mechanisms recorded in studied localities.
- The effect of resistance on the performance of LLINs was recorded. Organophosphate-based IRS introduction in some study sites seemed to alter and moderate the negative effect of this resistance phenomenon as vector populations remain susceptible to this class of insecticides.
- Good insecticide resistance management and implementation is required.
- There is a need to uptake education regarding the causes and risks of malaria, and the usage of LLINs.

RESEARCH APPROACH



Selection of study sites

- Susceptibility screening and selection of resistant sites (test sites) and susceptible sites (control sites)
- Increased resistance to Deltamethrin, a pyrethroid insecticide typically used in LLIN impregnation, was found in the presumed susceptible, controlled site, Bougouni.
- Full susceptibility to pyriphos-methyl (organophosphates), which is used for IRS, was found in both IRS and non-IRS areas.
- Due to the absence of sites susceptible to pyrethroids, Koula and Karadiè were chosen in the districts of Koulikoro (where IRS is used) and N'Galamadibi and Kolondialan in the nearby district of Banamba (where no IRS is used)



Entomological characterization of sites (resistance profiling)

- Review on the status of insecticides resistance in *Anopheles* populations conducted.
- Field and laboratory studies conducted to:
 - a. update information on resistance status and determine developed resistance mechanisms
 - b. determine vector density, biting rate, infection rate, human blood index, species composition and entomologic inoculation rate.
- Association between frequencies of resistance mechanisms and transmission, as measured by EIR, was determined.



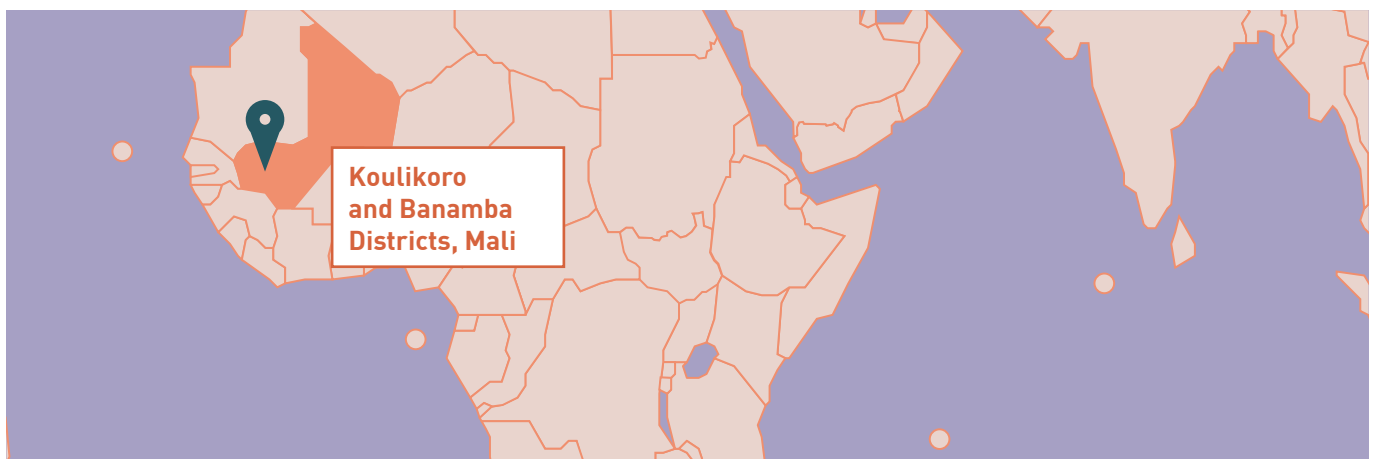
Parasito-clinical characterization of sites

- Data was collected on malaria prevalence according to demographics, such as age and gender.
- Data from local community health centers was collected.
- Cross-sectional prevalence studies in the selected study cohort were conducted.
- Passive case detection of malaria cases in the selected study cohort was recorded.
- Association between frequencies of resistance mechanisms and transmission, as measured by EIR, was determined.



Socio-anthropological characterization of sites (e.g. human practises)

- Assessed through interviews and focus group discussions with risk groups, and observational studies of behaviour, for example LLIN usage.
- A review was conducted on the acceptability and performances of LLNs and IRS in areas of resistance.



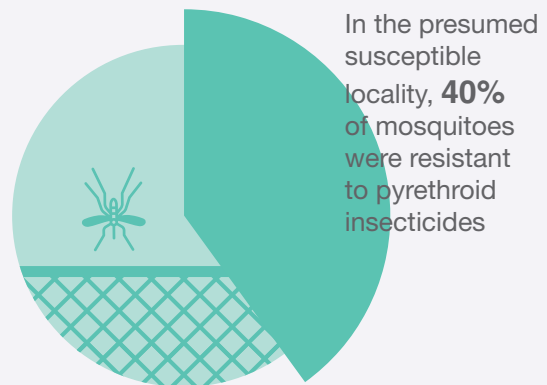
RESULTS

1 Implementation of LLINs was weak and net use was low

- LLIN utilisation varied from village to village, with a lower rate at non-IRS sites (60 to 70%) and a higher rate at IRS sites (75 to 85%).
- The main reason people used LLINs was as protection against mosquito bites and malaria.
- Reasons for not using the LLINs included to avoid quick tearing, space issues, the heat and an absence of mosquitoes.

2 Resistance to commonly used insecticides was high

- The resistance level had recently increased, including within the presumed susceptible locality, where only 60% of the mosquitoes exposed to the pyrethroid insecticides died.
- Vector population in all sites was fully susceptible to the organophosphates (pyrimiphos-methyl) currently used for IRS in Mali.
- There was widespread target site mutation (KdrW, N1575Y), and Ace1 resistance mechanism in all sites. Ace1 was less frequent at IRS sites compared to non-IRS sites.



3 Despite high resistance, IRS did have an effect

A. Entomological transmission indices were lower in IRS sites compared to non-IRS sites

Except for human blood index, all entomological transmission indices, including vector density per house, biting, and infection rates, were lower in IRS sites (Koula and Karadiè) compared to those without IRS (NGalamadibi & Kolondialan). Transmission was even undetectable in IRS sites, while it was still high in areas without IRS.

B. Malaria parasite prevalence was lower in IRS sites compared to non-IRS sites, according to parasito-clinical indices

- All parasitological indices, including *P. falciparum* prevalence and gametocyte rate and incidence, were lower in IRS sites than in sites without IRS.
- The expected seasonal peak in parasitological indices at the end of transmission season was absent in IRS sites, while it was apparent in sites without IRS.
- The incidence rate of the malaria parasite was 2.5 times higher in non-IRS sites (6.8 episodes for every 100 people per month) than in the IRS area (2.7 for every 100 people per month).
- Children living in IRS sites were more likely to be more protected against malaria than those in areas without IRS.



C. Overall, data on the efficacy of IRS was lacking

In Mali, there was no entomological data to guide when and how often IRS is implemented, and data to monitor changes in vector population and transmission was also lacking. No baseline information was available on IRS.

RECOMMENDATIONS

1 *Increase use of LLINs and IRS*



In the susceptible study sites, *Anopheles* mosquitoes have developed increasing resistance; this has resulted in the limited efficacy of LLINs and IRS as malaria vector control tools. However, LLIN implementation and use is low, and data on the efficacy of IRS is lacking. Thus, universal coverage and optimal use of LLINs and IRS is urgently necessary.

2 *Improve insecticide resistance management*



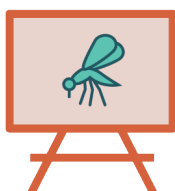
There is widespread and increasing insecticidal resistance with difference resistance mechanisms in malaria vector populations, which hampers the performance of LLINs. Therefore, an insecticide resistance management plan must be implemented in Mali.

3 *Added value of IRS*



Given the significant reduction in malaria transmission indices in sites with IRS compared to sites without IRS, we recommend pursuing the use of LLINs alongside organophosphate-based IRS.

4 *Knowledge uptake*



Improve education regarding the causes and risks of malaria. Disseminate information about resistance mechanisms of mosquitoes to local health authorities to distribute to local communities.

About this project

This policy brief summarizes outcomes of the research project on *Understanding the impact of insecticide resistance on the efficacy of IRS and LLIN in 3 ecological settings of Mali, Benin and Nigeria*. The principal investigator was Dr Nafomon Sogoba, Head of Vector Control and GIS Unit, Malaria Research and Training Center (MRTC), University of Sciences, Techniques and Technologies of Bamako, FMOS.

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