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RESEARCH PAPER

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Assessment of added protection conferred by combined use of indoor residual spraying (IRS) and seasonal malaria chemoprevention (SMC) for malaria prevention in Benin

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Abstract

Malaria is endemic in Benin with seasonal and spatial variation in intensity. Insecticide treated Net (ITN) is a major prevention tool which is deployed nationwide. Other malaria prevention interventions such as seasonal malaria chemoprevention (SMC) and indoor residual spraying (IRS) are also being implemented as complementary measures, either alone or in combination in high transmission health zones in northern Benin. This study aims to provide a precursory retrospective analysis of routine health facility data collected for two consecutive years comparing the cumulative malaria incidence in sites that received IRS alone and IRS + SMC with control sites that did not receive IRS or SMC. Three Health Zones (HZs) comprising 9 districts were used in the study analysis. In 2019, the HZs of Djougou-Copargo-Ouaké (DCO) and Kandi-Gogounou-Ségbana (KGS) both received IRS only. In 2020, KGS HZ received SMC in addition to IRS. The control HZ was Natitingou-Toukountouna-Boukoumbé (NTB) which did neither receive IRS nor SMC. Routine monthly malaria cases from the HZ information system were analyzed for incidence trends. The cumulative incidence (new cases/HZ population at-risk/year) was calculated for the 3 HZs. An unadjusted incidence rate ratio (IRR: incidence of IRS+/- SMC HZ over control HZ) was calculated in R using rate ratio test package. In 2019, similar cumulative malaria incidence in both HZs which was 322 cases/1000 in DCO ZS and 339 cases/1000 in KGS HZ against 420 cases/1000 in the control (NTB HZ). Moreover, in 2020, the number of new malaria cases avoided attributable to the various interventions is estimated at 104.62‰ in the IRS HZ (DCO) and 184.13‰ in the IRS + SMC HZ (KGS) which represents a reduction of 24.72% and 43.52% respectively compared to the control. While in this limited analysis, IRS +/- SMC HZ had lower malaria incidence than control HZ, future well-designed prospective multi-country studies in different transmission settings that address the question of whether a combined use of SMC and IRS provides additional protection are needed.

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Introduction

Malaria remains endemic and a leading cause of morbidity and mortality, causing an estimated 228 million cases of clinical malaria and 405 thousand deaths worldwide, of which 93% of cases and 94% of deaths occurred in Africa (WHO, 2019). Remarkable progress in malaria control has been realized over the last decade, with reductions in malaria burden such that many countries are now targeting elimination (Feachem *et al.*, 2010; Mendis *et al.*, 2009).

Vector control which relies primarily on two complementary tools namely long-lasting insecticidal nets (LLINs) and indoor residual spraying (IRS) has substantially reduced mortality and morbidity from malaria (WHO, 2012; Shargie *et al.*, 2010; Otten *et al.*, 2009). However, the spread of mosquito resistance to insecticide compromises these current vector control interventions (Gnanguenon *et al.*, 2015; Aïkpon *et al.*, 2013). Additional alternative preventive measures that could be used to control malaria in areas were therefore required. In 2012, the World Health Organization (WHO) recommended in areas where infection is highly seasonal, Seasonal Malaria Chemoprevention (SMC) with sulfadoxine-pyrimethamine and amodiaquine (SP plus AQ) in the Sahel countries in Africa to reduce malaria among children under 5 years of age (Organization, 2012). However, the big challenge for many National Malaria Control Program (NMCP) is the way (How, Where and When) to combine all those specific preventive interventions for more effectiveness.

Benin is one of the highest malaria burden countries in the world. Malaria preventive interventions in Benin have included vector control (IRS since 2008, universal distribution of LLINs since 2011 on a triennial basis and routine distribution targeted pregnant women and children of about one year), and SMC since 2019.

The combination of a vector control intervention, such as IRS, and a parasite control intervention, such as SMC in the same areas and at the same time, could complement each other and can have an enhanced effect. The fact of implementing simultaneously both interventions makes sense when disrupting malaria transmission at different stages of the parasite's life cycle (Elliott *et al.*, 2019; Stuckey *et al.*, 2016). However, the national malaria programs have to be tailored to local context to make decisions about where to implement those strategies simultaneously in the same communities for more efficiency. In Benin, the timing of implementation of IRS and SMC provided a singular opportunity to analyze the impact of both tools, deployed individually and in combination, using a retrospective analysis of cumulative malaria incidence in health zones applying IRS with and without SMC.

Materials and methods

Study area

This evaluation was carried out in two health zones in northern Benin namely: Kandi-Gogounou-Segbana (KGS) health zone in the Alibori department and Djougou-Copargo-Ouaké (DCO) in the Donga department (Fig. 1).

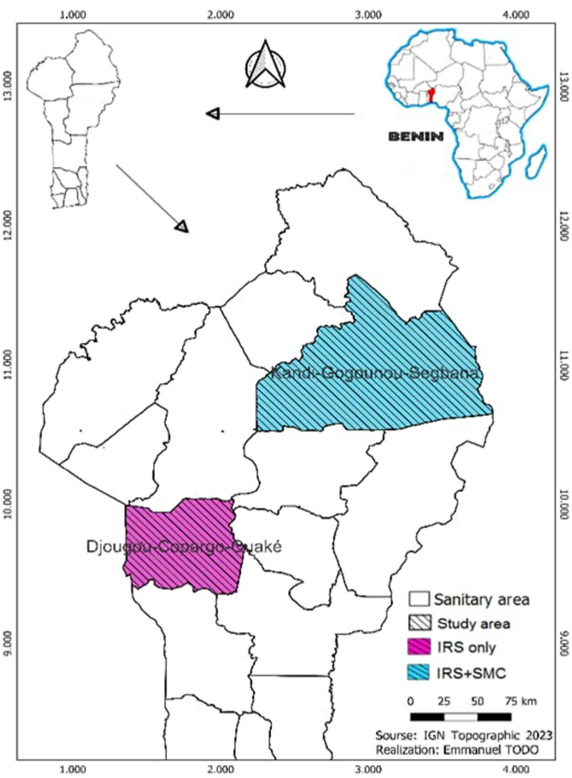

Fig. 1. Map of the study area

Table 1. Details from 2018 to 2020 IRS campaign performance

Year	Geographic area	Insecticide	Number of structures sprayed	Population protected
2018	Djougou-Copargo-Ouaké & Kandi-Gogounou-Ségbanan Health zones	Actellic® 300 CS* (Organophosphate)	322,115	1,038,221
2019	Djougou-Copargo-Ouaké & Kandi-Gogounou-Ségbanan Health zones	Actellic® 300 CS (Organophosphate)	335,207	1,077,411
2020	Djougou-Copargo-Ouaké & Kandi-Gogounou-Ségbanan Health zones	Fludora® Fusion (Clothianidin & Deltamethrin combination)	350,349	1,104,928

Table 2. Summary of seasonal malaria chemoprevention (SMC) in KGS health zone, 2020

Year	Doses	Rounds			
		Round 1 (July)	Round 2 (August)	Round 3 (September)	Round 4 (October)
2020	Dose 1 Coverage (Children)	88771 (94, 3%)	91 595 (97.3%)	103 276 (109.8%)	103 703 (110.2%)
	Dose 2 Coverage (Children)	84 057 (89, 3%)	88 644 (94.2%)	100 801 (107.1%)	101 068 (107.4%)
	Dose 3 Coverage (Children)	76755 (81,6%)	83 169 (884%)	95 845 (101.9%)	93 763 (99.6%)

IRS campaigns implementation in KGS and DCO health zones

A yearly IRS round was implemented in 2017 in KGS and DCO health zones. IRS round was implemented at the beginning of the rainy season and targeted all eligible households. Each round covered over 90% of the households in the target health zones. Details from 2018 to 2020 IRS campaign as regards the insecticides used and the populations protected in the two health zones are presented in Table 1.

SMC campaign implementation in KGS health zone

SMC was implemented in KGS health zone with support from Global Fund in 2020. The target population was all children aged 3 to 59 months, with a monthly course of SP+AQ for 4 months of the rainy season, beginning in July. The number of children who received SMC is presented in Table 2.

Data analyses

Routine monthly malaria cases from the HZ information system were analyzed for incidence trends. The cumulative incidence (new cases/HZ population at risk/year) was calculated for the 2 health zones. An unadjusted incidence rate ratio (IRR: incidence of IRS+/- SMC HZ) was calculated in R using rate ratio test package.

Results

Fig. 2 illustrates the dynamic of monthly incidence rates associated with each intervention package (SMC+IRS *Vs* IRS alone) compared to the control. In 2019, the trend of the dynamic of the incidence is similar in IRS intervention HZ (KGS and DCO) and shows the largest reduction compared to the control (NBT). The pick of transmission was observed from June to November in both the intervention and control zones. In 2020, when SMC was added in KGS HZ, during the 6 months of peak malaria transmission, the incidence was significantly lower in KGS compared with DCO which continued to receive only IRS; the incidence in the control zone always remained high compared with the IRS and IRS+SMC intervention. Furthermore, the extent of the transmission pick has considerably decreased in KGS with the addition of SMC and is concentrated in three months (June, July, and August) with relatively low amplitude.

Fig. 3 shows the cumulative annual incidence for each health zone by package of intervention. In 2020, the number of new malaria cases avoided attributable to the various interventions is estimated at 104.62‰ in the IRS HZ (DCO) and 184.13‰ in the IRS + SMC HZ (KGS) which represents a reduction of 24.72% and 43.52% respectively compared with the control.

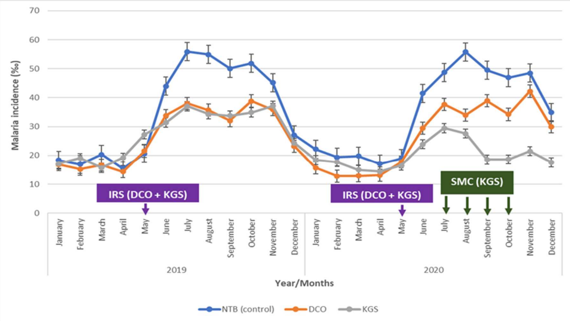

Fig. 2. Monthly incidence of malaria cases in KGS health Zone (IRS+ SMC) relative to the DCO Health zone (IRS alone)

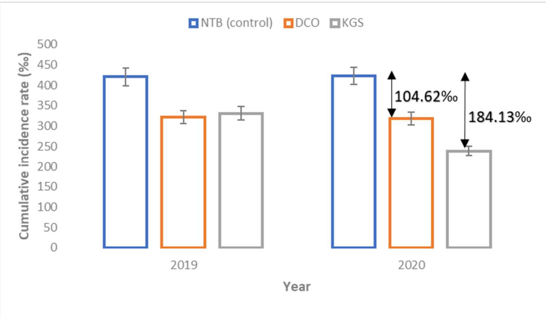

Fig. 3. Cumulative annual incidence in intervention districts relative to the control districts

Discussion

There are several preventive interventions available for the fight against malaria. Although most of them are effective at decreasing malaria burden (Katureebe *et al.*, 2016; West *et al.*, 2014; Kim *et al.*, 2012; Lengeler, 2004; Kouznetsov, 1977), no single intervention has been able to eliminate malaria on its own. On the basis of previously published studies, the evidence of added effect of combination various preventive interventions has been varied with some studies showing a positive combined effect and others no combined effect. Therefore, it is not correct to draw firm conclusions regarding the benefits of a combined vector control strategy. Most of these studies have evaluated the combination of IRS and ITNs, but very few studies have examined the combined effect of IRS and SMC co-implementation (Bhattarai *et al.*, 2007; Bradley *et al.*, 2012; Corbel *et al.*, 2012; Fullman *et al.*, 2013; Hamainza *et al.*, 2016; Kleinschmidt *et al.*, 2009; Pinder *et al.*, 2015; Protopopoff *et al.*, 2007; Rehman *et al.*, 2011).

Our results show a possible combined effect for the co-implementation of SMC and IRS in Benin through temporal observation of the malaria incidence in health zones having received differential packages of interventions (IRS Vs IRS+SMC). Routine malaria incidence rate was reduced annually by the greatest proportion in KGS Health Zone (43.52% reduction) where IRS and SMC were both implemented against 24.72% in DCO Health Zone where IRS alone was implemented. Our results presented are in line with recent modeling studies that indicate a high probability of strong synergies between complementary IRS and mass drug administration (Elliott *et al.*, 2019; Stuckey *et al.*, 2016). Another obviousness impact for the combined of IRS and SMC comes from the experience in Mali, when removing IRS led to a rebound in malaria transmission that year despite the implementation of SMC (Wagman *et al.*, 2018). This same situation was reported in Benin where an upsurge in malaria transmission was observed after IRS withdrawal (Aïkpon *et al.*, 2020).

This is likely to inform our understanding of conditions under which malaria prevention interventions might be safely withdrawn without risking the rebound of transmission. In spite of the proven addictive effect of combining IRS and SMC, further studies investigating need to be performed to ask when and where such combined strategies would make sense programmatically in terms of both cost and efficiency (Manguin and Dev, 2018).

Although improved malaria prevention could be achieved by the combined intervention approach, one rationale for such strategies is to manage good coverage and quality implementation of each each intervention on its own. Resistance management by preventing further selection of insecticide-resistance and spread in vector population must be considered as parasite resistance to antimalarial drug as well.

This study has some limitations that should be noted. It was not initially designed specifically to estimate the impact of the combination of SMC and IRS; the impact was read through incidence rates from the health facilities, which are not the best data for measuring the effect of these interventions.

Another limitation of this study is the choice of control without taking into account the disparity that could exist in the use of ITNs from one health zone to another.

Conclusion

This study gives the proof that the combined use of IRS and SMC in a context of universal ITN coverage was effective in reducing malaria incidence in comparison with single methods in the context of Benin. This could guide policy on integrated malaria prevention in endemic countries. However, future well-designed prospective multi-country studies in different transmission settings that address the question of whether combined use of SMC and IRS provide additional protection are needed.

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