Monthly trends in under-5 malaria cases in Guinea: Comparative analysis between a seasonal malaria chemoprevention (SMC) and a non-SMC health district

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Abstract

Background

In Guinea, where malaria is the leading cause of morbidity and mortality in children, seasonal malaria chemoprevention (SMC) is deployed to prevent malaria transmission in children during the rainy season. However, the effect of this intervention remains under-documented. The aim of this study was to analyse monthly trends in malaria cases among under-5 children in Guinea.

Methods

This was a quasi-experimental study using routine data from the National Health Information System. The two districts (Mamou and Kindia) were selected to compare monthly trends in malaria cases in under-5 children from July to October, covering the years 2015 to 2020. Interrupted time series were used to estimate the effects of SMC.

Results

The implementation of the SMC contributed to a significant average reduction of 225 cases per month in the intervention district (95% CI -362 to -88; p = 0.002), compared with the control district. However, the effect of the SMC varied according to its monthly cycles.

Conclusions

This study suggests that the seasonal malaria chemoprevention should be extended to other health districts not yet covered, in order to accelerate the elimination of malaria in Guinea.

Background

Worldwide, the number of malaria related deaths has increased by 10% in 2020 compared to 2019, reaching 631,000 according to recent estimates. In the African region, this number fell from 808,000 in 2000 to 548,000 in 2017, before rising again to 604,000 in 2020. Children under the age of 5 accounted for 87% of malaria-related deaths in 2000, compared with 76% in 2015. Approximately 51 children die every hour worldwide as a result of malaria [1]. The number of malaria cases is estimated at 249 million in 2022 in 85 malaria-endemic countries and territories. In 2022, the World Health Organisation's (WHO) African region accounted for around 94% of the world's estimated cases [1]. In sub-Saharan Africa, the risk of malaria in children increases during rainy season [2].

To reduce malaria mortality in highly endemic areas, since 2012 the WHO has recommended seasonal malaria chemoprevention (SMC) as a tool to prevent malaria in children in areas of high seasonal transmission [3]. The SMC strategy consists of administering sulfadoxine-pyrimethamine (SP) and amodiaquine (AQ) treatment in at least four cycles at one-month intervals to children aged between 3 and 59 months in areas of high seasonal malaria transmission [4, 5].

The effectiveness of SMC was demonstrated in research in Ghana evaluating the implementation of seasonal malaria chemoprevention on morbidity in children; in the district that implemented SMC, the proportion of children with malaria decreased significantly, from 31–12%, a difference of 19%; however, in the control district, the proportion of children with malaria increased significantly, from 9–21% [2]. A study in Mali reported a 61% reduction in malaria cases in localities benefiting from SMC, while in the control district, an increase of 23% was recorded [6]. Case-control studies conducted in 2015 in Mali and The Gambia, and in 2016 in Burkina Faso, Chad, Mali, Nigeria and The Gambia, showed an 88% protective efficacy of SMC against malaria [7]. Several studies carried out in different countries confirm the remarkable efficacy of SMC in malaria control and recommend its extension to other regions with a high incidence of malaria [6, 8]. A study carried out in Guinea showed that the incidence of uncomplicated and severe malaria was significantly lower in the SMC district than in the control district [9].

In Guinea, malaria remains the leading cause of morbidity and mortality in under-five children, with 2,422,445 confirmed cases and 1,029 deaths reported in 2021 [9]. SMC was introduced in the country in 2015, and then extended to 17 districts in 2021. However, the effect of this intervention remains under-documented in the Guinean context. The only published study on the impact of SMC did not examine monthly trends before and during its implementation, nor did it take into consideration the comparison of these monthly trends before and during the intervention.

This study aims to fill this knowledge gap by conducting a comparative analysis between a health district covered by SMC and one not covered by SMC. The aim of this study was to analyse monthly trends in malaria cases among under-5 children in Guinea. Specifically, it was to describe the monthly trends in malaria cases and to compare the monthly trends in malaria cases in children under 5 before and during the SMC campaigns (July-October).

Methods

Study design

This was a quasi-experimental before-and-after comparative study using data from the National Health Information System.

Study setting

General setting

Guinea is located in West Africa, covering a total area of 245,857 km², with an estimated population of 13.5 million in 2022. Administratively, the country is organised into 8 regions, each comprising 38 prefectures (districts). These districts represent the main administrative unit where many public services, particularly in the fields of health and malaria, are planned, managed and implemented. Guinea's climate is tropical and humid, with a rainy season (June to November) and a dry season (December to May). The rainy season is associated with maximum malaria transmission, with the peak of cases generally observed between July and November. Around 95% of malaria cases in Guinea are attributable to Plasmodium falciparum [10–12].

Specific setting

The study was carried out in the Mamou and Kindia health districts. The intervention area was the Mamou district, located 268 km from Conakry (the capital of Guinea). The healthcare system in the Mamou health district includes a regional hospital, 18 health centers and 40 health posts, providing primary healthcare services. In 2017, the district's population was estimated at 350,730, spread across 124 quarters and 456 sectors. Annual rainfall was around 1,954 mm in 2017 in Mamou district.

The Kindia district was chosen as the control zone, as it is a neighbouring district with high seasonal rainfall and similar malaria transmission to Mamou. It is close to Mamou, with comparable geographical and demographic characteristics, making it well suited to this study. Kindia is located 138 kilometers away from Conakry. Unlike Mamou, SMC has not been implemented in Kindia. The district has a regional hospital, 14 health centers and 63 health posts, and its population in 2017 was estimated at 466,865, spread over 168 quarters and 608 sectors. Annual rainfall in the Kindia district was approximately 1,996 mm [13].

Study population and period

The study population consisted of children aged 3 to 59 months diagnosed with malaria in the health posts or centers of the Mamou and Kindia health districts. The study covered the period from July to October, for the years 2015 to 2020.

Sampling

The study districts were selected purposively. For the comparability of the two districts, we took into account similar characteristics, in particular rainfall, geographical proximity and malaria prevalence. In each district, aggregate data were collected for all children aged between 3 and 59 months living in the district during the study period.

Data and sources

The data were extracted from the district health information software (DHIS)2, which collects data from the National Health Information System. These data come from consultation registers, are entered, aggregated monthly and then validated. We collected malaria data from the two districts for the period 2015 to 2020. Malaria indicators included the number of suspected cases, the number of cases tested, the number of malaria cases and the number of malaria-related deaths.

Study variables

Dependent variable

Our dependent variable was the number of malaria cases per month, coded 1 from 2018 and 0 before 2018. We compared the average monthly number of malaria cases before the intervention with that during the intervention using Student's t test.

Independent variables

We included the usual variables essential for an analysis of temporal trends [14]. For each district, we established a group variable to identify malaria cases. The time variable was coded sequentially to indicate the months elapsed since the start of the observation periods in each district. Any temporal change in this variable should logically influence malaria cases.

Data analysis

The data were processed using Excel and analysed using Stata 16. First, we performed a descriptive analysis and looked for averages of malaria cases by district. Next, we performed linear regression analyses with mixed effects in order to estimate the effects of the intervention on malaria cases. We assumed that the introduction of the intervention would lead to a change in intercept as well as a monthly change in trends. We also assumed that the pre- and post-intervention trends did not follow a linear trajectory. In addition, we considered that intercepts and trends varied from district to district. These assumptions led to the equation below:

In this model, Y_t represents the monthly number of malaria cases at time t. β_0 is the number of malaria cases at the beginning of the pre-intervention period. β_1 estimates the average monthly change in the number of malaria cases during the pre-SMC period, T_t is the time since the start of the study, β_2 represents the change in the level of the number of malaria cases occurring during the period immediately after the SMC (the SMC period denoted by the indicator variable X_t), β_3 represents the difference between the malaria case trend during the SMC compared with the pre-SMC period, β_4 represents the change in the number of malaria cases in the period immediately after the SMC, β_5 represents the difference between the malaria case trend in the period after the SMC and the period during the SMC, β_6 represents the difference in average monthly change in malaria cases after the SMC in the SMC district versus control district, β_7 represents the difference in average monthly change in malaria cases before the SMC and after the SMC in the SMC district versus control district and ε_t the random error term. Autocorrelation up to four lags was taken into account in our model.

The effects of the intervention over time were estimated by assuming that malaria cases would have increased in the absence of the intervention. The significance level of the statistical tests was set at 0.05.

Ethical considerations

This study obtained authorization from the National Malaria Control Program in Guinea with approval number 025/PNLP/2024 on March 12, 2024. We obtained authorization to use these data after clearly explaining the objectives of the study.

Results

Table 1 shows malaria case data for the SMC district (Mamou) and the control district (Kindia). During the period 2015 to 2017, the Mamou health district recorded 25,696 cases of malaria, while the Kindia health district recorded 18,294 cases. However, during the period 2018 to 2020, the cumulative number of malaria cases was 34,542 in Mamou and 32,616 in Kindia. The average monthly number of malaria cases was 2,141 (948) in the intervention district and 1,525 (374) in the control district from 2015 to 2017. After the intervention, the average monthly number of malaria cases was 2,878 (609) in Mamou and 2,718 (730) in Kindia.

Figure 1 shows the estimated monthly trends in malaria cases before and during the introduction of SMC. During the 2018 SMC in Mamou district, there was an increase in malaria cases in the first month, followed by a decrease in the third month. In 2019, there were continued decreases and the drop was more pronounced in the fourth month. In 2020, there was an increase in the first month, followed by a gradual decline up to the fourth month. The difference between the trends by SMC campaign was marked by an increase in cases in the second month of each cycle for the years 2018 and 2020. The downward slope was more pronounced between the third and fourth months for the 2019 and 2020 campaigns, and between the second and third months for the 2018 campaign.

Table 1
Description of the sample in the two districts before and after the introduction of seasonal malaria chemoprevention 2015–2020

	SMC health district (Mamou)	**Non-SMC health district (Kindia)**
Number of malaria cases in the pre-intervention period (2015–2017)	25 696	18 294
Number of malaria cases in the post-intervention period (2018–2020)	34 542	32 616
Incidence of malaria in the pre-intervention period (2015–2017)	378 per 1 000	195 per 1 000
Incidence of malaria in the post-intervention period (2018–2020)	465 per 1 000	319 per 1 000
Average number of monthly malaria cases during the pre-intervention period (SD) (2015–2017)	2 141 (948)	1 525 (374)
Average number of monthly malaria cases during the post-intervention period (SD)	2 878 (557)	2 718 (730)
SD : Standard Deviation		

Figure 2 compares monthly trends in malaria cases before and during the introduction of SMC in Mamou and Kindia districts. Before the introduction of SMC, an upward trend was observed in the SMC district (Mamou) compared with the control district (Kindia). During the introduction of the SMC, a downward trend was observed in the district that had benefited from the intervention. The trend in the control district remained upward. The effects of the intervention on the number of malaria cases decreased over time in Mamou. During the same period, the number of malaria cases increased in Kindia, as shown in Fig. 2.

Table 2 shows the evolution of the monthly trend in malaria cases in the intervention district (Mamou) and in the control district (Kindia). Before the implementation of the SMC, the average number of malaria cases in the control district was 1008, with an average monthly variation of about 80 cases per month, which was statistically significant (95% CI 42 to 117; $p < 0.001$). Immediately after the implementation of SMC, a significant decrease in the average number of malaria cases of approximately 1013 cases per month was observed (95% CI 22 to 2005; $p = 0.045$). However, after the intervention, the average monthly difference between post-intervention and pre-intervention malaria cases was 60 cases per month, but this variation was not statistically significant (95% CI -157 to 36; $p = 0.210$). The difference in average monthly variation in pre-SMC malaria cases between the intervention and control districts was less than 61 cases, without statistical significance (95% CI -54 to 178; $p = 0.288$). On the other hand, the difference in mean monthly variation in malaria cases after SMC between the intervention and control districts was 1177 cases, with statistical significance (95% CI 180 to 2175; $p = 0.022$). The difference in the average monthly variation in malaria cases post-intervention compared with pre-intervention was less than 164 cases. This difference was statistically significant (95% CI -328 to 0.4; $p = 0.049$). Overall, the intervention resulted in a significant reduction in the average number of 225 malaria cases per month in the intervention district (95% CI -362 to -88; $p = 0.002$).

Table 2
Comparisons of monthly trends in malaria cases in children under 5 in the intervention district (Mamou) and the control district (Kindia)

Variables	**Monthly cases of malaria**		
	Coefficients (β)	**95% CI**	**P.value**
Number of malaria cases at the start of the pre-intervention period in the control group (β0)	1008***	826 à 1190	< 0.001
Average monthly change in malaria cases during the pre-intervention period in the control group (β1)	80***	42 à 117	< 0.001
Average monthly change in malaria cases during the intervention in the control group (β2)	1013*	22 à 2005	0.045
Difference in malaria case trends during the intervention and the pre-intervention period in the control group (β3)	-61	-157 à 36	0.210
Average monthly difference in malaria cases between intervention and control groups prior to intervention (β4)	-100	-863 à 662	0.792
Average monthly difference in malaria case trends between intervention and control groups prior to intervention (β5)	61	-54 à 178	0.288
Average monthly difference in malaria cases between intervention and control groups just after the introduction of the intervention (β6)	1177*	180 à 2175	0.022
Average monthly difference in malaria case trends between intervention and control groups after intervention (β7)	-164*	-328 à 0.4	0.049
Net effect of CPS (β3 + β7)	-225**	-362 à -89	0.002
*** p < 0.05, ** p < 0.01, *** p < 0.001**			

Discussion

The results of this study show that SMC has contributed to a significant reduction in malaria cases in the Mamou health district compared with the Kindia district, where SMC has not been implemented. This reduction was estimated at an average of 225 cases per month. However, the trend in the reduction of malaria cases during the SMC was not linear over the months. These results have important implications for malaria control in Guinea.

The implementation of the SMC has reduced malaria cases in the Guinean context. Several previous studies have also demonstrated a reduction in malaria cases in areas where SMC has been implemented [15–21]. Similarly, an evaluation of the ACCESS-CPS program using DHIS2 data observed a 45.0% and 55.2% reduction in the number of malaria cases in Burkina Faso and The Gambia [22]. Controlled clinical trials and quasi-experimental studies have shown the efficacy of SMC [23–26]. The coverage evaluation conducted by the Gamal Abdel Nasser University in Conakry in 2023 showed that 81.2% of eligible children received SMC during the first cycle, 79.0% during the second cycle, 73.6% during the third cycle and 68.8% during the fourth cycle [27]. Another study conducted by the National Malaria Control Program in the health districts of Siguiri and Kankan in 2020 in Guinea showed that good coverage of targets was linked to the involvement of the health district management team, administrative and community authorities, pre-deployment training of SMC distributors and the supervision of SMC activities [28]. The results found in our study could be explained by the fact that the implementation strategy used for SMC in Guinea is effective. This indicates that SMC is a key strategy in the fight against malaria in Guinea.

Our results add new information to the existing literature. They reveal that the effects of SMC vary from one cycle to another. The difference between SMC cycles in terms of effects on malaria prevalence could be linked to different organisational reasons. Firstly, some cycles may have lower coverage of the target children than other cycles. Distributors probably did not reach all households, either because of logistical problems, lack of availability of distributors, refusal by parents for fear of side-effects or mistrust of public health services. Another possible reason for the ineffectiveness of the SMC is that the SMC doses are not taken correctly, or that the SMC drugs are probably resistant. These reasons could lead to an increase in malaria cases and deaths despite SMC campaigns. This highlights the importance of formative supervision, motivation and logistical support for field workers to ensure effective coverage of all children eligible for SMC. In addition, it would also be necessary to improve the awareness of children's parents by emphasising what to do in the event of side effects and the effectiveness of SMC. Parents should be informed and reminded of the dates of the next SMC cycles by distributors and other information channels.

Limitations and strengths

This study has two main limitations. Firstly, as the data used were secondary and aggregated, we were unable to control for the risk of missing data at the level of the primary sources of health posts and centers. Secondly, the potential contribution of malaria interventions parallel to SMC in the intervention district over the study period could bias the estimate of the effect of SMC. Nevertheless, the study used a control area to better estimate the effect of SMC. Another strength of this study is that it was conducted by a research team external to the implementation of SMC.

Implications for research and practice

This study suggests the need to scale up SMC to other health districts not covered by SMC in Guinea. However, it would be necessary to continue organisational efforts for each SMC campaign, i.e. by effectively involving health district management teams, administrative and community authorities, training SMC distribution agents before their deployment, and ensuring local supervision of the activities of each SMC distribution cycle. It is also important to raise community awareness of the benefits, side-effects and management of side-effects of SMC.

Conclusion

This study shows that in Guinea, SMC contributed to a significant reduction in malaria cases in children under 5 years of age in the Mamou health district from 2018 to 2020. However, this reduction varied per monthly cycle of SMC.

This evidence therefore supports the need to scale up SMC at national level. However, improving the implementation of each SMC cycle and raising community awareness of SMC would help to optimise SMC at the national level.

Abbreviations

SMC	Seasonal malaria chemoprevention
DHIS2	District Health Information System 2
WHO	World Health Organisation
NHIS	National Health Information System

Declarations

Acknowledgements

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Authors' contributions

KSK, BSC, KK and AC participated in the design of the study. KSK, SC, FB, TS, RD and MT participated in the analysis and interpretation of the results. KSK, BSC, KK and MDB contributed to the drafting of the manuscript. BSC and MDB contributed to the revision of the manuscript. All authors approved the final version of the manuscript.

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Availability of data and materials

Data are available at the National Malaria Control Program of Guinea and from the corresponding author on reasonable request.

Ethical approval and consent

This study used existing routine (secondary) data, collected for the purposes of planning and implementing public health programs. The study obtained authorization from the National Malaria Control Program in Guinea to use these data with approval number 025/PNLP/2024 on March 12, 2024.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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Figures

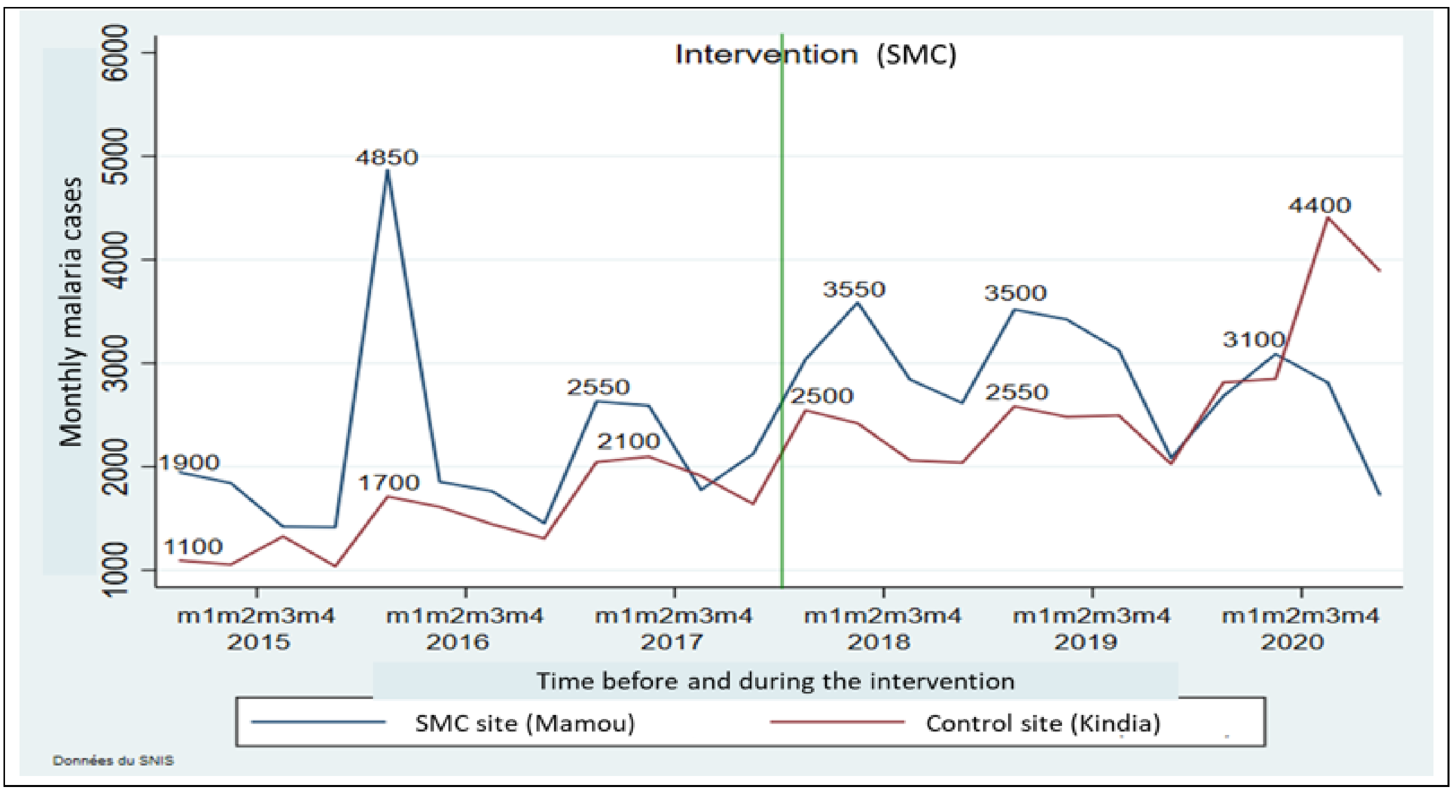

Figure 1

Estimated monthly trends in malaria cases before and during SMC in the districts

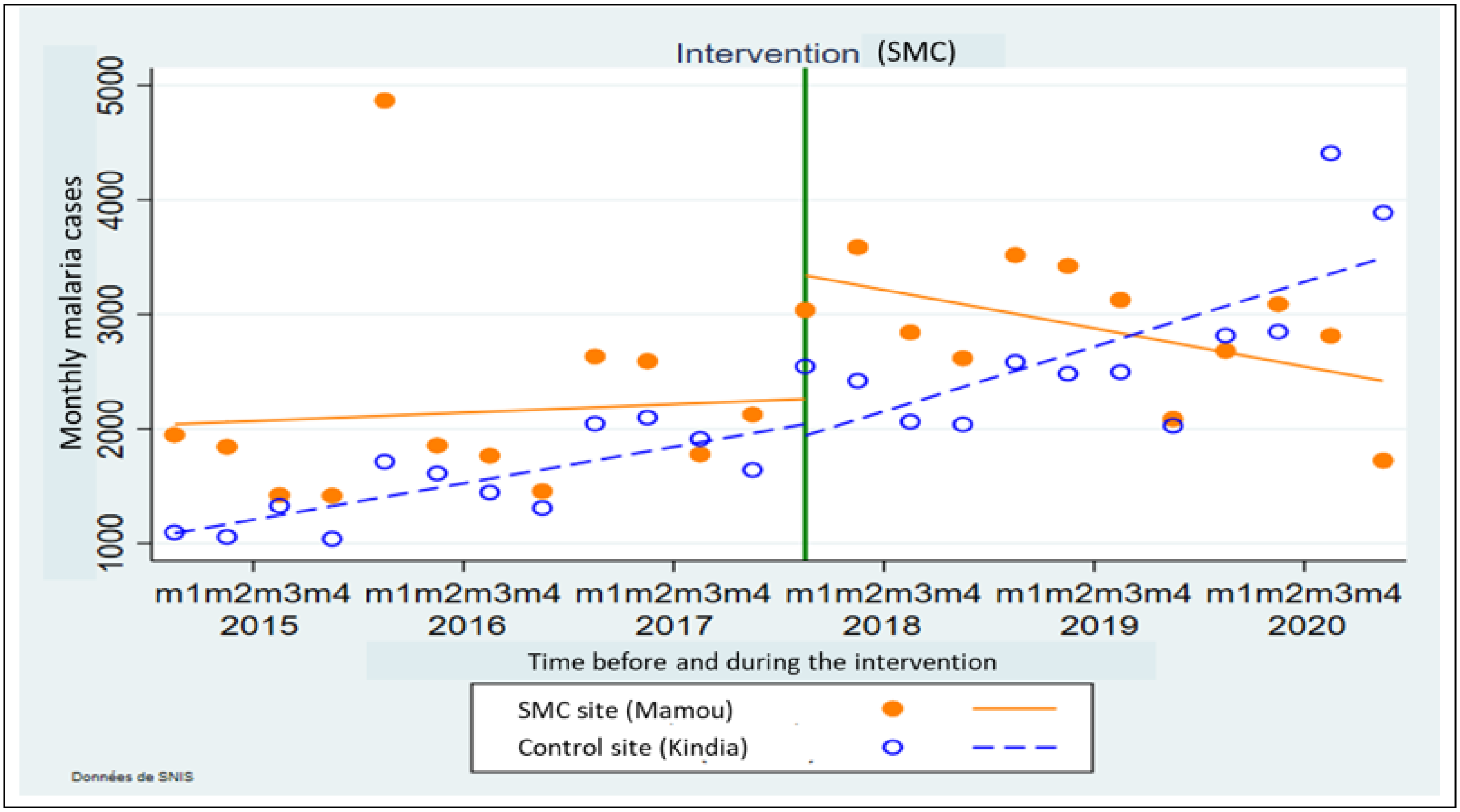

Figure 2

Comparison of trends in the number of malaria cases in SMC and control districts

Supplementary Files

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- Supplementaryfile3.pdf