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Evaluation of the Extension of Seasonal Malaria Chemoprevention to 5 Cycles and to Children Aged 6 to 9 Years in Niger: An Observational-analytical Case-control Study

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Abstract **Introduction:** Malaria infection is prevalent in the West African region more than any other region of the continent. To effectively combat this pathology, Seasonal Malaria Chemoprevention (SMC) has been recommended by WHO since 2012. Our objective is to evaluate the extension of seasonal malaria chemoprevention to 5 cycles and to children aged 6 to 9 years in Niger. **Method:** We conducted an observational case-control study in which we formed two groups for each of the SMC extensions. It took place in the departments of Damagaram Takaya, Takéta and Zinder city town (Zinder region). Children under 5 and those aged 6 to 9, targets of this survey, were randomly selected. The Excel file was used for graphic representations and the SPSS file for coding and analyses. We used descriptive statistics, comparison analyses, chi-square and Fisher tests. **Results:** The incidence of malaria was 56.5% in children under 5 years of age in the control group compared to 3.5% to 4.5% in children in the intervention group. The extension of SMC to five cycles significantly reduced the risk of malaria infection in children under 5 years by between 72% and 96.4%. It caused 11.8% of side effects in children under 5 years of age and 26% in children aged 6 to 9 years. **Conclusions:** The extension of SMC to five cycles and to children aged 6 to 9 years significantly reduces malaria incidence among the targeted children. In view of the significant results from the pilot phase, the Niger NMCP can gradually implement the extension of SMC on a national scale.

Keywords Impact, Seasonal Malaria Chemoprevention, Extension

1. Introduction

Malaria is the most widespread and most serious parasitic disease in the world. It is caused by a hematozoa of the genus Plasmodium, transmitted to humans by the infective bite of a female mosquito of the genus Anopheles during its blood meal [1]. SMC consists of administering monthly intermittent complete treatments with Sulfadoxine-Pyrimethamine (SP) plus Amodiaquine (AQ) to children aged 3 to 59 months [2]. SMC treatment is used in areas with high malaria transmission with a highly seasonal nature, where most cases are recorded during a period of 4 months [3]. Before recommending this strategy among existing preventive ones, several pilot studies were carried out in malaria-endemic areas with short seasonal malaria transmission. These studies demonstrated that SMC prevents 75% of malaria cases (simple and severe) and that it has an impact on anemia and the rate of malaria-related deaths [4]. In the body of children, the combination of SP + AQ provides immunity against malaria that lasts for 4 weeks. After this period, this immunity or protection decreases very quickly. In order to achieve the objectives of the SMC, it is essential to respect the monthly aspect of the administration of SMC during the period of high transmission. According to the WHO recommendation, a child eligible for the SMC must receive treatment for three (3) consecutive days per month for 4 successive months per year. On the first day of treatment, the child takes the combination of SP + AQ and only AQ on the 2nd and 3rd days [5, 6].

But after 5 years of implementing the SMC and based on the salient results from several scientific studies on the perception, acceptability and effectiveness of the SMC in the world in general and in Niger in particular, the extension of the SMC to 5 monthly cycles and to children aged 5 to 9 has become a necessity [7]. In order to extend this activity on a national scale, the NMCP of Niger in partnership with KOICA opts for a pilot phase in two districts of the Zinder region (Damagaram Takaya District and Takiéta District). It is urgent to conduct studies in order to have the information necessary for decision-making on the implementation of the extension on a national scale. This article is part of this framework and aims to evaluate the extension of seasonal malaria chemoprevention to 5 cycles and to children aged 6 to 9 in Niger. The results of this study could serve as a scientific basis for decision-makers and technical and financial partners to better direct resources to effectively combat malaria.

2. Methods

2.1. Study Settings

Our study is taking place in the departments of Damagaram Takaya, Takéita and Zinder city town (Zinder region), more precisely at the Kassama Integrated Health Center (IHC) of the Damagaram Takaya health district, at the Toudouagoua IHC of the Takéita health district and at the Malloumaoua IHC of the Zinder city town health district. The study covers three districts in the Zinder region: Damagaram Takaya, Takéita and Zinder city town and more precisely at one IHC in each of these health districts. The department of Zinder city town does not benefit from any extension of the SMC, however the Malloumaoua IHC (DS Zinder city town) was chosen to serve as a control arm for the evaluation of the extension of the number of cycles compared to the other two IHCs. This choice is justified by the fact that the said IHC presents the same social, environmental, demographic, clinico-epidemiological and climatic characteristics as the IHCs selected in the departments of the extension.

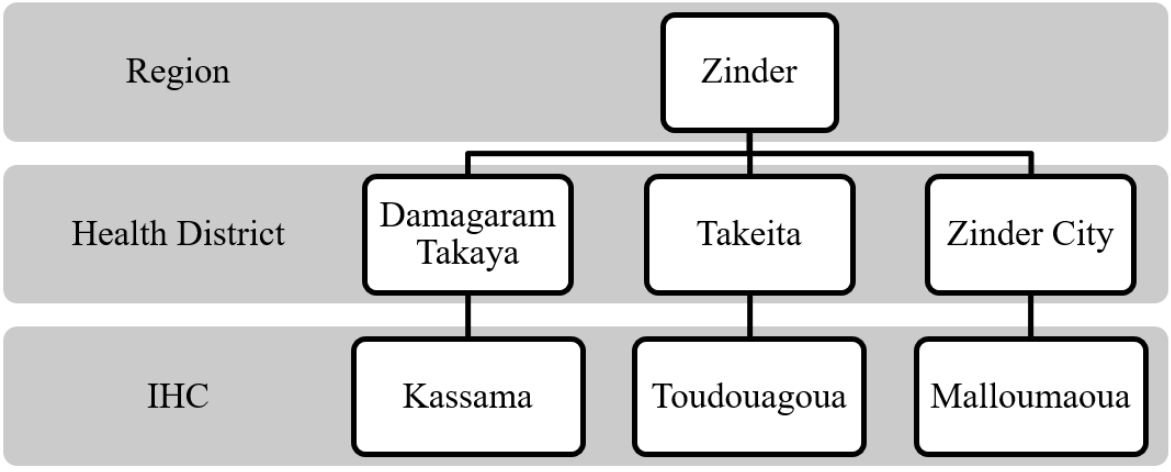

Figure 1. Flow diagram of the study sitting

2.2. Type of Study

This is a case-control analytical observational study in which we set up two groups for each of the SMC extensions: an intervention group and a control group.

2.3. Period of Study

The study took place over a period of one month (December 2023).

2.4. Study Population

The study population therefore consists of children aged 6 months to 59 months from the IHC of Kassama in the department of Damagaram Takaya, the IHC of Toudouagoua in the department of Takéta and the IHC of Malloumaoua in the department of Zinder city and those aged 6 to 9 years from the IHC of Kassama in the department of Damagaram Takaya and the IHC of Toudouagoua in the department of Takéta.

2.5. Inclusion Criteria

Included in the study are children of both sexes responding: aged 6 months to 9 years from the IHC of Kassama, Toudouagoua and Malloumaoua, from the IHC of Kassama and Toudouagoua aged 6 to 59 months and having received the 5th cycle of the SMC in 2023, from the IHC of Malloumaoua aged 6 to 59 months and having received the 4th cycle of the SMC in 2023, from the IHC of Kassama aged 6 to 9 years and having received the 5 cycles of the SMC in 2023, from the IHC of Toudouagoua aged 6 to 9 years and having not received any cycle of the SMC in 2023 and whose parents have given their consent to participate.

2.6. Non-inclusion Criteria

Not included in this study are children: under 6 months or over 59 months from the Malloumaoua IHC, under 6 months or over 9 years from the Kassama and Toudouagoua IHC, from the Kassama and Toudouagoua IHC aged 6 to 59 months and who did not receive the 5th ^{cycle} of the SMCin 2023, from the Malloumaoua IHC aged 6 to 59 months and who did not receive the 4th ^{cycle} of the SMC in 2023, from the Kassama IHC aged 6 to 9 years and who did not receive the 5 cycles of the SMC in 2023, from the Toudouagoua IHC aged 6 to 9 years and who received the SMC products in 2023 and whose parents did not give their consent to participate.

2.7. Sample Size

The sample size was determined by the SCHWARTZ formula

$$n = \frac{Z^2 x\ p\ (1-p)}{m^2}$$

$$n = \frac{1{,}96^2\ (0{,}384)(0{,}616)}{(0{,}05)^2} = 364.$$

The minimum sample size is 364 children, or 182 children per arm. To increase statistical power, we rounded this size to 400, or 200 per arm. Thus, to assess the impact of the extension of SMC to older children, we enrolled 200 children in the intervention arm and 200 in the control arm. For the extension of the number of cycles, we enrolled 200 children in each of the two selected intervention IHCs and 200 children in the control arm, or 600 children in total for this type of extension.

2.8. Sampling

To select children under 5 and those aged 6 to 9 for this research, we used a probabilistic method. This is the two-stage cluster sampling technique, proceeding in stages:

- At the first level, we carried out a draw without replacement to select five (5) villages from the number in each targeted IHC;
- In the second stage, in each of the villages selected in the first stage, 40 children under 5 years of age are enrolled in accordance with the inclusion and non-inclusion criteria for the evaluation of the extension of the number of monthly cycles of the SMC or 40 children aged 6 to 9 years for the second type of extension.

2.9. Ethical Approval and Participation Consent

Under deliberation number 29/2022/CNERS, the National Health Research Ethics Committee of Niger has given its ethical approval. Prior to data collection, the investigators obtained written consent from the participants for their participation in the study and for the confidentiality of their names and the data submitted.

3. Results

3.1. Sociodemographic Characteristics of Enlisted Children

This study takes into account a sample of 1,000 children from three departments of the Zinder region: Damagaram Takaya, Takéta and Zinder city town. This involves 400 children, including 200 children under 5 years old and 200 children aged 6 to 9 from each of the departments Damagaram Takaya and Takéta and 200 children under 5 years old from Zinder city town.

Taking into account gender, girls represent 41.5% of children under 5 years of age enrolled in Damagaram Takaya compared to 58.5% of boys. The proportion of girls in this age group is 47.5% and 47.0% respectively in the departments of Takéta and Zinder city town compared to 52.5% and 53.0% of boys respectively. For the age group under 5 years, boys appear to be more represented, however

the p-value (p = 0.409) is higher than the significance threshold of 5%. This difference in proportion according to gender is therefore not significant.

Boys are also more represented in the ranks of children aged 6 to 9 in Damagaram Takaya as in Takeita. In each of these departments, girls represent less than 50% of children aged 6 to 9 enrolled. However, this difference is not significant (p = 0.764).

3.2. Prevalence of Malaria among Children Enrolled in the Departments of DTK, Takiété and Zinder City in November 2023

Table 1 shows the prevalence of malaria in children under 5 years of age and those aged 6 to 9 years at the time of the survey in the departments of Damagaram Takaya, Takéta and Zinder Ville. The malaria prevalence is 13.7% in children under 5 years of age and 22.8% in children aged 6 to 9 years of age.

It was 0% and 2.5% respectively among children under 5 years of Damagaram Takaya and Takeita which are intervention departments against 38.5% among those of Zinder city town which is the non-intervention department (p-value = 0.000). The 5th cycle of the SMC showed a significant reduction in the prevalence of malaria in the rank of children under 5 years. As for children aged 6 to 9 years, the malaria prevalence is 3.5% in the Departments with SMC against 42% in the Departments without SMC (p-value = 0.000). It is observed that the administration or extension of the SMC to children aged 6 to 9 years considerably reduces the malaria prevalence in the rank of older children.

3.3. Malaria Incidence in Enrolled Children

Table 2 shows the incidence of malaria in the rank of children under 5 years and those aged 6 to 9 years during the month of November 2023 in the departments of Damagaram Takaya, Takéta and Zinder Ville. Analysis of the said table reveals that 129 children under 5 years out of the 600 enrolled in this study suffered from malaria during the month of November 2023, or 21.5% and 192 children aged 6 to 9 years out of the 400 enrolled in the study suffered from malaria during the SMC period (July to November 2023), or 48%.

Taking into account the departments, during the month of November 2023, only 3.5% and 4.5% of children under 5 years of age respectively in Damagaram Takaya and Takéta suffered from malaria compared to 56.5% of those in Zinder city, a department where children did not receive the 5th cycle of the SMC. It therefore appears that the 5th cycle of the SMC significantly reduced the incidence of malaria in the rank of children under 5 years of age (p = 0.000).

For children aged 6 to 9, the table shows that 3.5% suffered from malaria from July to November 2023 in Damagaram Takaya compared to 92.5% of those in Takeita (a department in which children aged 6 to 9 did not receive SMC). It is therefore concluded that the administration or extension of SMC to children aged 6 to 9 significantly reduces the incidence of malaria in the ranks of older children [8].

Table 1. Prevalence of malaria among enrolled children by department

Malaria prevalence			Department			Total	p-value
			Damagaram Takaya	Takeita	Zinder		
Less than 5 years old	No	Effective	200	195	123	518	0.000
		%	100%	97.5%	61.5%	86.3%	
	Yes	Effective	0	5	77	82	
		%	0%	2.5%	38.5%	13.7%	
6 to 9 years old	No	Effective	193	116		309	0.000
		%	96.5%	58%		77.3%	
	Yes	Effective	7	84		91	
		%	3.5%	42%		22.8%	

Table 2. Malaria incidence in enrolled children by age and department

Malaria infection			Department			Total	p-value
			Damagaram Takaya	Takeita	Zinder		
Less than 5 years old	No	Effective	193	191	87	471	0.000
		%	96.5%	95.5%	43.5%	78.5%	
	Yes	Effective	7	9	113	129	
		%	3.5%	4.5%	56.5%	21.5%	
6 to 9 years old	No	Effective	193	15		208	0.000
		%	96.5%	7.5%		52.0%	
	Yes	Effective	7	185		192	
		%	3.5%	92.5%		48.0%	

Table 3. Rate of reduction in malaria prevalence

Departments	Less than 5 years old		6 to 9 years old	
	OR [95% CI]	p-value	OR [95% CI]	p-value
Damagaram Takaya	0.00	0.000	0.050 [0.022-0.112]	0.000
Takeita	0.041 [0.016-0.104]	0.000	Ref	-
Zinder City	Ref	-		

Table 4. Rate of reduction in malaria incidence

Departments	Less than 5 years old		6 to 9 years old	
	RR [95% CI]	p-value	RR [95% CI]	p-value
Damagaram Takaya	0.28 [0.012-0.062]	0.000	0.003 [0.001-0.007]	0.000
Takeita	0.036 [0.018-0.075]	0.000	Ref	-
Zinder City	Ref	-		

3.4. Rate of Reduction in the Prevalence of Malaria in the Departments of DTK, Takiéta and Zinder City Town in November 2023

Table 3 shows the rate of reduction in malaria prevalence among children under 5 years and 6 to 9 years in Damagaram Takaya, Takeita and Zinder Ville. It shows a total reduction (100%) in the risk of malaria infection among children under 5 years of Damagaram Takaya (children with 5th cycle of SMC) compared to those in Zinder city town (children without 5th cycle of SMC). This rate of reduction in malaria infection is 95.9% among children under 5 years of Takeita (children with 5th cycle of SMC) compared to those in Zinder city town (children without 5th cycle of SMC). We can conclude that the extension of SMC to five cycles significantly reduces the prevalence of malaria among children under 5 years.

Among children aged 6-9 years, there was a 95% reduction in the prevalence of malaria infection in Damagaram Takaya (children's area with SMC) compared to children in Takeita (children without SMC). We conclude that extending SMC to children aged 6-9 years significantly reduces malaria prevalence.

3.5. Rate of Reduction in the Incidence of Malaria in the Departments of DTK, Takiéta and Zinder City Town in November 2023

Table 4 shows the rate of reduction in malaria incidence in children under 5 years and 6 to 9 years in Damagaram Takaya, Takeita and Zinder Ville. Its analysis shows a 72% reduction in the risk of malaria infection in children under 5 years of Damagaram Takaya (children with 5th cycle of SMC) compared to those in Zinder city town (children without 5th cycle of SMC). This rate of reduction in malaria infection rises to 96.4% in children under 5 years of Takeita (children with 5th cycle of SMC) compared to those in Zinder city town (children without 5th cycle of SMC). We can conclude that the extension of SMC to five cycles significantly reduces the incidence of malaria in children under 5 years. Among children aged 6 to 9 years, there was a 99.7% reduction in malaria infection in Damagaram Takaya (children's area with SMC) compared to children in Takeita (children without SMC). We conclude that extending SMC to children aged 6 to 9 years completely eradicates malaria over the period from July to November (p=0.000).

3.6. Side Effects

3.6.1. Frequency of Side Effects in Children under 5 Years Old in the Departments of DTK, Takiéta and Zinder City Town in November 2023

The most common side effects in children under 5 years of age are malaise (44%), headache (41%), nausea and vomiting (38%) and itching (35%) (Table 5).

One in three children experienced side effects, which showed that they suffered from discomfort, headache, nausea and vomiting and itching after taking the SMC medication.

3.6.2. Frequency of Side Effects in Children Aged 6 to 9 in the Departments of DTK, Takiéta and Zinder City Town in November 2023

In older children (6-9 years), the most commonly observed side effects are headache (75%), nausea and vomiting (71%), malaise (56%) and fatigue (48%) (Table 6). The proportions of these side effects are very high, over 50%, which means that almost half of the children with side effects have experienced headache, nausea and vomiting, malaise and fatigue at the same time following the taking of the SMC medications.

Table 5. Frequency of side effects in children under 5 years of age

	Yes			No		
Less than 5 years old	N	$\frac{n}{N}$x 100	%	N	$\frac{n}{N}$x 100	%
Headaches	71	29	41 %	71	42	59 %
Nausea/Vomiting		27	38%		44	62 %
Fever		12	17%		59	83 %
Fatigue		13	18%		58	82%
Cough		10	14%		61	86%
Diarrhea		9	13%		62	87%
Jaundice		0	0%		71	100%
Itching		25	35%		46	65%
Faintness		31	44%		40	56%
Joint pain		12	17%		59	83%
Convulsion		2	2%		69	98%
Confusion		0	0%		71	100%

Table 6. Frequency of side effects in children aged 6 to 9 years

	Yes			No		
Less than 5 years old	N	n	$\frac{n}{N}$x 100	N	n	$\frac{n}{N}$x 100
Headaches	52	39	75%	52	13	25%
Nausea/Vomiting		37	71%		15	29%
Fever		6	12%		46	88 %
Fatigue		25	48%		27	52%
Cough		0	0%		52	100%
Diarrhea		1	2%		51	98%
Jaundice		0	0%		52	100%
Itching		0	0%		52	100%
Faintness		29	56%		23	44%
Joint pain		5	10%		47	83%
Convulsion		1	2%		51	98%
Confusion		0	0%		52	100%

Table 7. Side effects in children by age and department

Side effects			Department			Total	p-value
			Damagaram Takaya	Takeita	Zinder		
Less than 5 years old	No	Effective	169	171	189	529	0.003
		%	84.5%	85.5%	94.5%	88.2%	
	Yes	Effective	31	29	11	71	
		%	15.5%	14.5%	5.5%	11.8%	
6 to 9 years old	No	Effective	148			148	0.000
		%	74.0%			74.0%	
	Yes	Effective	52			52	
		%	26.0%			26.0%	

From these two analyses it emerges that malaise, headaches, nausea and vomiting, itching and fatigue are the side effects frequently observed following the taking of SMC products and that a child could suffer from the combination of these effects.

Analysis of Table 7 presenting the side effects of SMC shows that 11.8% and 26% respectively of children under 5 years and 6 to 9 years enrolled in this study experienced side effects after taking SMC medication.

In Damagaram Takaya, 15.5% of children under 5 years of age who received SMC experienced side effects compared to 14.5% and 5.5% respectively in Takéta and Zinder city town (p=0.003). There are therefore more side effects in the under 5 age group in Damagaram Takaya and Takéta than in Zinder city town.

In the range of children aged 6 to 9 years, 26% of those in Damagaram Takaya who received SMC showed side effects. It is therefore concluded that SMC induces side effects in the range of children under 5 years and much more in the range of children aged 6 to 9 years.

3.6.3. Frequency of Side Effects in Children under 5 Years Old

Speaking about the type of side effects in children under 5 years old, the most common are malaise (44%), headache (41%), nausea and vomiting (38%) and itching (35%). The proportions of the most common side effects all exceed 33%. This means that 1 in 3 children who have experienced side effects have suffered from malaise, headache, nausea and vomiting and itching at the same time after taking SMC medications.

3.6.4. Frequency of Side Effects in Children Aged 6 to 9 Years

In older children (6-9 years), the most commonly observed side effects are headache (75%), nausea and vomiting (71%), malaise (56%) and fatigue (48%) (Table 6). The proportions of these side effects are very high, over 50%, meaning that almost half of the children with side effects experienced headache, nausea and vomiting, malaise and fatigue at the same time after taking SMC medications. From these two analyses, it appears that malaise, headache, nausea and vomiting, itching and fatigue are the side effects commonly observed after taking SMC products and that a child could suffer from the combination of these effects.

3.6.5. Mothers' Perception of the Causes of Side Effects

As for the causes of the side effects observed, 94.37% of mothers whose children under 5 years of age had side effects, stated that these effects were related to taking SMC medications compared to 5.63% of mothers for whom these side effects were not the result of taking SMC medications. For mothers whose children aged 6 to 9 years had side effects, they all stated that the side effects observed in children aged 6 to 9 years were related to SMC. This analysis shows that for the mothers of the children, the side effects were related to taking SMC medications.

3.7. Assessment of the Extension of the SMC by Mothers of Children

Table 8 shows the mothers' assessment of the extension of SMC to five cycles and to children aged 6 to 9 years. In Damagaram Takaya, 40.5% of the mothers of enrolled children think that the extension of SMC to five cycles is good, 29% of them think that it is very good and 30.5% think that the extension is bad.

In Takeita, 34.5%, 30% and 35.5% of mothers of enrolled children thought that the extension of SMC to five cycles was good, bad and very good, respectively. Overall, 1/3 of enrolled mothers thought that this extension was bad.

For children aged 6 to 9, 60% and 24% of enrolled mothers respectively think that the extension of the SMC to children aged 6 to 9 is good and very good, compared to 16% who think that the extension is bad. The p-values are all zero, so there is a significant difference between the proportions.

Table 8. Assessment of the extension of the SMC

Do you think that extending the SPC to five cycles is a good idea?			Department			Total	p-value
			Damagaram Takaya	Takéta	Zinder		
Under 5 years	Good	Count	81	69		150	0,000
		%	40,5%	34,5%		37,5%	
	Bad	Count	61	60		121	
		%	30,5%	30,0%		30,25%	
	Very good	Count	58	71		129	
		%	29,0%	35,5%		32,25%	
	No opinion	Count	0	0		0	
		%	0,0%	0,0%		0,0%	
6 to 9 years	Good	Count	120			120	0,000
		%	60,0%			60,0%	
	Bad	Count	32			32	
		%	16,0%			16,0%	
	Very good	Count	48			48	
		%	24,0%			24,0%	
	No opinion	Count	0			0	
		%	0,0%			0,0%	

3.8. Continuity of the Extension in the Future

The results of our analyses show that 72.2% of enrolled mothers want the extension of SMC to five cycles to continue, compared to 27.8% who want the opposite.

Taking into account the department, 80.5%, 69.5% and 66.5% of mothers of children under 5 years old respectively from Damagaram Takaya, Takéta and Zinder city town want the extension of the SMC to five cycles to be continuous.

Among mothers of children aged 6 to 9, 84% are in favour of continuing the extension of the SMC to children aged 6 to 9, compared to 16% who want the opposite. It is therefore noted that the majority of mothers accept that the extension of the SMC to five cycles and to children aged 6 to 9 should be continuous.

4. Discussion

4.1. Methodological Plan

We conducted an observational case-control study in which we formed two groups for each of the SMC extensions: an intervention group and a control group. For the extension of the number of monthly cycles, children under 5 years of age from Damagaram Takaya and Takéta form the intervention group and those from Zinder city town form the control group. As for the evaluation of the extension of the SMC to older children, the intervention group was made up of children aged 6 to 9 years from Damagaram Takaya and the control group was made up of children aged 6 to 9 years from Takéta. Children under 5 years of age in the control group did not receive the 5th round of SMC and those aged 6 to 9 years in the control group did not receive any round of SMC in the year 2023. Our methodology is consistent with that used by Mr. Abdourhamane CISSE in 2022 to evaluate the effect of a 5th round of SMC in children aged 5 to 14 years in the village of Dangassa, Ouélessébougou Health District in Mali [9]. It was also used by Tatiana KOUAKOU in her study aimed at evaluating SMC in children aged 3 months to 9 years in a high transmission area in Mali [10]. However, it is different from the methodology of Seydou Berthe who used two consecutive years 2019 and 2020 [11]. In his study, the year 2019 was without extension (control) and 2020 with extension of SMC (intervention).

4.2. Prevalence of Malaria in Enrolled Children

The prevalence of malaria is 13.7% in children under 5 years and 22.8% in children aged 6 to 9 years. This prevalence is different from that found by KOUAKOU (8.29%) and Moussa (11.66%) in children under 5 years and respectively (10.05%) and (16.83) in children aged 5 and over. This could be explained by different epidemiological approaches.

4.3. Incidence of Malaria in Children

According to our results, the incidence of malaria was 56.5% in children under 5 years of age in the control group compared to 3.5% to 4.5% in children in the intervention group. This incidence is lower than that found by Mr. Mahamadou Fayi çal (75%) and higher than those found by Abdourhamane CISSE and Tatiana KOUAKOU in their studies [9, 10, 12]. However, our conclusion is that the incidence of malaria remains and continues to be high in children in the control group [13].

4.4. Rate of Reduction in Malaria Prevalence

The results of our study show that extending SMC to five cycles significantly reduces the number of malaria cases in children under 5 years by between 95% and 100%. Similarly, extending SMC to older children reduces the prevalence of malaria in children in this age group to 95.9%. This rate of reduction in prevalence is different from that found by Mr. Mahamadou Fayi çal (60% in the intervention arm) and that of Abdourhamane CISSE (8% in the intervention group against 29.6% in the control group, i.e. a reduction rate of 73%) and that of I. SALISSOU (76.92% in the intervention area) [9, 14, 12].

These differences can be explained by the method used to collect the data, which includes household surveys, and also the size of their sample. The extension of the SMC considerably reduces the number of malaria cases.

4.5. Rate of Reduction in Malaria Incidence

In terms of reducing the incidence of malaria, the results of our study show that extending SMC to five cycles significantly reduces the risk of malaria infection in children under 5 years of age by between 72% and 96.4%. Similarly, extending SMC to older children reduces the incidence of malaria in children in this age group by 99.7%. This incidence reduction rate is comparable to that found by Mr. Mahamadou Fayi çal (78% in older children) [12], that of Seydou Berthe (from 37.97% in October 2019 to 5.24% in October 2020, a reduction rate of 86.2%) [11] and that of Abdourhamane CISSE (51% in the intervention group versus 49% in the control group, a reduction rate of 17%) [9]. Our conclusion that expanding SMC significantly and substantially reduces the risk of malaria infection is in full agreement with those of the above studies.

4.6. Side Effects

The results showed that extending SMC to five cycles caused 11.8% of side effects in the range of children under 5 years and 26% in the range of children 6 to 9 years. The most common side effects are malaise, headache, nausea, vomiting, itching and fatigue. It is comparable to those of several studies such as those of Mahamadou and Patrick [5, 6]. Thus, according to the work of Mahamadou Fayi çal, the main side effects are vomiting, hot body and weakness with an average of about 11% in children treated with SMC. Also finding an average of 11%, Patrick O. Ansah et al., found diarrhea and vomiting as the dominant adverse effects related to taking SMC drugs in Ghana. As for Touré et al., their study found that as the main side effects in 2016 in the villages of Binko and Carrière in Mali were headache, vomiting and nausea, malaise and diarrhea [15].

5. Conclusions

The extension of the SMC to five cycles and to children aged 6 to 9 years is an ideal solution to control malaria in the rank of children under 5 years but also in the rank of children of school age. In view of the important results from the pilot phase, the NMCP of Niger can gradually implement the extension of the SMC on a national scale.

Conflict of Interest

The authors declare that there is no conflict of interest.

Authors' Contribution

NTN participated in designing the study, conducting the literature search, obtaining authorization to use the data, selecting the study tools and managing the data, analyzing the statistical data, interpreting the data, and writing the manuscript. MNP, was responsible for the overall coordination of the study and participated in the design and selection of the study tools. OT and JBY was responsible for the documentary research and participated in the interpretation of the data and the writing of the manuscript. JS participated in the analysis of the statistical data, the interpretation of the data and the writing of the manuscript. PM participated in the interpretation of the data and drafting of the manuscript. All authors critically reviewed the manuscript and approved the final version for submission.

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