Impact Of Seasonal Malaria Chemoprevention On Morbidity And Mortality Dues To Malaria Among Children Under Five Years In Chad.

Kebfene Moundine, Zoukalne Moukenet, Kerah-Hinzoumbe Clement, Jean Gaudard

Abstract: In Chad, malaria remains the first cause of consultation with an annual morbidity of 35.39% and a mortality of51%. To reduce the burden of disease, Seasonal Malaria Chemo Prevention was adopted (SMC) in 2013.Since the adoption of SMC, no impact study was performed and no valuation model was proposed. The aim of this study was to model the impact of SMC on morbidity and mortality in children under five years in Chad. This was a prospective comparative study. Among the followed 8 health districts, a SMC program was applied on 4 in 2015. The impact of SMC was measured by the double-difference model on data from the Health Information System collected between January 1, 2011 and December 31, 2015. The incidence and mortality rate of malaria decreased globally between January 1, 2011 and December 31, 2015. The impact of SMC was a significantly increasing incidence of malaria by 1.587‰ and a decrease of mortality rate by 1.494 per 100 000. So, Seasonal Malaria Chemoprevention has contributed significantly to reduce severe malaria cases and frequentation of children aged between 3-59 months. Our results show that SMC contribute to fight malaria by increasing early frequentation of health center in case of simple malaria thus reducing the severe cases and the mortality.

Index Terms: Modeling, Impact, Seasonal, Malaria, Chemoprevention.

1 INTRODUCTION

In Chad, malaria remains a major public health problem with a high morbidity (33.729%) and a high mortality (35,22%) in children under 5 years of age in health facilities [13]. Five *Anopheles* species act as vectors but *Anopheles gambiae* S strain and *Anopheles arabiensis* account for almost 85% of transmission [9]. Three plasmodium species are implicated in the transmission of malaria in Chad namely, *Plasmodium falciparum*, *Plasmodium malariae* and *Plasmodium ovale*. However, 98% of malaria cases are attributable to *P. falciparum* [9]. An analysis of epidemiological data relating to malaria shows that transmission is seasonal [Unpublished data]. This seasonality provides an opportunity for introducing Seasonal Malaria Chemoprevention (SMC), a strategy recommended by the World Health Organization (WHO) in 2012 to reduce the burden of disease. [17; 3]. Chad has adopted the SMC program as part of its national policy against malaria as well as part of its 2014–2018 strategic plan and the National Malaria Control Program (NMCP). The country has selected 38 health districts for gradual implementation of the plan. The present work aimed at assessing the impact of SMC on morbidity and mortality due to malaria among children.

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2. MATERIALS AND METHODS

Study design

This was a prospective comparative study carried out in 8 health Districts, in which 4 were participant in the Seasonal Malaria Chemoprevention (SMC) in 2015. This allowed comparing malaria cases before and after the SMC implementation as well as comparing malaria cases between Districts with or without SMC program.

Materials

Between January 1, 2011 and December 31, 2015, routine data from the Health Information System were collected through malaria reports from the NMCP. These data concern malaria suspected cases and mortality reported in health centers and districts hospitals for the period of study. Incomplete Monthly Malaria Reports (MMRs), which lack information such as number of new cases among children less than 5 years or total number of deaths due to malaria in the targeted districts, were excluded from our study. Only health districts eligible for SMC with complete data for the period of study were selected. Within the potential control districts, we have chosen those not neighbor to a case districts. Some control districts which are neighbor to a case district without high participant rate to SMC was chosen. This choice is to avoid the fact that people in potential control district neighbor to case districts would receive the treatment. To perform our models, we used incidence, mortality rate, simple and severe cases and frequentation of health center of children between 3-59 months of age within group of case districts and control districts.

Statistical analysis

First of all, we have calculated incidence in 5 potential control groups which content 4 districts per group. After that, the potential control group which the malaria incidence before the SMC is not significantly different from the case districts one were chosen. The student-test was perform on incidence before treatment with t = - 0.2313 and p-value = 0.8181. To compare statistics, a 5% level of p-value was used.

Methods of impact assessment

To assess the impact of SMC, for which the choice of participating districts was made randomly from a set of districts not chosen at random because politics was involved, we adopted the double-difference (DD) or "difference-in-differences" method which allows an impact assessment of a program while taking into account the initial differences between the 2 groups (treatment group and controls) [7]. The aim of the SMC program being to lower the incidence and mortality rates due to malaria, we cannot be satisfied simply by observing these parameters before and after implementation of the program because multiple external factors can have an influence on its impact. Likewise, a simple comparison of the districts benefiting or not from the program is problematic because selection bias should occur even if SMC program was randomly applied. Furthermore, environmental or behavioral factors can affect exposure to malaria differently between districts, adding potential confusion bias. To do that, a combination of these 2 differences would appear to be appropriate. Thus, the first difference in time (before–after) for participating districts allows us to verify the constant time factors within the intervention group. The second difference relates to the control districts before and after the program, in so far as this group is subject to the same conditions as the first one. Finally, the difference of these 2 differences constitutes the impact of the program, since we have eliminated the bias associated with time, which is likely to affect our assessment Gertler PJ, Martinez S, Prenand P, Rawlings LB, Vermeersch CMJ (2001) gave more detail about this method, which we have implemented within the framework of our assessment [7].

Impact assessment model applied

The double-difference procedure is, in fact, structured like a randomized pre-test/post-test experiment that is missing its principal characteristic: random distribution [2]. An initial strategy with this method is to apply the models (1) below via modeling of the Ordinary Least-Squares (OLS) type. Another strategy consists of performing fixed-effects modeling on panel data by considering the 2 groups (treatment and control) as a panel whose measurements have been taken before and after the program. The latter modeling method can be carried out using OLS by adding indicator variables to characterize the groups. It is also possible to extract from it an instrumental strategy for these models. To do that, following are models:

$$\begin{cases} Y_{i0} = \alpha_0 + \beta_1 T + \varepsilon_{i0} \\ Y_{i1} = \alpha_1 + \beta_1 T + \beta_2 D + \varepsilon_{i1} \end{cases}$$

The panel version of the model is:

$$\begin{cases} Y_{i0} = \alpha_0 + \boldsymbol{C}_i + \mu_{i0} \\ Y_{i1} = \alpha_1 + \boldsymbol{C}_i + \beta_2 D + \mu_{i1} \end{cases} \quad (2)$$

Where Y_{i0} (or Y_{i1}, as the case may be) indicates the incidence or the mortality rate before SMC (or after SMC) and i indicate the district; D indicates the state of the group (D=1 if participating district or "treatment" group (SMC) after implementation of program and 0 if non-participating or "control group"); T indicates the state of the group, T=1 if participating district and 0 if "control group"; ε_{i0}, ε_{i1}, μ_{i0} and μ_{i1} are residuals suppose to be normally distributed; C_i is the indicator variable for the groups (SMC group and control group), it represents the fixed effect for those group.

- β_1 represents the difference between the SMC group and the control group before the implementation of SMC while t is period of program. t=0 before implementing SMC and t=1 after SMC.

From de first equation in (1), we have: for control group $E(Y_{i0}) = \alpha_0$ and for SMC group $E(Y_{i0}) = \alpha_0 + \beta_1$ then,

$$\beta_1 = \overline{Y_{t=0,T=1}} - \overline{Y_{t=0,T=0}} \quad (3)$$

- $\beta_1 + \beta_2$ represents the different between treatment and control group after SMC was implemented while t is period of program. t=0 before implementing SMC and t=1 after SMC.

From the second equation in (1), we have: for control group $E(Y_{i1}) = \alpha_1$ and for SMC group $E(Y_{i1}) = \alpha_1 + \beta_1 + \beta_2$

then $\beta_1 + \beta_2 = \overline{Y_{t=1,T=1}} - \overline{Y_{t=1,T=0}}$ (4)

- β_2 represents the difference of difference between the SMC and control groups after SMC and before SMC implemented and t is period of program. t=0 before implementing SMC and t=1 after SMC.

$$\left(\overline{Y_{t=1,T=1}} - \overline{Y_{t=1,T=0}}\right) - \left(\overline{Y_{t=0,T=1}} - \overline{Y_{t=0,T=0}}\right) = \left(\overline{Y_{t=1,T=1}} - \overline{Y_{t=0,T=1}}\right) - \left(\overline{Y_{t=1,T=0}} - \overline{Y_{t=0,T=0}}\right) \quad (5).$$

We assume that these last differences measure the effect of treatment.

3. RESULTS

The incidence and mortality rates of malaria in the 2 health districts groups showed a global decreasing. But, they increased in the months of July–October, displaying seasonality. Globally, incidence and mortality rate seems higher in the SMC group than the controls before SMC. After SMC, mortality rates became higher in the SMC districts than they are in the controls districts. But, during the period of high transmission (July-October), mortality and incidence rate have decreased steadily after SMC (Figures 1and 2). In fact, malaria transmission occurred from April to December and was due each month to at least two vector species, An. arabiensis being always involved. More than 80% of the total Entomologie Indicator Rate (EIR) was concentrated in the three last months of the rainy season (August to October) with a peak at 93 bites of infected anophelines/man/month in October [9].

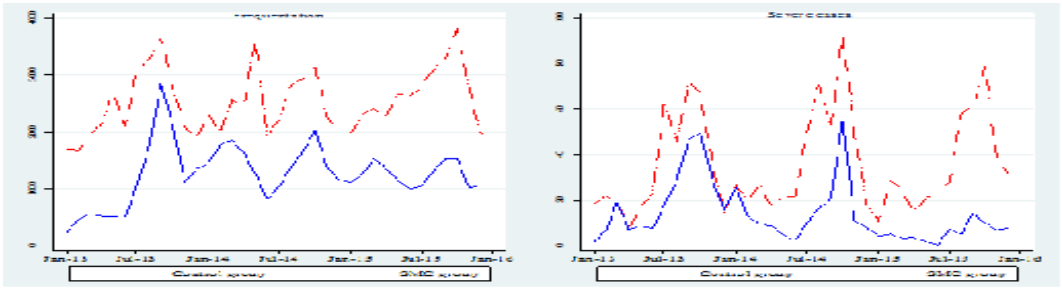

Figure 1: *Evolution Of Malaria Incidence And M(Smc And Control Groups). Ortality Rates Of Children 3-59 Months*
Note: *Malaria incidence and mortality rates are shown as per 100 000 and SMC= Seasonal Malaria Chemo-prevention.*

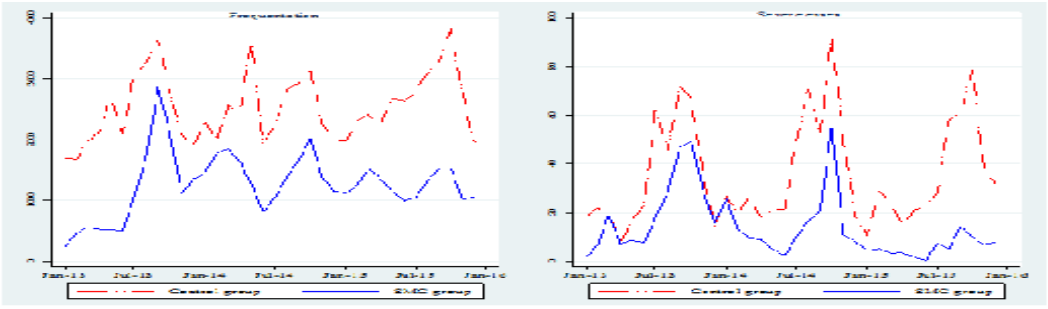

Figure 2: *Evolution of all cases consultations and severe malaria cases of children 3-59 months per district (SMC and control groups).*
Note: *all cases of consultation and severe malaria cases are shown as mean per district*

Table1: *Impact modeling on incidence rate and mortality: means with standard deviations in parentheses*

	Incidence rate			Mortality rate		
	Before	After	Difference	Before	After	Difference
SMC	485.5	336.5	-149.0	2.7	0.3	-2.4
	(62.34)	(38.61)	(73.33)	(0.61)	(0.10)	(0.61)
Control	469.1	161.3	-307.8	1.2	0.3	-0.9
	(34.23)	(26.53)	(43.31)	(0.29)	(0.11)	(0.31)
Difference	16.4^{ns}	175.2	158.7	1.5	-0.02^{ns}	-1.5
	(71.12)	(46.85)	(58.02)	(0.67)	(0.15)	(0.69)

Note: *ns=not significantly different to 0 (p-value>0.05)*

Table 2: *Impact modeling on severe cases of malaria and frequentations: means with standard deviations in parentheses*

	Severe cases			Frequentation		
	Before	**After**	**Difference**	**Before**	**After**	**Difference**
SMC	14.7	8.6	-6.1	1,261	1,251	-10.4
	(2.63)	(1.29)	(2.93)	(103.90)	(97.57)	(142.57)
Control	33.1	49.5	16.4	2,449	2,952	502.9
	(3.95)	(8.09)	(9.00)	(96.27)	(255.90)	(273.37)
Difference	-18.4	-40.9	-22.5	-1187.5	-1700.9	-513.4
	(4.74)	(8.19)	(9.47)	(141.68)	(273.83)	(308.31)

Note: *Severe cases and frequentation are means within groups. ns=not significantly different to 0 at 5%*

An analysis of Table 1 shows that, before the SMC was implemented, there are no difference in incidence rate in SMC districts and controls. But, SMC districts had an average lead of 1.5 per 100 000 in mortality of malaria vs controls districts. This gap remains constant over time (1.5 per 100 000). Unless, the difference of incidence rate grew bigger over time to 1.752‰ after SMC vs control group. Moreover, our assessment reveals that the impact of SMC on the incidence of malaria is an average increase of 1.587‰ and an average decrease of 1.494 per 100 000 on mortality. In the same time, all consultations per district decrease by 513 between SMC and Controls after the SMC while severe malaria cases per district decrease by 22.54 between SMC and controls group after SMC (Table 2 and Figure 2).

4. DISCUSSION

Our assessment revealed that the impact of SMC on the incidence of malaria is an average increase of 1.58‰, which is in opposition with results from Senegal, Gambia, Mali, and Burkina Faso [1; 4; 5; 10]. These authors reported in their studies using a monthly administration regimen for SMC a high level of protection against clinical cases of malaria of 78% with a confidence interval of 95% (69–89%). On the other hand, the impact of SMC on the mortality of malaria is an average decrease of 1.494 per 100 000. In fact, all cases of consultations per district decrease by 513.4 between SMC and Controls after the SMC has implemented while the decrease in severe malaria cases per district was an average of 22.54 cases between SMC and controls group after SMC was implemented. This result means that, the impact of SMC was the increase of early frequentation of health center in case of simple malaria since simple cases of malaria have grown by 6.07% than population of this group of age (3-59 months) who grew by 2.78% and people are suppose to conduct children early to health center because they expect to get free drugs from SMC, they hear about this and because the global free of charge program is not effective. In fact, our results show also the likely effect of the extensive awareness campaign using many communication channels (traditionals and religious leaders, town criers and mass-media) in french and arabic were utilized to inform people about the SMC and its benefits. This media campaign would result in a change of behavior favorable to the use of formal care in contrary to the period before SMC. Indeed, the survey report on preliminary indicators of SMC published in November 2015 indicated that 12% of parents of children under 5 years practicing self-medication while 5% preferred look for a traditional practitioner [13]. In addition to that, 60.24% of people involve are aware that their children could contract malaria [14]. Therefore, the intensity of the communication around the SMC could explain the increase of the consultation for any symptom of malaria. This, in any case, could justify the increase in the incidence of malaria reported by health facilities who participated to the SMC program.In fact, the intensity of information and communication network (ICN) is associated with reduced probability of deaths of people that are clinically identified as malaria infected. The results are significant for both interpersonal and mass communication networks [12]. Results show also a decrease in frequentation which content simple cases and severe cases of malaria and others causes of illness. But frequentation is growing by 4.53% less than simple malaria cases who grew by 6.07% it means that others cases of frequentation would decrease. Otherwise, results should lead to research on impact of SMC on others causes of frequentation It means positive externalities of SMC on others cause of health frequentation.

5. CONCLUSION

Results show that Seasonal Malaria Chemoprevention is a promising strategy to reduce mortality due to malaria among children of less than 5 years in the Sahel region of Chad. Moreover, this strategy shows an increase of early frequentation of health centers in cases of malaria. It's possible that information and communication networks can substantially scale up the effectiveness of the existing resources for malaria prevention. Resources spent in preventing malaria are far less than needed. Expanded information and communication networks about seasonal chemoprevention will widen the avenues for community based "participatory development" that encourages the use of local information, knowledge and decision making. Timely information, immediate care and collective knowledge based treatment can be extremely important in reducing child mortality and achieving the millennium development goal. However, it's very important to explore local factor that has contributed for increasing incidence rate after implementation of SMC program.

COMPETING INTERESTS:

No competing interest

AUTHORS' CONTRIBUTIONS

The authors contributed equally.

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