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Evaluation of seasonal malaria chemoprevention implementation in the Upper East region of Northern Ghana

Emmanuel Yidana Ayamba^{1*}, Emmanuel Kofi Dzotsi², William Dormechele¹, Nana Akosua Ansah¹, Oscar Bangre¹, Josephat Ana-Imwine Nyuzaghl², Sydney Ageyomah Abilba², Samuel Kwabena Boakye-Boateng² and Patrick Odum Ansah¹

Abstract

Background Ghana adopted the WHO-recommended Seasonal Malaria Chemoprevention (SMC) in 2016 following a pilot study as a vital strategy for malaria control. SMC is the intermittent administration of a preventive and curative dose of anti-malarial medicine (Sulfadoxine-Pyrimetamine + Amodiaguine) during four months of the malaria season. This study monitored the implementation of SMC to ensure the intervention is achieving its target.

Methods This was a longitudinal study in four administrative districts of the Upper East Region of Ghana. Children aged between 3 and 59 months were sampled and followed up one week after each cycle of SMC dosing to complete a guestionnaire. SMC status was determined through the caregiver's report and child welfare cards, if available. Caregivers were asked if the participant had been treated for malaria since the last cycle. Simple and multiple logistic regressions were employed to determine associations between SMC adherence and the independent variables, with all results interpreted at a 95% confidence level (CI).

Results This study reported an average SMC coverage of 87% (CI: 86.7–89.5) per cycle with a 2% dropout after the first cycle. SMC adherence rate remained above 82% (CI: 1.4–2.5), with malaria incidence decreasing in those who received all four doses of SMC compared to partial recipients. Health system/programme (49%) and patient related factors (33%) were the main reasons reported for non-adherence. Significant predictors of adherence were household size (aOR = 1.04, 95% Cl 1.01–1.08), sleeping under bed nets (aOR = 1.88, 95% Cl 1.44–2.48), and indoor residual spraying (IRS) presence (aOR = 0.83, 95% CI 0.69–1.99).

Conclusion Despite achieving an average coverage of 87% per cycle, it falls short of the national target of 90%. Notable reasons for drop-outs and non-adherence were, the caregiver being unavailable during the distribution, highlighting the need for diversified approaches in SMC campaigns to enhance coverage, and adherence, and maximize intervention benefits.

Keywords Malaria, Seasonal Malaria Chemoprevention (SMC), Coverage, Adherence, Non-adherence, Adverse events

*Correspondence:

Emmanuel Yidana Ayamba

emmanuel.ayamba@navrongo-hrc.org; yidana22@gmail.com

¹ Department of Clinical Science, Navrongo Health Research Centre,

Navrongo, Upper East Region, Ghana

² Regional Health Directorate, Navrongo, Upper East Region, Ghana



Background

Malaria continues to be endemic and perennial in all parts of Ghana, with seasonal variations that are more pronounced in the north despite the efforts by the governments of Ghana to mitigate its prevalence [1]. Children under five years of age and pregnant women are at

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higher risk of severe illness due to lowered immunity [1]. It has been reported as a leading cause of outpatient visits, and hospitalizations in all parts of Ghana with several deaths attributed to malaria [2]. Several efforts including the use of insecticide-treated nets (ITN), indoor residual spraying (IRS), seasonal malaria chemoprevention (SMC), malaria Vaccine, and case management have been employed over the years to help reduce this burden in Ghana [3].

The World Health Organization (WHO) has recommended chemoprevention strategies to deal with malaria in children under 5 years, pregnant women, travellers, and people with HIV or AIDS who are at higher risk of severe malaria infection [4]. SMC is the intermittent administration of a preventive and curative dose of antimalarial medicine (Sulfadoxine-Pyrimetamine + Amodiaquine) during the malaria season, regardless of whether the child is infected with malaria. This establishes antimalarial drug concentrations in the blood that clear existing infections and prevent new ones during the period of greatest malaria risk [4].

Ghana introduced the SMC intervention as a strategy for malaria control following a successful pilot implementation in the Upper West Region in 2015 which demonstrated the feasibility and effectiveness of SMC by reducing malaria parasitaemia [5]. Continuous monitoring of the intervention is required to ensure the achievement of its target. This study, therefore, aimed to ascertain the intervention's impact on reducing malaria burden by exploring three key areas: (1) SMC coverage and adherence rates across different cycles; (2) factors influencing these rates; and (3) the consequent effect on malaria incidence. This study focuses on determining how well SMC is being implemented and its direct effects on reducing malaria episodes among the target demographic.

Methods

Study settings

The study was conducted in four administrative districts of the Upper East Region of Ghana, namely, Kassena-Nankana Municipal, Kassena-Nankana West, Builsa North, and Builsa South Districts (see Fig. 1). All four administrative districts fall within the catchment area of the Navrongo Health and Demographic Surveillance System (NHDSS) and Builsa Health and Demographic Surveillance System (BHDSS) and have similar demographic characteristics. About 90% of the population



Fig. 1 Map of study districts—study area. Source: Adopted from Navrongo Health and Demographic Surveillance System, 2024

of the area live in the rural parts of the districts where subsistence agriculture is the main source of livelihood. The area is characterized by Guinea Savannah vegetation with a short rainy season and a prolonged dry season from October to March. The mean annual rainfall is about 1300 mm, with the heaviest usually occurring in August. Mean monthly temperatures range from 22.8 °C to 34.4 °C. The local economy of the area is based on subsistence agriculture, government establishments, and tourist attractions [6].

SMC implementation

SMC involves administering two anti-malarial drugs, sulfadoxine-pyrimethamine (SP) and amodiaquine (AQ), to children aged 3–59 months. This is done over a four-month period from July to October 2024, coinciding with the high-risk malaria transmission season. Community health workers (CHWs) and community-based volunteers deliver the drugs directly to households. In this study, each 'cycle' refers to a five-day period within each month when the drugs are administered [4, 7]. In this study, each 'cycle' refers to a five-day period within each month when the drugs are administered.

Eligible children are grouped into two broad categories: 3–11 months and 12–59 months. Every eligible child is assessed, and the appropriate dosage is given to the child in the presence of the CHW/volunteer. The caregiver is then given the remaining doses of medications to be given on the second and third days. Monitoring teams from the District Health Management Teams supervise the successful implementation of the programme by ensuring all logistics needed are provided adequately and on time.

Study design

A prospective longitudinal study design was adopted. A cohort of children aged between 3 and 59 months were sampled from each of the four districts for this study. These sampled participants were followed up one week after each cycle of SMC dosing and their parents or legally acceptable representatives (LAR) were made to complete a questionnaire.

Sampling

A simple random sampling method was employed using the Navrongo Health and Demographic Surveillance System (NHDSS) and Builsa Health and Demographic Surveillance System (BHDSS) database of children under five years of age.

All children aged between 3 and 59 months in each of the four districts were eligible for sampling. The NHDSS and BHDSS monitor demographic and health changes of all individuals and households in the Kassena Nankana West District, Kassena Nankana Municipal, Builsa North, and Builsa South Districts. Trained field workers visit compounds every four to six months and interview heads of households using an electronic data capture (openHDSS-CAPI) which contains health and demographic information about all individuals in a household. Community key informants trained by the research team also capture and report events including births making the database more comprehensive [6].

The Cochran formula $n = \frac{Z^2 pq}{e^2}$ was used to estimate the sample size. Where: e is the desired level of precision (i.e., the margin of error), p is the (estimated) coverage of the SMC intervention, and q is 1 - p.

Since the coverage for the region was unknown, a default 50% was assumed. At a 95% confidence- level that gives a Z value of 1.96 and a margin of error at 0.05 [8].

$$n = \frac{1.96^2 \times 0.5 \times 0.5}{0.05^2}$$
$$n = \frac{0.9604}{0.0025} = 384.16 = 384$$

Considering issues of non-response, a 30% margin was included. Based on the sample size calculations made, approximately 500 participants will be sampled in each of the four districts for this study. A minimum of 500 participants were sampled from each of the four districts. Overall, 2099 participants were sampled and enrolled in the study.

Data collection

At the end of the first cycle of SMC dosing, trained field staff identified and informed all sampled participants about the study. Caregivers who consented for their children to take part in the study were interviewed using a structured questionnaire deployed in the REDCap mobile application v5.26.3. At the end of each of the subsequent cycles, the parents/LAR of the cohort were then approached again and administered a questionnaire. Study data were collected and managed using REDCap electronic data capture tools hosted at Navrongo Health Research Center, Ghana. REDCap (Research Electronic Data Capture) is a secure, web-based software platform designed to support data capture for research studies, providing: (1) an intuitive interface for validated data capture; (2) audit trails for tracking data manipulation and export procedures; (3) automated export procedures for seamless data downloads to common statistical packages; and (4) procedures for data integration and interoperability with external sources [9, 10].

Ethical considerations

Ethics approval was obtained from the Navrongo Health Research Centre Institutional Review Board (NHRCIRB), with Ethics Approval ID NHRCIRB538. Informed consent was also obtained from all caregivers before enrolment into the study. Unique identification numbers were assigned to all participants to ensure confidentiality. Personal information and study results were kept confidential and always protected per the guidelines set by the Institutional Review Board and GCP/ICH E6 R2 guidelines.

Data analysis

Data management and analysis were done using STATA 17 software. One-way table analysis was used for the descriptive statistics to examine frequencies and percentage distribution of the background characteristics of the children included in the study.

Both the SMC status and coverage were determined using estimate proportions with cluster effect at a 95% confidence level. The SMC status was determined from the caregiver's verbal report and the child welfare card, if available. The proportion (coverage) of participants dosed with SMC was estimated at the end of each dosing cycle. The drop-out rate per cycle was determined by conducting a difference-in-difference analysis of the proportions dosed in the first cycle with the remaining three cycles.

Adherence was broadly defined as the extent to which patients take medications as prescribed by their

healthcare providers. In this study, being adherent was therefore defined as taking all the prescribed doses of SMC medication during each cycle of the campaign. Missing at least one dose of the medication was classified as non-adherence.

Confirmed malaria occurrences post each SMC cycle was determined by linking the SMC participant data with the health facilities outpatient and hospitalization data within the study catchment area.

Simple and forward stepwise multiple logistic regression was employed to determine the factors associated with SMC adherence. Independent variables for the regression analysis were selected by reviewing relevant literature. Key variables included household size, use of insecticide-treated nets, and indoor residual spraying, known for their impact on malaria prevention. To refine the selection and ensure the variables' relevance, preliminary statistical tests such as correlation analysis and variance inflation factor (VIF) assessments were conducted to identify and mitigate multicollinearity. All results interpreted at a 95% confidence level.

Results

Characteristics of participants

The descriptive statistics of participants' characteristics are reported in Table 1. The median age of the participants was 49 months (Interquartile range (IQR): 44–52), 50% were female whilst the median household size of the participants was 6 (IQR: 5–8). Regarding the availability of treated insecticide bed nets in the homes

Characteristics	N (%)	Kassena-Nankana Municipal		Kassena-Nankana West		Builsa North		Builsa South	
		n	%	n	%	n	%	n	%
Sex									
Female	1056 (50.31)	264	50.87	262	49.43	269	52.23	261	48.79
Male	1043 (48.69)	255	49.13	268	50.57	246	47.77	274	51.21
Age in months									
Median (IQR)	49 (44–52)	51 (48–54)		51 (48–55)		44 (39–49)		45 (39–49)	
Household									
Median (IQR)	6 (5–8)	6 (5–8)		7 (5–9)		6 (5–7)		6 (5–8)	
IRS use									
Yes	1286 (61.27)	30	5.78	423	79.81	399	77.48	434	81.12
No	813 (38.73)	489	94.22	107	20.19	116	22.52	101	18.88
ITN available in home									
Yes	1826 (86.99)	475	91.52	114	21.51	437	84.85	498	93.08
No	273 (13.01)	44	8.48	416	78.49	78	15.15	37	6.92
Previous night ITN usage									
Yes	1785 (97.75)	466	98.11	411	98.80	420	96.11	488	97.99
No	41 (2.25)	9	1.89	5	1.20	17	3.89	10	2.01

Table 1 Background information of study participants

of participants, about 87% of the participants reported having them at their homes with 98% sleeping under a bed net the previous night indicating a high level of bed net usage. Most of the participants (61.27%) had indoor residual spraying (IRS) carried out in their homes over the last 12 months. However, when examining the data across districts, a notable difference was observed in Kassena-Nankana Municipal, where approximately 6% of the participants reported having IRS in their homes.

Coverage of SMC and dropout rates between cycles

The coverages of SMC per cycle of dosing in the districts are portrayed in Fig. 2. Generally, the coverage decreased sequentially from cycle 1 through to cycle 4. On average, 87% of the participants received SMC per cycle.

On dropout rates between the cycles, a dropout rate of 7.43% between cycle 1 and 2, 6.24% between cycle 2 and cycle 3, and 12.34% between cycle 3 and cycle 4 were observed (Fig. 3). Generally, about 2% of the participants dropped out after cycle 1 and never took other doses during the remaining cycles (Fig. 3). Reasons

for drop-out after each cycle were assessed. Reasons for dropouts were categorized as drug-related reasons (18%), including bad taste and side effects; health system/programme-related reasons (49%), mainly due to volunteers not visiting homes or caregivers being absent; and participant-related reasons (33%), such as forgetfulness and refusal (Fig. 4).

Occurrence of malaria after SMC

Of the total number of participants, 97% received at least one dose of SMC with 31.57% of these experiencing at least one episode of malaria. Among those who did not receive any dose of SMC (59), 23.73% experienced at least one episode of malaria within the study period. Also, in terms of malaria episodes, among those who received all doses (fully dosed), 29% experienced at least one episode of malaria compared with 33% among those who did not receive all 4 doses (not fully dosed) of SMC. No mortality was recorded (Table 2).



Fig. 2 SMC Coverage per cycle



Fig. 3 Drop-out rate after each cycle



Reasons for Dropout between cycles

Fig. 4 Reasons for dropout between cycles

Table 2 Occurrence of malaria after SMC dosing

SMC dose	At least 1 episode of malaria, n (%)	No malaria, n (%)
At least 1 dose of SMC	644 (31.57)	1396 (68.43)
No dose of SMC	14 (23.73)	45 (76.27)
Fully Dosed	190 (28.74)	471 (71.26)
Not fully dosed	468 (32.55)	970 (67.45)

Adherence to SMC

The adherence rate to SMC among participants during the first cycle of drug distribution was 84.47% whilst that of the second round was 84.33%. The third and fourth cycles also had similar adherence rates of 87.05% and 82.26%, respectively. The main reason for non-adherence was the participants mostly being at school or not available where the medication was found (74%). Some participant caregivers also refused to administer the medication to the participants as requested (14%). Other reasons for non-adherence included forgetfulness, side effects of the medications, and bad taste of the medications (Fig. 5).

Adverse events following dosing of SMC

Adverse events were reported by some of the participants after taking the SMC doses. These adverse events were however not mutually exclusive of each other. The most prominent adverse events reported were fever (22.31%), vomiting (19.47%), drowsiness (8.62%) and diarrhoea (7.81%). Other less prominent adverse events reported included nausea, cough, body itching, and abdominal pains among others (See Fig. 6).

Factors associated with adherence to SMC

Table 3 presents the Crude Odds Ratio (COR) and Adjusted Odds Ratios (AOR) at a 95% Confidence Interval (CI) of independent variables and adherence to SMC. Increasing household size was associated with adhering to SMC dosing (COR: 1.04, 95% CI 1.01-1.08). Participants who slept under bed nets were about two times more likely to adhere to SMC dosing as compared to their non-user counterparts (COR: 1.93, 95% CI 1.47-2.52). In multivariable analysis, household size, sleeping under a bed net, and indoor residual spray in homes showed a statistically significant association with adherence to SMC. The odds of adherence among participants who sleep under bed nets were 1.88 times higher compared to those who did not sleep under bed nets (aOR: 1.88, 95% CI 1.44-2.48, p=0.020). Additionally, for every unit increase in the household size, there is an increased odds of 1.04 in adhering to SMC (aOR: 1.04, 95% CI 1.01-1.08, p < 0.001). Also, participants whose homes had indoor residual spraying against mosquitoes had 17% lower odds of adhering to SMC compared to those whose homes did not have indoor residual spraying (aOR: 0.83, 95% CI 0.69 - 0.99, p = 0.042).

Discussion

SMC has been shown to reduce malaria cases by approximately 75% during the intervention period, with some studies reporting up to an 88% reduction in clinical malaria incidence shortly after treatment [11]. This substantial decrease in malaria cases directly correlates with high coverage rates [11]. The study identified an average SMC coverage of 87% per cycle with coverage decreasing sequentially from cycle one through to cycle 4. Again, the



Fig. 5 Reasons for non-adherence



Table 3 Factors associated with adherence to SMC

	Univariable	e model		Multivariable model			
Factors	COR	95% CI	p-value	aOR	95% CI	p-value	
Household size	1.04	1.01-1.08	0.010	1.04	1.01-1.08	0.020	
Gender (ref: Male)							
Female	0.90	0.76-1.07	0.24	0.89	0.76-1.07	0.224	
Bed net usage (ref: No)							
Yes	1.93	1.47-2.52	< 0.001	1.88	1.44-2.48	< 0.001	
IRS (ref: No)							
Yes	0.87	0.73-1.03	0.112	0.83	0.69-0.99	0.042	
Residence (ref: urban)							
Rural	1.25	0.98-1.61	0.07	1.08	0.84-1.40	0.530	

Bold values represent statistically significant result

OR: Odds ratio; aOR: Adjusted odds ratio; CI: Confidence interval; Bolded p-value: Statistically

significant at p < 0.05; IRS: Indoor residual spray; ref.: Reference category

study witnessed a consistent drop-out in the number of participants receiving SMC between each of the cycles. This reported coverage falls short of the national target of 90% per cycle, but is similar to other findings in several studies across Ghana and sub-Saharan Africa [12–15]. This emphasizes the need to continue monitoring coverage in subsequent years, as well as engaging the communities and social mobilizations to prevent the continuous decrease in coverage as this would adversely impact the benefits of the intervention. Health system/programmerelated factors such as non-availability of caregivers at the time of distribution and patient related reasons such as forgetfulness were identified as the main reasons for drop-outs. Information and sensitization of the communities on the SMC schedule and the importance of SMC before implementation remains essential in minimizing the proportion of children who would miss the rounds due to unavailability or forgetfulness.

Evidence of the impact of adhering to the prescribed schedule for SMC has been demonstrated by some studies within sub-Saharan Africa. SMC when taken as prescribed during the peak transmission of malaria prevents a significant number of clinical bouts of malaria in children [11, 16, 17]. Adherence is important in realizing the full effect of the drugs [18]. In this study, adherence for each of the SMC cycles remained above 82%. This reported high adherence is similar to findings from other studies in the sub-region [11, 16]. The study also provided further evidence that having indoor residual spray in homes was associated with a decrease in the odds of adhering to SMC. The association between IRS in homes and decreased adherence to SMC could be attributed to the perception of reduced malaria risk which may arise from the simultaneous implementation of multiple malaria prevention strategies for instance the distribution of long-lasting insecticide-treated nets, and the introduction of the RTSS vaccine. Continuous education is, therefore, needed to ensure community members appreciate the extra need for SMC though there exists indoor residual spraying in their homes. Reasons for non-adherence included participant unavailability, particularly in schools, and caregivers' refusal to adhere to the schedule.

This highlights the need for volunteers/distributors to implement strategies to ensure medication delivery directly to children in schools, rather than relying solely on leaving medications at their homes. Additionally, volunteers/distributors should use their interactions with caregivers during the initial supervised dosing to educate them about the importance of adhering to the medication regimen on subsequent days. Expanding supervisory activities during the campaign to include monitoring volunteers/distributors' engagement with caregivers and ensuring that all pertinent messages are conveyed will help decrease instances of non-adherence.

Few adverse events were reported after the SMC administration. Consistent with other studies [12, 19, 20], fever, vomiting, and drowsiness were the most commonly reported adverse events. These adverse events have also been widely reported to be associated with amodiaquine (AQ) and sulfadoxine-pyrimethamine (SP) [21, 22]. Efforts aimed at incorporating these known drug reactions in messages to caregivers must be strengthened to reduce the levels of non-adherence resulting from adverse events.

Receiving all doses of SMC was attributed to a reduced proportion of malaria incidence compared with those who did not receive all doses of SMC as observed in similar studies [5, 11, 23]. This is in line with the primary objective of the implementation being to prevent new malaria cases and decrease its prevalence.

A limitation of this study is that, as with observational studies, there is a risk of selection bias, observation bias, and recall bias. To mitigate this, participants were randomly selected, and data collectors were not involved in the implementation of the SMC campaigns. Also, data collection was done immediately (not later than seven days) after each cycle of SMC distribution. This study used a relatively large sample size conducted across four different administrative districts allowing generalizability of the results. The study demonstrates the importance of routine monitoring of programs or interventions to draw improved strategies for future improvements. Future research should focus on employing randomized controlled trial design, to further investigate the effectiveness of varied approaches in improving SMC coverage and adherence.

Conclusion

While this study monitored SMC implementation in the Upper East Region of Ghana, it found that despite achieving approximately 87% coverage per cycle, it fell short of the national target of 90%. The study identified caregiver unavailability during distribution as a primary reason for dropouts and non-adherence. Therefore, the implementation of diversified approaches, such as community engagement initiatives and mobile outreach programmes, is necessary for SMC campaigns to enhance coverage and adherence, ensuring maximum intervention efficacy.

Abbreviations

aOR	Adjusted odds ratio
AQ	Artesunate–Amodiaquine
BHDSS	Builsa health and demographic surveillance system
CHW	Community health worker
CI	Confidence intervals
IQR	Interquartile range
IRS	Indoor residual spraying
ITN	Insecticide-treated net
LAR	Legally acceptable representative
NHDSS	Navrongo Health and Demographic Surveillance System
SMC	Seasonal Malaria chemoprevention
SP	Sulfadoxine–Pyrimethamine
WHO	World Health Organization

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Author contributions

EYA, EKD, and POA conceived and designed the study. EYA, WD, OB and NAA supervised data collection whilst EAY and WD conducted analyses. EKD, JA, SA and SKB are implementors of the SMC program in the region and provided valuable insights and supervision. EYA wrote the first draft. EKD, POA, NAA and OB critically reviewed the manuscript. All authors read and approved the final draft before submission.

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Availability of data and materials

The datasets used and/or analysed during the current study are available from the corresponding author upon reasonable request.

Declarations

Ethics approval and consent to participate

This study was reviewed and approved by the Navrongo Health Research Institutional Review Board (Ethics approval ID: NHRCIRB538). Informed consent was also sought from all caregivers/LARs before enrolment into the study.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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