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Factors associated with adherence to the unsupervised daily dose of seasonal malaria chemoprevention in Builsa North District, Upper East Region of Ghana

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Abstract

Background: Since 2015, seasonal malaria chemotherapy (SMC) with amodiaquine–sulfadoxine-pyrimethamine (AQ-SP) has been implemented during the high malaria transmission season in three regions of Ghana. Adherence to the SMC is a critical determinant for successfully protecting children < 5 years. In Ghana, the SMC implementation was started in 2015.

Objective: This study aimed to determine the level of adherence to SMC and the associated factors among caregivers in Builsa North District.

Methods: We conducted a cross-sectional study in four sub-districts in the Builsa North District. The 435 participants were recruited via balloting using a random sampling procedure. Simple and multiple logistic regressions were performed to determine associations between SMC adherence and the independent variables, with all results interpreted at a 95% confidence level.

Results: The SMC adherence rate among the caregivers in the Builsa North District was 95.63% (n = 416/435) with an awareness level of 97.94% (n = 427/435). The reasons reported for non-adherence were the child's refusal of the drug (38.88%, n = 7/18), the child vomiting the drug (33.33%, n = 6/18), the occurrence of an illness within the period of medication (15.38%, n = 3/18) and forgetting to give the subsequent doses (12.82%, n = 2/18). About half (49.31%, n = 214/435) of caregivers had a good knowledge of malaria, while 66.51% (n = 290/435) had a fair knowledge of SMC. Significant predictors of SMC on multiple logistic regression were the place of residence [adjusted odds ratio (aOR) = 3.59, 95% confidence interval (CI) = 1.02 –12.56]; caregivers' dissatisfaction (aOR = 0.10, 95% CI = 0.01 – 0.74), and being informed by a friend (aOR = 0.04, 95% CI = 0.01 – 0.51).

Conclusion: This study found a very high adherence rate to SMC in Builsa North District. The key factors associated with SMC adherence were being aware of SMC through non-health professional sources, place of residence, and caregivers' satisfaction with the previous SMC campaign.

Keywords: Seasonal malaria chemoprevention, children under five, Amodiaquine-Sulfadoxine-Pyrimethamine, adherence

INTRODUCTION

The intermittent preventive treatment in infants is a dynamic and effective primary health intervention designed to prevent malaria in children under five years of age during the period of high malaria transmission, which is typical during the rainy season. This intervention is commonly referred to as seasonal malaria chemoprevention (SMC). During this period, the effectiveness of the SMC has been shown in malaria prevention among children. The

implementation of this chemoprevention is done through routine immunization services by the administration of the combination of sulfadoxine-pyrimethamine and amodiaquine among children aged 3 – 59 months, regardless of whether the child is infected with malaria. The World Health Organization (WHO) has recommended this combination since March 2012 for children living in areas of high seasonal malaria transmission in the Sahel subregion of Africa [1]. In 2014, seven countries in sub-Saharan Africa (Burkina Faso, Chad, Mali, Niger, Nigeria, Gambia, and Guinea) had adopted this malaria control strategy [2]. According to the WHO, 15.7 million children in 12 countries in Africa's Sahel subregion were protected

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through SMC in 2017 [3]. This intervention is effective, cost-effective, safe, and feasible for preventing malaria in children < 5 years. In Ghana, the National Malaria Control Program started implementing SMC in 2015 in the Upper West Region (UWR). Following the implementation of SMC in the UWR, an impact assessment showed that SMC's efficacy was 45%. Based on this success, the intervention was extended to the Upper East Region (UER) in 2016. Most of the studies have analyzed SMC's efficacy, impact, accessibility, availability, and coverage. Few studies have examined hidden sociodemographic, operational, individual, and seasonal factors within households that predict or prevent adherence to SMC [4]. These challenges associated with non-adherence fail to protect the child from malaria infection. This interrupted protocol may induce AQ-SP resistance development, which has devastating consequences for the malaria burden in children < 5 years. The prevalence, morbidity, and mortality of malaria in children < 5 years would be more likely to be perpetuated if factors that are associated with the adherence of SMC within caregivers are not determined for appropriate advocacy [4]. Despite the high coverage of the SMC campaign in the region in 2018, the national malaria control program (NMCP) reports that the overall prevalence is still 8.9% and children < 5 years are still facing malaria infection and its consequences [5]. It is necessary to understand why some children < 5 years suffer malaria despite having a high SMC implementation coverage. This study used a quantitative method to investigate the adherence to the three-dose finalization of SMC among caregivers in Builsa North in the UER of Ghana.

MATERIALS AND METHODS

This study was a cross-sectional household survey conducted in four subdistricts of Builsa North District, which is one of the 15 districts in the UER of Ghana and has a total population of 56,477. In August 2020, community meetings were held with caregivers and local community representatives to explain the study's purpose, after which communities were offered the choice to participate in the survey. Signed informed consent before the interview was also obtained from all the caregivers interviewed during the study. The study was conducted during the COVID-19 pandemic. The researchers provided personal protective equipment (PPEs) to research assistants. The study ensured that a social distance of 6 feet (about two arm's lengths) was maintained during the data collection.

Study design and sampling

The multistage sampling procedure was used. The sampling design was used at various stages to get multiple sampling units from the district level to respondents at the different households. The Builsa North District was stratified into six sub-districts (Sandema Central, Bilinsa-Bilimonsa, Wiaga Central, Chuchuliga Central, Siniensi-Yikpien, and Suwarensa-Ndaasa) to ensure fair representation of some of

the population's essential characteristics. At this point, simple random sampling by non-replacement balloting was used to select four communities from the six strata by balloting. The names of the different sub-districts or communities were written on pieces of paper, folded, and placed in a bowl. A hand was blindly dipped into the bowl to choose a folded paper without replacement. The sub-districts selected in this way were used as study sites where caregivers were recruited for the study. A proportionate sampling approach was used to assess the number of participants included per population. At the community level, each community was stratified into four areas, east, west, south, and north. Starting from the community chief's house, the researcher randomly selected the direction of movement. Depending on the direction chosen, for instance, to the west, the researcher went from house to house in that direction, then to the south, east, and north in the same area. Overall, 435 participants were included in the study.

At the household level, in each house, a caregiver who met the inclusion criteria (≥ 18 years of age, gave consent to participate in the study, and lived in a household) was included and interviewed. The exclusion criteria were having a mental health issue, and not having at least one child < 5 years). In the case that a house had more than one household, one of them was chosen randomly to complete a questionnaire. If the sample size was not obtained from one area due to a lack of eligible participants within the population of that area, data collection proceeded in the next enumeration area. This method was repeated until the final size of the sample was collected. The number of interviews performed in each sub-district depended on the approximate proportion of women of reproductive age. We assumed that women around reproductive age (18 – 49) were the primary caregivers for drug administration during SMC campaigns for this study. In this study, we chose the age groups (15 – 54 years) as the target population. We used the World Bank demographic database on the distribution of age groups by sex. This study used a closed-ended structured questionnaire to collect data from the 435 participants from the four sub-districts using a face-to-face interview. The questionnaire focused on the respondents' specific vital demographic characteristics, general knowledge about malaria, and general knowledge of SMC.

Statistical analysis

The raw data from the field were manually cross-checked to ensure completeness and were entered in Kobo-collect using tablets, then downloaded as a Microsoft Excel file before being exported to STATA Statistical Software (Version 14, StataCorp LLC, Texas, USA) for further management and analysis. To ensure accuracy and completeness, the data was further cleaned up by running the frequencies of all variables to verify coding using STATA. The dependent variable was the adherence to SMC, which is the full completion of the three daily doses. The proportion of caregivers who adhered to SMC was calculated by dividing the number of caregivers who said their children completed the three doses of AQ-SP by the

total sampled population. Basic descriptive statistics were obtained on the sociodemographic characteristics of the respondents and the knowledge variables. Two derived variables on the malaria knowledge level and SMC knowledge level were generated in STATA by scoring as a dichotomous variable when a correct answer was given. While a correct answer was given, it was scored as '1', and a wrong answer was scored as '0'. Then total scores were categorized into four groups: poor knowledge (score 1 – 2); insufficient knowledge (score 3 – 4); good knowledge (score 5 – 6); and very good knowledge (score > 6). The results were presented in frequencies and percentages using tables and graphs. Frequencies were generated to describe categorical variables. Continuous variables were expressed as arithmetic means and standard deviations for normally distributed variables, median, and quartiles for variables not following the binominal distribution. A univariate analysis was performed to estimate the strength of associations between the adherence and its predictors. After then, all the independent variables with $p < 0.05$ were used to perform different regression models.

RESULTS

Characteristics of the participants

The median age of participants was 29 years, 60.92% (n = 265/435) of them were married, and 37.47% (n = 163/435) were illiterate. The descriptive statistics of participants' characteristics are reported in Table 1. Most (91.03%, n = 396/435) of the interviewed caregivers reported that all their children received the AQ-SP from drug distributors during the first round of 2020. The adherence rate to SMC among caregivers whose children were covered during the first-round drug distribution was (95.63%, n = 416/435).

Reasons for non-adherence. Four main reasons were reported by the 18 caregivers who did not adhere to SMC during the first round of drug distribution. The primary cause for non-adherence was the child's refusal which represented 38.89% (n = 7/18), followed by the child vomiting the drug, and an illness within the medication period. Besides, 11.11% (n = 2/18) reported that they forgot to give the drugs the subsequent two days (Figure 1). Almost all respondents (98.16%, n = 427/435) reported having ever heard of SMC (Figure 2).

Participants awareness. Among those aware of SMC, the responses were collected from the knowledge assessment on malaria in children and SMC (Table 2). The level of knowledge was the total score of correct answers responded by participants about malaria or SMC. Half of the respondents (49.42%, n = 215/435) had good knowledge of malaria in children, while 2.29% (n = 10/435) had poor knowledge. The knowledge level of SMC was mainly fair for respondents (66.67%, n = 290/435), while a few had good knowledge of SMC (8.28%, n = 36/435). Those who had very good knowledge of SMC represented the minority (4.14%, n = 18/435) (Table 3).

Table 1: Sociodemographic characteristic of caregivers in the Builsa North District

Characteristics	Frequency	Percentage
Age (years)		
Median (IQR)	29 (23 – 40)	
<20	18	4.14
20 – 29	208	47.82
30 – 39	164	37.70
40 – 49	45	10.34
Marital Status		
Never married	80	18.39
Married	265	60.92
Cohabiting	60	13.79
Divorced	16	3.68
Widowed	14	3.22
Religion		
Christian	357	82.07
Muslim	55	12.64
Traditional	23	5.29
Ethnic		
Builsa	343	78.85
Mossi	40	9.20
Sissala	28	6.44
Others [a]	24	5.52
Educational Status		
No formal education	163	37.47
Primary	77	17.70
Secondary	99	22.76
Higher	96	22.07
Occupation		
Unemployed/Housewife	215	49.43
Formal work	122	28.05
Others [b]	98	22.53
Number of children < 5 years		
1	281	64.60
≥ 2	154	35.40
Household Size		
Mean (± SD)	5.24 (±1.63)	-
Median (IQR)	5 (4 - 6)	-
3 – 4	163	37.47
5 – 6	164	37.70
7 – 8	108	24.83

*IQR, interquartile range; SD, standard deviation; [a] Fulani, Akan, dago; [b] artisan, hairdressing, farming, buying, and selling

Sources of information. Nearly half of the respondents (43.44%, n = 189/435) reported that local radios were their source of knowledge on SMC, followed by health centres (29.04%, n = 127/435) and community health workers (11.71%, n = 51/435). However, a few reported public announcements, friends, and television as their sources of knowledge on SMC (Figure 3).
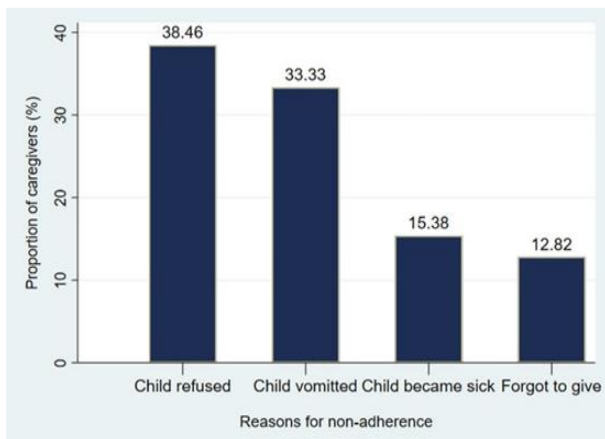
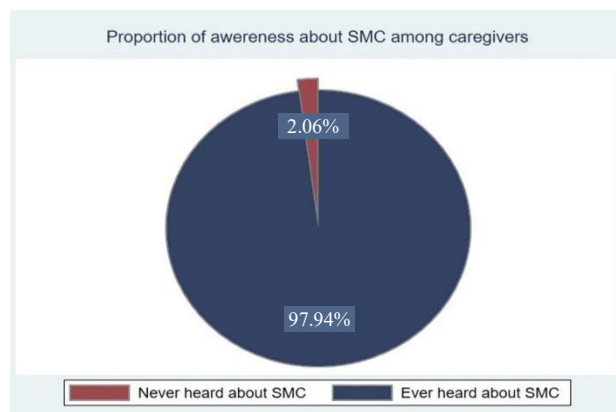Figure 1: Reasons for non-adherence to unsupervised daily treatment doses of seasonal malaria chemoprevention

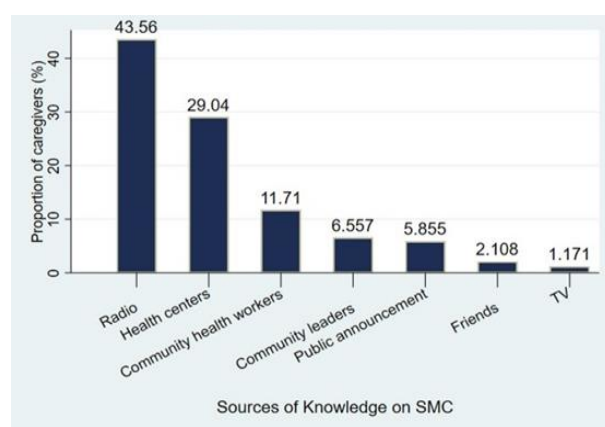Figure 2. Levels of awareness of seasonal malaria chemoprevention (SMC)

Figure 3: Source of Knowledge on seasonal malaria chemotherapy (SMC)

Table 2: Knowledge of malaria and seasonal malaria chemoprevention among caregivers

Variables	Responses	Frequency (%)
Cause of malaria		
	Mosquito bite	430 (98.85)
Effect of untreated malaria on child		
	Anaemia	395 (90.80)
	Convulsion	409(94.02)
	Mental Confusion	400 (91.95)
	Death	401 (92.18)
Malaria Preventive methods		
	Insecticide treated Nets	403 (92.64)
	Daily use of mosquito repellent	405 (93.10)
	IRS during the rainy season	203 (46.67)
Seasonal Malaria Chemoprevention		
Purpose of SMC	Prevent malaria in children under five	288 (66.21)
Number of regimens	3 doses	242 (55.63)
Intervention season in the year	Only raining season	255 (58.62)
Number of days for a child	Three days	295 (67.81)
Minimum age required for SMC medication	Three months	18 (4.14)

%, percentage

Table 3: Level of knowledge about malaria of caregivers on Malaria and seasonal malaria chemoprevention

Level of knowledge about malaria	Malaria Frequency (%)	SMC Frequency (%)
Poor knowledge (Score 1 – 2)	10 (2.29)	92 (21.14)
Fair knowledge (Score 3 – 4)	59 (13.56)	290 (66.67)
Good knowledge (Score 5 – 6)	215 (49.42)	36 (8.27)
Very good knowledge (Score 7 and higher)	152 (34.94)	18 (4.14)

SMC, seasonal malaria chemoprevention; %, percentage

Multivariable logistic regression for adherence to SMC
Table 4 shows the results of multivariable logistic regression on SMC adherence and selected independent variables. Data from the 388 caregivers in Builsa North District who received the AQ-SP in July 2020 were used to perform this logistic regression model. Place of residence, level of satisfaction, marital status, number of children < 5 years, occupation, SMC Level of knowledge about malaria, knowledge of SMC's purpose, source of knowledge on SMC, and household size were used to perform a logistic

regression. The place of residence, the level of satisfaction, knowing SMC through a friend, and residing in a household of at least five other persons affected the SMC adherence. The odds of adherence was 2.62 times higher among caregivers residing in urban areas than caregivers residing in rural areas. This finding was not significant while unadjusted, but it was found to be statistically significant when adjusted for other factors [adjusted odds ratio (aOR) = 2.62, 95% confidence interval (CI) = 0.96 – 7.14]. Participants who reported being very dissatisfied with drug

Table 4: Factors associated with adherence to seasonal malaria chemoprevention

Characteristics	Observations		crude odds ratio		adjusted odds ratio	
	Non-Adherent	Adherent	OR (95% CI)	*p* value	aOR (95% CI)	*p* value
Place of residence						
Rural (Ref.)	12	160	1		1	
Urban	6	210	2.62 (0.96 - 7.14)	0.059	3.59 (1.02 - 12.56)	0.045**
Satisfaction Level						
Very satisfied (Ref.)	2	81	1		1	
Satisfied	8	264	0.81 (0.17 - 3.91)	0.798	0.74 (0.13 - 4.10)	0.735
Dissatisfied	6	23	0.09 (0.01 - 0.50)	0.006**	0.10 (0.01 - 0.74)	0.024**
Very dissatisfied	2	2	0.02 (0.00 - 0.27)	0.003**	0.02 (0.00 - 0.37)	0.008**
Marital Status						
Single (Ref.)	6	66	1		1	
Married	9	229	2.31 (0.79 - 6.73)	0.124	3.68 (0.93 - 14.60)	0.063
Cohabiting	2	48	2.18 (0.42 - 11.28)	0.352	4.45 (0.49 - 40.03)	0.183
Divorced /Widowed	1	27	2.45 (0.28 - 21.36)	0.416	1.67 (0.15 - 18.35)	0.673
Number of Children Under five						
One child (Ref.)	10	232	1		1	
≥ 2	8	138	0.36 (0.28 - 1.92)	0.542	0.51 (0.15 - 1.69)	0.272
Occupation						
Unemployed (Ref.)	10	176	1		1	
Formal work	4	109	1.54 (0.47 - 5.06)	0.469	2.7 (0.55 - 13.05)	0.216
Others	4	85	1.20 (0.36 - 3.96)	0.756	1.57 (0.36 - 6.84)	0.546
SMC Knowledge Level						
Low knowledge (Ref.)	17	320	1		1	
Good knowledge	1	50	2.65 (0.34 - 20.40)	0.348	1.93 (0.18 - 20.03)	0.582
Knowing the purpose						
No (Ref.)	4	53	1		1	
Yes	14	317	1.70 (0.54 - 5.38)	0.361	1.03 (0.20 - 5.31)	0.966
Source of knowledge on SMC						
Health Centers (Ref.)	4	106	1		1	
Community Leaders	0	46	0.86 (0.09 - 8.12)	0.901	0.43 (0.03 - 5.56)	0.519
Public announcement	1	23	0.37 (0.06 - 2.20)	0.279	0.30 (0.02 - 3.30)	0.327
Friends	2	20	0.07 (0.01 - 0.41)	0.003**	0.04 (0.00 - 0.51)	0.013**
Radio	3	6	0.88 (0.25 - 3.11)	0.855	0.36 (0.08 - 1.62)	0.187
TV	7	165	0.15 (0.01 - 1.67)	0.124	0.72 (0.02 - 19.33)	0.85
Household Size						
< 6 (Ref.)	10	232	1		1	
≥ 6	8	138	3.24 (1.04 - 10.04)	0.041**	8.26 (1.81 - 37.62)	0.006**

p value notation: *, *p* value < 0.05; **, *p* value < 0.01; ***, *p* value < 0.001; CI, confidence interval; OR, odds ratio; Ref, reference category; SMC, seasonal malaria chemoprevention; TV, television

distributors had 98% lower adherence odds than those who reported being very satisfied [adjusted odds ratio (aOR) = 0.02, 95% CI = 0.00 – 0.37]. Respondents who reported friends as their knowledge source had 93% lower odds of adherence than those reporting their knowledge source as health centres (aOR = 0.04, 95% CI = 0.01 – 0.51). Respondents who indicated that their household composition was six or more were 8 times more likely to adhere than those who indicated that their household size was less than six (aOR = 8.26, 95% CI = 1.81 – 37.62).

DISCUSSION

This study has identified some factors that significantly influenced the adherence to unsupervised daily doses of SMC among caregivers in Builsa North District during the first SMC campaign in 2020. The study shows that the adherence rate to the SMC was equal to 95.36%. This study also provides further evidence that having more than one child under five, inquiring about information on SMC through any other sources different from health professionals and being dissatisfied with the SMC are associated with a decrease in the odds of adherence to SMC. In this study, the caregivers who adhered to SMC represented 95.36%, and this is similar to the self-reported adherence of 95% to SMC reported by Diawara et al. in 2017 [6]. While this was not in SMC's setting, a study comparing various malaria preventive regimens in Ugandan children showed that adherence to a 3-day course of dihydroartemisinin-piperaquine was much higher when reported by the caregiver (approximately 100%) compared to the unbiased concentration of drugs [7]. A lower adherence was found using a longitudinal study in Nigeria by Ward et al. in 2019. Their research found that adherence was 83.84% [8]. Several factors may explain these observations, and a mix of these reasons — rather than one alone — is likely responsible.

First, there may have been a good understanding of SMC in the Ghanaian community than in the Nigerian community because the Ghanaian health system is better in terms of coverage [9]. Perhaps, the AQ-SP interventions contributed to increasing adherence in the Builsa North District by reducing the frequency and severity of infections among participating children. A similar study in southern Ghana and other African countries using AQ-SP also found a high adherence level (81 – 97%) among caregivers [10]. These findings indicate that high adherence to AQ-SP can be reached in remote areas where a successful treatment education program is in place. However, the adherence rate found in this sample could be an overestimation. A randomized, placebo-controlled SMC trial in Ghana showed nearly 100% self-reported adherence to SMC's 3-day course across all research communities. However, some caregivers were found to have residual SMC tablets that had not been administered [11]. Another way to measure adherence is by testing the levels of medications in children's blood during a follow-up period [11]. To reduce malaria incidence in children under five within an

endemic community, a high proportion of adherence to SMC is indispensable. The adherence demonstrated by this study is associated mainly with good knowledge of SMC's purpose, the larger household size, the place of residence, the satisfaction of caregivers with previous SMC and the source of knowledge of caregivers about SMC.

The study revealed that the respondents demonstrated a better awareness of malaria and SMC. This result is not different from what Mazigo et al. reported in 2010 on the knowledge of SMC [12]. Having good knowledge is a basic predisposition for committing to adhere to all three doses of AQ-SP. There is a tremendous need to intervene in the communication channels related to the SMC. The caregivers who reported that they had been introduced to SMC through friends are likely not to adhere to the 3-day protocol. In contrast, those introduced through professional sources are likely to adhere. This factor may be explained by a lot of rumours about the mass drug administration. Some people do not trust any free medication. In some remote areas, people still trust only traditional medicine. This knowledge gap may explain why caregivers reported that they forgot to give the medicine to the children. Households composed of more than five people were more likely to adhere to SMC, and this may be due to the increased number of people available to take care of the child. The perceptive factor assessed in this study is the satisfaction level with SMC. Most caregivers reported that they are satisfied with SMC. However, the study found that the tendency to adhere varied significantly with caregivers' level of satisfaction: the more satisfied they were, the more they adhered to SMC. Diawara et al., 2017, in Mali, found that parents' opinions about SMC were very positive, with 99.9% of parents reporting that they felt the strategy was good or very good, and 99% of them were in favour of continuing the intervention [6]. The SMC's strong support and favourable opinion are major assets for continuation and scale-up [6].

The reasons for non-adherence in this study were the child's refusal to swallow the drug, vomiting, illness after the first dose, and mothers forgetting about the medication. Ding et al., 2020, in Niger, found that children refusing to take the drug; suboptimal health worker instructions; small children spitting out medication, even if it is dissolved; vomiting within 30 minutes of dosing; caregivers saving medicines for the treatment of another family member with acute malaria later on; caregivers sharing/giving medication to older children who were not eligible for SMC; fathers not allowing the medicine to be taken; and fatigue of giving medication, mainly when the child is not sick were the main reasons for non-adherence cited by study participants [13]. Ultimately, an integrated approach to funders, policymakers, health workers, applied health social scientists, drug distributors, community members, and all stakeholders will be appropriate for achieving the National Malaria Control Program's goal in the Upper East region of Ghana. The study results were based on the opinions and experiences of representatives from Builsa North District subdistricts, but not on the entire subdistricts within the

Upper East Region of Ghana. Therefore, the results can be generalized only to the sampled population in the district and not to the whole regional or national level. The present study adopted a quantitative approach. would help define the deep reasons behind factors influencing the non-adherence.

Conclusion

The present study found the level of SMC adherence in Builsa North District, Upper East Region, Ghana to be high. The main reason for non-adherence was the child's refusal to take the drug, the child vomiting, the occurrence of a disease, and caregivers forgetting to give medication. Caregivers with good knowledge, those who have obtained extensive information about SMC from health care providers, those who have only one child, and those who live in town are likely to adhere to SMC. The results of this study indicate that the caregivers in the Builsa North District have very good knowledge of the cause of malaria, its consequences on children, and its preventive methods. It also shows that more than half of caregivers in the district are aware of SMC. There has been considerable progress in Ghana's implementation of SMC at the district level. However, some factors regarding SMC still have a bad effect on the adherence rate to unsupervised doses. If specific strategies are not implemented to control them, they could spread and undermine all attempts made so far to achieve the reduction of the burden of malaria in children < 5 years.

DECLARATIONS

Ethical considerations

Ethical approval for the protocol of this survey was obtained from Ghana Health Service Ethical Committee [GHS-ERC 034/02/20].

Consent to publish

All authors agreed to the content of the final paper.

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None

Competing Interests

No potential conflict of interest was reported by the authors.

Author contributions

COD, EK conceptualized the study, developed the methods, and conducted the study. COD was also involved in data curation, formal analysis, producing the original draft, reviewing, and editing. EK, SeD, SaD, MoD, MaD, ID, BK provided supervision and were involved in data validation, drafting of the original manuscript, and reviewing and editing of the final manuscript. All authors have read and approved the manuscript.

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Availability of data

Data is available upon request to the corresponding author

REFERENCES

1. World Health Organization (WHO) (2013) WHO 2012 world malaria report. WHO Press

2. York A (2017) Seasonal malaria chemoprevention in the Sahel. Lancet Infect Dis. https://doi.org/10.1016/S1473-3099(17)30255-4

3. Druetz T (2018) Evaluation of direct and indirect effects of seasonal malaria chemoprevention in Mali. Sci Rep 8:588. https://doi.org/10.1038/s41598-018-26474-6

4. Chatio S, Ansah NA, Awuni DA, Oduro A, Ansah PO (2019) Community acceptability of Seasonal Malaria Chemoprevention of morbidity and mortality in young children: A qualitative study in the Upper West Region of Ghana. PLoS One 14:e0216486. https://doi.org/10.1371/journal.pone.0216486

5. Fondjo LA, Addai-Mensah O, Annani-Akollor ME, Quarshie JT, Boateng AA, Assafuah SE, Owiredu EW (2020) A multicenter study of the prevalence and risk factors of malaria and anemia among pregnant women at first antenatal care visit in Ghana. PLoS One 15:e0238077. https://doi.org/10.1371/journal.pone.0238077

6. Diawara F, Steinhardt LC, Mahamar A, Traore T, Kone DT, Diawara H, Kamate B, Kone D, Diallo M, Sadou A, Mihigo J, Sagara I, Djimde AA, Eckert E, Dicko A (2017) Measuring the impact of seasonal malaria chemoprevention as part of routine malaria control in Kita, Mali. Malar J 16:325. https://doi.org/10.1186/s12936-017-1974-x

7. Bruxvoort K, Festo C, Cairns M, Kalolella A, Mayaya F, Kachur SP, Schellenberg D, Goodman C (2015) Measuring patient adherence to malaria treatment: A comparison of results from self-report and a customised electronic monitoring device. PLoS One 10: e0134275. https://doi.org/10.1371/journal.pone.0134275

8. Ward A, Guillot A, Nepomnyashchiy LE, Graves JC, Maloney K, Omoniwa OF, Emegbuonye L, Opondo C, Kerac M, Omoluabi E, Bhattacharya A, Hariharan KM, Wiwa O, Cohen JM, Le Menach A (2019) Seasonal malaria chemoprevention packaged with malnutrition prevention in northern Nigeria: A pragmatic trial (SMAMP study) with nested case-control. PLoS One 14:e0210692. https://doi.org/10.1371/journal.pone.0210692

9. Amu H, Dickson KS, Kumi-Kyereme A, Maafo Darteh EK (2018) Understanding variations in health insurance coverage in Ghana, Kenya, Nigeria, and Tanzania: Evidence from demographic and health surveys. PLoS One 13:e0201833. https://doi.org/10.1371/journal.pone.0201833

10. Asante KP, Owusu R, Dosoo D, Awini E, Adjei G, Amenga Etego S, Chandramohan D, Owusu-Agyei S (2009) Adherence to Artesunate-Amodiaquine Therapy for Uncomplicated Malaria in Rural Ghana: A Randomised Trial of Supervised versus Unsupervised Drug Administration. J Trop Med 2009:1–7. https://doi.org/10.1155/2009/529583

11. Bigira V, Kapisi J, Clark TD, Kinara S, Mwangwa F, Muhindo MK, Osterbauer B, Aweeka FT, Huang L, Achan J, Havlir D V., Rosenthal PJ, Kamya MR, Dorsey G (2015) Protective efficacy and safety of three antimalarial regimens for the prevention of malaria in young Ugandan children: A randomized controlled trial. PLoS Med 11:e1001689. https://doi.org/10.1371/journal.pmed.1001689

12. Mazigo HD, Obasy E, Mauka W, Manyiri P, Zinga M, Kweka EJ, Mnyone LL, Heukelbach J (2010) Knowledge, Attitudes, and Practices about Malaria and Its Control in Rural Northwest Tanzania. Malar Res Treat 2010:1–9. https://doi.org/10.4061/2010/794261

13. Ding J, Coldiron ME, Assao B, Guindo O, Blessborn D, Winterberg M, Grais RF, Koscalova A, Langendorf C, Tarning J (2020) Adherence and Population Pharmacokinetic Properties of Amodiaquine When Used for Seasonal Malaria Chemoprevention in African Children. Clin Pharmacol Ther 107:1179–1188. https://doi.org/10.1002/cpt.1707

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