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Impact of mass media campaigns on knowledge of malaria prevention measures among pregnant mothers in Uganda: a propensity score-matched analysis

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Abstract

Background Uganda grapples with a considerable malaria burden, reporting prevalence rates of over 33% in some regions. To address this, the Uganda Ministry of Health employs audiovisual platforms for disseminating malaria prevention messages. However, the impact of these messages on pregnant women's knowledge of malaria prevention remains insufficiently explored. This paper therefore emphasizes the influence of audiovisual messages on the knowledge of malaria prevention measures among pregnant women in Uganda.

Methods Secondary data obtained from the Uganda Malaria Indicator Survey (MIS) 2018–2019 was used for this analysis. Women aged 15–49 were included in the study. A total of 8868 women were selected using a two-stage sample design. The two stages of selection included clusters and households. Women who were currently pregnant were included in the study, resulting in a weighted sample of 721 women. Propensity score-matched analysis was used to evaluate the impact of access to malaria messages on knowledge of prevention measures.

Results The study revealed that 39% [95% CI 34.0–44.2] of pregnant women were exposed to malaria messages before the survey. Those exposed had a 17.2% higher knowledge [ATT = 0.172; 95% CI 0.035–0.310] of using mosquito nets for prevention compared to those unexposed. Among women exposed, radios accounted for most form of access to mass media campaigns [64.8, 95% CI 57.0–71.8] followed by interpersonal communication [45.0, 95% CI 37.6–52.6], community health workers [38.8, 95% CI 29.6–48.8], community events [21.4, 95% CI 15.8–28.3], and social mobilization [18.3, 95% CI 12.7–25.8].

Conclusion Results highlight the importance of radios in spreading important malaria prevention messages to pregnant women. Being exposed to these messages is linked to increased awareness and knowledge about the proper use of insecticide-treated bed nets (ITNs) for preventing malaria. This finding underscores the importance of evaluating different channels for mass media campaigns to ensure the effective delivery of information about malaria prevention to the intended audiences.

Keywords Malaria, Insecticide-treated nets, Propensity score matching, Pregnancy, Uganda, Pregnant women

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Background

Malaria, a life-threatening illness caused by *Plasmodium* parasites and transmitted through the bite of infected female *Anopheles* mosquitoes, remains a significant global public health concern, especially during pregnancy [1–3]. According to the World Health Organization (WHO), there were an estimated 288 million cases and 410,000 deaths worldwide in 2018 [4]. Sub-Saharan Africa (SSA) consistently bears the highest burden, contributing to 93% of cases and 94% of global deaths. Uganda ranks among the top three countries with the highest malaria cases globally, following Nigeria (27%) and the Democratic Republic of Congo (12%) [5]. More than 90% of Uganda's geographical area is malaria endemic, with prevalence ranging from 9% in the western region, 26% in the West Nile to 33% in the Karamoja sub-region [6–9], highlighting the uneven distribution of malaria endemicity.

Approximately 35% of the pregnancies in Africa are thought to be affected by malaria [5]. Severe malaria in pregnant women presents a substantial risk of death, frequently attributed to malaria-induced anaemia [1, 10–12]. The study by Gontie et al. reveals that malaria-related anaemia is responsible for 10,000 maternal deaths annually in pregnant women in West Ethiopia [13]. Malaria can cause detrimental outcomes on the developing fetus, resulting in various complications such as gestational anaemia, premature birth, low birth weight, stillbirths, intrauterine growth retardation, impaired neurological development, early labour, and spontaneous loss of pregnancy [3, 12, 14].

WHO recommends key malaria prevention strategies, emphasizing the proper use of insecticide-treated bed nets (ITN), intermittent preventive treatment of malaria during pregnancy (IPTP), and effective management of malaria and anemia cases [15]. Additionally, long-lasting insecticide-treated nets (LLINs) and indoor residual spraying (IRS) are employed to prevent the interaction between vectors and hosts, which has resulted in a decrease in malaria occurrence [16]. In a recent Malaria Indicator Survey (MIS) conducted in Uganda, 83% of households possess at least one insecticide-treated net (ITN), and 54% of households have at least one ITN for every two members [17].

Furthermore, the Ministry of Health Division of Health Education and Promotion has developed various malaria-related messages that have been extensively employed to enhance awareness about malaria, including appropriate measures for prevention, treatment, and control. These messages are disseminated through various forms of media, such as visual and audio platforms like television and radio, billboards or posters, and interpersonal communication through community events and village health teams [18]. Despite these efforts, the Malaria Indicator Survey (MIS) conducted in 2019 shows that the exposure of women of reproductive age (15–49 years) to malaria prevention messages (having heard or seen malaria messages) is 39%, while in refugee settlements, it is only 16% [17]. Research has further explored determinants of intermittent preventive treatment (IPT) of malaria during pregnancy [19], utilization of insecticide-treated nets (ITN) [20–23], among pregnant women. While the link between exposure to malaria prevention messages via different mass media sources, including radio, television, health clinics and the use of IPT during pregnancy (IPTp), ITN and indoor residual spraying (IRS) has been observed [19, 22, 24–27], studies assessing the impact of these messages on knowledge of malaria prevention are still missing. A matched propensity score analysis, a quasi-experimental design, was used to reliably measure the impact of mass media campaigns on knowledge of malaria prevention. Importantly, this approach provides a quantitative measure of how much effect an intervention may have on a particular outcome. A considerable amount of resources have been committed to various malaria interventions, including social behavioral change and communication (SBCC), in order to combat the high malaria burden in Africa [28]. However, there is limited evidence to date to show that social behavioral change and communication interventions, in particular, have caused a significant change within communities as the malaria burden continues to soar [29]. A recent study conducted among pregnant women attending routine antenatal care at one of the country's largest healthcare centers found that 3 out of 10 pregnant women examined had malaria [7]. Additionally, statistics on the uptake of malaria interventions such as ITN use and IPTp have stagnated at 83% & 41%, respectively, over the past 5 years in Uganda [17], and reasons for the poor uptake remain inconsistent in different studies [19, 30–32]. In light of these findings, we assessed the effect of mass media campaigns on knowledge of malaria prevention among pregnant women using a comprehensive dataset from the 2018–2019 Malaria Indicator Survey in Uganda.

Methods

Data source and study population

The research utilized secondary information from the Uganda MIS 2018–2019 data. This is the most recent MIS data for Uganda. It was conducted in 15 sub-regions in of the country and nine refugee settlements in Northern and Western Uganda, covering a total of 8351 households. The study focused on women aged between 15 and 49 years. A two-stage sample design was used to select 8868 women of childbearing age. This process involved selecting clusters (enumeration areas) in the first stage.

This was followed by the systematic selection of households. Of the selected women, 8231 were nationals and 637 were refugees. Important to note is that only pregnant women were included in this study, resulting into a weighted sample of 721 women. More details on how the Uganda MIS data was gathered can be found in the MIS reports [17, 33].

Data analysis

Data analysis involved estimating the prevalence of access to malaria messages and describing baseline characteristics using frequencies, proportions, and their 95% confidence intervals. Characteristics examined included age, education level, parity, sex of the household head, number of household members, woman's education level, type of residence, and region.

The same approach was used to determine the distribution of sources of malaria messages and perceived prevention methods. Cross-tabulations were applied to identify the distribution of malaria message access by women's characteristics. Stata Version 14.0 was utilized for the analysis.

Propensity score matched analysis (PSMA)

To assess the impact of access to malaria messages on knowledge about malaria prevention methods, we employed a propensity score-matched analysis. The propensity score-matched analysis is a statistical technique that is utilized to determine the treatment effects from observational data [34]. Propensity scores refer to the likelihood of assigning a woman, denoted by "i" ($i=1, 2, \ldots, n$), to either the treatment group (women who had access to malaria messages, called "exposed" in this study) or the control group (women who did not have access to malaria messages, called "unexposed" in this study), based on a set of observed baseline characteristics denoted by "$\boldsymbol{X}$" [35]. The above is represented by [Eq. 1] below.

$$e(X) = \Pr(Z_i = 1|\boldsymbol{X}_i = x_i) \quad (1)$$

which shows that *e(X)* represents the conditional probability of having access to malaria messages, given the vector of observed characteristics denoted by $\boldsymbol{X}_i = x_i$. The variable Z is an indicator variable that takes the values of 0 and 1, where 0 is assigned to the unexposed group and 1 is assigned to the exposed group. The vector $\boldsymbol{X}$ is associated with access to malaria messages [36–39].

PSMA is recommended when a randomized clinical trial is impractical, unethical, or prohibitively expensive [39–42]. This methodology involves the use of observational data and calculates propensity scores for each woman based on measured variables such as age, education level, type of place of residence, and region, which helps to address confounding between participant characteristics and minimize bias [37, 43, 44]. This analysis focused on calculating the Average Treatment Effect of the Treated (ATT) related to knowledge of malaria prevention methods (such as sleeping under insecticide-treated bed nets, intermittent preventive treatment of malaria during pregnancy, and indoor residual spraying) among individuals who received malaria messages. To ensure fair comparisons between participants, we implemented a 1:1 matching strategy based on participant-level covariates (age and education level) and community-level covariates (such as type of place of residence and region). To estimate the effects of the treatment, we utilized logistic regression as an estimation algorithm and employed radius, caliper (with a tolerance level of 0.05), and nearest neighbor (with a value of 1) as our matching algorithms [45–48]. The Average Treatment Effect of the Treated (ATT) is framed within a counterfactual framework expressed by [Eq. 2] below.

$$\mathrm{ATT} = \mathrm{E}[\,\mathrm{Y_i}(1) - \mathrm{Y_i}(0)|\mathrm{Z_i} = 1] \quad (2)$$

where $\mathrm{Y_i}$ (1) is the outcome in the treatment group, $\mathrm{Y_i}$ (0) is the outcome in the unexposed group, $\mathrm{E}[\,\mathrm{Y_i}(1)|\mathrm{Z_i} = 1]$ represents the expected outcome of knowledge regarding mosquito net use, and uptake of intermittent preventive treatment for malaria, assuming that all pregnant women have been exposed to malaria messages. $\mathrm{E}[\,\mathrm{Y_i}(0)|\mathrm{Z_i} = 1]$ represents the expected outcome of knowledge regarding mosquito net use, and uptake of intermittent preventive treatment for malaria, assuming that all pregnant women have not been exposed to malaria messages (unobserved) [37, 49]. The Average Treatment Effect of the Treated (ATT) signifies the expected difference in knowledge regarding preventive methods, (mosquito net use, and intermittent preventive treatment of malaria), between women in the treatment group and the same women if they were not in the treatment group [50].

The procedure for calculating the treatment effects involved several steps including, which included: (1) selecting appropriate covariates for the propensity score; (2) calculating the propensity score; (3) stratifying and ensuring balance in the propensity scores, and (4) computing the ATT [50].

To establish a counterfactual scenario, women who had been exposed to malaria messages were matched with those who had not, based on four distinguishable covariates, which were: the age and education level of the women, as well as the type of place of residence and region they belonged to. The balance of propensity scores was evaluated between women in the exposed group and those in the unexposed group by analysing graphs illustrating the propensity scores for each group. These

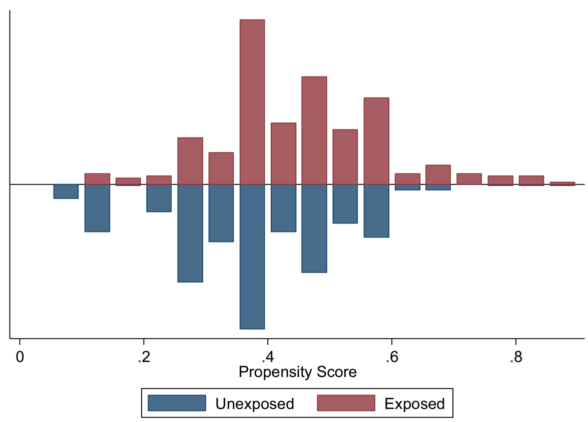

Fig. 1 Propensity scores in relation to exposure to malaria messages (1 = Exposed, 0 = Unexposed) and knowledge of sleeping under ITN

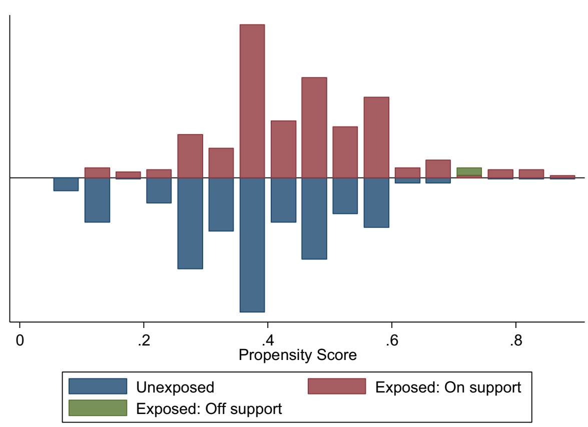

Fig. 2 Propensity scores in relation to exposure to malaria messages (1 = Exposed, 0 = Unexposed) and knowledge of intermittent preventive treatment during pregnancy

graphs demonstrated that there was a balance between the exposed and unexposed groups in terms of overlap between propensity scores and similar distribution. Refer to Figs. 1 and 2 for these graphs. Bootstrapping was used to estimate the standard errors, and respective confidence intervals for the parameter estimates [51]. The off-support individuals were excluded from analysis to ensure unbiased parameter estimates and stable treatments effects [37].

Variables

- **Treatment Z:** Seen/heard any messages about malaria (s111). (Yes (exposed) = 1, No (unexposed) = 0). This is defined as exposure to malaria prevention messages in the study.
- **Outcome Y:** There are two outcomes considered in this study as ways to avoid malaria: (1) sleeping under the mosquito net (Yes = 1, No = 0), and (2) taking preventative medication, defined as IPTp (Yes = 1, No = 0). This is defined as knowledge of malaria prevention measures. Each was treated as an independent outcome and the effect of treatment was investigated.
- **Baseline Characteristics X:** These include Woman's age (15–19, 20–24, 25–29, 30–34, 35–39, 40–44, 45–49), Woman's education level (No Education, Primary, Secondary, Higher), residence (urban, rural, refugee) and region (central, eastern, northern, western).

Results

This section presents the prevalence of exposure to malaria messages, sample characteristics before matching and the effect of exposure of malaria messages on knowledge of malaria prevention, that is, use insecticide-treated bed nets (ITN), and uptake of intermittent preventive treatment of malaria in pregnancy (IPTp).

Prevalence of exposure to malaria messages and the characteristics of the sample population

Among the surveyed group of pregnant women in the MIS 2018–19 study, it was found that 39 [95% CI 34.0–44.2] had been exposed to malaria messages prior to the survey. This group was largely composed of women aged 15–24 years [42.2, 95% CI 37.3–47.2] with a primary level of education [61.9, 95% CI 55.7–67.8] and a parity of 0–1 [40.3, 95% CI 35.5–45.3]. Most lived in male-headed households [75.5, 95% CI 71.4–79.6], with 4–6 household members [38.9, 95% CI 33.8–44.2], from the poorest quintile households; [26.1, 95% CI 21.6–31.2], rural areas [70.9, 95% CI 63.0–77.7], and from Western Uganda [36.4, 95% CI 31.2–42.0]. The results also showed that the highest proportion of women who had access to malaria messages were those aged 15–24 years [37.4, 95% CI 30.9–44.5], with a primary level of education [59.6, 95% CI 50.1–68.5], a parity of 0–1[38.6, 95% CI 31.3–46.5], from male-headed households [76.6, 95% CI 69.5–82.4], living in households with 7 or more members (39.1, 95% CI 29.6–49.4), and from the poorest households [25.6, 95% CI 19.7–32.6]. Women from rural areas had the highest access to malaria messages with [75.4, 95% CI 66.3–82.7] and were mainly from Eastern Uganda [33.9, 95% CI 26.2–42.6]. Significant associations between exposure to malaria messages and education level of women ($p < 0.05$), woman's place of residence ($p < 0.01$) and region ($p < 0.05$) were observed. The results are presented in Table 1.

Table 1 Distribution of currently pregnant women by selected characteristics on the entire sample

Covariates	Category	Overall sample % [95% CI]	Seen or heard any messages about malaria: No (*n* = 440), col 61.0 [95% CI 55.8–66.0]	Seen or heard any messages about malaria: *Yes (n = 281), col* 39.0 [95% CI 34.0–44.2]	*p*-value
Age groups	15–24	42.2 [37.3–47.2]	45.2 [39.0–51.6]	37.4 [30.9–44.5]	
	25–29	27.7 [23.4–32.6]	26.9 [21.6–33.1]	29.0 [22.7–36.2]	0.201
	30–49	30.1 [25.5–35.1]	27.9 [23.0–33.3]	33.6 [26.0–42.1]	
Education level	No education	13.4 [10.0–17.7]	16.0 [11.9–21.3]	9.3 [6.2–13.7]	
	Primary	61.9 [55.7–67.8]	63.4 [56.7–69.6]	59.6 [50.1–68.5]	0.014
	Secondary +	24.7 [19.7–30.4]	20.6 [15.4–26.9]	31.1 [23.0–40.5]	
Parity	0–1 birth	40.3 [35.5–45.3]	41.3 [35.3–47.6]	38.6 [31.3–46.5]	
	2–3 births	28.4 [23.7–33.6]	30.2 [24.5–36.6]	25.5 [19.6–32.6]	0.222
	4 or more births	31.3 [27.2–35.7]	28.4 [23.8–33.5]	35.8 [28.7–43.7]	
Sex of HH head	Male	75.7 [71.4–79.6]	75.2 [69.4–80.2]	76.6 [69.5–82.4]	0.754
	Female	24.3 [20.4–28.6]	24.8 [19.8–30.6]	23.4 [17.6–30.5]	
Number of household members	1 – 3 members	26.2 [22.3–30.5]	28.5 [23.7–33.8]	22.6 [17.3–28.9]	
	4 – 6 members	38.9 [33.8–44.2]	39.2 [34.4–44.3]	38.4 [29.6–48.0]	0.218
	7 or more members	34.9 [28.9–41.4]	32.3 [26.7–38.4]	39.1 [29.6–49.4]	
Wealth index	Poorest	26.1 [21.6–31.2]	26.5 [21.3–32.4]	25.6 [19.7–32.6]	
	Poorer	22.4 [17.9–27.6]	24.1 [18.5–30.8]	19.6 [14.4–26.2]	
	Middle	19.3 [14.3–25.4]	19.7 [13.8–27.1]	18.6 [12.1–27.6]	0.708
	Richer	18.1 [13.6–23.6]	17.1 [12.4–23.1]	19.7 [12.7–29.3]	
	Richest	14.1 [9.5–20.4]	12.7 [7.5–20.6]	16.4 [10.9–24.0]	
Place of residence	Urban	20.0 [14.2–27.5]	18.9 [12.3–27.9]	21.7 [14.7–30.9]	
	Rural	70.9 [63.0–77.7]	68.0 [58.6–76.2]	75.4 [66.3–82.7]	0.002
	Refugee	9.1 [5.7–14.2]	13.1 [8.4–19.8]	3.9 [1.6–5.1]	
Region	Central	16.0 [10.4–23.8]	17.5 [10.9–26.8]	13.7 [8.5–21.2]	
	Eastern	29.9 [24.5–35.9]	27.3 [22.3–33.0]	33.9 [26.2–42.6]	0.025
	Northern	17.7 [14.7–21.1]	13.9 [11.3–16.9]	23.6 [19.4–28.5]	
	Western	36.4 [31.2–42.0]	41.3 [35.1–47.8]	28.7 [23.4–34.8]	

Source: MIS Data 2018–2019 (Sample weighted)

Sources of malaria messages and malaria prevention methods

Among women who have heard or seen malaria messages, radios were the highest source, accounting for [64.8, 95% CI 57.0–71.8] followed by interpersonal communication [45.0, 95% CI 37.6–52.6], community health workers [38.8, 95% CI 29.6–48.8], community events [21.4, 95% CI 15.8–28.3], and social mobilization [18.3, 95% CI 12.7–25.8]. In contrast, billboards [17.6, 95% CI 11.8–25.3], televisions [16.6, 95% CI 10.8–24.6], flyers [11.4, 95% CI 6.6–19.0], and social media [6.2, 95% CI 3.0–12.5] accounted for lower proportions of messages accessed through these platforms. Most women [74.4, 95% CI 67.1, 80.5] stated that sleeping under the net is an effective way to prevent malaria, while only [6.7, 95% CI 4.7, 9.5] maintained that taking preventative medicine prevents malaria. Results are shown in Table 2.

Table 2 Sources of malaria messages and prevention methods

	Percent	95% CI
Different forms of sources of malaria messages (*n* = 281)		
Radio	64.8	57.0–71.8
Television	16.6	10.8–24.6
Billboard	17.6	11.8–25.3
Community health worker	38.8	29.6–48.8
Community event	21.4	15.8–28.3
Interpersonal communication	45.0	37.6–52.6
Flyers	11.4	6.6–19.0
Social mobilization	18.3	12.7–25.8
Social media	6.2	3.0–12.5
Malaria preventive methods (*n* = 721)		
Sleeping under the net	74.4	67.1–80.5
Taking preventative medication	6.7	4.7–9.5

Source: MIS Data 2018–2019. (Sample weighted)

Effect of exposure to malaria messages on knowledge of malaria prevention

The propensity score graphs used to assess the matching quality of pregnant women exposed to malaria messages and those unexposed by ITN and IPTp are presented in Figs. 1 and 2. Figure 1 indicates well-balanced groups with comparable distributions based on mosquito net use. No deviation from the expected distribution is observed, suggesting suitability for comparison. The propensity score graph assessing matching quality among pregnant women exposed to malaria messages and those unexposed, based on their uptake of intermittent preventive treatment of malaria during pregnancy (IPTp), reveals balanced groups with some off-support. The off-support was excluded when examining the impact of access to malaria messages on knowledge of IPTp uptake. The results are shown in Fig. 2.

After matching, to estimate the average treatment effect on the treated (ATT) for knowledge of mosquito net use, and intermittent preventive treatment during pregnancy, the descriptive statistics indicated that the ATT was 17.2% ± 0.076 for mosquito net use, and 0.037 ± 0.046 for intermittent preventive treatment of malaria during pregnancy. The results are shown in Table 3.

The implications of these findings can be seen in Table 4, in which the standard errors were calculated using bootstrapping with 150 repetitions. The table indicates that women who have been exposed to malaria messages are 17.2% more likely to have knowledge of mosquito net use [ATT = 0.172; 95% CI 0.035–0.310] compared to those who have not been exposed to these messages. This suggests that exposure to malaria messages increases the knowledge of using mosquito nets to prevent malaria by up to 17.2% compared to those who have not been exposed to the messages. The study found that exposure to malaria messages had a positive effect on knowledge of preventive treatment of malaria, with an estimated [ATT = 0.037; 95% CI − 0.047–0.121]. This indicates that women who have heard or seen malaria messages had a 4% higher likelihood of knowing preventative medication as a preventive measure for malaria compared to women who had not seen or heard malaria messages. In general, the findings from this study suggest that exposure to malaria messages is linked to greater awareness of the importance of using insecticide-treated nets (ITNs) as a preventative measure against malaria. However, there was no significant effect of exposure to messages on uptake of preventative medication, which is a key strategy for malaria prevention and control in Uganda. The results are shown in Table 4.

Discussion

This study is the first to investigate the influence of health education and promotion initiatives by the Uganda Ministry of Health targeting awareness about malaria and its prevention, focusing on two WHO-recommended strategies: the consistent use of insecticide-treated bed nets (ITNs) and intermittent preventive treatment of malaria during pregnancy (IPTp). To assess the impact of exposure to malaria prevention messages on maternal knowledge of malaria prevention and control measures, a nationally representative sample and

Table 3 Estimation of ATT of Access to Malaria Messages on Knowledge of Prevention of Malaria

Variable	Sample	Exposed	Unexposed	Difference	SE	T-stat
Mosquito nets	Unmatched	0.768	0.727	0.041	0.010	1.25
	ATT	0.768	0.596	0.172	0.076	2.26
Preventive medication	Unmatched	0.139	0.043	0.959	0.020	4.74
	ATT	0.137	0.101	0.037	0.046	0.80

Source: MIS Data 2018–2019

Table 4 Quality of matching and average treatment effects on the treated (ATT) of access to malaria message on malaria prevention

		Model Diagnostics					
		Pseudo R^2	LR Chi2	p > chi2	Mean Bias	Median Bias	ATT [95% CI]
ITNs	Unmatched	0.065	65.20	0.000	13.9	8.2	
	Nearest Neighbor (1)	0.005	4.52	0.991	4.6	4.5	0.172 [0.035–0.310]*
IPTp	Unmatched	0.060	59.74	0.000	13.5	7.8	
	Radius, Caliper (0.05)	0.005	4.79	0.992	4.7	4.1	0.037 [− 0.047–0.121]

Source: MIS Data 2018–2019. Note: Standard Errors Were bootstrapped with 150 Repetitions, *$p < 0.05$ [$p = 0.014$]

propensity score-matched analysis was used. In general, nearly 40% of pregnant women reported having seen or heard malaria prevention messages, with the majority receiving information through radios, interpersonal communication, and community health workers. The study found that the level of knowledge regarding intermittent preventive treatment of malaria during pregnancy (IPTp), referred to as preventative medication in this study, did not show a significant difference among women exposed to malaria messages and those who were unexposed to these messages. However, exposure to malaria messages did impact the level of knowledge regarding the use of ITNs as a preventive measure. The recent national surveys and other research studies suggest that the differences in access, availability, and utilization of crucial malaria intervention measures may account for these results [17, 33, 52, 53].

Other studies have identified several methods to disseminate malaria messages such as radios, television, posters, community events and dialogues, community healthcare workers, and interpersonal communication [54–57]. In alignment with these findings, our study observed radios, interpersonal communication, and community health workers as the primary sources of malaria messages. The existing research has consistently shown that exposure to malaria-related messages is associated with an increased use of ITNs [16, 54, 56, 58–60] and IPTp [18, 19, 21, 26, 61]. In the current study, after matching exposed and unexposed pregnant women based on age, education level, residence, and region within the MIS 2018–19 dataset, it was found that exposure to malaria messages had a significant and positive impact on knowledge of malaria prevention by user ITNs.

The outcomes of this study are consistent with previous research that established a positive correlation between exposure to mass media and the use of ITNs, as mentioned earlier. The results of this study regarding the influence of exposure to malaria messages on knowledge of using ITNs as a malaria prevention measure are consistent with studies conducted in Cameroon and Ghana [62, 63]. However, this study found no significant effect of malaria message exposure on IPTp as a malaria prevention method in Uganda. It is not clear why mass media campaigns have minimal effect on knowledge of IPTp. However, it is possible that media content may lack sufficient information about IPTp. Typically, IPTp is started in the second trimester [64, 65], which also means that pregnant women who are late for their second or subsequent visits miss out on this important intervention. As a result, this affects both the uptake and exposure to knowledge about this crucial malaria intervention during pregnancy.

It is important to note that the findings of this study rely on observational data, and while propensity score-matched analysis can reduce bias from observable characteristics, there is still a possibility of bias due to unobserved confounders. This may result in an over or underestimation of the impact of malaria message exposure on pregnant women's knowledge of malaria prevention. Although randomized controlled trials are considered the gold standard for establishing causality, they are not always feasible or ethical [66–68] and require a lot of time to execute. In such cases, propensity score-matched analysis offers a better alternative. Therefore, the researchers chose this method to answer their research question. Equally, the knowledge of malaria prevention measures was based on the item asking whether women knew ways on how malaria can be prevented. This was a multiple-response question which included, among others, the use of mosquito bed nets and using of preventative medication. Each of these was measured as an independent outcome and thus, women who mentioned any of these were regarded as having knowledge of malaria prevention. This may not have provided an overall knowledge score of malaria prevention measurement. The researchers could not solve this problem since secondary data were used. In addition, the sample size reduced after matching and such a low sample could have affected the findings of the study. A study with a very large sample size could be very necessary to verify these findings. Lastly, this study was based on the analysis of secondary data, which made it impractical to evaluate the impact of mass media campaigns on the uptake of various malaria prevention measures. However, the results provide the first piece of evidence that mass media campaigns may have a limited impact on certain malaria prevention measures, indicating a need to appraise the current SBCC strategies.

Conclusion and recommendations

The findings revealed that nearly 40% of pregnant women had interacted with malaria prevention-related messages, primarily through radios, community health workers, and interpersonal interactions. The propensity score-matched analysis demonstrated a significant and positive impact of exposure to malaria messages on knowledge of preventing malaria through ITN use. It is crucial to implement effective strategies for disseminating information about malaria, including its causes, prevention, and treatment, to enhance knowledge of malaria prevention through ITN use in Uganda. However, further investigation is necessary to understand why these messages have a limited impact on knowledge of IPTp. This exploration will help identify barriers and inform the development of more targeted and effective messaging strategies to promote IPTp uptake among pregnant women in Uganda.

Abbreviations

ATT	Average treatment effect of the treated
IPT	Intermittent preventive treatment
IPTp	Intermittent preventive treatment during pregnancy
IRS	Indoor residual spraying
ITN	Insecticide-treated net
LLINs	Long-lasting insecticidal nets
MIS	Malaria indicator survey
PSMA	Propensity score matched analysis
SBCC	Social behavioural change and communication
SSA	Sub-Saharan Africa
WHO	World Health Organization

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Author contributions
EM – Conceptualized the study, methods, analysis and wrote the initial draft, SA, CN—Contributed to methods, data analysis and review of manuscript, RD, IDL, DO, RMA and NMT—provided extensive edits and inputs. All authors read and approved the final draft.

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None.

Availability of data and materials
Data used in this manuscript was obtained from MEASURE Demographic Health Survey (DHS) Program which granted access to thedataset up n request. The link is https://dhsprogram.com/data/dataset_admin/index.cfm.

Declarations

Ethics approval and consent to participate
The study obtained approval from MEASURE DHS to use their data, but consent to participate was not necessary as this was a secondary analysis of non-identifiable, publicly available data. The researchers treated the DHS data confidentially, and no attempt was made to identify individual women interviewed in the survey. All procedures were conducted in compliance with applicable guidelines and regulations.

Consent for publication
Not applicable.

Competing interests
None declared.

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