Influence of maternal exposure to malaria social and behavioral change messages and effectiveness of communication media on bed net use and malaria infection in Malawi

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Word count: Abstract: 236 words Text: 4651 words; 3 tables; 2 figures, 27 references

Acknowledgements: We acknowledge the International Classification of Functioning Disability and Health (ICF) for the permission to use the Maawi MIS dataset for our analysis.

Contributors: ON conducted data analysis, interpreted the data, and drafted the manuscript. TWC assisted in the literature review and provided suggestions for manuscript preparation. YHC conceived and designed this study and supervised all critical data analysis and manuscript preparation. All the authors have read and approved the manuscript.

Funding: This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Declaration of Conflicting Interests

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Abstract

Background: Malawi is a malaria-endemic country. A national malaria communication strategy was adopted to disseminate malaria messages with the aim of improving knowledge and adoption of malaria interventions.

Objective: To examine the effect of maternal exposure to malaria messages and the medium through which such messages are delivered on insecticide-treated net (ITN) use and malaria infection among children under 5 years of age in Malawi.

Methodology: Utilizing the data from the 2017 Malawi Malaria Indicator Survey, 2055 children (aged under 5 years) and 1886 children (aged 6–59 months) were analyzed for ITN use and malaria infection outcomes, respectively. Components of exposure to malaria messages were tested for association with ITN use and malaria infection outcomes using multiple logistic regression models.

Results: Children whose mothers had reported hearing any malaria-related message in the past 6 months were more likely to sleep under an ITN and less likely to have malaria infection compared with those whose mothers had not heard any malaria-related message. Region and sex of the child were effect modifiers on the relationship between exposure to any malaria-related message and malaria infection. Knowledge regarding cause or protection methods partially mediated the relationship between exposure to any malaria message and malaria infection.

Discussion and Conclusion: Health workers were an effective communication channel. Strengthening topic-specific malaria messages and building the capacity of health workers while alternately strengthening other message outlets may prove vital for effective malaria communication.

Keywords: Insecticide treated nets, malaria infection, social and behavioral change messages, mediation, moderation

Background

Malaria continues to be a major public health challenge, and in 2017, progress in terms of reduction of malaria cases stalled globally (World Health Organization, 2018). An estimated 219 million malaria cases worldwide were reported, with 10 of the highest malaria-burdened African countries reporting 3.5 million more malaria cases than those reported in 2016 (World Health Organization, 2018). Additionally, children under the age of 5 years are the most vulnerable group and accounted for 61% of all malaria-related deaths in 2017 worldwide (World Health Organization, 2018). Despite this, poor uptake of malaria interventions, particularly insecticide-treated nets (ITNs), has been observed globally (i.e., approximately half of people at risk slept under an ITN in 2018) (World Health Organization 2019). ITNs are said to be a key malaria vector control method, with studies attributing a 50% reduction in malaria incidence to ITN use (Lengeler, 2004). Therefore, the increase in malaria cases and the reported low uptake of ITNs and other interventions is concerning.

Malawi is a malaria-endemic country that experienced fluctuations in malaria prevalence between 2010 and 2014. As an example, among children aged under 5 years, 43% had malaria infection in 2010 with a sharp decline observed in 2012 to 28% and an increase to 33% in 2014 (National Statistical Office (NSO) [Malawi] and ICF, 2015). Conversely, ITN use among this population has been on the rise from 57.8% in 2010 to 69.0% in 2015 (Nkoka, Chipeta, Chuang, Fergus, & Chuang, 2019). However, the increased ITN usage in Malawi is relatively low compared with other countries in the region (e.g., the 75% usage rate in Rwanda) (Ruyange et al., 2016). These rates thus present crucial evidence on the need for evaluating the effectiveness of current malaria strategies being implemented in Malawi. One such strategy is the Malaria Communication Strategy developed and adopted by the Malawi Ministry of Health (MoH) under the National Malaria

Control Program. The strategy focuses on providing tailored social and behavioral change (SBC) messages to increase awareness and improve uptake of malaria interventions (Malawi Ministry of Health, nd). The strategy further targets different channels through which these messages may be communicated to their intended audiences. Therefore, SBC messages make up an integral part of Malawi's national malaria strategic plan.

Regarding SBC messages, several communication channels have been employed to relay malaria-related messages with the aim of increasing the demand and use of ITNs, and overall improving malaria-preventive behaviors. The use of radio, health workers, and newspapers coupled with the distribution of booklets for households, posters, and leaflets have been key components of the malaria communication strategy targeting caregivers of under-five children and heads of households in Malawi. In 2014, 40.3% of those surveyed cited government clinics/hospitals, 42.6% radio, and 11.3% community health workers as their main sources of malaria messages (Malawi Ministry of Health, nd). Thus it is important to evaluate how these different sources have influenced ITN use behaviors as well as helped reduce malaria infection among under-five children.

Previous studies in Nigeria (Zalisk et al., 2019), Ghana (Adjah & Panayiotou, 2014), and Zambia (Keating et al., 2012) have attempted to examine the effectiveness of malaria messaging and channels of communication on ITN usage with inconsistent findings reported. Given the varied findings regarding the association between malaria messages and ITN usage across different settings, setting-specific data are therefore necessary in order to evaluate country-specific programs and strategies geared towards improving ITN usage and reducing malaria infection. However, despite the MoH adopting malaria communication strategies in Malawi, there has been no study evaluating the effectiveness of the SBC messages, and more substantially, the

effectiveness of the channels through which these messages are delivered. Most importantly, previous studies in other settings have only examined the association of malaria messages with ITN usage and did not examine its link to malaria infection. SBC messages are aimed at improving malaria knowledge and thereby increasing malaria-related behaviors, such as use of ITNs, and ultimately decreasing malaria infection. However, there have been limited studies examining the pathway to establish whether the effect of SBC messages on ITN use or malaria infection is mediated by malaria knowledge.

Therefore, the goals of this study were to (1) assess the relationship between maternal exposure to malaria SBC messages, and ITN use and malaria infection among children under 5 years of age, (2) examine the effective channels of message delivery of any malaria-related message with regards to ITN usage and malaria infection among these children, (3) investigate the moderation effects of key sociodemographic factors on the relationship between ITN-related SBC messages, mode of delivery of SBC messages, and ITN use or malaria infection, and (4) evaluate the mediational role of knowledge regarding cause and protection of malaria on the relationship between exposure to malaria messages and malaria infection.

Methods

Study design and data source

This cross-sectional study used the 2017 Malawi Malaria Indicator Survey (MIS), which collected information from a nationally representative sample. The methods used in this survey have been detailed previously (National Statistical Office (NSO) [Malawi] and ICF, 2018). A total of 3861 women were eligible to be interviewed in the sampled households and 3860 women were

successfully interviewed, representing a 100% response rate. The study was restricted to children whose mothers were interviewed.

Data collection

Questionnaires

A structured questionnaire was used and administered through face-to-face interviews to women of reproductive age (15–49 years). The MIS collected information exclusively on malaria, such as prevention strategies (e.g., use of ITNs and indoor residual spraying), and malaria knowledge. The MIS was designed to be consistent with the Roll Back Malaria Monitoring and Evaluation Reference Group guidelines.

Malaria diagnosis

Malaria testing was done using rapid diagnostic test and microscopy. For consistency with the MIS report (National Statistical Office (NSO) [Malawi] and ICF, 2018), the current study used results from microscopic tests. Thin and thick blood smears were prepared in the field and then transported to the laboratory for logging and reading. Detailed explanation on microscopic test for MIS 2017 has been described elsewhere (National Statistical Office (NSO) [Malawi] and ICF, 2018).

Measures

Outcome Variables

Two outcome measures were considered in this study. The first outcome measure was ITN use, which was defined as whether a child under 5 years of age slept under an ITN the night before the survey (yes/no) (MEASURE Evaluation, 2018). An ITN was defined as a factory-treated net that did not require any further treatment (National Statistical Office (NSO) [Malawi] and ICF, 2018). The second outcome measure was malaria infection, which was defined as whether a child aged 6–59 months had a positive malaria test by microscopy (yes/no).

Main independent variables

The main independent variable, "exposure to any malaria-related SBC message," was examined in line with the malaria social and behavior change communication indicator reference guide under the RBM Partnership to End Malaria (RBM Partnership to End Malaria, 2017). Exposure to any malaria-related message was defined as maternal exposure to any malaria-related message through TV, radio, newspaper, poster, health worker (government or community health worker), and peer educators in the 6 months preceding the survey. The subitems were assessed individually; furthermore, a composite variable was formulated categorizing the variable into two (i.e., those who heard any malaria message from at least one source as "yes" and those who did not hear any malaria-related message from any source as "no").

Covariates

Several sociodemographic factors were included, such as sex of the child (male/female), age of the child categorized as infants (<12 months)/toddlers (12–36 months)/older (>36 months), maternal education (no formal education, primary, secondary, and higher), sex of the head of the household (male/female), age of the head of the household, household size (<5, ≥5), residence (urban/rural), and region (northern, central, and southern). Wealth was calculated using principle component analysis using scored household items ("National Malaria Control Programme (NMCP) and ICF. 2018. Malawi Malaria Indicator Survey 2017. Lilongwe,Malawi, and Rockville, Maryland, USA: NMCP and ICF.,"). In this analysis, wealth was categorized as poor (lower 40%), middle (middle 20%), and rich (upper 40%). Household ITN ownership (yes/no) and household owning at least one ITN per two household members (yes/no) were coded. To assess knowledge of women on the topics of malaria cause and preventive measures, women who correctly responded that mosquito bites would cause malaria or that sleeping under ITN is one way of

malaria prevention were regarded as having knowledge (yes) or who responded otherwise as having no knowledge (no). Both individual items and a composite score (any yes for "yes" and both no for "no") were recorded.

Statistical analyses

To avoid repetition from the same mother, one child was randomly selected per woman for analysis. All analyses were performed using Stata version 15.0 (Stata Corp LP, College Station, TX, USA). The "svy" command was used to adjust for cluster sampling design and sampling probabilities across clusters and strata.

Distribution of study participants

The distributions of participants' characteristics according to ITN use and malaria infection were examined using chi-square tests and independent sample *t* tests.

Multivariate regression models (Objective 1 and 2)

The association between maternal exposure to any malaria message, and ITN use and malaria infection were examined using logistic regression models. Adjusted odds ratio (aOR) and 95% confidence intervals (CIs) were used to report the strength of the association. Selection of factors to be included in the adjusted models was based on their importance in literature (Adjah & Panayiotou, 2014; Bowen, 2013; Zalisk et al., 2019).

Stratified analyses (Objective 3)

To test for possible interaction between maternal exposure to malaria message (i.e., the composite variable) and key sociodemographic factors (wealth, education, age of the child, sex of the child, region, and residence), an interaction term was added to the multivariable regression model one at a time. A p of < 0.1 was used for interaction terms as a cut-off to signal potential effect

modification (Evans et al. 2018), and a sub-group analysis was further used to examine the moderation effects.

Mediation analyses (Objective 4)

Finally, the recommendations of Baron and Kenny (1986) were followed to test mediation (Baron & Kenny, 1986). The bootstrapping method of Preacher and Hayes (Preacher & Hayes, 2004) to assess mediation for binary outcomes by calculating the indirect effects was used, which reported coefficients for all paths in the mediation model as depicted in Fig. 2 (where "knowledge of malaria cause and protective measures" was assumed to mediate the effect of maternal exposure to any malaria-related message on malaria infection). The bootstrapping analysis reported the indirect effects with bias-corrected 95% CIs (Zhao, Lynch Jr, & Chen, 2010).

Sensitivity analysis

Three sensitivity analyses were conducted. First, household ITN ownership and exposure to malaria messages were cross-tabulated and a correlation test was done to test whether these two variables would be correlated. Second, a sensitivity analyses for including children from households owning at least one ITN was done to assess the effect of main independent variables on ITN use (as usage may not be possible if there is no ITN ownership) and malaria infection. Third, an analysis to assess specific exposure to ITN-related messages was conducted to examine whether this would be consistent with the results from exposure to any malaria-related message. "ITN-related malaria message" was defined as maternal exposure to at least one ITN-related malaria messages in the 6 months preceding the survey (RBM Partnership to End Malaria, 2017). This was a two-level variable (yes/no). The messages included "*sleeping inside a mosquito net is important*" and "*who should sleep inside a mosquito net.*" The association between exposure to ITN-related messages and ITN use and malaria infection was assessed.

Ethical considerations

The Malawi Health Science Research Committee under the MoH reviewed and approved the MIS survey protocol. Informed consent was obtained from all participants prior to the interview by the MIS surveyors. For malaria testing children aged 6–59 months, parental consent was sought. Children who tested positive for malaria were introduced to full treatment for uncomplicated malaria according to the set procedures in Malawi (National Statistical Office (NSO) [Malawi] and ICF, 2018). Authors were granted permission to use the data by the Demographic and Health Survey program.

Results

Distribution of participants according to ITN use and malaria infection

Table 1 displays the characteristics of participants according to ITN use and malaria infection status. Out of 2055 children under the age of 5 included in the study for the ITN use outcome, 1427 (69.4%) slept under an ITN the previous night before the survey. Additionally, 1886 children aged 6–59 months were analyzed for the malaria infection outcome, of which 390 (20.7%) tested positive for malaria by microscopy.

Among others, children who were infants/toddlers, whose mothers had secondary and higher education, and who were from rich households had high proportions of ITN use and negative malaria tests (by microscopy) (Table 1). Specifically, children whose mothers heard any malaria messages through the radio were more likely to have slept under an ITN (77.5%) than those whose mothers did not hear any malaria message through radio (68.5%) ($p = 0.011$). Children whose mothers heard any malaria messages through health workers were more likely to sleep under an ITN (75.6%) than those whose mothers did not hear any malaria message through health workers

(67.1%) (p=0.006). Additionally, children whose mothers heard any malaria message from at least one source (composite) were more likely to sleep under an ITN (75.7%) than those whose mothers did not hear any malaria message from at least one source (66.6%) (p=0.002). Similar observations were made in terms of malaria infection status where lower proportions of malaria infection were reported among children whose mothers heard any malaria message through the radio, posters, health workers, or from at least one source, and whose mothers had knowledge of malaria protection (all $p< 0.05$).

Types of malaria messages received

Table 2 lists the types of malaria messages reported to have been received by the women. Most women reported to have received malaria message related to "sleeping under a mosquito net is important" (17.2%) and "malaria is dangerous" (16.4%). The least received malaria message was "importance of house spraying" (0.2%).

Association between SBC messages and channels of communication with ITN use

Table 3 presents the crude and adjusted odds ratios for the association of SBC messages and channels of communication with ITN usage. Results from the adjusted model revealed that children whose mothers heard any malaria message from a health worker (aOR = 1.53, 95% CI = 1.12–2.10), and heard any malaria message from at least one source (aOR = 1.50, 95% CI = 1.10–2.05) were more likely to use ITNs compared with those whose mothers did not report hearing any malaria message from a health worker, and who reported not hearing any malaria message from at least one source, respectively.

Association between SBC messages and channels of communication with malaria infection

Children whose mothers heard any malaria messages from health workers (aOR = 0.56, 95% CI = 0.36–0.89), heard any malaria messages from at least one source (aOR = 0.59, 95% CI = 0.38–0.92), had knowledge of malaria protection (aOR = 0.57, 95% CI = 0.36–0.92), and had overall knowledge about malaria (aOR = 0.62, 95% CI = 0.39–0.99) were less likely to have malaria infection compared with their respective counterparts after other covariates were adjusted (Table 3).

Subgroup analysis

The interaction terms between exposure to any malaria-related message and sociodemographics on ITN usage and malaria risk were examined. Region and sex were found to be potential effect modifiers (i.e., interaction p-values with maternal exposure to malaria message were <0.1). Therefore, stratified analyses by region and sex were conducted. Stratified analysis revealed significantly greater reductions in the likelihood of malaria infection due to maternal exposure to any malaria-related message among children from the southern region (aOR = 0.30, 95% CI = 0.12–0.74), while the reductions were weaker and not significant among those from the northern (aOR = 0.94, 95% CI = 0.42–2.17) and central (aOR = 0.75, 95% CI = 0.41–1.35) regions. Additionally, stronger significant effect for malaria messaging was observed among female children (aOR = 0.38, 95% CI = 0.22–0.69) than the effect among male children, which was not statistically significant (aOR = 0.69, 95% CI = 0.38–1.34) (Fig1). No significant interaction terms were observed between exposure to any malaria-related message and other social demographic factors on malaria infection hence no further stratified analyses were conducted. Similarly, no significant interaction terms were observed between maternal exposure to malaria messages and key sociodemographic factors on ITN use thus no further stratified analyses were warranted.

Mediational role of knowledge of malaria

The mediational role of malaria knowledge between the relationship of maternal exposure to any malaria-related message from at least one source and malaria infection was further examined as shown in Fig 2. Maternal exposure to any malaria-related messages from at least one source was significantly and negatively associated with malaria infection (paths *c*, B = −0.65 and *c'*, B = −0.55 with mediator included in the model for path *c'*). Furthermore, maternal exposure to any malaria-related messages from at least one source was significantly associated with knowledge of malaria causes or protective measures (the path *a* with B = 0.83), and knowledge of malaria causes or protective measures in turn was independently associated with malaria infection (the path *b*, B = −0.58).

The indirect effect of maternal exposure to any malaria-related messages from at least one source through knowledge of malaria causes or protective measures was significant (B = −0.031, 95% CI [−0.031, −0.014]), suggesting that knowledge of malaria causes or protective measures mediates the effect of maternal exposure to any malaria-related messages from at least one source on malaria infection (the proportion of the total mediated effect was 18.2%).

Sensitivity analysis

After cross-tabulation, there was no significant association between household ITN ownership and exposure to malaria messages. Additionally, the correlation test between household ITN ownership and exposure to any malaria-related message exhibited very weak positive correlation (i.e., Cramér V = 0.06) (Table s1). After restricting the analysis to only women from households owning at least one ITN (Table s2), the results were fairly consistent with those including the whole sample (Table 3). Results examining the association between maternal exposure to ITN-related messages

and ITN use and malaria infection were consistent with those regarding maternal exposure to any malaria-related messages and ITN use and malaria infection (Table s3).

Discussion and conclusion

Discussion

This is the first study to examine the association between exposure to SBC messages, the channels through which such messages are relayed, and malaria infection in children under 5 years of age. It is also the first population-based study to investigate exposure to any malaria-related messages through different outlets and ITN use among children under 5 years of age in Malawi. Additionally, the study examined the mediational role of knowledge of malaria causes and protective measures on the effect of maternal exposure to any malaria messages on malaria infection. Our findings revealed that exposure to malaria SBC messages was independently associated with a 50% increase in the likelihood of sleeping under an ITN and a 41% reduction in the chances of being infected by malaria among children under 5 years in Malawi. It was further revealed that using health workers was an effective mode of delivering malaria messages in terms of improving ITN usage and reducing the likelihood of malaria infection among these children. Our findings also suggested that knowledge of malaria causes and preventive measures plays a mediational role in the relationship of maternal exposure to any malaria messages and malaria infection among children.

The prevalence of ITN usage was 69.4%, whereas malaria infection prevalence was 20.7%. The ITN usage rate was similar to the 69.0% reported in 2015 but higher than the 57.8% reported in 2010 in Malawi (National Statistical Office (NSO) [Malawi] and ICF, 2017). Similarly, the 20.7% prevalence of malaria represented a decline compared with 28.0% in 2012 and 33.0% in 2014

(National Statistical Office (NSO) [Malawi] and ICF, 2012; National Statistical Office (NSO) [Malawi] and ICF, 2015). Malawi's malaria prevalence is also lower compared with the 40.0% reported in Mozambique among the same age group (Cassy et al., 2019). The increase in ITN usage and reduction in malaria prevalence may be attributed to the mass ITN distribution campaigns that were conducted in 2012 and 2015. The campaigns may have increased access to ITNs in households, thereby improving usage and ultimately preventing malaria infections. Additionally, the mass ITN distribution campaigns were accompanied by comprehensive SBC messages, which may have played a role in increasing awareness of malaria prevention measures, thereby improving adoption of such measures within households. However, only malaria threat and the importance of sleeping under an ITN were the widely reported malaria messages to have been received by the women. Therefore, a comprehensive malaria messaging package that emphasizes on other key issues such as environmental sanitation and treatment-seeking behavior, should be reinforced. Additionally, there was a weak positive correlation between maternal exposure to any malaria-related messages and household ITN ownership, underscoring the need of strengthening malaria messages/education during ITN distribution.

Consistent with results from Cameroon (Bowen, 2013) and Nigeria (Zalisk et al., 2019), maternal exposure to ITN-related messages and exposure to any malaria-related messages (from at least one source) was associated with increased odds of ITN use. Furthermore, the current study's results revealed protective effects of maternal exposure to ITN messages and any malaria-related messages on malaria infection in children under 5 years of age. These findings highlight the need to strengthen SBC messages in the fight against malaria in Malawi. Children whose mothers heard messages from health workers were more likely to sleep under an ITN and were less likely to be

infected with malaria. This is consistent with a Ghanaian study that revealed health workers to be an effective way of communicating malaria messages (Adjah & Panayiotou, 2014). Therefore, capacity building of health workers with regards to health education on malaria preventive measures may be warranted. Other mediums of communication were not independently associated with the outcomes under study. In Ghana, radios and posters were associated with ITN usage (Adjah & Panayiotou, 2014). Approximately 52.2% of Malawians own a radio with only 11.9% having electricity, whereas those with electricity mostly experience intermittent connections (National Statistical Office (NSO) [Malawi] and ICF, 2018). This means that batteries are the most reliable sources of power (Malawi Ministry of Health, nd) to listen to radios. Without these sources, many may miss out on critical information passed through this channel, rendering it an ineffective means of communication.

Having maternal knowledge of malaria protection was associated with reduced likelihood of having malaria infection. Women who are knowledgeable about malaria protection issues are more likely to make informed choices on the method of malaria control to use for their children (Diema et al. 2019). However, maternal knowledge of malaria protection was not associated with ITN use among under-five children. Indeed, while knowledge is an essential first step, it is likely not sufficient to boost health behavior. Promotion of interventions with the applications of behavior change principles would be important to help implement maternal knowledge of malaria protection on behavior of ITN usage.

The effect of exposure to any malaria-related message on reducing malaria infection was considerable among children from the southern region, and female children. The central and the southern regions of Malawi have been reported as having high malaria prevalence (National

Statistical Office (NSO) [Malawi] and ICF, 2018). Therefore, providing residents of these regions with ITN messages or any malaria messages would improve ITN usage and also reduce malaria risks in children in these areas. In Kenya, a higher malaria prevalence was observed in male children than female children (Sultana et al. 2017). Male children are more likely to be involved in outdoor activities which may expose them to mosquito bites compared with their female counterparts. As such, female children may be better protected from malaria infection compared to male children. However, the results from the stratified analysis should be carefully interpreted as some of the estimates had wide confidence intervals owing to smaller sample sizes within different levels.

The current study demonstrated that knowledge of causes and preventive measures of malaria mediates the effect of malaria SBC messages on malaria infection among children under 5 years. Knowledge of malaria causes and preventive measures is a component of malaria ideational factors (Do et al., 2018) and ideation has been shown to have a positive influence on achieving household universal ITN coverage elsewhere (Ricotta et al., 2015). Mothers' knowledge on the causes and preventive measures of malaria may influence good behaviors for malaria prevention, thereby reducing the risk of malaria in their children under 5 years of age. The total proportion mediated through knowledge of malaria causes and preventive measures was 18.2%, suggesting that there are other pathways that influence malaria risk in children under 5. These may include other ideation components, such as perceived susceptibility to and severity of malaria and attitude towards malaria. Therefore, providing appropriate messages regarding cause and preventive measures among women would improve their knowledge regarding malaria, which may improve their behaviors and ultimately reduce risk of infection among their children. As such, provision of

information on SBC messages, particularly on the causes and preventive measures of malaria, in Malawi should be largely emphasized among women with children under the age of 5 years.

The study had nationally representative samples that may allow generalization of the results to the Malawian population. Thus, SBC messages could be strengthened to improve ITN usage and other malaria-related behaviors in order to reach the WHO's goal of eliminating malaria by 2030. The results demonstrated how SBC messages influence ITN usage and reduce malaria risks among vulnerable groups, thereby generating evidence of the effectiveness of SBC messages in malaria programs. The current results were further confirmed in sensitivity analyses by restricting the analysis among children from households owning at least one ITN with consistent results observed. The examination of the mediational role of knowledge of causes and preventive measures provided an understanding of the relationship between exposure to SBC messages and malaria risk among children aged under 5 years. This may have vital implications in the designing of malaria communication programs and topic-specific SBC messages with the goal of increasing mothers' knowledge of malaria causes and preventive measures. As the study relied on self-reported ITN use, social desirability bias may have occurred; therefore, the results for ITN use should be interpreted with caution (Krezanoski, Bangsberg, & Tsai, 2018). The frequency at which these messages were received was not examined, as the information was not available in the dataset. The cross-sectional design could not allow causality inferences to be made. Finally, there may be also a potential recall bias among survey respondents on exposure to malaria messages since the recall period was 6 months. Possibly due to less concerns about malaria-related issues, under-reporting of exposure to malaria message may be more likely among those whose children did not use ITN or had malaria infections. However, the MIS surveyors were well trained to

administer the questionnaires and ask such questions regarding exposures and this may have helped reduce the recall bias.

Conclusion and practice implications

The results demonstrated that SBC messages are an important aspect of malaria programs in Malawi as they were associated with improvement of ITN usage and reduced risk of malaria infection among children under the age of 5 years. Health workers are an essential part of the communication strategy, as they have been shown to improve the outcomes under study. Therefore, capacity building of these health workers may prove beneficial. Future studies should seek to examine the frequency and content of exposure to malaria SBC messages and how that may improve ITN usage or reduce malaria infection. Additionally, future studies may consider examining the mediation role of other malaria ideational components, such as perceived severity, susceptibility, and self-efficacy for protection against malaria on SBC messages and malaria infection.

Abbreviations: ITN: insecticide-treated net; aOR: adjusted odds ratio; SBC; social and behavior change; MIS: Malaria Indicator Survey; MoH: ministry of health; ICF: International Classification of Functioning Disability and Health; and CI: confidence interval.

Availability of data and materials: The study used, with permission, data from the 2017 Malawi Malaria Indicator Survey. The data are publicly available and may be requested at https://dhsprogram.com/data/available-datasets.cfm

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Table 1 Distribution of study characteristics according to ITN use and malaria infection

Characteristic	Child slept under an ITN* *n* = 2055			Malaria infection ** *n* = 1886		
	No (*n* = 628)	Yes (*n* = 1427)	*p*-value	Micro- (*n* = 1496)	Micro+ (*n* = 390)	*p*-value
Sociodemographic						
Sex of the child			0.167			0.862
Male	298 (28.7)	740 (71.3)		756 (79.1)	200 (20.9)	
Female	330 (32.5)	687 (67.5)		740 (79.5)	190 (20.5)	
Age of the child (months)			**< 0.001**			**< 0.001**
Infants (<12 mo.)	75 (19.6)	309 (80.4)		201 (93.4)	14 (6.6)	
Toddlers (12 – 36 mo.)	247 (29.2)	601 (70.8)		693 (81.7)	155 (18.3)	
Older (>36 mo.)	306 (37.1)	517 (62.9)		602 (73.2)	221 (26.8)	
Maternal education			**< 0.001**			**< 0.001**
No formal education	115 (39.6)	175 (60.4)		189 (68.4)	87 (31.6)	
Primary	433 (31.2)	955 (68.8)		988 (78.0)	280 (22.0)	
Secondary+	80 (21.3)	297 (78.7)		319 (93.1)	23 (6.9)	
Sex of head of the household			0.422			0.226
Male	488 (30.0)	1138 (70.0)		1189 (80.1)	296 (19.9)	
Female	140 (32.6)	289 (67.4)		307 (76.5)	94 (23.5)	
Age of head of the household $\bar{x} \pm SD$ [t]	37.36 ± 12.57	36.72± 11.87	0.296	36.85 ± 11.75	36.89 ± 12.79	0.966
Wealth			**0.035**			**< 0.001**
Poor (lowest 40%)	325 (34.3)	623 (65.7)		612 (69.7)	267 (30.3)	
Middle (middle 20%)	99 (26.5)	275 (73.5)		276 (80.2)	68 (19.7)	
Rich (highest 40%)	204 (27.8)	529 (72.2)		608 (91.6)	55 (8.4)	
Number of household members			**< 0.001**			0.924
<5	214 (25.6)	622 (74.4)		597 (79.2)	157 (20.8)	
≥5	414 (34.0)	805 (66.0)		899 (79.4)	233 (20.6)	
Residence			0.457			**< 0.001**
Urban	88 (28.9)	217 (71.1)		265 (97.1)	8 (2.9)	
Rural	540 (30.9)	1210 (69.1)		1231 (76.3)	382 (23.7)	
Region			**0.001**			0.058
Northern	68 (29.5)	163 (70.5)		181 (90.2)	20 (9.8)	
Central	314 (35.8)	563 (64.2)		639 (78.0)	180 (22.0)	
Southern	246 (26.0)	701 (74.0)		676 (78.1)	190 (21.9)	
ITN-related factors						
Household own at least 1 ITN			**<0.001** [f]			**0.008**
Yes	256 (20.0)	1427 (80.0)		1310 (80.7)	313 (19.3)	
No	272 (100)	0 (0)		186 (70.8)	77 (29.2)	
Household has 1 ITN per 2 individuals			**< 0.001**			**< 0.001**
Yes	77 (12.5)	543 (87.5)		491 (88.2)	66 (11.8)	
No	551 (38.4)	884 (61.6)		1005 (75.6)	324 (24.4)	
Mode of delivery of any malaria SBC messages						
Specific sources of any malaria message						
TV			0.899			< 0.059 [f]
Yes	21 (31.2)	47 (69.4)		56 (93.1)	4 (6.9)	
No	607 (30.6)	1380 (69.4)		1440 (78.9)	386 (21.1)	
Radio			**0.011**			**0.021**
Yes	49 (22.5)	169 (77.5)		178 (88.1)	24 (11.9)	
No	579 (31.5)	1258 (68.5)		1318 (78.3)	366 (21.7)	
Newspaper			0.507			**0.049** [f]
Yes	14 (35.6)	26 (64.5)		31 (100)	0 (0)	
No	614 (30.5)	1401 (69.5)		1645 (79.0)	390 (21.0)	

Poster			0.356			**0.040**
Yes	23 (25.8)	70 (74.2)		77 (91.1)	7 (8.9)	
No	605 30.8)	1357 (69.2)		1419 (78.7)	383 (21.3)	
Health worker			**0.006**			**0.002**
Yes	139 (24.4)	431 (75.6)		452 (86.0)	73 (14.0)	
No	489 (32.9)	996 (67.1)		1044 (76.7)	317 (23.3)	
Peer educators			0.598			0.808
Yes	18 (35.2)	35 (64.8)		43 (81.4)	10 (18.6)	
No	610 (30.5)	1392 (69.5)		1453 (79.2)	380 (20.8)	
At least one message outlet (composite)[§]			**0.002**			**< 0.001**
Yes	154 (24.3)	484 (75.7)		511 (86.2)	81 (13.8)	
No	474 (33.4)	943 (66.6)		985 (76.1)	309 (23.9)	
Malaria Knowledge						
Knowledge of malaria cause			0.114			0.515
Yes	23 (21.9)	85 (78.1)		80 (82.4)	17 (17.6)	
No	605 (31.1)	1342 (68.9)		1416 (79.1)	373 (20.9)	
Knowledge of malaria protection			0.680			**0.003**
Yes	148 (31.6)	321 (68.4)		373 (87.0)	56 (13.0)	
No	480 (30.3)	1106 (69.7)		1123 (77.0)	334 (23.0)	
Malaria knowledge (composite)			0.934			**0.006**
Yes	164 (30.4)	377 (69.6)		423 (86.0)	69 (14.0)	
No	464 (30.6)	1050 (69.4)		1073 (77.0)	321 (23.0)	

[¶] ITN-related malaria message heard in the last 6 months, SD standard deviation, ITN insecticide treated nets, [ᶠ] *p*-value from Fisher's exact test, *Micro+/-* malaria status using microscopy test, [ᵗ] results from t-test, all *p* values are from chi square test unless specified, bold means significant at $p < 0.05$ * sample included all children aged under 59 months, ** sample included all children aged between 6 and 59 months, [§] composite variable for different sources of any malaria messages (i.e., TV, radio, newspaper, poster, health worker, and peer educators) in the last 6 months, $\bar{x}$ mean

Table 2 Type of malaria massages (n=2055)

Message type	n (%)
Malaria is dangerous	337 (16.4)
Malaria can kill	200 (9.7)
Mosquito spread malaria	108 (5.2)
Sleeping under a mosquito net is important	353 (17.2)
Who should sleep under a mosquito net	73 (3.6)
Seek treatment for fever	82 (4.0)
Seek treatment for fever promptly (within 24 hours)	97 (4.7)
Importance of house spraying	3 (0.2)
Not plastering walls after spraying	7 (0.3)
Environmental sanitation activities	154 (7.5)

Table 3 Association between sources of malaria messages, ITN usage, and malaria infection

Characteristic	ITN usage**				Malaria infection (Micro+)*			
	OR	95% CI	aOR[a]	95% CI	OR	95% CI	aOR[a]	95% CI
Mode of delivery of any malaria SBC messages								
TV source of malaria-related messages								
No	1.00		1.00		1.00		1.00	
Yes	0.97	(0.60–1.57)	0.70	(0.41–1.19)	0.28	(0.07–1.15)	0.59	(0.13–2.77)
Radio source of malaria-related messages								
No	1.00		1.00		1.00		1.00	
Yes	**1.58**	**(1.11–2.26)**	1.28	(0.85–1.93)	**0.49**	**(0.26–0.91)**	0.87	(0.43–1.73)
Newspaper source of malaria-related messages								
No	1.00		1.00		-		-	
Yes	0.79	(0.40–1.58)	0.46	(0.22–1.23)	-	-	-	-
Poster source of malaria-related messages								
No	1.00		1.00		1.00		1.00	
Yes	1.28	(0.75–2.18)	0.99	(0.51–1.91)	**0.36**	**(0.13–0.99)**	0.52	(0.18–1.53)
Health worker source of malaria-related messages								
No	1.00		1.00		1.00		1.00	
Yes	**1.52**	**(1.13–2.04)**	**1.53**	**(1.12–2.10)**	**0.54**	**(0.36–0.80)**	**0.56**	**(0.36–0.89)**
Peer educator source of malaria-related messages								
No	1.00		1.00		1.00		1.00	
Yes	0.81	(0.36–1.81)	0.89	(0.36–2.24)	0.87	(0.29–2.62)	1.03	(0.31–3.40)
At least one message outlet (composite)[§]								
No	1.00		1.00		1.00		1.00	
Yes	**1.56**	**(1.18–2.08)**	**1.50**	**(1.10–2.05)**	**0.51**	**(0.34–0.75)**	**0.59**	**(0.38–0.92)**
Malaria Knowledge								
Knowledge of malaria cause								
No	1.00		1.00		1.00		1.00	
Yes	1.61	(0.89–2.91)	2.09	(0.98–4.47)	0.81	(0.42–1.54)	0.99	(0.51–1.94)
Knowledge of malaria protection								
No	1.00		1.00		1.00		1.00	
Yes	0.94	(0.70–1.26)	1.07	(0.75–1.52)	**0.50**	**(0.32–0.80)**	**0.57**	**(0.36–0.92)**
Malaria knowledge (composite)								
No	1.00		1.00		1.00		1.00	
Yes	1.01	(0.76–1.34)	1.17	(0.83–1.65)	**0.54**	**(0.35–0.84)**	**0.62**	**(0.39–0.99)**

[§] Heard ITN-related messages during 6 months preceding the survey, [§] composite variable for different sources of any malaria messages (i.e., TV, radio, newspaper, poster, health worker, and peer educators) in the last 6 months, *CI* confidence interval, *OR* odds ratio, *aOR* adjusted odds ratio, *ITN* insecticide treated nets, *TV* television, *Micro+* positive malaria using microscopy test, [a] Adjusted for sex of the child, age of the child, maternal education, age of head of the household, sex of head of household, wealth, household size, residence, region, household has one ITN per two individuals , * sample included children aged 6–59 months, ** sample included all children aged under 59 months

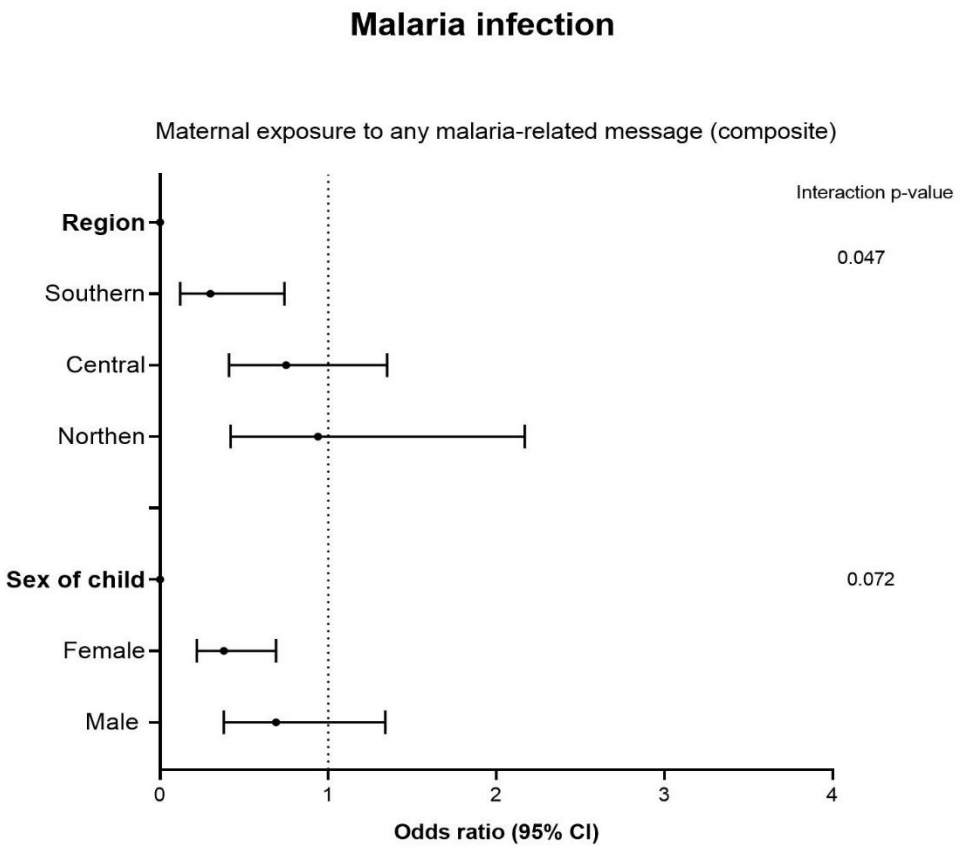

Figure 1 Subgroup analysis of sociodemographics for effects of maternal exposure to malaria messages

Effects of maternal exposure to any malaria-related message on malaria risk. The p-*values included are interaction* p-*values*. heard at any malaria message from at least one outlet: yes, or no (ref.). Results were adjusted for potential confounding factors (i.e., sex of the child, age of the child, age of head of household, sex of head of household, maternal education, wealth status, residence, region, and household size, household has one ITN per two individuals. The variable that was treated as the effect modifier was excluded).

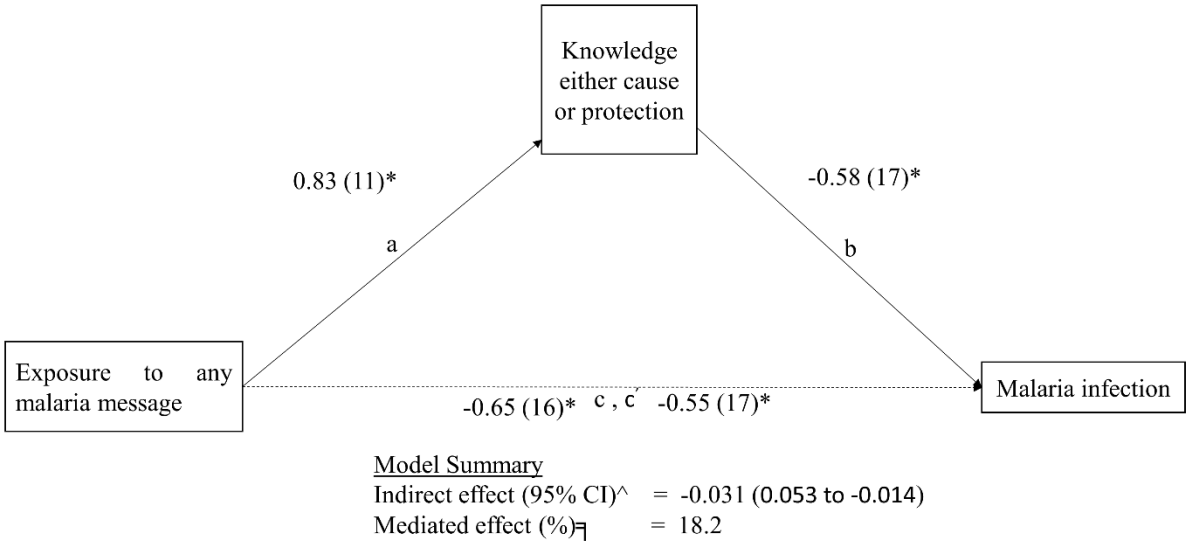

Figure 2 Mediation role of malaria knowledge on the relationship between malaria messages and malaria infection.

*Values represent unstandardized path coefficients and the values in parenthesis are standard errors. (a) coefficient for the effect of the main independent variable on the mediator (knowledge of malaria cause and protection), (c) coefficient for the effect of the main independent variable on malaria infection, (b) coefficient for the effect of mediator (Knowledge of malaria cause and protection) on malaria infection while controlling for the main independent variable, (c´) effect of main independent variable on malaria infection while controlling for mediator (Knowledge of malaria cause and protection). ^ bias-corrected confidence interval, ㅋ proportion of total effect mediated, * p-value <0.05*