Social Interactions and the Uptake of Long-Lasting Insecticide-Treated Nets (LLINs) among Under-Five Children in Kenya: Policy Implications

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Abstract
Background: *Despite the availability of effective prevention measures such as long-lasting insecticide-treated nets (LLINs) and indoor residual spraying (IRS), malaria remains a major global health concern. In 2023, the WHO African region accounted for 95% of global malaria deaths, of which 76% occurred among children under five years.*
Methods: *This study analyzed data from the 2020 Kenya Malaria Indicator Survey, including 6,771 eligible child caregivers. Bivariate and logistic regression analyses were employed to examine the influence of religious social interactions on LLIN use among children under five.*
Results: *Logistic regression revealed that LLIN use among children under five was significantly influenced by child age, caregiver education, household wealth, and place of residence, with social interactions by religious affiliation amplifying these effects. Compared to infants, one-year-olds were 13.4% more likely to use an LLIN ($p<0.05$), although this advantage declined with age. Caregiver education strongly predicted use, with primary schooling raising uptake by 18.6% and secondary or higher by 25.2% ($p<0.01$); these effects were further strengthened when caregivers belonged to active religious networks. Similarly, children in the highest wealth quintile were 22.7% more likely to use LLINs than those in the lowest ($p<0.01$), but peer influences within faith-based groups widened this wealth gap, especially in rural settings where uptake was otherwise 11.5% lower than in urban areas ($p<0.05$). Overall, social interactions shaped how education, wealth, and rural residence translated into preventive behavior, underscoring the importance of community-level peer effects in malaria prevention.*
Conclusion: *Religious social interactions play an important role in shaping malaria prevention behaviors. Policy measures should leverage faith-based networks to strengthen community education, address rural–urban disparities, and optimize resource allocation for malaria control.*

Keywords: *Social interactions; religious affiliations; LLINs; malaria prevention; health behavior*

Introduction

Malaria remains a major public health challenge despite the scale-up of proven preventive strategies such as indoor residual spraying (IRS) and long-lasting insecticidal nets (LLINs). Over 90% of global malaria morbidity and mortality caused by Plasmodium falciparum occurs in sub-Saharan Africa, where in 2023 an estimated 597,000 people died from the disease. The WHO African Region bears 95% of this burden, with children under five accounting for approximately three-quarters of malaria deaths [1]. In Kenya, malaria is endemic in western, coastal and lake regions, contributing an estimated 5 million cases and more than 12,000 deaths in 2022 [2]. Among children under five, the disease accounts for nearly one-third of outpatient consultations, underscoring their heightened vulnerability.

Although LLINs are widely distributed through national and global initiatives, gaps remain in consistent and effective use. Most malaria control programs emphasize household-level determinants such as wealth, education, or rural–urban residence [3,4]. However, such approaches often overlook the social context in which health behaviours are embedded. A growing body of evidence shows that social interactions through family, peers, community networks, and religious affiliations can strongly shape adoption of health interventions [5–8]. Mechanisms such as norm formation, observational learning, social reinforcement, and trust within networks can diffuse practices and influence both uptake and sustained adherence [7,9,10].

While peer effects are well documented in areas such as alcohol consumption, adolescent health, and mental health promotion [13–15], their influence on malaria prevention remains underexplored. Religious networks, though influential in shaping norms and behaviors across Africa, have been studied quantitatively only to a limited extent. Existing studies of faith-based influences on LLIN use are largely qualitative or program-based [16,17], and few have examined how denominational differences, such as between Christian and Muslim communities, may mediate these effects [18,19].

This study addresses this gap by using data from the 2020 Kenya Malaria Indicator Survey [20] and applying logistic regression models [21,22] to assess the role of social interactions, particularly religious peer influences, on LLIN use among children under five. By quantifying these effects, we aim to provide insights into how community networks can be leveraged to strengthen malaria prevention strategies. These findings have direct policy implications for designing culturally sensitive, community-aligned interventions that enhance LLIN uptake and contribute to reducing malaria burden among high-risk populations.

Methods

Study design and setting

This analysis draws on data from the 2020 Kenya Malaria Indicator Survey (KMIS), a nationally representative cross-sectional survey conducted between 8 November and 23 December 2020.

The KMIS employed a rigorous two-stage sampling approach to ensure comprehensive geographic and demographic coverage across Kenya, encompassing both urban and rural communities. Eligible respondents included women aged 15-49 years living in the selected households, with the survey achieving high participation rates among both women and households. The present analysis focused specifically on caregivers of children under five years,

drawing from those households with complete net-use data for each child, and aligning with the study's aim to examine how social interaction influences LLIN usage within this vulnerable age group. The survey's robust methodology, including the use of standardized questionnaires and collaboration between the Ministry of Health and the Kenya National Bureau of Statistics, provided reliable and nationally representative data for subsequent statistical analyses.

Guided by the Kenya Malaria Strategy (2019–2023), the country is stratified into four epidemiological zones based on transmission intensity and ecological conditions: endemic (coastal and lake), highland epidemic-prone, semi-arid/seasonal transmission, and low-risk zones. The KMIS sampling strategy was designed to provide reliable estimates at national, urban–rural, and endemicity-zone levels.

Study population and sampling

Eligible participants were women aged 15-49 years residing in selected households. The survey achieved high response rates (96% for women and 97% for households). This study focused on caregivers of children under five years. From 7,952 interviewed households, 6,771 women provided eligible data. After excluding women without a birth in the preceding five years (n = 3,946) and children with incomplete net-use information (n = 374), the final analytic sample comprised 2,451 children under five years.

The survey followed a two-stage sampling design. In the first stage, 301 clusters were selected (134 urban and 167 rural). In the second stage, 30 households were systematically sampled within each cluster, with no replacements for non-response.

Study variables

The main outcome variable was whether a child slept under a long-lasting insecticidal net (LLIN) on the night before the survey (coded 1 = yes, 0 = no). Independent variables included child characteristics (age, sex), caregiver characteristics (age, education, knowledge), household factors (wealth, urban–rural residence), and social interaction measures, with particular attention to religious affiliation and peer effects.

Data collection

Data were collected by the Ministry of Health in collaboration with the Kenya National Bureau of Statistics. Standardized Malaria Indicator Survey questionnaires, adapted from the Demographic and Health Surveys program, were used. Datasets were obtained in STATA-compatible format from the KNBS repository.

Data analysis

All analyses were conducted in STATA version 16. Descriptive statistics summarize sample characteristics (means, medians, proportions). Associations between LLIN use and explanatory variables were examined using chi-squared tests. Logistic regression models were then applied to estimate adjusted odds ratios (ORs) with 95% confidence intervals (CIs).

Analytical model

A binary logistic regression model was specified to assess determinants of LLIN use. In the baseline model, uptake of LLINs (yes = 1, no = 0) was regressed on individual, household, and contextual factors. A second model introduced interaction terms to capture religious peer effects

(Christian and Muslim). This two-step approach enabled assessment of both direct effects and the moderating influence of social interactions.

Ethical Considerations

This study used secondary data from the Kenya Malaria Indicator Survey (KMIS), which received ethical approval from the [insert specific institutional review board/committee, e.g., the Kenya Medical Research Institute (KEMRI) Scientific and Ethics Review Unit] and the [insert collaborating institution if applicable]. Informed consent was obtained from all survey participants during data collection. Access to the anonymized dataset was granted through the Demographic and Health Surveys (DHS) Program data request system, and all analyses complied with relevant guidelines and regulations. No additional ethical approval was required for this secondary analysis.

Descriptive analysis

A total of 2,451 children under five were included in the analysis. Overall, 55.2% had slept under a long-lasting insecticidal net (LLIN) the night before the survey. The sex distribution was balanced, with 58.2% females and 41.8% males, and no significant difference in LLIN use was observed by gender (p = 0.887).

Among continuous variables, mean child age was slightly lower among LLIN users compared with non-users (2.47 vs. 2.73 years; $t = 4.09$, $p < 0.001$). Caregiver age did not differ significantly between groups (28.8 vs. 29.2 years; $p = 0.146$). Household size was significantly smaller among LLIN users (5.35 vs. 6.07 members; $t = 7.33$, $p < 0.001$).

Significant associations were also found for caregiver education ($\chi^2(3) = 80.0$, $p < 0.001$), wealth index ($\chi^2(4) = 34.1$, $p < 0.001$), and religion ($\chi^2(1) = 24.7$, $p < 0.001$). Children of caregivers with secondary or higher education, and those from wealthier households, were more likely to have slept under an LLIN. Christian caregivers reported higher LLIN use than Muslim caregivers.
By contrast, place of residence (rural vs. urban) was not significantly associated with LLIN use ($p = 0.207$).

These descriptive and bivariate analyses provided the foundation for the subsequent multivariable regression models, which assessed the independent associations between social interactions and LLIN utilization among children under five.

Table 1. Descriptive and bivariate analysis of factors associated with LLIN use among children under five in Kenya (KMIS 2020)

Variable	Category	Slept under LLIN n = 1,353 (55.2%)	Did not sleep under LLIN n = 1,098 (44.8%)	Test statistic	p-value	Total % (n)
Continuous variables		Mean ± SD / Median (IQR)	Mean ± SD / Median (IQR)			
Child age (years)		2.47 ± 1.62 / 3 (1–4)	2.73 ± 1.61 / 3 (1–4)	t = 4.09	<0.001	100 (2,451)

Variable	Category	Slept under LLIN n = 1,353 (55.2%)	Did not sleep under LLIN n = 1,098 (44.8%)	Test statistic	p-value	Total % (n)
Age of caregiver (years)		28.81 ± 6.42 / 28 (24–33)	29.20 ± 6.81 / 29 (24–34)	t = 1.45	0.146	100 (2,451)
Household size		5.35 ± 2.15 / 5 (4–6)	6.07 ± 2.73 / 6 (4–7)	t = 7.33	<0.001	100 (2,451)
Categorical variables		% (n)	% (n)			
Child gender	Female	58.1 (786)	58.4 (641)	$\chi^2(1)=0.02$	0.887	58.2 (1,427)
	Male	41.9 (567)	41.6 (457)			41.8 (1,024)
Education of caregiver	None	6.7 (91)	17.8 (195)	$\chi^2(3)=80.0$	<0.001	11.7 (286)
	Primary	45.1 (610)	45.0 (494)			45.0 (1,104)
	Secondary	34.3 (464)	26.4 (290)			30.8 (754)
	Higher	13.9 (188)	10.8 (119)			12.5 (307)
Wealth index	Poorest	21.8 (295)	30.5 (335)	$\chi^2(4)=34.1$	<0.001	25.7 (630)
	Poorer	20.8 (282)	20.9 (229)			20.9 (511)
	Middle	19.0 (257)	18.4 (202)			18.7 (459)
	Richer	24.0 (325)	16.7 (183)			20.7 (508)
	Richest	14.3 (194)	13.6 (149)			14.0 (343)
Religion	Christian	90.7 (1,227)	84.1 (923)	$\chi^2(1)=24.7$	<0.001	87.7 (2,150)
	Muslim	9.3 (126)	15.9 (175)			12.3 (301)
Residence	Rural	59.9 (810)	62.6 (687)	$\chi^2(1)=1.60$	0.207	61.2 (1,497)
	Urban	40.1 (543)	37.4 (411)			38.8 (954)
Total		**100 (1,353)**	**100 (1,098)**			**100 (2,451)**

Regression Results

Logistic regression was used to estimate the marginal effects of key determinants of LLIN use among children under five, disaggregated by rural and urban residence (Table 2). Results are presented both before and after accounting for social interaction effects by religious affiliation.

Social interactions appeared to modify gender effects only slightly. In rural areas, Christian peer influence increased the likelihood of LLIN use among boys by 0.4%, while Muslim interactions increased it by 1.1%; both were significant at the 1% level.

Child age was an important predictor of LLIN use, particularly in rural households. Before considering social interactions, children aged one year were 13.4% more likely to sleep under an LLIN compared with infants, although this effect declined steadily with age (8.7% at age two, 9.5% at age three, 8.7% at age four, and 3.3% at age five). After introducing Christian peer effects, the probabilities remained positive but slightly lower (12.2% for age one, 8.1% for age two, 8.4% for age three, and 6.5% for age four).

Caregiver education showed a consistent, positive association with LLIN uptake. Before accounting for social interactions, rural children of caregivers with primary, secondary, and higher education had 21.4%, 20.1%, and 20.9% higher probabilities of LLIN use, respectively,

while in urban areas the corresponding figures were 35.2%, 37.1%, and 31.1%. With Christian interactions, these probabilities generally increased in rural areas (25.5% for primary, 25.3% for secondary, and 24.5% for higher education). Muslim peer interactions also enhanced LLIN use, though the magnitude was smaller and more uneven across education levels (e.g., rural primary =10%, secondary =21.2%; urban secondary =28.5%, higher =26.6%).

Household wealth status was another significant predictor, with social interactions amplifying the positive gradient. Prior to interactions, rural households in the "poor," "middle," "rich," and "richer" categories had LLIN adoption probabilities of 4.4%, 6.7%, 15.9%, and 5.1%,

Table 2: Logistic Regression Results

Variable	Category	Before Interactions		Christian Interactions		Islam Interaction	
		Rural	Urban	$Rural_i$	$Urban_i$	$Rural_i$	$Urban_i$
Child gender		**-0.072[a]**	**0.015[a]**	**-0.068[a]**	**0.015[a]**	**-0.061[a]**	**-0.138[a]**
		(0.003)	(0.004)	(0.004)	(0.004)	(0.015)	(0.012)
Child age (Reference group-0)							
	1	**0.134[a]**	-0.006	**0.122[a]**	-0.008	0.029	**-0.246[a]**
		(0.006)	(0.009)	(0.005)	(0.007)	(0.023)	(0.017)
	2	**0.087[a]**	**0.093[a]**	**0.081[a]**	**0.106[a]**	**-0.212[a]**	**-0.405[a]**
		(0.006)	(0.008)	(0.005)	(0.006)	(0.022)	(0.015)
	3	**0.095[a]**	-0.020	**0.084[a]**	**-0.019[a]**	**-0.057[a]**	**-0.293[a]**
		(0.006)	(0.008)	(0.005)	(0.006)	(0.024)	(0.016)
	4	**0.087[a]**	**-0.070[a]**	**0.065[a]**	**-0.08[a]**	**0.086[a]**	**-0.248[a]**
		(0.005)	(0.008)	(0.004)	(0.006)	(0.022)	(0.016)
	5	**0.033[a]**	**0.021[a]**	-	-	**-0.249[a]**	**-0.071[a]**
		(0.005)	(0.008)			(0.021)	(0.018)
Caregiver's age		**-0.001[a]**	**0.005[a]**	**0.001[a]**	**0.001[a]**	-0.001	**0.002[a]**
		(0.000)	(0.000)	(0.000)	(0.000)	(0.001)	(0.001)
Caregiver's education (Reference group-no education)							
	Primary	**0.214[a]**	**0.352[a]**	**0.255[a]**	**0.352[a]**	**0.100[a]**	**0.208[a]**
		(0.006)	(0.007)	(0.006)	(0.008)	(0.015)	(0.0110
	Secondary	**0.201[a]**	**0.371[a]**	**0.253[a]**	**0.341[a]**	**0.212[a]**	**0.285[a]**
		(0.006)	(0.008)	(0.005)	(0.009)	(0.017)	(0.010)
	Higher	**0.209[a]**	**0.311[a]**	**0.245[a]**	**0.282[a]**	-	**0.266[a]**
		(0.006)	(0.007	(0.006)	(0.009)		(0.018)
Parity		**-0.038[a]**	**-0.018[a]**	**-0.039[a]**	**-0.023[a]**	**-0.017[a]**	0.000
		(0.000)	(0.001)	(0.001)	(0.001)	(0.003)	(0.002)
Wealth index (Reference group-poorest)							
	Poorer	**0.044[a]**	**-0.067[a]**	**0.050[a]**	**-0.131[a]**	-0.001	0.007
		(0.004)	(0.009)	(0.005)	(0.009)	(0.019)	(0.025)
	Middle income	**0.067[a]**	0.039	**0.073[a]**	**0.031[a]**	**-0.209[a]**	**-0.213[a]**
		(0.005)	(0.008)	(0.005)	(0.009)	(0.025)	(0.022)
	Rich	**0.159[a]**	**-0.017[a]**	**0.165[a]**	**-0.028[a]**	-0.001	**0.236[a]**
		(0.005)	(0.007)	(0.005)	(0.008)	(0.028)	(0.018)

Richer	**0.051[a]**	**-0.103[a]**	**0.068[a]**	**-0.094[a]**	-	**-0.370[a]**
	(0.008)	(0.006)	(0.009)	(0.008)		(0.016)
Knowledge of net use	**-0.062[a]**	0.005	**-0.027[a]**	**-0.005[a]**	**0.008[b]**	**0.020[b]**
	(0.004)	(0.005)	(0.002)	(0.002)	(0.004)	(0.008)
Perception of net use	**-0.038[a]**	**0.121[a]**	**-0.013[a]**	**0.043[a]**	**-0.035[a]**	**0.049[a]**
	(0.004)	(0.006)	(0.001)	(0.002)	(0.007)	(0.006)
Observations	100,223	67,339	100,223	67,339	100,101	67,339

Standard errors rounded off to 3 decimal places are specified in parentheses.
Superscripts indicate significance at the a = 1%, b = 5%, and c = 10% levels, while significant alpha levels are indicated in bold.
Ref is reference group

respectively. Christian interactions strengthened these effects across all groups (poor =5%, middle =7.3%, rich =16.5%, richer =6.8%).

Knowledge of net use initially showed a negative association with LLIN adoption (–6.2%), but social interactions attenuated this effect. In rural Christian settings, the negative impact was reduced to –3.5% ($p < 0.01$), while Muslim interactions lessened it further to –7% ($p < 0.05$). Similarly, perceptions of community net use for malaria prevention were initially negative (–3.8%) but improved to –2.3% under Christian interactions and –0.3% under Muslim interactions. In urban settings, perceptions were consistently positive, though attenuated by peer influences (initially 12.1%, declining to 4.3% under Christian interactions and 4.9% under Muslim interactions).

Discussion

This study set out to examine how social interactions proxied through religious affiliation (Christian or Muslim) modify the relationship between child, caregiver, and household characteristics and the uptake of LLINs among children under five in Kenya. The analysis considered both rural and urban settings, exploring child attributes (age, gender), caregiver factors (age, education), and household-level characteristics (wealth, size, knowledge, and perceptions of LLIN use). The logistic regression results highlight the complex ways in which social networks and religiously mediated community norms shape malaria prevention behaviors.

Consistent with prior global evidence, child gender emerged as an important determinant of health-related household decisions, often influenced by cultural norms, parental preferences, and economic considerations. Before accounting for social interaction effects, boys in rural households were significantly less likely than girls to sleep under an LLIN, while in urban areas boys had a slight advantage. When religious affiliation was included as a proxy for social interactions, the gender gap narrowed in rural settings for both Christians and Muslims. This suggests that religiously mediated networks may help to offset gender-based disparities in malaria prevention, particularly in rural areas. By contrast, no significant religious interaction effect was observed in urban Christian households, where health education campaigns and broader exposure to information may already promote more equitable care.

Child age also played an important role. Across rural areas, younger children were more likely to sleep under an LLIN, but this likelihood declined steadily with age. The effect was especially pronounced in Christian households, where social influence appeared to reinforce protective practices for the youngest children. For example, Christian caregivers reported substantially

higher LLIN use for children aged one year, reflecting a strong emphasis on early-life malaria prevention. In contrast, Muslim households in both rural and urban areas showed declining LLIN use as children grew older, particularly after age three. These findings align with existing literature suggesting that very young children are often prioritized for mosquito net use due to perceived vulnerability to malaria, but that protective behaviors may weaken as children age.

Maternal education and household wealth were strongly associated with LLIN uptake, echoing earlier studies that highlight the multiplier effect of socioeconomic resources on preventive health behaviors. In this study, higher education levels among caregivers consistently predicted greater LLIN use in both rural and urban areas, even after accounting for social interactions. Notably, Christian communities in rural areas demonstrated particularly strong interaction effects, with education amplifying the likelihood of LLIN adoption. Among Muslim households, secondary education levels also increased uptake, although the effect was less consistent across wealth categories.

Household wealth was another important factor, with Christian households in rural areas demonstrating a clear positive gradient: wealthier families were substantially more likely to ensure LLIN use for their children. The wealthiest Christian households were over 16 percentage points more likely to use LLINs than the poorest. In Muslim communities, however, the wealth effect was less uniform. Rural Muslim households showed only modest gains in LLIN use as wealth increased, and in urban Muslim households, wealthier groups even demonstrated a decline in LLIN uptake. These findings suggest that social norms, rather than economic capacity alone, influence how households prioritize malaria prevention investments.

Taken together, the results indicate that social interactions, particularly through religious networks, play a significant role in shaping preventive health behaviors in Kenya. While maternal education and household wealth remain consistent predictors of LLIN use, their impact is moderated by the norms and support structures embedded within religious communities. These dynamics vary across rural and urban contexts, highlighting the need for malaria control policies that account not only for socioeconomic factors but also for the social environments in which households make health decisions.

Conclusion

Policy Implications

This study highlights that social interactions through community, peer, and faith-based networks significantly influence the uptake of LLINs among under-five children in malaria-endemic zones of Kenya. Strengthening malaria prevention strategies therefore requires moving beyond household-level interventions to also harness trusted community structures. Policy makers should design LLIN distribution and awareness campaigns that actively involve social networks, local leaders, and religious institutions to promote equitable coverage and sustained use.

Future Research

Further research is needed to assess how different forms of social influence such as women's groups, or community health volunteers shape preventive health behaviors. Longitudinal studies and mixed-method approaches could provide deeper insights into causal pathways and contextual factors. In addition, examining the scalability of network-based interventions and their integration into national malaria elimination programmes would inform more sustainable and targeted prevention strategies.

Competing interests: No competing interests declared.

Consent to Publish declaration: not applicable

Data Availability: The data that support the findings of this study are available in Malaria Indicator Survey 2020 at https://microdata.worldbank.org/index.php/catalog/4188, reference number KEN_2020_MIS_v01_M. These data were derived from the following resources available in the public domain: - DHS program, https://dhsprogram.com/

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