



Risk factors for malaria among children under five living in net-owning households in Mozambique from the 2022–3 Demographic and Health Survey

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Background: Children under 5 (CU5) in Mozambique are highly susceptible to malaria. Few studies focus on household-level mosquito net use using 2022–3 national survey data (n = 1924). This study analyzed household mosquito net use as a predictor of CU5 malaria positivity.

Methods: We used a cross-sectional multivariable logistic regression including households with ≥ 1 CU5 (one record per household). The outcome was household-level CU5 malaria positivity, defined as ≥ 1 rapid diagnostic test-positive CU5. Variables included household mosquito net use, CU5 net use, wealth index, and region.

Results: Household net use showed no significant association with CU5 malaria after controlling for wealth index. Wealth index indicated a dose-response, where middle-resource households were 43% less likely (adjusted OR [aOR] = 0.57; 95% CI 0.38 to 0.84; $P < .0048$) and highest-resource households were 84% less likely (aOR = 0.16; 95% CI 0.09 to 0.27; $P < .0001$) compared with lowest-resource households. Seven regions had higher odds of malaria positivity compared with Cidade de Maputo, with significantly higher odds ($P < .0005$) in Nampula (aOR = 18.97) and Cabo Delgado (aOR = 14.70).

Conclusions: Campaigns should prioritize lower-wealth households and higher-risk regions to reduce CU5 positivity.

Keywords: children, epidemiology, households, malaria, mosquito nets, Mozambique

Introduction

This study uses 2022–3 Demographic and Health Survey (DHS) data from Mozambique to assess the association between household mosquito net use and the likelihood that a child under five tests positive for malaria, by region, among households with children under 5 (CU5) (n = 1924 households).¹

At the time of this analysis (2025), malaria had been rapidly declining from 2000 to 2020, with 37% fewer global malaria cases and a 60% reduction in global mortality. This decline is largely attributed to widespread mosquito net accessibility and use.² However, cases have been steadily increasing since 2020.³

The US Agency for International Development (USAID) President's Malaria Initiative (PMI) highlights that, despite a 514% increase in CU5 sleeping under long-lasting insecticide-treated nets (LLINs) and a 61% reduction in child deaths since the cre-

ation of the PMI in 2005, malaria remains the leading cause of death in Mozambique, particularly among CU5.^{4–7}

During the 2022–3 rainy season, 32% of CU5 in Mozambique contracted malaria, contributing to 42% of CU5 deaths. Household context remains critical, as rurality is a major risk factor, with twice the prevalence of malaria compared with urban regions.⁶

Malaria persists despite multifaceted prevention and control strategies, including vaccination, education, net distribution, insecticide spraying and rapid response efforts.^{8–11} Mosquito nets therefore remain the most affordable and effective malaria-prevention strategy, particularly among CU5.^{8–10}

Global malaria-prevention efforts are closely tied to the stability of international funding and programmatic infrastructure. In 2022, global malaria funding totaled US\$4.1 billion, supporting the distribution of 16.8 million LLINs and 124.5 million malaria rapid diagnostic tests (RDTs).^{6,11} Recent disruptions

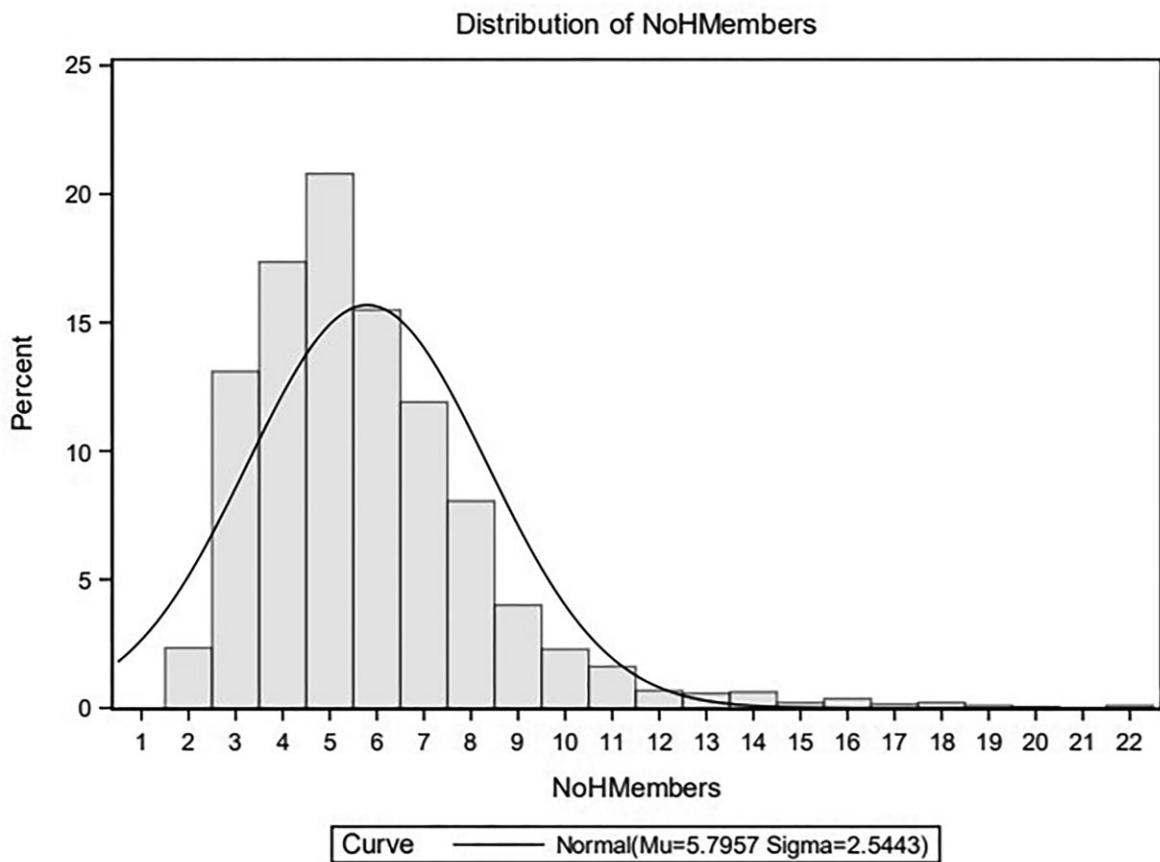


Figure 1. The histogram displays the distribution of household members (NoHMembers) across the sample ($n = 1924$ households) with a fitted normal curve (mean = 5.80, SD = 2.54). The distribution informed the decision to group household size into three categories: small (2–4 members), medium (5–7) and large (8–15).

to US-supported global health infrastructure, including reductions in staffing and uncertainty surrounding major malaria-control initiatives, such as the PMI, raise concerns regarding the sustainability of prevention and surveillance efforts in high-burden countries.¹² These uncertainties underscore the importance of understanding how malaria-prevention tools—particularly mosquito nets—are currently used at the household level.

Household mosquito net utilization, particularly for CU5, plays a crucial role in malaria prevention.^{8,13,14} DHSs have reported on malaria and mosquito net use in Mozambique since 1997.¹⁵ The most recent DHS was conducted in 2022–3 and it provides detailed epidemiologic data on malaria prevalence and net use at individual and community levels.¹⁶ However, limited attention has been given to household-level patterns of net utilization, particularly among households with CU5.^{9,10,17}

In DHSs, household net use is reported generically as mosquito net use; however, malaria-control programs in Mozambique distribute LLINs.¹⁶

Recognizing this gap, the WHO and its partners emphasize social and behavioral change communication (SBCC) strategies, and the RBM Partnership to End Malaria (RBM) specifically rec-

ommends monitoring household net use among CU5.^{8,18} This study addresses this recommendation by examining household-level mosquito net use in relation to malaria positivity among CU5, incorporating a region-specific context. Its findings may support local decision-makers in tailoring malaria-prevention strategies based on household practices, environmental conditions and regional patterns of risk.

A 22-y longitudinal study in rural Tanzania observed that consistent bed net use during infancy was associated with an 11% increase in survival into adulthood and a 46% reduction in mortality.¹⁹ Other research shows that nets provide a 37% protective effect against malaria positivity, particularly for CU5.²⁰ Despite strong evidence of net effectiveness, household perceptions of net use influence behavior. Households that perceived community-wide net use as the norm had higher usage rates than those who believed that net use was not the norm.²¹ In Mozambique, only 56.2% reported strong household norms, while only 38% believed that their community used nets.⁵

While mosquito net effectiveness and community norms have been well studied within the SBCC framework, household-level practices remain less frequently studied using the DHS. This study explores household characteristics—such as net prioritization

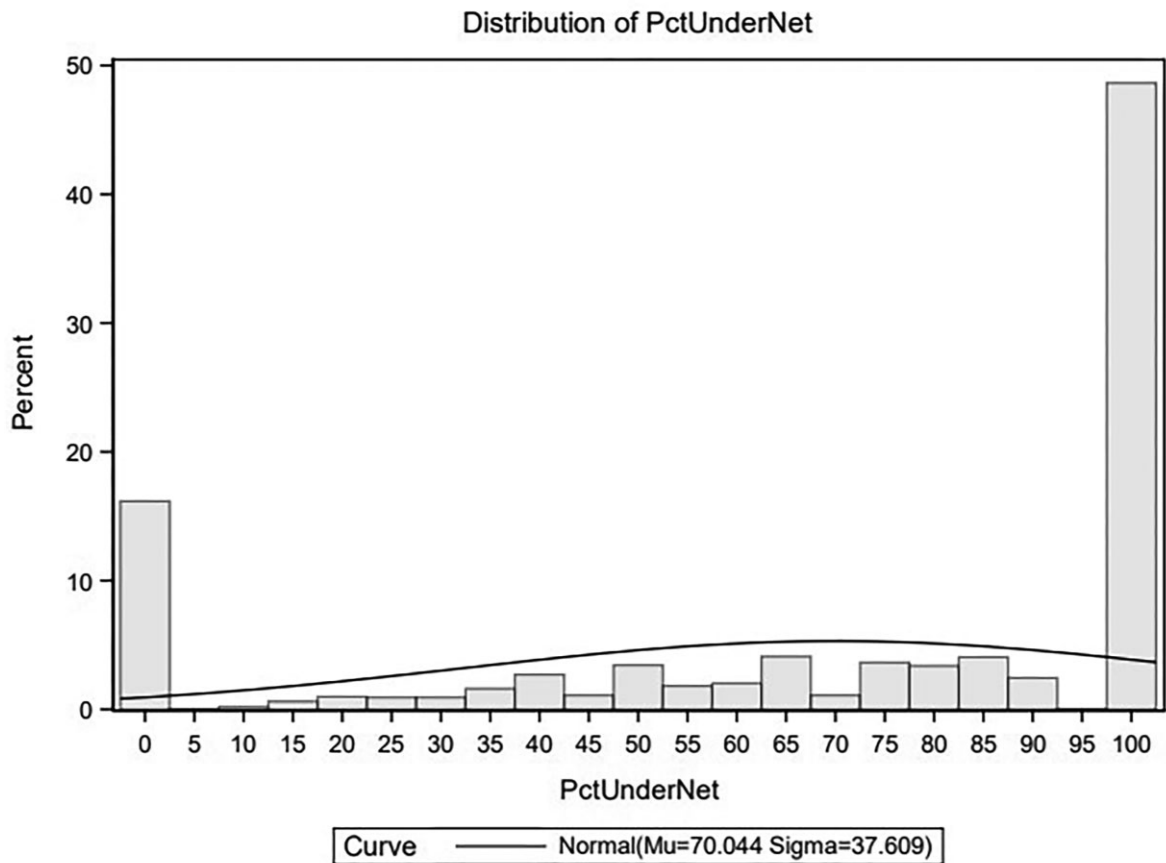


Figure 2. The histogram illustrates the distribution of the percentage of household members who slept under a mosquito net (PctUnderNet) in the sample ($n = 1924$ households). The data show a bimodal pattern, with peaks at 0% (no household members) and 100% (all members) sleeping under a net. This distribution informed the creation of three value-based categories: none (0%), some (1%–99%) and all (100%).

for CU5, household size, wealth index and rurality—as potential factors influencing malaria RDT positivity. The null hypothesis posited that household mosquito net use does not predict malaria positivity (RDT) among CU5 after adjusting for household wealth index and region.

Materials and methods

The DHS Phase 8 (March 2022–July 2023) included 14 250 households and was conducted during the rainy season, when mosquito abundance is at its highest. Interviewers surveyed women of reproductive age and men, as per DHS protocols.²² Of all the households included in the 2022–3 DHS, 40.0% reported owning no mosquito nets and were excluded from the analytic sample; the remaining 60.0% of households owned at least one net. Of the 14 250 surveyed households, 7725 included at least one child under 5. A household was included if at least one child under 5 had undergone a malaria RDT ($n = 3127$) and the household owned at least one mosquito net ($n = 1954$). Of these, 30 were removed due to biologically implausible values (e.g. more CU5 or RDT-positive results than total household members, or extreme outlier household sizes > 15).

The final analytic sample included 1924 households. Household size distribution was examined visually using a histogram (Figure 1) to determine appropriate grouping cut-offs. The distributions of the percentage of household members (Figure 2) and CU5 (Figure 3) who slept under a mosquito net were also examined visually to guide value-based grouping of none (0%), some (1%–99%) and all (100%) categories. Household size was categorized to avoid assuming linearity and to maintain conceptual consistency with the categorical net-use groupings. Results were weighted according to DHS strata and cluster design and adjusted for population size.¹⁵

Descriptive frequencies indicated that most households contained a single child under 5 (median = 1, range = 1–4), supporting the household as the primary unit of analysis. Descriptive statistics were generated for additional key variables, including household size, the percentage of household members who slept under a net, the percentage of household CU5 that slept under a net, region and wealth index. Variable distributions were examined using histograms to assess skewness and inform grouping decisions (see Figures 1–3). The mean household size was 5.77 (SD = 2.42, range 2–15), with a median of 5.0 members. The DHS wealth index is a composite measure derived using principal component analysis of household assets, housing characteristics and access to services, and is used to rank households into relative

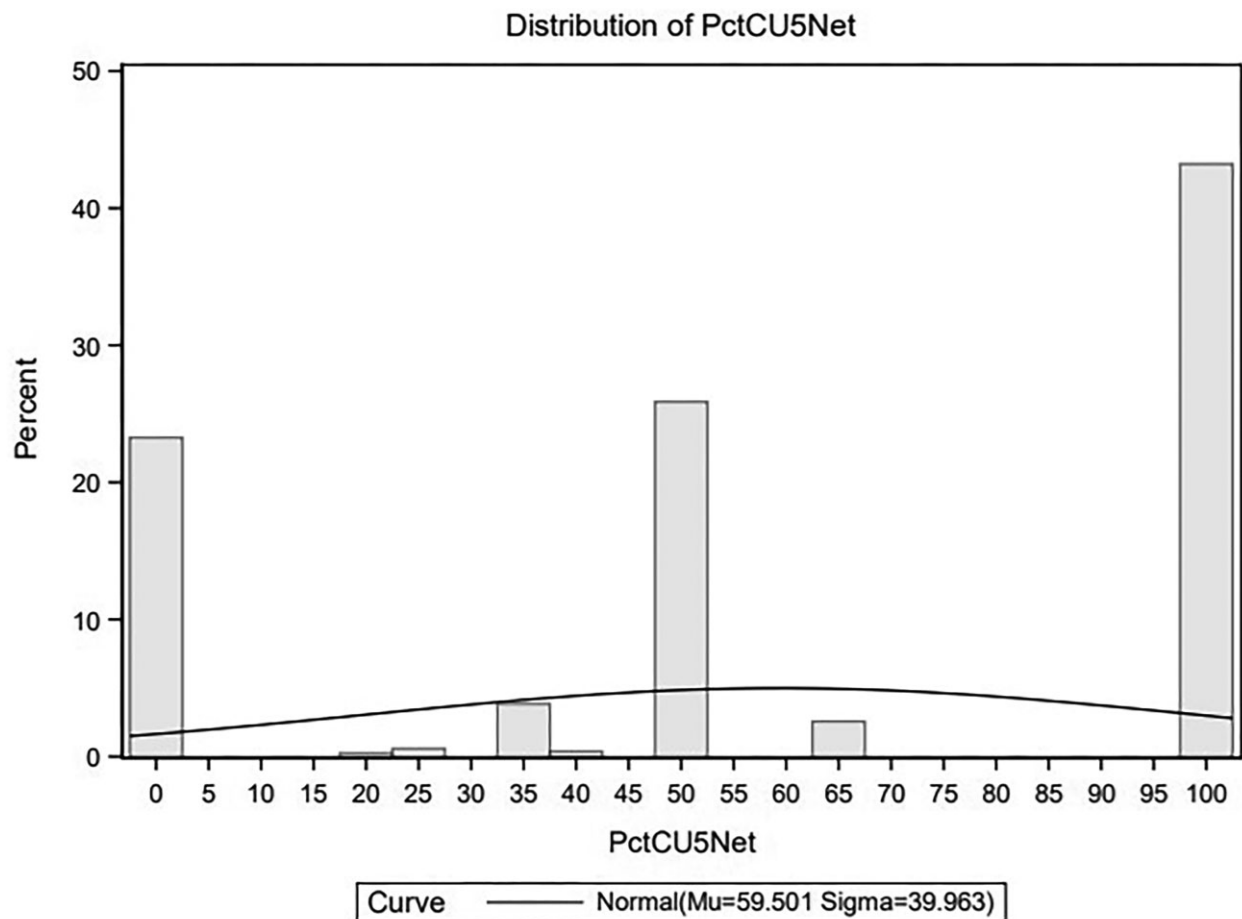


Figure 3. The histogram illustrates the distribution of the percentage of CU5 who slept under a mosquito net (PctCU5Net) across households ($n = 1924$). Similar to household-level patterns, the data show peaks at 0%, 50% and 100%, indicating that many households either had no CU5 under nets or all CU5 under nets, with some partial coverage in between. This visualization informed the creation of the three value-based categories: none (0%), some (1%–99%) and all (100%).

wealth quintiles.²³ Although tertile-based groupings were considered, the percentage of household members who slept under a net (% under net) was grouped into three value-based categories (none = 0%, some = 1%–99%, all = 100%) due to skewness towards 100% net use. Household sizes were placed into value-based groupings due to histogram distribution. The categories were small (2–4 members, $n = 631$), medium (5–7 members, $n = 698$) or large (8–15 members, $n = 595$) (Table 1). The regional reference group was Cidade de Maputo because of its low malaria prevalence.²⁴ The analytic sample consisted of 652 children testing RDT-positive and 1272 testing RDT-negative, representing weighted counts of 774 490 and 1 151 360 children, respectively (weighted $N = 1\,925\,850$).

Each record represented a unique household identifier. The main outcome, CU5 malaria positivity, was defined as at least one child under 5 in the household testing positive for malaria via RDT. Assessing at the household level eliminates within-household non-independence.

Pearson correlation coefficients were conducted to assess potential collinear relationships between variables. Bivariable

logistic regression analyses were conducted to examine unadjusted associations between household characteristics and malaria RDT positivity, and to guide variable selection for the multivariable logistic regression model (Table 2). The household percentage that slept under a net, the number of household members, region and wealth index were assessed for their relationships with the health outcome of malaria positivity. A weighted sample design included 21 strata and 557 clusters for variance estimation in the logistic regression. Model fit was evaluated using the c-statistic and concordance statistics. A stepwise backward elimination approach was applied to refine the multivariable logistic regression model, while also retaining conceptually appropriate variables (Table 3).

Results

Descriptive characteristics of the 1924 households are presented in Table 1. Most households were medium size (5–7 members) and nearly one-half reported full household mosquito net

Table 1. Descriptive epidemiology of households with ≥ 1 child under 5, Mozambique DHS 2022–3, weighted and unweighted results.

	Unweighted		Weighted	
	N	%	N	%
Total	1924	1.00	1902	100.00
Household size				
Small	631	32.46	625	32.50
Medium	698	37.20	716	37.20
Large	595	30.34	584	30.30
Household % that slept under a net				
None	311	15.93	307	15.90
Some	677	35.08	676	35.10
All	936	48.98	943	49.00
CU5% that slept under a net				
None	436	23.30	0	22.00
Some	628	33.50	0	33.40
All	810	43.20	0	41.80
Region				
Cabo Delgado	257	6.95	134	6.90
Cidade de Maputo	92	2.36	45	2.40
Gaza	159	4.73	91	4.70
Inhambane	156	4.66	90	4.70
Manica	217	8.46	163	8.50
Maputo	126	6.60	127	6.60
Nampula	284	31.36	604	31.40
Niassa	154	6.20	119	6.20
Sofala	230	9.10	175	9.10
Tete	118	6.83	132	6.80
Zambézia	131	12.74	245	12.70
Wealth index				
Lowest resource	299	19.21	370	19.20
Lower resource	326	21.41	412	21.40
Middle resource	406	19.03	367	19.00
Higher resource	462	21.68	417	21.70
Highest resource	431	18.68	360	18.70
Malaria positivity				
Negative	1272	66.10	1151	59.80
Positive	652	33.90	774	40.20

Weights were normalized using DHS methodology to divide by 1 000 000. Weighted n are sums of normalized weights and are not population totals. Percentages use the weighted denominator of households with non-missing malaria positivity.

coverage. Overall, 33.9% of households had at least one child under 5 who tested positive for malaria ($n = 652$ of 1924 households). At the child level, 39.4% of CU5 tested positive ($n = 1236$ of 3139). Among all households, 20.6% had one malaria-positive child under 5, 5.7% had two, 4.3% had three and 1.6% had four. Fewer than 2% of households had ≥ 5 malaria-positive children.

Household size was statistically correlated with household % under a net, with a decrease in household net use for each additional household member ($r = -0.19$, $P < .0001$). However, household size only accounts for 3.5% of the variance in net use, indi-

cating that additional challenges arise in net-use patterns as household size increases. The household % under a net showed a moderately positive correlation with CU5% under a net ($r = 0.63$, $P < .0001$), indicating that net use among household children increased as overall household net use increased. CU5 net use was removed from the final model due to conceptual redundancy. Urbanicity had a moderately negative correlation with wealth index ($r = -0.62$, $P < .0001$), with those in more urban areas experiencing higher wealth. Wealth index was prioritized for policy and resource-allocation decisions, and urbanicity was removed to reduce redundancy. Household size and household net use ($\rho = -0.18$) demonstrated low correlation, so both variables were retained in the final model.

Weighted and unweighted logistic models were assessed to examine associations between household predictor variables and malaria positivity in household CU5. The weighted model accounted for DHS design, including 21 strata and 557 clusters for variance estimation.

Results from the final multivariable model are presented in Table 3. Table 2 shows that CU5 were significantly less likely to test positive for malaria in households with all members under a net than those with no net coverage (unadjusted OR [uOR] 0.68, 95% CI 0.52 to 0.88, $P < .0035$ and adjusted OR [aOR] 0.62, 95% CI 0.42 to 0.93, $P < .0190$, respectively). Households with some net coverage (1%–99%) showed lower odds of CU5 malaria positivity compared with those with no coverage in unadjusted models (uOR 0.68, 95% CI 0.52 to 0.90, $P < .0062$). In the adjusted bivariable models (Table 2), the association remained in the same direction but was not statistically significant (aOR 0.70, 95% CI 0.47 to 1.06, $P = .0894$). These associations were not statistically significant in the multivariable model (Table 3).

Household size was not associated with child malaria positivity, so it was not retained in the model (medium household aOR 1.01, 95% CI 0.76 to 1.34, $P = .9432$; large household size aOR 1.15, 95% CI 0.88 to 1.51, $P = .2998$).

There were considerable regional differences, with several regions showing significantly higher odds of children testing positive for malaria compared with the reference region of Cidade de Maputo. The highest statistically significant odds were observed in Nampula (aOR 18.97, 95% CI 4.30 to 83.68, $P = .0001$), Cabo Delgado (aOR 14.70, 95% CI 3.34 to 64.72, $P = .0004$) and Zambézia (aOR 11.53, 95% CI 2.49 to 53.44, $P = .0018$).

A statistically significant ($P < .0001$) dose–response relationship was observed between wealth index and CU5 malaria positivity. In the multivariable model (Table 3), children in middle-resource households had 43% lower odds of malaria positivity compared with those in the lowest-resource wealth index (aOR 0.57, 95% CI 0.38 to 0.84, $P = .0048$). Children in the higher-resource households had 76% lower odds of malaria positivity (aOR 0.24, 95% CI 0.15 to 0.38, $P < .0001$) and children in the highest-resource households had 84% lower odds of malaria positivity (aOR 0.16, 95% CI 0.09 to 0.27, $P < .0001$).

A multivariable logistic regression analysis was conducted using a backward stepwise selection (Table 3). The main predictor variable, the percentage of household members that slept under a net, showed statistical significance in the all vs none category, but not for some vs none. The variable was retained due to conceptual importance. Final multivariable results emphasize that region and wealth index were the strongest

Table 2. Unadjusted and adjusted bivariate regression analysis results.

Comparison group	uOR	95% CI	P-value	aOR	95% CI	P-value
Household % under net						
None (0%)	Ref.	–	–	–	–	–
Some (1%–99%)	0.68	0.52–0.9	.0062	0.7	0.47–1.06	.0894
All (100%)	0.68	0.52–0.88	.0035	0.62	0.42–0.93	.019
Household size						
Small (2–4)	Ref.	–	–	–	–	–
Medium (5–7)	1.105	0.88–1.3	.3929	1.01	0.76–1.34	.9432
Large (8–15)	1.142	0.9–1.45	.2738	1.15	0.88–1.51	.2998
Region						
Cidade de Maputo	Ref.	–	–	–	–	–
Cabo Delgado	46.05	11.11–190.92	<.0001	48.88	11.7–204.24	<.0001
Gaza	6.85	1.57–29.9	.0105	6.92	1.5–31.98	.0133
Inhambane	13.99	3.29–59.55	.0004	15.11	3.46–65.98	.0003
Manica	11.44	2.71–48.27	.0009	11.49	2.74–48.26	.0009
Maputo	5.18	1.14–23.52	.0333	4.78	1.05–21.78	.043
Nampula	66.11	15.97–273.74	<.0001	72.09	17.14–303.18	<.0001
Niassa	25.71	6.1–108.38	<.0001	26.6	6.22–113.75	<.0001
Sofala	31.66	7.61–131.67	<.0001	29.14	7.01–121.06	<.0001
Tete	13.35	3.08–57.78	.0005	15.31	3.47–67.62	.0003
Zambézia	35.74	8.45–151.28	<.0001	43.87	10.3–186.83	<.0001
Household wealth index						
Lowest resource	Ref.	–	–	–	–	–
Lower resource	0.87	0.63–1.19	.3775	0.97	0.66–1.42	.8725
Middle resource	0.36	0.26–0.49	<.0001	0.41	0.27–0.6	<.0001
Higher resource	0.16	0.12–0.22	<.0001	0.16	0.11–0.25	<.0001
Highest resource	0.09	0.06–0.12	<.0001	0.08	0.05–0.14	<.0001

independent predictors of CU5 malaria positivity (Table 3). Model fit was appropriate, with c-statistic 0.78, Somers' D = 0.55 and 77.2% concordance.

Discussion

The analysis observes associations between household mosquito net use and malaria positivity in Mozambique CU5. A statistically significant association was found between household mosquito net use and child malaria positivity, until controlling for household wealth index. The findings are consistent with prior studies suggesting that wealthier households may benefit from improved housing conditions, access to healthcare and malaria-prevention resources.^{25–30} It is also common for nets in lower-income settings to be older, untreated or improperly used. Some household members may not have nets, or they may be torn, no longer effective or not sprayed with insecticide.³¹ These nuances can dilute the observed protective effect.

Wide confidence intervals at the regional level reflect limited sample size and variance from survey adjustment, indicating reduced precision. Regional variation may also be due to differences in net distribution or net campaigns, access or affordability of nets, net condition, climatic differences in rainfall (i.e. increas-

ing mosquito-breeding grounds), altitude (with less mosquito survivability among higher altitudes), farming ecosystem practices or cultural differences.^{32,33} These differences may enhance a population's exposure to mosquitoes, even if they sleep under a net later that night.

Collinearity between larger households and fewer children sleeping under a net may reflect the logistical challenges of net coverage for multiple young children, compared with smaller households that are likely to have fewer young children.

Future studies should explore regional differences using longitudinal and mixed methods to examine household barriers (climatic, cultural and socioeconomic) that influence net use. Household demographics, such as the number of children, gender, age and parental job status, provide more granular detail for regional decision-makers to properly allocate resources and net campaigns. Household net use overall and among CU5 could be used to add further nuance to resource differences or cultural practices that influence household-level population behaviors. Studies may observe whether age-specific net prioritization protects more vulnerable populations from malaria risk, and if net campaigns should encourage households with limited nets to prioritize the use of higher-quality and insecticide-treated nets (ITNs) among vulnerable populations (such as CU5). Additionally, this study aligns with previous literature that shows wealthier

Table 3. Final model; household net use as a predictor for malaria positivity in household CU5.

Variable	Point estimate (OR)	95% CI	P-value
Intercept	-	-	.0102
Household % that slept under a net			
None (0%)	Ref.	-	-
Some (1%–99%)	1.01	0.64–1.58	.9831
All (100%)	0.88	0.58–1.32	.5307
Region			
Cidade de Maputo	Ref.	-	-
Cabo Delgado	14.70	3.34–64.72	.0004
Gaza	3.47	0.70–17.14	.1272
Inhambane	6.21	1.33–29.06	.0204
Manica	4.27	0.96–19.11	.0574
Maputo	3.66	0.77–17.40	.1026
Nampula	18.97	4.30–83.68	.0001
Niassa	7.29	1.60–33.13	.0102
Sofala	10.31	2.38–44.67	.0019
Tete	5.24	1.12–24.44	.0352
Zambézia	11.53	2.49–53.44	.0018
Wealth index			
Lowest resource	Ref.	-	-
Lower resource	1.04	0.72–1.52	.8293
Middle resource	0.57	0.38–0.84	.0048
Higher resource	0.24	0.15–0.38	<.0001
Highest resource	0.16	0.09–0.27	<.0001

households often have greater access to healthcare resources and preventative measures, such as ITNs and net availability and the use of antimalarial medications, compared with households in lower wealth indexes. Future studies should include a list of malaria-protection or -prevention resources available in the household.

Future net education and distribution campaigns should prioritize households in the regions of Nampula, Cabo Delgado, Zambézia, Sofala, Niassa and Inhambane, as well as households with lower wealth indexes across regions.

Strengths and weaknesses

Causation cannot be inferred from a cross-sectional survey. Self-reported data are subject to recall bias, which may reduce accuracy, and social desirability bias, which may inflate net-use reports.³⁴ The study lacked details on net condition and insecticide treatment. Nonetheless, multivariable logistic regression controlled for potential confounders, and field workers used RDTs for objective malaria diagnosis. Aggregating to the household level avoids within-household non-independence. Region-specific analyses allow local officials to incorporate contextual factors—such as history, traditions, topography and climate—into interpretation.

Conclusion

While mosquito nets remain a low-cost and reliable tool for malaria prevention, this study highlights the need to reduce the malaria burden among CU5, a high-risk group captured in DHS data, with particular attention to regional disparities and socioeconomic factors. Policymakers could strengthen malaria-control strategies by integrating behavioral interventions, targeted net distribution and poverty-reduction initiatives. Continued DHSs in Mozambique will be essential for tracking whether prevention efforts lead to sustained behavioral change among CU5 populations.

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Conflicts of interest: None declared.

Ethical Guidelines: This study utilized secondary, de-identified data from the Demographic and Health Surveys (DHS) Program, which is publicly available upon application and approval (<https://dhsprogram.com>). No new data were collected, and all analyses were conducted using SAS version 9.4 (SAS Institute, Cary, NC, USA). Access to the DHS data was obtained through an approved application; datasets were downloaded in .sav format, cleaned, recoded and analyzed in SAS 9.4. Secondary data collection adhered to international and national ethical standards, with DHS obtaining informed consent from all participants during the original surveys. Form 129 was submitted to the East Tennessee State University (ETSU) Institutional Review Board, which issued a written determination that this project does not meet the definition of research involving human subjects and therefore does not fall under Institutional Review Board (IRB) purview. Artificial-intelligence tools (ChatGPT 5.0, OpenAI, San Francisco, CA, USA) were used for grammar revision only; all analyses and interpretations are the authors' own.

Data availability: The data underlying this study are publicly available from the Demographic and Health Surveys (DHS) Program upon application and approval (<https://dhsprogram.com>). All analyses were conducted

using de-identified DHS datasets. The SAS code used for data cleaning and analysis is available from the corresponding author upon reasonable request.

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