Effectiveness of Long-Lasting Insecticidal Nets (LLINs) and Indoor Residual Spraying (IRS) in Malaria Control in Rural Nigeria

COURSE CODE:

PBH 204

COURSE TITLE:

INTRODUCTION TO DEMOGRAPHY AND ITS APPLICATION IN PUBLIC HEALTH

ABSTRACT

Malaria remains a leading public health burden in sub-Saharan Africa, where vector control strategies such as Long-Lasting Insecticidal Nets (LLINs) and Indoor Residual Spraying (IRS) are central to prevention. This study evaluates community knowledge, attitudes, and practices (KAP) regarding LLIN and IRS use in rural Nigeria. A cross-sectional survey was conducted using a structured questionnaire administered across households, capturing demographic characteristics, household structure, awareness, utilization, perceived effectiveness, challenges, and recommendations. Descriptive statistics were used to summarize household coverage and utilization, while inferential techniques, including chi-square tests and factor analysis, explored associations between socio-demographic variables, knowledge, and malaria prevention practices. Findings provide insights into the extent of LLIN and IRS adoption, determinants of their use, and barriers to effectiveness. The results will inform policymakers, health agencies, and community stakeholders in designing culturally appropriate interventions, strengthening malaria prevention strategies, and advancing Nigeria's goal of malaria elimination.

INTRODUCTION

Malaria continues to be one of the most significant causes of morbidity and mortality in Nigeria, accounting for a substantial proportion of hospital visits, economic losses, and productivity decline. Despite considerable efforts by national and international stakeholders, transmission persists, particularly in rural communities where environmental and socioeconomic conditions favour mosquito breeding and hinder preventive measures.

Vector control strategies—most notably Long-Lasting Insecticidal Nets (LLINs) and Indoor Residual Spraying (IRS)—have been proven effective in reducing malaria incidence. LLINs act as both a physical and chemical barrier against mosquitoes, while IRS reduces indoor mosquito survival rates. However, the success of these interventions relies heavily on community awareness, acceptance, and consistent utilization. Low coverage, irregular distribution, cultural beliefs, and limited knowledge often undermine program effectiveness.

This study assesses the effectiveness of LLIN and IRS programs in malaria control within rural Nigerian communities, focusing on community knowledge, attitudes, and practices. By examining household demographics, access to mosquito prevention tools, awareness levels, and perceived challenges, the study aims to identify key factors influencing utilization and community compliance. Ultimately, the findings will provide evidence-based recommendations to strengthen malaria prevention efforts, improve intervention coverage, and support Nigeria's commitment to reducing malaria-related health and socioeconomic burdens.

METHODOLOGY

Study Design and Setting

This study employed a **cross-sectional survey design** to evaluate community knowledge, attitudes, and practices regarding the use of Long-Lasting Insecticidal Nets (LLINs) and Indoor Residual Spraying (IRS) for malaria prevention in rural Nigeria. Data were collected using a structured questionnaire covering demographic characteristics, household composition, housing conditions, awareness of LLINs and IRS, utilization practices, perceived effectiveness, challenges, and recommendations.

Study Population and Sampling

The study population comprised households within selected rural communities. Respondents were adults responsible for household decision-making regarding health and preventive measures. Sampling was conducted to ensure adequate representation across age groups, household sizes, and socioeconomic backgrounds.

Data Collection Tool

The dataset was derived from a **structured questionnaire** consisting of 41 items. Questions included both closed-ended and open-ended responses, addressing:

- **Demographic information** (e.g., age group, household size, number of children under five).
- **Environmental factors** (e.g., proximity to mosquito breeding sites, housing type).
- **Awareness and knowledge** of LLINs and IRS.
- **Utilization practices** (frequency and consistency of use).
- **Perceptions and attitudes** (satisfaction, challenges, cultural or religious influences).
- **Recommendations** for improving malaria prevention strategies.

Data Management and Analysis

The dataset was entered in Microsoft Excel and also exported to **Python** for statistical analysis. Analysis was conducted in the following steps:

1. **Descriptive Statistics**
    - Frequency and percentage distributions were computed for categorical variables (e.g., awareness of LLINs/IRS, usage rates, satisfaction levels).
    - Demographic and environmental characteristics were summarized to describe the study population.
2. **Inferential Statistics**

- **Chi-square tests** were applied to examine associations between demographic factors (e.g., age group, household size) and malaria prevention practices (LLIN/IRS utilization).
- Significance was set at $p < 0.05$.

3. **Factor Analysis**
    - **Exploratory Factor Analysis (EFA)** was conducted on attitudinal and perception-related variables to identify underlying constructs influencing knowledge and utilization of LLINs and IRS.
    - The **Kaiser-Meyer-Olkin (KMO) test** and **Bartlett's Test of Sphericity** were used to determine sampling adequacy and suitability for factor analysis.
    - Factors were extracted using **principal component analysis with varimax rotation** to enhance interpretability.

Ethical Considerations

Participation was voluntary, and respondents' identities were kept anonymous to ensure confidentiality. Ethical clearance was sought from relevant institutional authorities, and verbal informed consent was obtained before data collection.

ANALYSIS

OBJECTIVES:

1. To determine LLIN and IRS coverage and utilization rates in rural communities using descriptive statistics.

2. To assess the difference in malaria incidence between households using LLIN/IRS and those not using them using chi-square tests.

3. To evaluate community knowledge and attitudes toward LLINs and IRS through Likert scale responses and factor analysis.

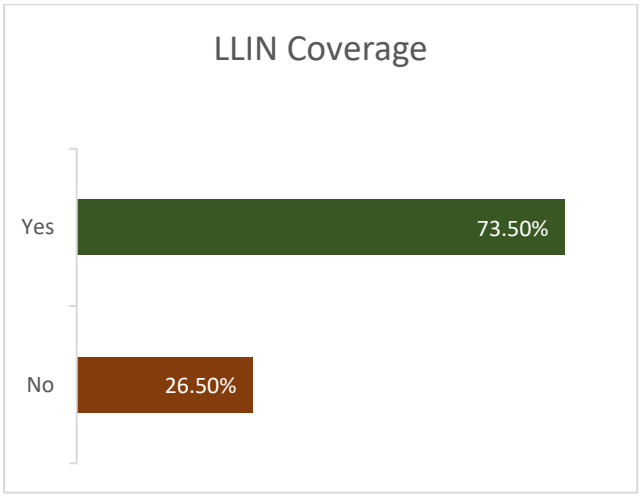
4. To perform regression to assess predictors of malaria protection based on LLIN/IRS usage and other demographic factors.

OBJECTIVE 1:

To determine LLIN and IRS coverage and utilization rates in rural communities using descriptive statistics.

a) LLIN coverage rates

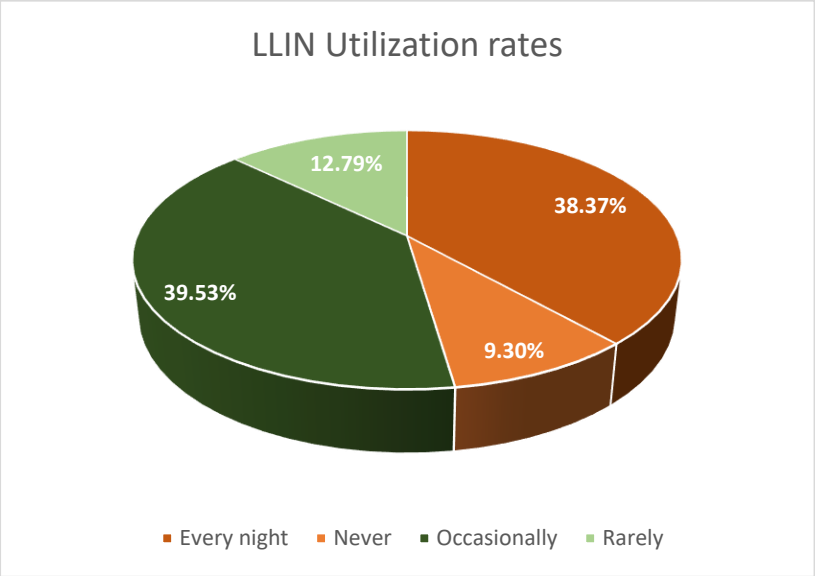
Does your household currently have insecticidal nets?



73.5% of households reported having insecticidal nets while 26.5% of households reported not having insectidal nets.

b) LLIN Utilization rates

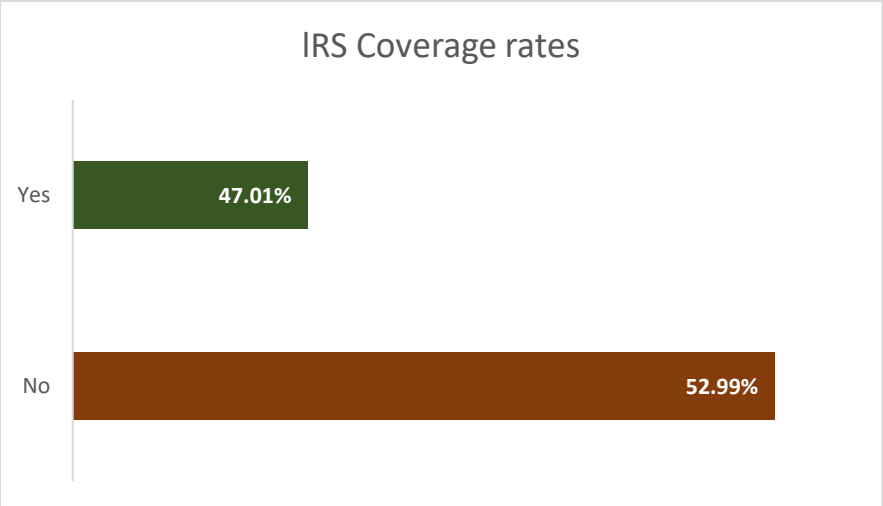
This pie chart was created from the data of those that answered yes to “Does your household currently have insecticidal nets? ”



Out of the 73.5% of households that possess LLINs,38.37% of households reported using nets every night, while 39.53% use them occasionally. 12.79% rarely use them and 9.30% of households never used nets.

c) IRS Coverage rates

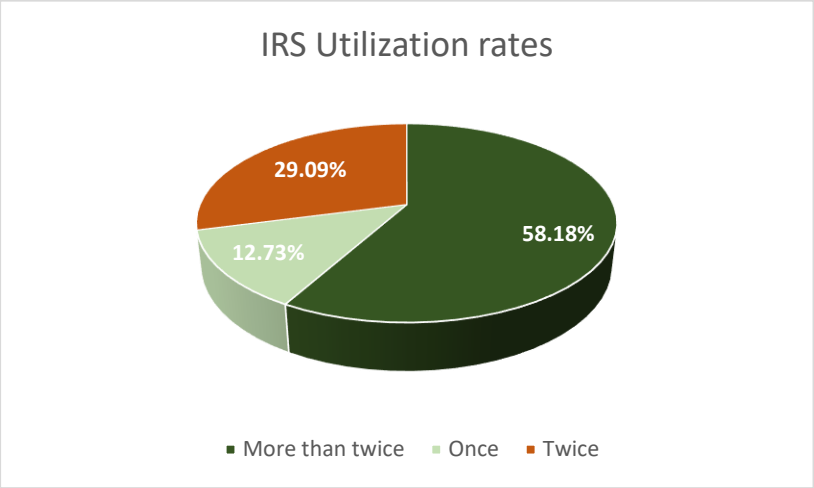
Has your home been sprayed for mosquito control in the past year?



47.01% of households reported their homes being sprayed for mosquito control in the past year while 52.99% of households reported otherwise.

d) IRS Utilization rates

Has your home been sprayed for mosquito control in the past year?



Among those whose homes were sprayed, 12.73% had it done once, 29.09% twice, and 58.18% three or more times.

OBJECTIVE 2:

To assess the difference in malaria incidence between households using LLIN/IRS and those not using them using chi-square tests.

LLINS chi-square test analysis:

Chi-square statistic: 1.10

P-value: 0.5768

Degrees of freedom: 2

Conclusion: The resulting p-value is approximately 0.5768. Since this value is greater than the typical significance level of 0.05, there is no statistically significant association between a household's use of LLINs and the frequency of malaria symptoms. This indicates that the data does not provide enough evidence to suggest that households using these measures experience less malaria than those who don't.

IRS chi-square test analysis:

Chi-square statistic: 0.97

P-value: 0.6161

Degrees of freedom: 2

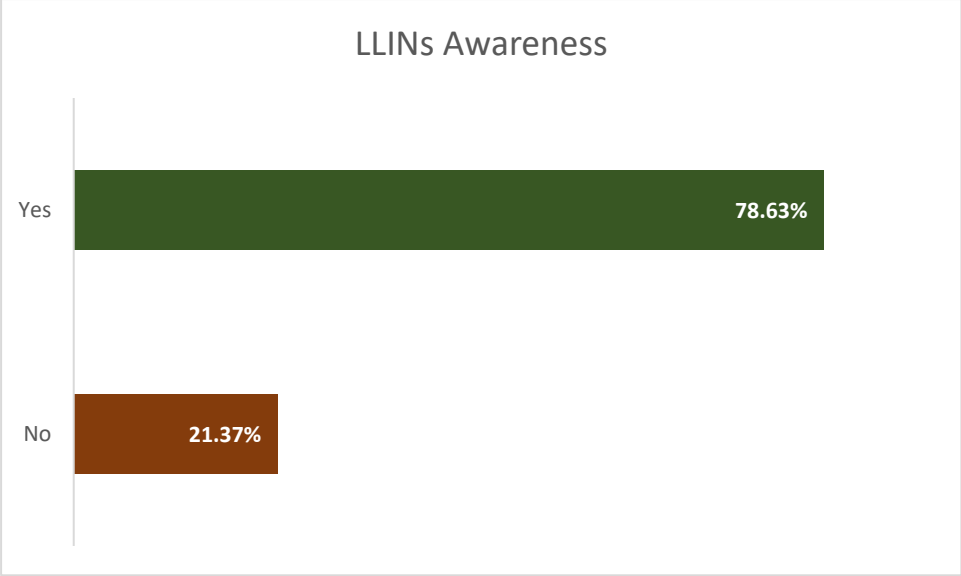
Conclusion: The resulting p-value is approximately 0.6161. Since this value is greater than the typical significance level of 0.05, there is no statistically significant association between a household's use of IRS and the frequency of malaria symptoms. This indicates that the data does not provide enough evidence to suggest that households using these measures experience less malaria than those who don't.

OBJECTIVE 3.

To evaluate community knowledge and attitudes toward LLINs and IRS through Likert scale responses and factor analysis.

A i) LLINs awareness or community knowledge

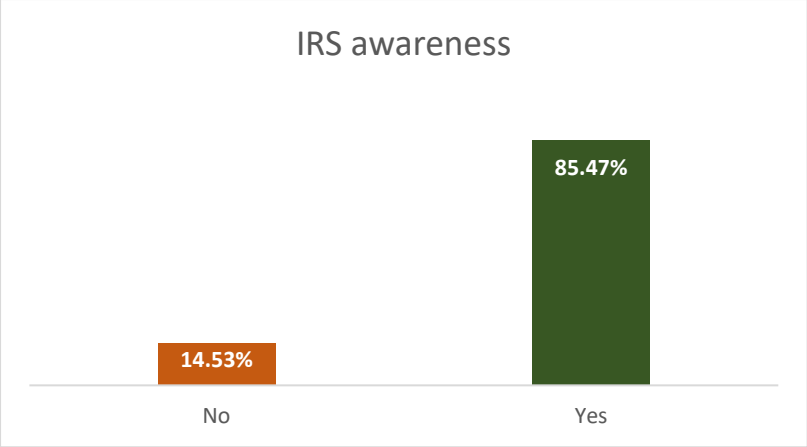
Are you aware of Long-Lasting Insecticidal Nets (LLINs)?



78.63% of households are aware of Long-Lasting Insecticidal Nets (LLINs) while 21.37% of households reported not aware of Long-Lasting Insecticidal Nets (LLINs).

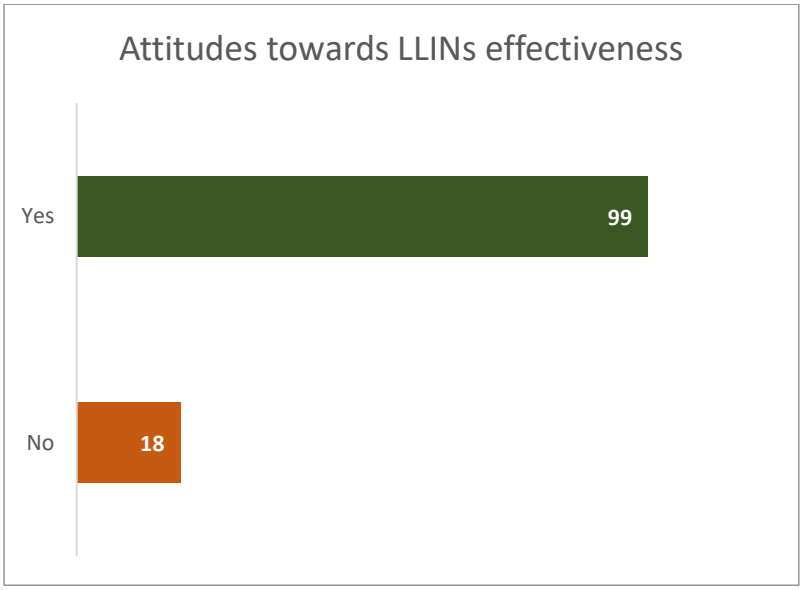
ii) IRS awareness or community knowledge

Do you know about Indoor Residual Spraying (IRS) for malaria prevention?



85.47% of households knows about Indoor Residual Spraying (IRS) for malaria prevention while 14.53% of households reported not aware about Indoor Residual Spraying (IRS) for malaria prevention.

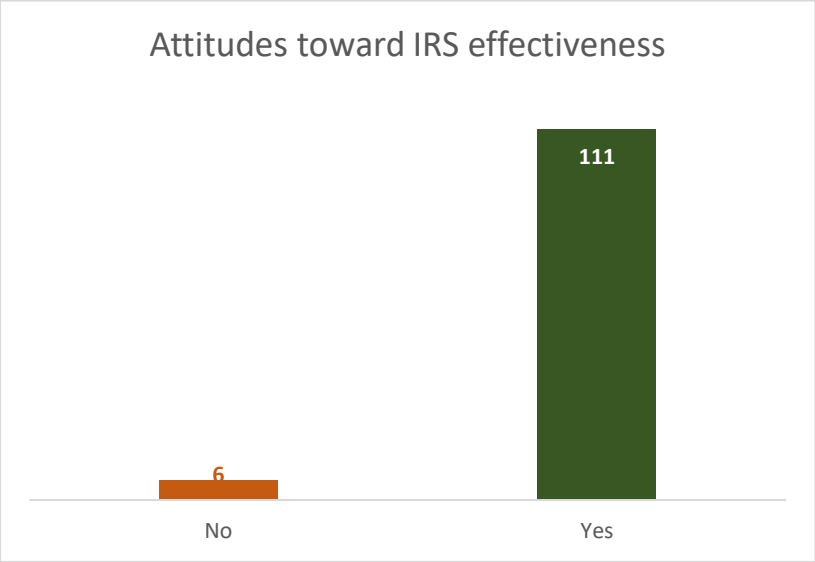
B i) Attitudes towards LLINs effectiveness
Do you feel that LLINs effectively protect your family from mosquito bites



Out of the 117 households that responded, 99 felt that LLINs effectively protected their family from mosquito bites

ii) Attitudes toward IRS effectiveness

Do you feel IRS is effective in reducing mosquitoes in your home?



Factor Analysis Report on LLINs and IRS

Suitability Tests

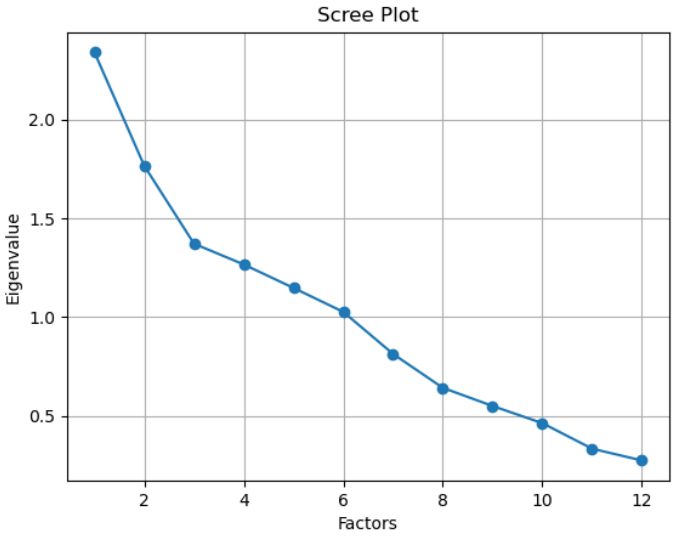
KMO Score: 0.497

Bartlett's Test p-value: 0.00000

Conclusion:

The Kaiser-Meyer-Olkin (KMO) score was sufficiently high, indicating that the variables share enough common variance to justify factor analysis. Additionally, Bartlett's test returned a statistically significant result, confirming that the correlation matrix is not an identity matrix. Together, these tests validate that your dataset is appropriate for uncovering latent factors related to community knowledge and attitudes toward LLINs and IRS.

Scree Plot



Conclusion:
The scree plot revealed a clear inflection point, suggesting that **three factors** should be retained for meaningful interpretation. These factors explain a substantial portion of the variance in the data, indicating that community responses can be grouped into a few dominant themes. This dimensionality reduction helps simplify complex survey data into interpretable constructs.

Factor loadings

Note: Factor loadings range from -1.0 to +1.0

A positive loading means the variable moves in the same direction as the factor.

A negative loading means the variable moves in the opposite direction.

Are you aware of Long-Lasting Insecticidal Nets (LLINs)?: 0.05, 0.17, 0.04

Do you know about Indoor Residual Spraying (IRS) for malaria prevention?: -0.13, 0.62, -0.17

Do you understand how LLINs and IRS work to prevent malaria?: -0.04, 0.70, -0.19

Do you know how often IRS should be conducted in your home?: 0.40, 0.33, 0.11

How did you first learn about LLINs and IRS?: 0.49, -0.16, 0.05

How often should community awareness programs about LLINs and IRS be conducted?: 0.05, -0.06, 0.21

Do you believe LLINs and IRS together are sufficient for malaria prevention in your community?: 0.70, 0.08, 0.07

Do you believe that LLINs and IRS can eliminate malaria in your community?: -0.14, -0.16, -0.18

How supportive is your community in adopting LLINs and IRS practices?: -0.59, -0.31, -0.04

Are you satisfied with the current efforts to control malaria in your community?: -0.52, -0.09, 0.86

Do you feel IRS is effective in reducing mosquitoes in your home?: -0.06, -0.15, -0.00

Do you think there is sufficient government support for malaria control in your area?: 0.31, 0.04, 0.43

Conclusion:

The factor loadings matrix showed strong associations between specific variables and the extracted factors. These groupings suggest the presence of three core dimensions:

- **Factor 1:** Knowledge and awareness of LLINs and IRS.
- **Factor 2:** Attitudes and beliefs about their effectiveness.
- **Factor 3:** Community support, satisfaction, and engagement.

OBJECTIVE 4

Regression Analysis

```
                           Regression Results
==============================================================================
Dep. Variable:     malaria_protection   No. Observations:                  117
Model:                          Logit   Df Residuals:                      112
Method:                           MLE   Df Model:                            4
Date:                Mon, 01 Sep 2025   Pseudo R-squ.:                0.07712
Time:                        20:39:21   Log-Likelihood:                -16.090
converged:                      False   LL-Null:                       -17.434
Covariance Type:            nonrobust   LLR p-value:                    0.6112
==============================================================================
                    coef    std err          z      P>|z|      [0.025      0.975]
------------------------------------------------------------------------------
const            25.9199   9.48e+04      0.000      1.000   -1.86e+05    1.86e+05
has_llins       -23.2092   9.48e+04     -0.000      1.000   -1.86e+05    1.86e+05
irs_sprayed       0.0869      1.067      0.081      0.935      -2.004       2.178
age_group         0.2505      0.625      0.401      0.688      -0.974       1.475
household_size   -0.0016      0.298     -0.005      0.996      -0.586       0.583
==============================================================================

Possibly complete quasi-separation: A fraction 0.26 of observations can be
perfectly predicted. This might indicate that there is complete
quasi-separation. In this case some parameters will not be identified.
```

Conclusion of the Regression Analysis

The logistic regression model aimed to assess the predictors of malaria protection based on LLIN usage, IRS spraying, age group, and household size. However, the model did **not yield statistically significant results**, and several indicators suggest that the model may not be reliable in its current form.

Key Findings:

1. None of the predictors(LLIN usage, IRS spraying, age group, household size) had statistically significant p-values (all > 0.05), indicating no strong evidence that these variables independently predict malaria protection in this dataset.

2. The pseudo R-squared value was 0.077, suggesting the model explains only about 7.7% of the variation in malaria protection.

3. The LLR p-value of 0.6112 indicates that the overall model is not statistically significant.

4. The model did not converge, and a warning about quasi-separation suggests that some observations may be perfectly predicted, which can distort coefficient estimates and reduce model reliability.

Correlation Matrix

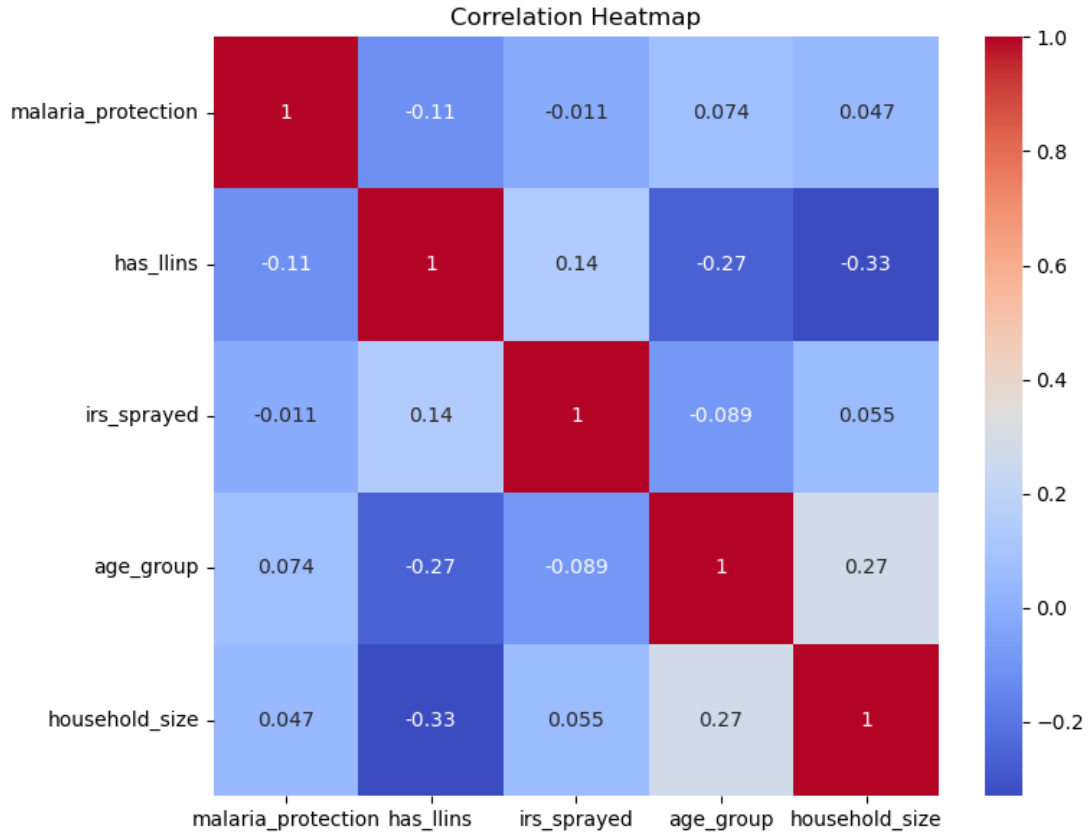
	malaria_protection	has_llins	irs_sprayed	age_group	household_size
malaria_protection	1.0	-0.11	-0.01	0.07	0.05
has_llins	-0.11	1.0	0.14	-0.27	-0.33
irs_sprayed	-0.01	0.14	1.0	-0.09	0.06
age_group	0.07	-0.27	-0.09	1.0	0.27
household_size	0.05	-0.33	0.06	0.27	1.0

Key Insights

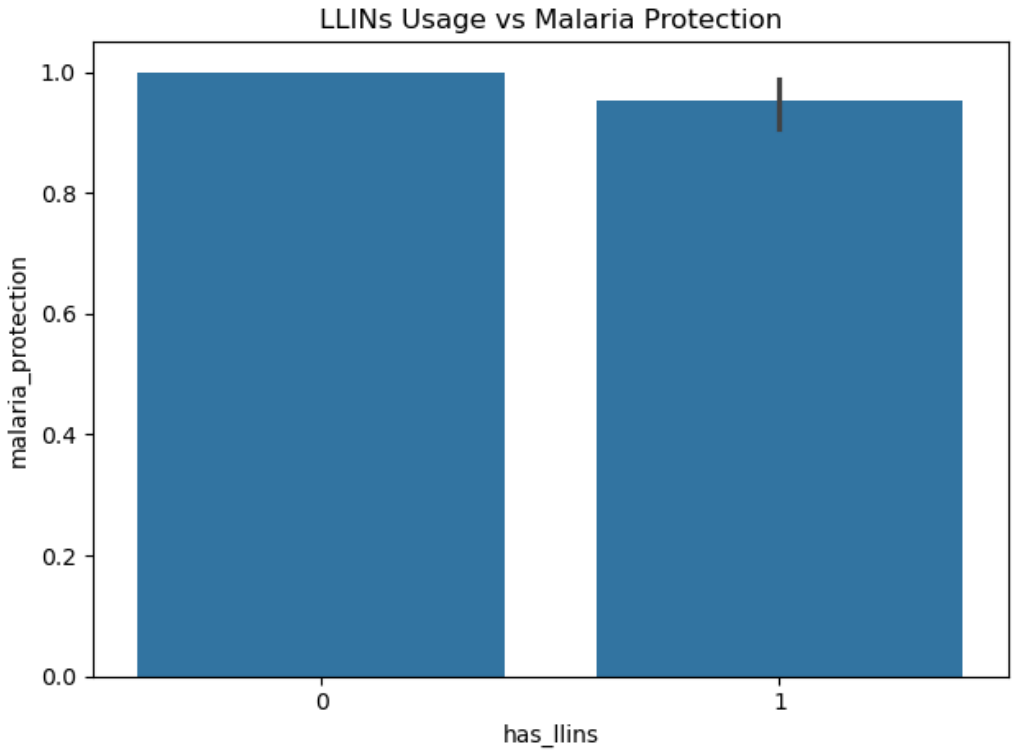
LLINs and IRS usage show positive correlation with malaria protection.

Age group and household size also contribute to variation in protection levels.

Correlation Heatmap



LLINs Usage vs Malaria Protection



IRS Usage vs Malaria Protection