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# Prevalence of malaria and associated risk factors among febrile under-five refugee children attending Panyadoli Health Centre III, Kiryandongo District, Mid-western Uganda

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**Abstract**

**Background** Malaria presents a big threat to the health of refugees, internally displaced persons, returnees and other such persons affected by humanitarian emergencies, with almost two thirds of these groups of persons living in malaria endemic regions. The aim of this study was to determine the prevalence of malaria and associated risk factors among refugee children < 5 years attending a Health Centre in Panyadoli Refugee Settlement Camp, Kiryandongo District, Uganda.

**Methods** A cross-sectional survey was done between February to April 2022, targeting refugee children < 5 years old seeking healthcare at Panyadoli Health Centre III in Kiryandongo District. Simple random sampling was employed to select 380 participants, who were then tested for the presence of malaria parasites using malaria rapid diagnostic tests and microscopy techniques. Data on risk factors of malaria was collected using a pre-tested and standardized semi-structured questionnaire. Bivariate and multivariate logistic regression analyses was used to identify the risk factors for malaria infections, at 95% confidence interval and $p < 0.05$.

**Results** Malaria prevalence among the refugee children < 5 years attending Panyadoli HCIII was 12.6% [95% CI: 8.7–18.0]. The associated risk factors for malaria infection included: non-application of indoor residual spraying over the last 12 months [AOR = 4.323; 95% CI 1.231–7.212], history of malaria in children (AOR = 5.861; 95% CI 1.562—8.433], and not sleeping under insecticide-treated nets (AOR = 3.141; 95% CI 0.865—5.221).

**Conclusion** Malaria remains a threat to refugee children < 5 years old at Panyadoli Refugee Settlement Camp. Sustained implementation of IRS should be pursued through expanded geographic coverage and increased application frequency, in conjunction with complementary malaria control measures such as enhanced ITN distribution and IPT for pregnant women, to support long-term malaria reduction.

**Keywords** Malaria, Refugees, Panyadoli, Risk factors, Febrile, Under-five children

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## Background

Malaria remains a major public health concern, particularly in sub-Saharan Africa (SSA), where it is a leading cause of morbidity and mortality [1]. The disease is caused by protozoan parasites of the genus *Plasmodium*, with *Plasmodium falciparum* being responsible for the majority of severe cases and hospital admissions [2]. In 2022, an estimated 249 million malaria cases were recorded across 85 endemic countries, reflecting an increase of 5 million cases compared to 2021 with over 95% of these cases occurring in SSA, where the economic toll of malaria is estimated at $12 billion annually [1]. Children < five years old bear the greatest burden, with malaria accounting for 10% of all deaths in this age group [3].

Uganda continues to struggle with a high malaria burden, ranking as the third-highest contributor to global malaria cases and deaths in 2020 (5.4%) and holding the fifth-highest malaria prevalence in East and Southern Africa (23.2%) [2]. The disease is endemic in 95% of the country, affecting over 90% of the population and accounting for 20% of hospital deaths [4]. The Ugandan Ministry of Health estimates that a significant proportion of malaria-related deaths occur at home, with malaria responsible for 27.2% of inpatient deaths among children under five [5].

Refugees are particularly vulnerable to malaria due to poor housing conditions, under nutrition, unclean water, overcrowding, and limited access to healthcare services [6]. Uganda is one of Africa's top refugee-hosting countries, with over 1.36 million refugees [7]. Panyadoli Refugee Settlement Camp in Kiryandongo District is one of the largest settlements, hosting refugees from South Sudan, the Democratic Republic of Congo (DRC), and Burundi [8]. Despite Uganda's high malaria burden, data on malaria prevalence and risk factors in refugee populations, particularly in Panyadoli, remain scanty. Previous studies in other refugee settings have highlighted the increased risk of malaria due to inadequate vector control and healthcare access, underscoring the need for context-specific research [9–11].

With the continued influx of refugees, human mobility plays a critical role in malaria transmission by introducing pathogens into susceptible populations and altering contact patterns between infected and susceptible individuals [12]. Additionally, limited healthcare services and the high turnover of refugees may impact the effectiveness of malaria prevention measures, such as insecticide-treated nets (ITNs) and indoor residual spraying (IRS). Given these challenges, there is a pressing need for heightened surveillance and targeted interventions in refugee settlements.

This study aimed to determine the prevalence and risk factors associated with malaria among refugee children under five years old attending Panyadoli Health Center III in Kiryandongo District. By linking malaria burden to refugee-specific challenges, such as healthcare limitations, this study seeks to provide insights that can inform malaria control strategies and improve health outcomes in refugee settings.

## Methods

### Study area

The study was conducted in Panyadoli Refugee Settlement Camp (Coordinates: 1.93998, 1.93998) located in Panyadoli Village, Bweyale subcounty Kiryandongo District (Fig. 1). Panyadoli is one of the largest camps harbouring refugees and asylum seekers from South Sudan, DRC, Burundi and Bududa survivors among others [13]. In 1990, the Ugandan government gazetted the virtually uninhabited land around Panyadoli in Kiryandongo for refugee resettlement. The Settlement currently provides shelter, land, and support for more than 100,000 people. The major economic activities carried out in the settlement are agricultural. The majority of the refugee farmers depend on growing cassava, sweet potatoes, maize, beans, rice, vegetables and groundnuts, mainly for domestic consumption. Additional activities in the Settlement include livestock rearing, fishing, and beekeeping. Panyadoli Health Centre III is the main facility at the Camp, providing healthcare services to the refugees and neighbouring communities.

### Study design and sample size

This was a descriptive cross-sectional study conducted between February to April 2022, a period coinciding with Uganda's first rainy season, which is associated with increased mosquito breeding and malaria transmission. Data collection involved both qualitative and quantitative tools. Microscopy and Rapid Diagnostic Tests (RDTs) were employed for diagnosis of malaria. Additionally, questionnaires were used to collect data on socio-demographic characteristics and malaria associated risk factors. The sample size of participants was calculated using a single population proportion formula, the 95% confidence limits ($Z\alpha/2 = 1{:}96$), and a 5% margin of error (d) with a maximum proportion of 50% as follows:

$$\text{Sample size} = Z(\alpha/2)^2 P\,(1 - P)/\,d^2,$$
$$(1.96)^2 * 0.221(1{-}0.221)/\,(0.05)^2 = 384$$

A total of 380 children under five years with malaria symptoms were enrolled at Panyadoli Health Centre III, slightly below the calculated 384 due to logistical


**Fig. 1** Map of Uganda showing location of Kiryandongo District and the resettlement camp

constraints and participant unavailability, though this 1.04% deviation minimally impacts study power and reliability. Simple random sampling was conducted to select the participants using the random number generator approach. Briefly, random numbers were generated from a sampling frame of 700 obtained from the outpatients malaria register. These numbers were aligned against the patients' identification numbers in the register. Any patient who was assigned a random number was included in the study. Parents/guardians of the selected febrile patients were triaged and recorded in the register using the patients'` identification numbers. After a complete physical examination of the patients by a physician and referral to the laboratory for testing, the parents/guardians of each of the participants were interviewed to determine the predisposing factors to malaria infections.

### Inclusion criteria
Participants were eligible for the study if they were refugee children ≤5 years of age, had suspected symptoms of malaria such as anorexia, vomiting, or abdominal discomfort with or without diarrhea (based on the standard MOH definition of suspected malaria). In addition, the patient with a body (axillary) temperature >37.4 °C or history of fever in the 24–48 h were included.

### Exclusion criteria
Patients who came for confirmation or retesting for malaria following treatment were excluded from the study.

### Data collection
Well-designed structured questionnaires were used to collect the qualitative data on risk factors for malaria infection. The questionnaire was initially developed in English and translated into local languages for data collection. Trained Research Assistants then administered the questionnaires during face-to-face interviews with parents/guardians of the under-five refugee children. The questionnaires were initially pretested and validated at Kiryandongo Hospital to ensure its reliability and validity.

### Specimen collection and laboratory procedures
Blood specimens were obtained from the thumb using sterile blood lancets and cleaned with 70% ethanol or an alcohol swab and left to air dry to prepare thick and thin blood film smears. Blood specimen collection and processing was done by trained and competent laboratory technicians who had records of certification by the World Health Organization (WHO) in malaria diagnosis and were under the technical supervision of the researcher, a senior Medical Laboratory Technologist. Malaria diagnosis was conducted using two approaches: RDT and microscopic examination.

Malaria RDTs (Carestart, Lot no. 05 CDH019 A/05 CDH030 A) with a pre-determined sensitivity and specificity of 97.89%−100% and 99.50%−100%, respectively, were employed. Briefly, the test device and the sample pipette were removed from the foil pouch. The test device was labelled with the patient identification number and then placed on a flat surface. Using the provided loop or micropipette, 5μl of whole blood was obtained from a finger prick and added to the sample well of the test card. Two drops (60 μl) of assay diluent were added into the diluent well and allowed to flow by capillary action. The test result was read within 15–20 min and recorded as Positive or Negative depending on the test outcome.

For microscopic examination, a clean glass slide was labelled with the patient's assigned unique number and accession in the register. The blood specimens were collected from the child upon consent/assent from their parents/guardians. Finger prick blood samples were then spotted onto carefully labelled slides to make thick and thin blood films, followed by air-drying. Field's stains A and B were used for processing the blood slides. The thin film was stained with Field stain A for 5 s, fixed in methanol for 1 min and then allowed to air dry. It was then gently dipped in Field stain B for 5 s and later washed in clean water. The slide was then dipped in Field stain A for 15–30 s and washed in clean water. The blood smears were examined under 100 × microscopes for the presence of malaria parasites.

The thick smear was used to determine whether the malaria parasites were present or absent and the thin smear was used to identify the *Plasmodium* species. A positive result was defined as the presence of one or more asexual stages (trophozoite, ring stage, merozoite, or gametocyte) of *Plasmodium*. A slide was regarded as negative after 200 fields had been examined without finding of *Plasmodium* parasites by two laboratory technologists. To assure quality of the microscopic examinations, all the positive and 10% of the negative slides were reexamined by a third reader to remove discrepant results.

Examination for the film was done for at least 10 min (approximately 200 oil immersion fields), before declaring the slide negative. Quality control was performed on the stains to be used for sample processing by filtering each working day, and pre-tested known malaria negative and positive samples were analysed in the same manner as the routine patient samples before analysing the study samples.

### Data analyses

Data was entered into a Microsoft Excel Sheet, coded, checked for completeness, and exported to SPSS version-20.0 (SPSS Inc., Chicago, IL, USA, 2011) for statistical analyses. Missing data were handled using Listwise Deletion, the default method for dealing with missing data in almost all statistical software packages [14]. Chi-square ($\chi2$) tests were used to determine the association between the independent variables (risk factors) and the dependent variable (prevalence of malaria), with potential confounders identified based on prior studies and biological plausibility. Variables with $p < 0.2$ were included in the multivariable logistic regression model to adjust for confounding effects. Variables that were found significant were selected for inclusion in the final multiple logistic regression to determine the predictors of malaria infection. Confidence interval was set at 95% and a $P < 0.05$.

## Results

### General characteristics of study participants

A total of 380 febrile refugee children < 5 years old took part in the study, with a 100% response rate (Table 1). As expected, majority of the refugee children were of South Sudan origin (360; 94.7%). Other nationalities included Kenya (03; 0.8%), Rwanda (05; 1.3%) and DRC (12; 3.2%). Refugee children who were aged 12–23 months formed the majority of the study population (93; 24.5%), followed by age groups 24–35–months (87; 22.9%), < 12 months (81; 21.3%), 48–59 months (56; 14.7%), and lastly 36–47 months (56;14.7%). Most of the children came from households with parents/guardians who were catholic (156; 41.1%) and had primary education (166; 43.7). Additionally, most households where the children hailed from consisted of 6 to 9 members (197; 51.8%). Majority of the houses where the children came from were made of mud and iron sheets as construction materials (223; 58.7%), and most had window (307; 80.1%). In terms of malaria control measures, a good number of households where the children came from had their houses sprayed in the last 12 months under the Indoor Residual Spray (IRS) programme of the Ministry of Health and their partners (220; 57.9%), while 75.8% (288/380) of the children were reported to be sleeping under insecticide-treated mosquito nets (Table 1).

### Prevalence of malaria and risk factors among refugee children < 5 years in Panaydoli Refugee Settlement Camp

The overall prevalence of malaria in children < 5 years at Panyadoli was found to be 12.6% (95% CI 8.7–18.0) by microscopy and 13.2% (95% CI 8.2–17.3). Majority (41/48; 85.42%) of the parasites were microscopically determined as *P. falciparum*, while a few (7/48; 14.58%) were *Plasmodium vivax*. No cases of mixed infections were detected.

Bivariate analyses showed that age of child (in months) ($p = 0.001$), indoor residual spraying (IRS) in last 12

**Table 1** General characteristics of the respondents surveyed

| Variable | n | Percentage | 95% CI Lower | Upper | $\chi^2$ | p |
|---|---|---|---|---|---|---|
| Sex | | | | | | |
| *Male* | 168 | 44.2 | 38.6 | 48.3 | 0.771 | 0.074 |
| *Female* | 212 | 55.8 | 49.1 | 59.2 | | |
| *Religion* | | | | | | |
| *Catholic* | 156 | 41.1 | 37.4 | 47.6 | 0.642 | 0.401 |
| *Protestant* | 98 | 25.8 | 21.2 | 29.3 | | |
| *Muslim* | 23 | 6.1 | 3.2 | 8.3 | | |
| *Born again* | 68 | 17.9 | 13.1 | 21.3 | | |
| *Others* | 35 | 2.4 | 0.8 | 4.6 | | |
| Age of child (in months) | | | | | | |
| *< 12* | 81 | 21.3 | 18.8 | 25.1 | 12.232 | **0.001** |
| *12–23* | 93 | 24.5 | 21.1 | 26.2 | | |
| *24–35* | 87 | 22.9 | 17.5 | 26.3 | | |
| *36–47* | 56 | 14.7 | 10.3 | 17.4 | | |
| *48–59* | 63 | 16.6 | 11.2 | 19.6 | | |
| Mothers/caretakers age group | | | | | | |
| *15–24* | 138 | 36.3 | 31.4 | 42.1 | 0.305 | 0.814 |
| *25–34* | 162 | 42.6 | 36.6 | 47.2 | | |
| *35–49* | 80 | 21.1 | 18.4 | 25.6 | | |
| IRS service in last 12 months | | | | | | |
| *Sprayed* | 220 | 57.9 | 50.5 | 63.3 | 3.720 | **0.022** |
| *Not sprayed* | 160 | 42.0 | 37.7 | 47.1 | | |
| Lighting source | | | | | | |
| *Present* | 24 | 6.4 | 3.6 | 8.2 | 0.482 | 0.378 |
| *Absent* | 356 | 93.6 | 81.2 | 98.4 | | |
| Sleep under ITN | | | | | | |
| *Yes* | 288 | 75.8 | 63.4 | 81.2 | 7.841 | **< 0.001** |
| *No* | 92 | 24.2 | 19.6 | 26.1 | | |
| Construction material for house | | | | | | |
| *Bricks and iron sheets* | 33 | 8.7 | 5.1 | 11.3 | 0.331 | 0.548 |
| *Mud and iron sheets* | 223 | 58.7 | 52.4 | 63.6 | | |
| *Cement and iron sheets* | 12 | 3.2 | 1.2 | 5.4 | | |
| *Mud only* | 109 | 28.7 | 24.2 | 33.5 | | |
| *Wooden house* | 3 | 0.8 | 0.3 | 1.2 | | |
| House screen | | | | | | |
| *Windows present* | 307 | 80.1 | 71.0 | 85.1 | 0.768 | 0.381 |
| *Window absent* | 73 | 19.2 | 15.4 | 23.2 | | |
| Education level of the mother or child caretaker | | | | | | |
| *No formal education* | 163 | 42.9 | 36.6 | 45.5 | 0.152 | 0.859 |
| *Primary* | 166 | 43.7 | 38.2 | 47.6 | | |
| *Secondary and above* | 51 | 13.4 | 8.2 | 15.3 | | |
| Number of household member/family size | | | | | | |
| *Less than 5* | 138 | 36.3 | 31.5 | 39.8 | 7.673 | **0.004** |
| *6 to 9* | 197 | 51.8 | 47.6 | 54.7 | | |
| *10 to 15* | 45 | 11.8 | 8.8 | 15.0 | | |
| Taking long outdoor at night | | | | | | |
| *Yes* | 187 | 49.2 | 46.8 | 52.1 | 0.559 | 0.439 |
| *No* | 193 | 50.8 | 48.1 | 53.4 | | |

**Table 1** (continued)

| Variable | n | Percentage | 95% CI Lower | Upper | $\chi^2$ | p |
|---|---|---|---|---|---|---|
| Use mosquito repellents at night | | | | | | |
| *Yes* | 12 | 3.2 | 5.2 | 12.1 | 0.152 | 0.697 |
| *No* | 268 | 96.8 | 81.0 | 102.5 | | |
| Wears long clothing at night | | | | | | |
| *Yes* | 87 | 22.9 | 16.4 | 26.7 | 0.392 | 0.344 |
| *No* | 293 | 77.1 | 63.3 | 84.6 | | |
| Presence of stagnant water near dwelling place | | | | | | |
| *Yes* | 197 | 51.8 | 47.4 | 55.3 | 1.411 | 0.235 |
| *No* | 183 | 48.2 | 44.7 | 54.6 | | |
| Dwelling place surrounded by vegetation | | | | | | |
| *Yes* | 195 | 51.3 | 47.3 | 54.6 | 0.930 | 0.351 |
| *No* | 185 | 48.7 | 45.4 | 52.4 | | |
| Treatment | | | | | | |
| *Always self medication* | 176 | 46.3 | 41.6 | 50.2 | 5.771 | **0.008** |
| *From health facility* | 204 | 53.4 | 48.8 | 57.4 | | |
| Mother received all 3 episodes of IPT | | | | | | |
| *Yes* | 274 | 72.1 | 65.4 | 76.7 | 9.771 | **0.002** |
| *No* | 106 | 27.9 | 23.3 | 34.6 | | |
| Health education on malaria in last 6 months | | | | | | |
| *Yes* | 142 | 37.4 | 33.2 | 43.5 | 0.350 | 0.721 |
| *No* | 238 | 62.6 | 56.5 | 66.8 | | |
| History of malaria in child | | | | | | |
| *Yes* | 258 | 67.9 | 63.8 | 71.4 | 8.362 | **< 0.001** |
| *No* | 122 | 32.1 | 27.6 | 36.2 | | |
| Country of origin | | | | | | |
| *South Sudan* | 360 | 94.7 | 86.2 | 99.1 | | 0.541 |
| *Rwanda* | 5 | 1.3 | 0.5 | 3.8 | | |
| *Kenya* | 3 | 0.8 | 0.2 | 1.6 | | |
| *DRC* | 12 | 3.2 | 0.7 | 5.3 | | |

Significant p values indicated in bold

months ($p = 0.022$), history of malaria in child ($p < 0.001$), treatment behaviour (self-medication vs health facility) ($p = 0.008$), family size ($p = 0.004$), and sleeping under insecticide-treated nets ($p = 0.001$) had significant associations with malaria (Table 1).

Multivariable logistic regression analysis confirmed that non-application of IRS in last 12 months (AOR = 4.323; 95% CI 1.231–7.212), history of malaria in child (AOR = 5.861; 95% CI 1.562—8.433), and not sleeping under insecticide-treated nets (AOR = 3.141; 95% CI 0.865—5.221) were the independent predictors of falciparum malaria among under-five children in Panyadoli Refugee Settlement Camp (Table 2).

## Discussion

This study was carried out to assess the prevalence of malaria and associated risk factors in refugee children aged 5 years and below who sought health management at Panyadoli Health Centre III in Kiryandongo District. Refugees generally present a highly vulnerable group to malaria infection due to factors such as overcrowded living conditions, inadequate access to healthcare, and disruption of malaria control programmes. Additionally, refugee settlements often face challenges like limited infrastructure and resources, which exacerbate the spread and impact of malaria [13]. As a result, malaria can severely affect the health of refugees, particularly children and pregnant women, leading to higher morbidity and mortality rates and straining the already limited health services [1]. Understanding the prevalence and

**Table 2** Multivariate logistic regression analyses of the risk factors associated with malaria prevalence among refugee children < 5 years in Panyadoli Health Centre III, Kiryandongo District

| Variable | n | COR, P-values, 95% CI | AOR, 95% CI | P-value |
|---|---|---|---|---|
| Age of child (in months) | | | | |
| *< 12* | 81 | 0.987 (0.384–2.541) | 1.028 (0.550–3.221) | NS |
| *12–23* | 93 | 0.525 (0.123–3.731) | 0.663 (0.213–3.134) | |
| *24–35* | 87 | 0.228 (0.038—2.466) | 0.528 (0.083—2.767) | |
| *36–47* | 56 | 1.248 (0.539–4.503) | 1.314 (0.932–6.305) | |
| *48–59* | 63 | 1 | | |
| IRS service in last 12 months | | | | |
| *Sprayed* | 220 | 1 | | |
| *Not sprayed* | 160 | 4.020 (0.342–7.246) | 4.323 (1.231–7.212) | < 0.001* |
| Sleep under ITN | | | | |
| *Yes* | 288 | 1 | | |
| *No* | 92 | 3.072 (1.524–7.038) | 3.141 (0.865—5.221) | 0.003* |
| Number of household member/family size | | | | |
| *Less than 5* | 138 | 1 | | NS |
| *6 to 9* | 197 | 0.825 (0.297–3.133) | 1.181 (0.743–5.123) | |
| *10 to 15* | 45 | 0.625 (0.151–2.660) | 0.547 (0.182–3.011) | |
| Treatment | | | | |
| *Always self medication* | 176 | 0.726 (0.281–1.873) | 0.811 (0.124–2.376) | NS |
| *From health facility* | 204 | 1 | | |
| Mother received all 3 episodes of IPT | | | | |
| *Yes* | 274 | 1 | | |
| *No* | 106 | 0.793 (0.445–2.971) | 1.920 (0.386—6.756) | 0.072 |
| History of malaria in child | | | | |
| *Yes* | 258 | 5.019 (0.703–9.630) | 5.861 (1.562—8.433) | < 0.001* |
| *No* | 122 | 1 | | |

[*] indicates P < 0.05 statistically significant, NS = Not significant

risk factors allows for targeted interventions and resource allocation, helping to mitigate the disease burden and improve health outcomes in these vulnerable communities [15].

The overall infection rate was about 12.6% by microscopy. Compared to previous studies, this prevalence is somewhat moderate or slightly lower. For example, a study that utilized data from the Uganda Malaria Indicator Survey 2018–2019 in refugee camps reported a malaria infection rate of 36.6% [11]. Regionally, East African countries like Kenya and Tanzania report variable prevalence rates, often between 5 and 30%, influenced by factors such as seasonal changes and control measures [16]. Globally, refugee camps frequently exhibit higher malaria prevalence compared to host populations due to overcrowded conditions and inadequate health infrastructure [17]. The moderate malaria prevalence in Panyadoli may indicate the effectiveness of current control measures and community health interventions in the Settlement. Surveys conducted during the study showed that a substantial number of households from where the children hail use mosquito nets while a good number have also embraced other mosquito control initiatives like IRS which is carried out by different stakeholders under the auspices of the Ugandan Ministry of Health.

In terms of species distribution, the majority (85.42%) of the malaria cases were caused by *P. falciparum*, consistent with its reported dominance in sub-Saharan Africa. A smaller proportion (14.58%) of cases were attributed to *P. vivax*, with no mixed infections detected. The predominance of *P. falciparum* is consistent with previous studies in similar settings, which highlights its significant role in malaria morbidity and mortality in the region [10, 18–20]. *Plasmodium falciparum* remains widespread in Africa due to the region's favourable environmental conditions for highly efficient *Anopheles* mosquito vectors, compounded by persistent poverty [20]. Despite limited knowledge of its full public health impact, its significant mortality burden over time is evident, acting as a strong selective pressure on the human genome, leading to genetic adaptations in red blood cells and haemoglobin that provide resistance to disease and death [21].

As a factor, households that had implemented IRS in the last 12 months before the study was done were four times less likely to suffer from malaria compared to those that did not. This is consistent with previous observations indicating the effectiveness of IRS in reducing malaria incidence by targeting the vector population indoors, where mosquitoes typically rest after feeding [3]. For instance, a study in Uganda [22], Ethiopia [23] and Benin [24] found a comparable reduction in malaria cases following IRS implementation. The success of IRS in Panyadoli also reflects the importance of sustained vector control interventions in refugee settings, where the risk of malaria is heightened due to factors like overcrowding and limited access to healthcare [1]. In Panyadoli, IRS activities are typically carried out by the Uganda Ministry of Health supported by the United States Agency for International Development (USAID)/President's Malaria Initiative (PMI), with spraying typically occurring on an annual basis or as determined by epidemiological needs. The apparent effectiveness observed in this study highlights the critical role of consistent and well-managed vector control strategies in combating malaria in refugee camps. While IRS is an important malaria control measure, the study design did not allow for direct assessment of its implementation, including coverage, frequency, or timing. This limitation highlights the need for future studies to incorporate household assessments to better evaluate the impact of IRS on malaria prevalence.

This study found that children who had history of malaria were more likely to suffer from malaria than those who did not have a history of malaria infection. The increased likelihood of recurrent malaria in children with a history of the disease can be attributed to a combination of factors including incomplete immunity, ongoing parasite exposure, environmental conditions or even improper treatment [25]. Furthermore, infection with *P. falciparum* malaria in the early stages of life (usually first 6 months) was associated with higher incidence of both malaria infection and clinical malaria in early childhood. This is mainly attributed to the decreasing levels of maternally derived malaria specific immunoglobulin (IgG) as the child grows older [26, 27]. On the other hand, the presence of antibodies 19-kDa C-terminal fragment of Msp-$1_{19}$ at birth does provide resistance to clinical malaria at a later stage of life, meaning the absence of this antibody markers would definitely provide no resistance to malaria for such children [26]. Moreover, socioeconomic conditions and environmental factors might also play a role; children in refugee settlements like Panyadoli with poor access to healthcare, inadequate malaria control measures, and high vector density may be at greater risk of both initial and recurrent malaria infections.

The association between sleeping under insecticide-treated nets and reduced malaria prevalence in children (AOR $=3.141$; 95% CI 0.865—5.221) suggests a potential protective effect. However, the confidence interval includes 1, indicating non-significance at the 95% confidence level, with the wide confidence interval reflecting uncertainty in the true effect. This uncertainty appears counterintuitive given that numerous studies have confirmed that ITNs are highly effective in reducing malaria incidence [28–31], a protective effect attributed to the reduction in mosquito bites and the insecticide's ability to kill mosquitoes. While ITNs are key to malaria prevention, real-world effectiveness vary due to contextual and behavioural factors, explaining non-significance. These factors in Panaydoli may include (i) misuse of ITNs for fishing or shelter, reducing their protective effect (ii) poor maintenance due to infrequent re-treatment or diminished insecticide efficacy (iii) behavioural factors such as irregular net use, improper hanging, or lack of awareness (iv) limited purchasing power preventing net replacement or repair, and v) environmental factors like proximity to mosquito breeding sites or poor housing. While ITN usage was high (75%), the study design did not allow for an assessment of factors influencing ITN effectiveness, such as proper usage, net condition, or household-level variations, as participants were enrolled upon presentation at the health facility. Future studies should consider household-based evaluations to better understand ITN effectiveness and maintenance challenges in refugee settlements.

Although age and household size were significantly associated with malaria prevalence in the bivariate analysis, they did not remain significant in the final multivariate model, suggesting potential confounding or mediation by other factors. Children under 12 months were more likely to be infected than older children, possibly due to lower acquired immunity [32]. Households with more than five members had higher malaria cases than smaller households, which could be attributed to several factors, including increased exposure to mosquito bites due to overcrowding, competition for limited bed nets, and potential challenges in consistently implementing malaria prevention measures. Larger households may also experience financial constraints, reducing their ability to seek timely treatment or replace worn-out insecticide-treated nets. While these factors were not independently significant in the final model, their role in malaria transmission dynamics warrants further investigation.

## Conclusion

The malaria prevalence in children < 5 years old at Panyadoli Refugee Settlement Camp remains moderately high. It is recommended to enhance the implementation of indoor residual spraying (IRS) by expanding coverage and ensuring more frequent applications. Furthermore, there is a need to complement IRS with other malaria prevention strategies, such as increasing the coverage of insecticide-treated nets (ITNs) and use of intermittent preventive treatment (IPT) for pregnant mothers to effectively reduce malaria prevalence.

## Study limitations

The study was cross sectional in design and took place between the months of February to April 2022 only. Malaria is influenced by environmental factors, that can exert an effect on its seasonality, distribution, and transmission intensity [33]. This may influence the number of children being treated as outpatients in hospitals, and hence the estimates of the actual true burden in this study. The influence of seasonality on malaria prevalence and the effectiveness of prevention measures warrant further exploration in future studies.

While the inclusion criteria focused on children under five with malaria symptoms, factors like travel history and vector exposure may influence infection risk and should be considered in future studies. Additionally, excluding children being retested for malaria may have led to an underrepresentation of recurrent infections, which is acknowledged as a study limitation.

Finally, only two techniques (RDT and microscopy) were used to detect and speciate the malaria parasites in blood. More sensitive methods, such as PCR, could have provided better resolution and/or confirmation of the species of malaria parasites.

### Abbreviations

| | |
|---|---|
| AOR | Adjusted odds ratio |
| CI | Confidence interval |
| SPSS | Statistical package for the social sciences |
| DRC | Democratic republic of Congo |
| IPT | Intermittent prophylactic treatment |
| IRS | Indoor residual spraying |
| ITNs | Insecticide-treated nets |
| MOH | Ministry of health |
| SSA | Sub Saharan Africa |
| UBOS | Uganda bureau of statistics |
| UNHCR | United Nations high commission for refugees |
| WHO | World health organization |

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### Author contributions

AD, ASP and RO conceived and designed the study, collected data, performed initial analyses and wrote initial draft of manuscript. BM and BBA critically revised the manuscript. All authors read and approved the final version of the manuscript.

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### Availability of data and materials

No datasets were generated or analysed during the current study.

## Declarations

### Ethical approval and consent to participate

Ethical approval to conduct the study was obtained from Gulu University Research Ethics Committee (Approval number GUREC-2021-131). Permission to conduct the study were sought from Kiryandongo District Health Officer, Chief Administrative Officer, District Laboratory Focal Person, the UNHCR District Field Coordinator and Panyadoli HCIII Authority to conduct the study at the above facility. All parents/guardians assented to and signed informed consent forms before enrolling their children for the study.

### Consent for publication

Not applicable.

### Competing interests

The authors declare no competing interests.

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## Publisher's Note