Prevalence and determinants of malaria infection among children of local farmers in Central Malawi

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Abstract

Background: Malaria is a leading cause of morbidity and mortality among children under 5 years in Malawi, and especially among those from rural areas of central Malawi. The goal of this study was to examine the prevalence and determinants of malaria infection among children in rural areas of Dowa district in central Malawi.

Methods: A multistage, cross-sectional study design was used to systematically sample 523 child-mother dyads from postnatal clinics. A survey was administered to mothers and a rapid malaria infection diagnostic test was administered to children. The main outcome was positive malaria diagnostic tests in children. Logistic regressions were used to determine risk factors associated with malaria among children aged 2 to 59 months.

Results: The prevalence of malaria among children under 5 years was 35.4%. Results suggest that children of mothers who experienced recent intimate partner violence (IPV) were more likely to be diagnosed with malaria (AOR: 1.88, 95% CI 1.19–2.97; P = 0.007) than children of mothers who did not. Children of mothers who had no formal education were more likely to be diagnosed with malaria (AOR: 2.77, 95% CI 1.24–6.19; P = 0.013) than children of mothers who had received secondary education. Children aged 2 to 5 months and 6 to 11 months were less likely to be diagnosed with malaria (AOR: 0.21, 95% CI 0.10–0.46; P = 0.000 and AOR: 0.43; 95% CI 0.22–0.85; P = 0.016, respectively) than children aged 24 to 59 months.

Conclusion: The prevalence of malaria infection among children in the study area was comparable to the national level. In addition to available malaria control programmes, further attention should be paid to children whose mothers have no formal education, children aged 24 to 59 months, and children of mothers that are exposed to IPV in the area.

Keywords: Malaria infection, Prevalence, Risk factors, Children under five, Rural Malawi

Background

Malaria is a mosquito-borne disease that kills a significant number of people in Africa every year [1]. The pathology is mainly caused by the Plasmodium falciparum parasite and is transmitted to human beings through female Anopheles mosquito bites [2]. In 2017, 61% of cases of malaria worldwide were in children under the age of 5 years. Geographically, approximately 92% (200 million) of malaria cases in the world were diagnosed in Africa, claiming about 404,550 lives [1].

In Malawi, malaria is among the three most significant public health issues. Nearly 4 million people are diagnosed with the infection every year [3]. Malawi accounts for 2% of malaria cases worldwide and is among the top 15 countries with a high malaria burden [1]. Children under 5 years and pregnant women are at a high risk for malaria morbidity compared to other groups in Malawi [4]. Since 2005, the Malawi Government has...
been implementing comprehensive malaria control programmes that target more than 85% of its population. The two main strategies have been preventing the malaria vector mosquitoes from biting people, and case management. Prevention efforts include promoting the use of insecticide-treated nets (ITNs) and indoor spraying of insecticide. Case management includes diagnostic testing and prescribing anti-malarial drugs to children with positive malaria tests [5]. These strategies are combined with messages about social behavioural changes in order to increase community uptake and utilization [6].

Despite these investments, little progress has been made so far to reduce the burden of malaria in children under five in Malawi. Studies have shown that the prevalence of malaria among children detected by a gold standard microscopy technique was at 28% in 2012; it increased to 33% in 2014 and slightly dropped to 24% in 2017 [7]. Malaria morbidity among children is not evenly distributed across Malawi. According to national data collected through malaria rapid diagnostic tests (RDTs) and microscopy in 2017, the prevalence of child malaria is significantly higher in rural areas (40.6 and 27.5%) compared to urban areas (6 and 4%), respectively. In addition, the prevalence of malaria among children in central Malawi was higher (39.7%) compared to children in southern (36.4%) and northern (19.4%) regions [8]. These studies suggest that geography plays a significant role in malaria prevalence among children. Therefore, there is a need to broaden the scope of studies that consider social and environmental risk factors for malaria to inform local policies and programmes.

The study was conducted in rural areas of Dowa district in Malawi because of two reasons. First, Dowa district is one of the highest-risk areas for child malaria in Malawi. Despite this, there is no literature to date that specifically focuses on this region apart from national aggregated studies [8]. Second, the research aimed at contributing to the study by Sassi [9], who assessed the risk factors of child under-nutrition in the Dowa district. In the study, the researcher used household access to mosquito nets as a proxy variable for malaria control among children. The assumption was that children from households without mosquito nets would be more likely to suffer from malaria as there are synergistic interactions between the two child morbidities. The present study specifically used cross-sectional quantitative data to examine individual and household risk factors for child malaria infection in order to understand the phenomenon in the Dowa district.

Methods

Study setting

The study was implemented in six postnatal clinics in the Dowa district of central Malawi in southern Africa (Fig. 1). Malawi has a population of about 17,563,749 people [8]. In 2017, about 71% of the population was living in extreme poverty according to United Nations indicators [10]. Malaria is an endemic disease in Dowa and surrounding districts, but higher numbers of cases are recorded during and after the rainy season (December to July) due to increased potential breeding environments [9, 11]. This study was conducted between May and September 2018 because this period would allow to capturing of average malaria cases in the study areas.

Study sample

A multistage, descriptive, cross-sectional study design was employed to select a representative sample of children aged 2 to 59 months and their mothers in the Dowa district. A random selection of 6 out of 8 outreach clinics that were part of the Mvera mission hospital was conducted. The selected clinics were located in Gogo, Ching'amba, Mkhalanjoka, Kalinyengo, Mvera and Mphande, within approximately 5–10 km of the Mvera mission hospital. During the study, the Mvera mission hospital served a population of 27,719 people, of whom 5240 were mothers with a child under 5 years old. A total population of 4527 mothers with children between 2 and 59 months were identified in postnatal registers in the 6 randomly selected postnatal clinics. The sample size was determined by a Raosoft sample size calculator [12]. A margin of error of 5% with a 95% confidence level and 50% response distribution was set. A systematic sampling strategy was used to select a sample of 523 children and their mothers from the postnatal registers. The first child-mother dyad was randomly picked and subsequently every 9th child-mother dyad were selected.

Participant recruitment

Selected mothers and their children were contacted at the 6 postnatal clinics during the regular monthly health screening for children. The screening programme is an initiative of the Malawi Government to promote maternal and child health through a framework of a continuum of care for mothers, newborns and children [13]. Community health workers who were assigned as research assistants sought informed consent from mothers to take part in the study. All interviews took place in the consultation room at each outreach postnatal clinic using a pre-tested questionnaire. The questionnaire contained questions on household socio-demographic characteristics, household food security, house structure type, use of mosquito nets, and maternal exposure to intimate
partner violence (IPV). The child’s and the mother’s anthropometric and health status data from their health passports were recorded in the questionnaire after their health screening programme was completed [14].

**Measures**

**Outcome variable**

The main outcome variable of the study was malaria infection in children 2 to 59 months old. The term child malaria infection was operationalized as the presence of the malaria parasite in children's red blood cells.
as recorded in the child’s health passport [15]. In all the
postnatal clinics, RDTs were used to assess the malaria
parasitaemia in children. If the diagnostic test was po-
tive, the child was coded as $1 =$ malaria infection, and
$0 =$ otherwise.

**Explanatory variables**
The selection of potential covariates of child malaria
infection in the regression models was based on current
literature in Malawi and other countries in sub-Saharan
Africa (SSA) [4, 16–20]. These were characteristics of
the children, characteristics of the parents that influ-
ence childcare practices and characteristics of the house-
hold. The covariate variables were child gender, age and
weight at birth. Variables that captured child’s history of
other morbidities in the past 30 days as reported by the
mother were also included. These included diarrhoeal
episodes and acute respiratory infection (ARI); child
de-worming in the past 12 months was also considered.
Child nutrition status was determined through height-
for-age, weight-for-height and weight-for-age Z-score
values. Child stunting, underweight and wasting were
categorized as those that were ≤ -2 standard deviations
of height-for-age, weight-for-age and weight-for-height
Z-scores [21].

Other independent variables that were considered as
risk factors for child malaria included the mother’s age,
level of education, pregnancy planning and exposure
to IPV perpetrated by their current or recent husband.
Cases of IPV was assessed by using a WHO multi-coun-
try study questionnaire on women’s health and life expe-
riences that was validated and used in Malawi [22, 23].
The questionnaire contained 18 items that made up four
sub-scales measuring different forms of IPV: physical
abuse, emotional abuse, controlling behaviour, and sexual
abuse. Maternal exposure to IPV was operationalized as
any mother who reported that they experienced any form
of IPV.

Fathers’ characteristics were also considered as risk fac-
tors. These included levels of education, age and health
risk behaviours, such as alcohol consumption and smok-
ing. Household malaria predisposing and enabling factors
in Malawi such as the use of an ITN, household poverty,
type of dwelling, and presence of animals in the house
were included. Mothers were asked if their child had an
ITN, and whether the child slept under the net the night
before the survey. Household poverty was defined based
on the international poverty measure of US$1.90 a day
[24]. The presence of animal kraals/sheds within 1–10 m
of the dwelling house was considered a risk factor [25].
Mothers were also asked if their houses had been sprayed
with insecticides and how many people were sleeping in
the house.

Survey enumerators administered the survey on
android tablets using an Open Data Kit (ODK). A WHO
protocol for conducting research on sensitive topics
was adopted because some of the questions in the study
focused on domestic violence [26, 27]. Enumerator ori-
entation and questionnaire pre-testing was conducted for
5 days. A PhD candidate in social work, a clinical officer
and an environmental health officer were responsible for
training the enumerators. The research team, including
the enumerators, had professional training in community
health, nutrition and primary health care.

**Research ethics review**
Ethics approval to conduct this study was obtained from
the University of Livingstone research ethics committee
in Malawi (protocol number: UNILILLA-REC-4/18) and the
Research Ethics Board of McGill University in Canada
(protocol number: REB File #: 503-0518). Written per-
mission was also sought from the Dowa district com-
misioner’s office, the Dowa district health office and the
Mvera mission hospital management. Oral consent was
obtained from local health leaders and research partici-
pants in the study areas.

**Data analysis**
The Kolmogorov–Smirnov test was used to test the nor-
mality of the distribution of numerical variables. These
include age, number of children, number of household
members, and household food security. Categorical vari-
ables were constructed from the numerical data because
the data were not normally distributed [28]. Bivariate
logistic regressions were performed to examine signifi-
cant predictors of child malaria. Significant predictors
of child malaria at the bivariate level of ($p < 0.05$) were
included in the final multivariable logistic regression
model using the forward enter method.

Multicollinearity of explanatory variables were tested
and a variance inflation factor (VIF) of 5143, was
obtained which indicated independence among the
explanatory variables both at the individual and the clus-
ter level. Consequently, a fixed effects model was used
to account for the clustering effect in the analysis. The
results of the multivariable analysis have been reported
as crude and adjusted odds ratios (AOR) with a 95%
confidence interval (CI). A $p$ value of less than 0.05 was
considered statistically significant in the study. The data
were analysed using an IBM Statistical Package of Social
Sciences (SPSS) for Windows version 23.0 (IBM Corp.,
Armonk, NY, USA).
Socio-demographic characteristics of study population

Socio-demographic and malaria infection data for all 523 selected children aged 2 to 59 months were obtained over 4 months (see Table 1). In terms of gender, 49.1% of the children were girls and 50.9% were boys. In terms of age, 13.4% of the sample was aged 2 to 5 months, 17.2% was aged 6 to 11 months, 29.6% was aged 12 to 23 months, and 41.9% was aged 24 to 59 months. It was observed that 14.3% of the selected children were born with a low birth weight (birth weight of less than 2.5 kg); 27.2% of the mothers reported that their children did not sleep under mosquito nets the night before the survey; 67.1% of mothers reported that their children had signs of fever 30 days preceding the survey. The study found that 42.0% of the children were stunted, and 11.3% were underweight.

### Table 1

| Characteristics of children, mothers, fathers, and the environment |  |
| --- | --- |
| **Mothers' characteristics** |  |
| Age (years) N = 523 | % |
| 15–19 | 39 | 7.5 |
| 20–29 | 299 | 57.3 |
| 30–39 | 155 | 29.6 |
| 40–49 | 29 | 5.5 |
| Education |  |
| No education | 80 | 15.3 |
| Primary | 356 | 68.1 |
| Secondary | 87 | 16.6 |
| Received childcare education |  |
| Yes | 464 | 88.7 |
| No | 59 | 11.3 |
| Exposed to IPV |  |
| Yes | 392 | 75.0 |
| No | 131 | 25.0 |
| Confidant |  |
| Yes | 382 | 73.0 |
| No | 141 | 27.0 |
| **Children's characteristics** |  |
| Nutrition status |  |
| Stunted | 219 | 42.0 |
| Not stunted | 304 | 58.0 |
| Underweight | 59 | 11.3 |
| Normal weight | 57 | 10.6 |
| Fever |  |
| No | 172 | 32.9 |
| Yes | 351 | 67.1 |
| Malaria |  |
| No | 338 | 62.6 |
| Yes | 185 | 35.4 |
| Cough |  |
| Yes | 213 | 40.7 |
| No | 308 | 59.3 |
| Child birth weight |  |
| Normal | 447 | 85.6 |
| Low birth weight | 75 | 14.3 |
| De-wormed |  |
| Yes | 240 | 45.9 |
| No | 283 | 54.1 |
| Sleep under mosquito net |  |
| Yes | 380 | 72.8 |
| No | 142 | 27.2 |
| Gender |  |
| Female | 257 | 49.1 |
| Male | 275 | 50.9 |
| Age (months) |  |
| 2–5 | 59 | 13.4 |
| 6–11 | 90 | 17.2 |
| 12–23 | 155 | 29.6 |

| **Table 1 (continued)** |  |
| --- | --- |
| 24–59 | 219 | 41.9 |
| **Husbands' characteristics** |  |
| Age category |  |
| 15–24 | 85 | 16.3 |
| 25–34 | 239 | 45.7 |
| 35–49 | 199 | 38.0 |
| Educational level |  |
| No education | 76 | 14.5 |
| Primary | 296 | 56.2 |
| Secondary | 150 | 28.7 |
| **Household characteristics** |  |
| Poverty level (US$1.90/day) |  |
| Below poverty line | 500 | 95.6 |
| Above poverty line | 23 | 4.4 |
| Keep pigs around |  |
| Yes | 59 | 11.3 |
| No | 464 | 88.7 |
| Keep goats around |  |
| Yes | 117 | 22.4 |
| No | 406 | 77.6 |
| Number of children |  |
| 1–2 | 283 | 54.4 |
| 3–4 | 162 | 31.0 |
| 5 and more | 75 | 14.4 |
| Walls of house |  |
| Mud/sticks | 387 | 74.1 |
| Bricks | 135 | 25.8 |
| Roof of house |  |
| Grass thatched | 455 | 87.0 |
| Iron sheets | 67 | 12.8 |
| Indoor residual spraying (IRS) | 0 | 0 |

### Results

**Socio-demographic characteristics of study population**

Socio-demographic and malaria infection data for all 523 selected children aged 2 to 59 months were obtained over 4 months (see Table 1). In terms of gender, 49.1% of the children were girls and 50.9% were boys. In terms of age, 13.4% of the sample was aged 2 to 5 months, 17.2% was aged 6 to 11 months, 29.6% was aged 12 to 23 months, and 41.9% was aged 24 to 59 months. It was observed that 14.3% of the selected children were born with a low birth weight (birth weight of less than 2.5 kg); 27.2% of the mothers reported that their children did not sleep under mosquito nets the night before the survey; 67.1% of mothers reported that their children had signs of fever 30 days preceding the survey. The study found that 42.0% of the children were stunted, and 11.3% were underweight.
In terms of parental characteristics, the study found that 15.3% of the mothers had no formal education, 68.1% had a primary education and 16.6% had a secondary education. Seventy-five per cent (n = 392) of the mothers reported that they experienced IPV perpetrated by their current or most recent partner in the past 12 months. Regarding age, 7.5% of the mothers were 15 to 19 years old, 57.3% were 30 to 39 years old, 29.6% were 30 to 39 years old, and 5.5% were 40 to 49 years old. The results show that 88.7% (n = 464) of the mothers reported that they had received childcare counselling during their pregnancy. With respect to the fathers, the study found that 14.5% (n = 76) had no formal education, 56.2% (n = 296) had a primary education, and 28.7% (n = 150) had a secondary education. Slightly fewer than half of the husbands (43%) were beer drinkers and a quarter (26%) were tobacco smokers.

The study found that 11.3% (n = 59) of the households had pigs and 22.4% (n = 117) had goats in kraals/sheds close to their dwelling. Regarding house construction materials, 25.8% (n = 135) of the children lived in brick-walled houses, and only 12.8% (n = 67) lived in iron-roofed houses.

### Prevalence and factors associated with child malaria in bivariate and multivariate analyses

The study found that 35% of children (n = 185) were diagnosed with the malaria parasite within 48 h prior to the research interview. There was no gender difference in malaria cases among the sampled children ($\chi^2 = 0.00$, $df = 1$, $p = 0.987$). Unadjusted logistic regressions (Table 2) indicated that children of mothers who had no formal education were more likely to be diagnosed with malaria.

### Table 2 Crude and adjusted odds ratios (95% CI) for factors associated with child malaria in the Dowa district

| Variables                  | Crude OR (95% CI) | $P$-value | Adjusted OR (95% CI) | $P$-value |
|----------------------------|------------------|-----------|-----------------------|-----------|
| Mother’s education         |                  |           |                       |           |
| No education               | 2.92 (1.44–5.91) | 0.003     | 2.77 (1.24–6.19)      | 0.013     |
| Primary                    | 1.12 (0.69–1.80) | 0.656     | 1.07 (0.62–1.87)      | 0.806     |
| Secondary                  | 1                |           | 1                     |           |
| Child’s age (months)       |                  |           |                       |           |
| 2–5                       | 0.14 (0.07–0.26) | 0.000     | 0.21 (0.10–0.46)      | 0.000     |
| 6–11                      | 0.26 (0.16–0.44) | 0.000     | 0.43 (0.22–0.85)      | 0.016     |
| 12–23                     | 0.64 (0.40–1.02) | 0.063     | 0.91 (0.52–1.57)      | 0.136     |
| 24–59                     | 1                |           | 1                     |           |
| Child de-wormed            |                  |           |                       |           |
| No                        | 2.61 (1.79–3.82) | 0.000     | 1.42 (0.84–2.39)      | 0.191     |
| Yes                       | 1                |           | 1                     |           |
| Child’s ITN use            |                  |           |                       |           |
| Yes                       | 0.47 (0.30–0.75) | 0.001     | 0.72 (0.43–1.20)      | 0.200     |
| No                        | 1                |           | 1                     |           |
| Husband’s age              |                  |           |                       |           |
| 15–24                     | 0.55 (0.33–0.91) | 0.021     | 0.83 (0.47–1.54)      | 0.588     |
| 25–34                     | 1.09 (0.73–1.63) | 0.678     | 1.24 (0.78–1.96)      | 0.362     |
| 35–49                     | 1                |           | 1                     |           |
| IPVAM (control)            |                  |           |                       |           |
| Yes                       | 1.83 (1.22–2.74) | 0.003     | 1.88 (1.19–2.97)      | 0.007     |
| No                        | 1                |           | 1                     |           |
| Confidant                  |                  |           |                       |           |
| Yes                       | 0.64 (0.43–0.99) | 0.48      | 0.70 (0.43–1.12)      | 0.136     |
| No                        | 1                |           | 1                     |           |
| Mother’s age               |                  |           |                       |           |
| 15–19                     | 0.37 (0.12–1.19) | 0.096     | 0.39 (0.11–1.48)      | 0.168     |
| 20–29                     | 0.40 (0.13–1.07) | 0.068     | 0.45 (0.15–1.34)      | 0.152     |
| 30–39                     | 0.31 (0.11–0.86) | 0.025     | 0.29 (0.10–0.90)      | 0.032     |
| 40–49                     | 1                |           | 1                     |           |

1 is a reference category
the malaria parasite than children of mothers with a secondary school education (crude odds ratio (COR): 2.92, 95% CI 1.44–5.91, \( P = 0.003 \)). Children who were in the age range of 2 to 5 and 6 to 11 months were less likely to be diagnosed with malaria compared to children who were in the age range of 24 to 59 months (COR: 0.14, 95% CI 0.07–0.26, \( P = 0.000 \) and COR: 0.26, 95% CI 0.16–0.44, \( P = 0.000 \), respectively). Children whose mothers experienced IPV in the form of controlling behaviour in the past 12 months were more likely to be diagnosed with the malaria parasite than children whose mother did not (COR: 2.92, 95% CI 1.44–5.91, \( P = 0.003 \)). Children who were consistently sleeping under mosquito nets were less likely to be diagnosed with the malaria parasite than children who were not regularly sleeping under the net (COR: 0.45, 95% CI 0.30–0.75, \( P = 0.001 \)). Children who did not receive de-worming drugs were more likely to be diagnosed with the malaria parasite than children who were de-wormed (COR: 2.61, 95% CI 1.79–3.82, \( P = 0.000 \)). Children whose mothers had female confidants were less likely to be diagnosed with the malaria parasite than children whose mothers had no confidant (COR: 0.64, 95% CI 0.43–0.99, \( P = 0.048 \)). Children whose fathers were in the age range of 15 to 24 years old were less likely to suffer from malaria than children whose fathers were in the age range of 35 to 49 (COR: 0.55, 95% CI 0.33–0.91, \( P = 0.021 \)). Finally, children whose mothers were in the age range of 30 to 39 years old were less likely to suffer from malaria than children whose mothers were 40 to 49 years old (COR: 0.14, 95% CI 0.07–0.26, \( P = 0.000 \)).

In multivariable analysis (Table 2), the odds of children being diagnosed with malaria was higher among children whose mothers had no formal education than among children whose mothers had a secondary education (AOR: 2.77, 95% CI 1.24–6.19, \( P = 0.013 \)). It was also found that children whose mothers had experienced IPV in the form of controlling behaviour in the past 12 months had higher odds of being diagnosed with the malaria parasite compared to children whose mothers did not experience IPV in the past year (AOR: 1.88, 95% CI 1.19–2.97, \( P = 0.007 \)). Children who were 2 to 5 and 6 to 11 months old were less likely to suffer from malaria than children who were 24 to 59 months old (AOR: 0.21, 95% CI 0.10–0.46, \( P = 0.000 \) and AOR: 0.43, 95% CI 0.22–0.85, \( P = 0.016 \), respectively). Finally, children of mothers who were 30 to 39 years old were less likely to be diagnosed with the malaria parasite than children whose mothers were 40 to 49 years old (AOR: 0.29, 95% CI 0.10–0.90, \( P = 0.032 \)).

**Discussion**

This study examined the prevalence of and risk factors for malaria infection among children 2 to 59 months old in order to contribute to the understanding of various socio-demographic determinants associated with poor child health in rural areas of the Dowa district in Malawi. The prevalence of child malaria in this study area was 35.4%, which was equivalent to the national malaria prevalence in 2017 (36%) [3] and just slightly lower than malaria prevalence in central and rural Malawi, at 39.7 and 40.6%, respectively. This finding raises concerns regarding whether long-lasting insecticidal nets (LLINs) and sulfadoxine-pyrimethamine preventive treatment programmes, that were introduced in the study area in 2007 and 2006, respectively and were still running in 2019, are associated with the reduction in malaria prevalence. But a study by Mwendera et al. [29] observed that malaria reduction programmes in Malawi are facing various challenges, including the failure to understand the social cultural context in the uptake of the malaria control programmes. Another study in Malawi suggested that a limited number of health workers and poor prescription of anti-malarial drugs were some of the challenges that constrain malaria prevention in Malawi [30]. In the preceding paragraphs, the study identified risk factors that were significantly associated with child malaria infection in the study areas.

This study found that mothers’ exposure to IPV in the form of controlling behaviour was a significant determinant of malaria infection in children under 5 years of age. The current study supports the findings of a study in South Asia where IPV against women was found to be a predisposing factor for child cough, malaria and diarrhoea [31]. In Tanzania, a nationally representative study also found that children of mothers who were exposed to any form of IPV were at high risk of suffering from fever, cough and diarrhoea [32]. Two explanations can be offered for the observed association between controlling behaviour IPV and child malaria. First, it was anticipated that husbands’ controlling behaviour constrained mothers’ capacity to implement preventative measures suggested by childcare counsellors, including regularly sleeping under the mosquito net. It was also speculated that mothers who were experiencing IPV were more likely to be depressed, which may have compromised their capacity to take care of children [33].

In addition, this study found that children of mothers who had no formal education were more likely to suffer from malaria compared to children whose mothers had a secondary education. This reflects findings from a regional study in SSA, which found that households where children of mothers with a sixth-grade education or higher had lower odds of suffering from malaria.
(OR = 0.73) compared to children of mothers with lower levels of education [34]. The finding can be explained by a study in Malawi, which found that mothers with higher levels of education were more knowledgeable about malaria prevention and signs, and were therefore more proactive and reactive with regard to prevention than mothers with lower levels of education [35].

Furthermore, this study found that children who were over 2 years old had higher odds of being diagnosed with malaria infection than younger children. This is consistent with other studies which reported that malaria prevalence increases with child age [4, 36]. This may be because younger children in Malawi share a bed with their mothers and are more likely to be covered properly with a blanket or mosquito net than older children. This suggestion is supported by studies in Uganda and other parts of Africa where children who were sharing their mother’s bed were more likely to sleep under a mosquito net compared to children who were not sharing a bed with their mother [37, 38]. Another explanation is that the majority of children in Malawi are weaned from breastfeeding at the age of 2, after which they receive less caregiver attention and have an increased risk of exposure to malaria vectors [39].

Finally, the current study found that children of mothers between 30 to 39 years old were less likely to be diagnosed with malaria than children of mothers between 40 to 49 years old. This finding was surprising, as it was initially assumed that children born from adolescent mothers (16–19 years) would be at higher risk of malaria diagnosis than children born of mothers 40 to 49 years. This suggests that children of both adolescent mothers and older mothers may be at risk of poor health outcomes. This support findings from earlier studies. A longitudinal study in South Africa observed similar prevalence of low birth weight among children of adolescent and adult mothers (aged [40]), and a study in Kenya found that the survival rate of children of adolescent mothers was similar to that of children of older mothers (aged [41]). Therefore, a suggestion is made that child malaria mitigation programmes in Dowa district should also pay attention to the needs of older mothers.

Implications for practice

The results of the study demonstrate that malaria infection among children under 5 is an important public health problem in rural areas of the Dowa district. To address the problem, it is imperative that in addition to the available interventions such as LLINs and sulfadoxine-pyrimethamine preventive treatment programmes, health planners should also consider developing malaria control programmes that accommodate mothers without formal education. For example, the community-based, peer-to-peer, malaria education model has been an effective tool for behavioural changes in selected rural areas of southern Malawi, and may be applicable [42, 43].

The study also suggest that malaria control programmes in Dowa district should incorporate interventions that address IPV against mothers of young children. The current malaria proactive programmes in the Dowa district are gendered as they mainly target mothers by providing them with ITNs and by administering anti-malarial drugs during pregnancy. There is a need to involve fathers in all programmes that address child malaria. One such intervention could be a community-based participatory child malaria programmes that involve both men and women, as this has been found to improve fathers’ participation in childcare activities in similar contexts [44].

Finally, health professionals should consider engaging parents to find health promotion strategies that can reduce the risk of malaria among children 2 to 5 years old. The interventions should consider the developmental stages of children, geographical space, and the times of day and night that predispose these children to malarial vectors. For example, application of mosquito repellents can protect children from mosquito bites both indoors and outdoors. However, because current evidence on the effectiveness of repellents in the prevention of malaria in developing contexts is inconclusive, more research is needed before this intervention is adopted [45–47].

Strengths and limitations of the study

The main strength of this study is that it is based on a systematic sampling technique and therefore, the findings can be generalized to all children 2 to 59 months old who accessed primary health care services in the studied clinics. Nevertheless, this study has some limitations. First, the study was conducted during the dry season, a period with significantly fewer mosquito-breeding sites compared to the wet season. Therefore, the findings do not represent seasonal variations in malaria prevalence. A suggestion is made that a longitudinal study should be conducted in order to provide a broader picture of malaria infection prevalence and risk factors in the study area. This study also used a cross-sectional design and as such, no causal inference can be made regarding the identified determinants and child malaria infection. Despite these limitations, the study has identified potential risk factors for malaria infection among children under 5 in rural areas of the Dowa district that can inform local programmes.

Conclusion

The current study shows that the prevalence of malaria infection among children aged 2 to 59 months in rural areas of Dowa district was at 35.4%, which is equivalent
to the prevalence of the phenomenon at the national level in 2017. Apart from well-known risk factors of child malaria infection such as child age range (24 to 59 months) and lack of maternal formal education, the study identified that maternal exposure to IPV is also a risk factor. Therefore, apart from increasing the distribution of treated mosquito nets and malaria screening, child malaria programmes in Dowa should also consider addressing IPV against mothers.

Abbreviations
AOR: Adjusted odds ratios; CI: Confidence interval; IPV: Intimate partner violence; ITN: Insecticide-treated bed nets; NMCP: National Malaria Control Programme; NSO: National Statistics Office; RDT: Rapid diagnostic test; SRF: Self-reporting questionnaire; SSA: Sub-Saharan Africa; USS: United States dollar; WHO: World Health Organization.

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Authors' contributions
EC designed the study, collected and analysed the data, and wrote the first draft of the manuscript. DCV, HM and CM supervised the study design, data analysis and writing. KC supported the writing of the draft manuscript. All authors read and approved the final manuscript.

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Availability of data and materials
The study involved generating sensitive data according to WHO standards. We documented mothers' disclosures of violence by their current husbands. Due to the sensitivity of the study, the two ethics boards did not recommend sharing the raw data publicly.

Ethics approval and consent to participate
We received research ethics approval from the Non-Medical Research Ethics Board at University of Livingstonia in Malawi (UNLVA-REC-4/18), and at McGill University, Canada (REB File #: S03-0518). The study also received written consent from the Dowa district health office. Informed consent was obtained from all participants before each interview.

Consent for publication
We informed the participants that the study will be published to partially fulfill the requirement for a PhD. With full understanding of the research and its intended purpose, all participants gave full consent for us to publish the findings.

Competing interests
We declare no competing interests.

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