New Microbiologica, 48, 3, 226-233, 2025, ISSN 1121-7138

FULL PAPER

Determinants of loss to follow-up among pregnant women living in a high malaria burden setting in Northern Uganda

Jerry Ictho[1]*, Francesco Vladimiro Segala[2-3]*, Roberta Novara[2]*, Nelson Olung[4], Giulia Patti[2], Roberta Papagni[2], Gloria Atim[4], Valentina Totaro[2], Lameck Olal[4], Elda De Vita[2], Jacqueline Adongo[4], Mariangela L'episcopia[5], Samuel Okori[4], Giovanni Dall'Oglio[1], Giovanni Putoto[6], Annalisa Saracino[2], Francesco Di Gennaro[2], Peter Lochoro[1]

[1] *Doctors with Africa, CUAMM, Kampala, Uganda;*
[2] *Clinic of Infectious Diseases, Department of Precision and Regenerative Medicine and Ionian Area, University of Bari "Aldo Moro", Bari, Italy;*
[3] *Doctors with Africa CUAMM, Beira, Mozambique*
[4] *St. John XXIII Hospital Aber, Oyam District, Uganda;*
[5] *Department of Infectious Diseases, Istituto Superiore di Sanità, Rome, Italy;*
[6] *Operational Research Unit, Doctors with Africa CUAMM, Padua, Italy;*
* *These authors have contributed equally*

SUMMARY

Malaria remains a significant global health challenge, disproportionately affecting Sub-Saharan Africa. Pregnant women represent one of the most vulnerable populations. Despite numerous advances in malaria control measures, lost-to-follow-up (LTFU) in antenatal care (ANC) programs poses a critical barrier to achieving optimal maternal and neonatal outcomes and the success of public health interventions. The factors driving LTFU, particularly in rural, high-burden settings, are not completely understood. This study investigates the determinants of LTFU among pregnant women receiving malaria screening in the context of the ERASE-Rise Against Malaria project in Northern Uganda. An observational retrospective cohort study was conducted on 1,558 women, recruited from July 2022 to June 2024, during the operational research held to assess the impact of antimalarial resistance on malaria care among pregnant women in three healthcare facilities in Oyam and Kole districts. Data on individual level (sociodemographic and clinical) and health care-related factors were analyzed using a multilevel logistic regression model to identify predictors of LTFU, defined as the absence of cohort outcome data 30 days after the expected delivery date. Efforts to recover missing data included delivery register consultation, active phone calls, and contact tracing by village health team workers. 871 (55.9%) of the 1,558 women were LTFU. Recovery strategies reduced the missing data rate to 29.1% (n=454). Protective factors against LTFU included higher education (aOR=0.75, 95% CI: 0.54–1.03, p=0.0798), being primigravida (aOR=0.73, 95% CI: 0.56–0.97, p=0.0275), and experiencing malaria during pregnancy (aOR=0.61, 95% CI: 0.48–0.78, p<0.0001). Women attending Aboke Health Center IV (n=385) were over five times more likely to be LTFU than those at Aber Hospital (n=955) (aOR=5.57, 95% CI: 4.08–7.71, p<0.0001), highlighting significant geographic and structural barriers. The high rate of LTFU in malaria screening programs underscores the need for targeted interventions addressing individual, systemic and structural barriers. Strengthening community-level support, improving healthcare infrastructures, and integrating malaria prevention into broader maternal health services are crucial for enhancing retention in care. Addressing determinants of LTFU, systematically, through further qualitative and quantitative research, is essential to improving maternal and neonatal health outcomes and achieving malaria eradication goals in high-burden settings.

Received May 16, 2025 *Accepted* July 17, 2025

Keywords:
Malaria, low-and-middle income country, malaria in pregnancy, loss to follow-up.

Corresponding author:
Francesco Vladimiro Segala
E-mail: fvsegala@gmail.com

INTRODUCTION

Malaria remains a significant public health challenge globally. It disproportionately affects populations in low- and middle-income countries, particularly in Sub-Saharan Africa. In Uganda, the third highest burden country, malaria is the leading cause of morbidity and mortality, particularly in pregnant

women and children under five (World Health Organization, 2024a).

As in other infectious diseases (Frallonardo *et al.*, 2023), pregnancy remains an important risk factor for both acquisition of the infection and development of severe disease, and is associated with adverse health outcome for both the mother and the infant (Desai *et al.*, 2007). In 2023, malaria affected 12.4 million pregnant women living in moderate- to high-transmission countries (World Health Organization, 2024a), with younger women, primigravidae, and women living with HIV (Obase, Bigoga & Nsagha, 2023) facing the greatest risk. The highest rate of infection is documented in the second trimester. Intermittent preventive treatment (IPTp) and early detection represent the main strategies to reduce malaria incidence and mortality (Bangirana *et al.*, 2023) among pregnant women. Although, globally, the percentage of pregnant women attending the Antenatal Care (ANC) clinic at least once has reached the target of 80% and IPTp coverage reached its highest historical level, many challenges persist (World Health Organization, 2024a). Significant barriers to ANC and IPTp include gender-related and social determinants, family and community influences, poor infrastructure and sociodemographic factors, emphasizing the need for community-targeted interventions. Restricted financial resources, low levels of education and poor decision-making hinder women's capacity to protect themselves and their children, as well as to receive timely diagnosis and treatment (World Health Organization, 2024b). Furthermore, the emergence and spread of resistance to sulfadoxine-pyrimethamine (Flegg *et al.*, 2022) could slow and endanger the control programs currently in place.

One critical issue undermining maternal health programs in malaria-endemic settings is the high rate of lost-to-follow-up (LTFU) among pregnant women attending ANC. LTFU represents a missed opportunity to ensure continuity of care, impacting both maternal and neonatal health outcomes and the validity of operational research findings. Factors driving LTFU in malaria prevention and treatment programs are poorly understood, particularly in high-transmission rural settings, where structural, cultural, and individual barriers intersect. Moreover, evidence-based strategies to mitigate LTFU and improve adherence to such programs are still lacking.

The aim of this study is to explore the determinants of LTFU among pregnant women enrolled in malaria screening and care programs in the Oyam and Kole districts of Northern Uganda during the operational research conducted in the context of the ERASE–Rise Against Malaria project (Segala *et al.*, 2022). By identifying predictors of LTFU and evaluating the impact on maternal and neonatal outcomes, we aim to provide actionable recommendations to improve retention in malaria care programs for pregnant women in similar high-burden settings.

METHODS AND MATERIALS

Study design

The present study was designed as an observational retrospective cohort study conducted on a population of 1,558 pregnant women attending antenatal care and receiving malaria screening in the context of the broader research project ERASE – Rise Against Malaria project in Oyam and Kole District, Northern Uganda, conducted from July 2022 to June 2024.

The detailed study protocol has been registered on ClinicalTrials.gov repository (NCT05348746) and has been published elsewhere (Segala *et al.*, 2022).

The main objectives of the ERASE project were to assess the incidence of malaria and the incidence of malaria-related adverse maternal and fetal outcomes. Clinical assessments and malaria screening through microscopic examination of thick and thin blood smears were conducted at each ANC visit.

For all pregnant women with microbiologically confirmed malaria, the presence of molecular markers for resistance to sulfadiazine-pyrimethamine (DHFR and DHPS loci) and artemisinin derivatives (kelch13 locus) was analyzed using dried blood spots. These samples were transferred to the Italian National Institute of Health (Istituto Superiore di Sanità, ISS) for molecular diagnosis and advanced *P. falciparum* polymorphism analysis (unpublished data).

Study population and setting

The study was conducted at St. John XXIII Hospital of Aber and at two health centers-Atipe Health Center (HC) and Aboke Health Center (HC-which are third- and fourth-level facilities located in the districts of Oyam and Kole in the Lango Region of Uganda. All study sites were in rural areas with high malaria incidence. According to the most recent Uganda Malaria Indicator Survey (Uganda National Malaria Control Division (NMCD), Uganda Bureau of Statistics (UBOS), and ICF, 2020), Oyam and Kole districts reported 407 and 361 new malaria cases per 1,000 inhabitants, respectively, compared to the national average of 289 new cases per 1,000 inhabitants.

All pregnant women presenting to the antenatal care clinic between July 14, 2022 and October 10, 2024 were eligible for recruitment. The study protocol was approved by Lacor Hospital Research and Ethics Committee (prot. no. LACOR-2022-95). All women included in the study provided written informed consent.

Study outcome

Lost-to-follow-up has been defined as not having outcome data 30 days after the expected date of delivery. Individual level (socio-demographics and clinical) characteristics and healthcare-related factors have been collected and analyzed to understand the correlations with being LTFU.

Strategies to recover outcome delivery data have been implemented to reduce the percentage of missing data and the impact of LTFU on overall operational research results. These included:

- *study center delivery register consultation* (Aber Hospital, Atipe HC III, Aboke HC IV);
- *government health facilities delivery register consultation* (mostly the health centers near the village of the mother);
- *active phone calls,* when the phone number was available;
- *active contact tracing through Village Health Team workers* (VHTs), knowing the place of residence (district, village, parish) of the study participants.

When a pregnant woman reported having delivered at home, information on the delivery outcome and the reason for not delivering at the study centers were collected, as specified in the operational research protocol.

Statistical analysis

To investigate the associations between being lost-to-follow-up (LTFU) and the characteristics of both pregnant mothers and antenatal care (ANC) assistance, a multilevel logistic regression model was employed, incorporating a random intercept. This modeling approach allowed to account for the hierarchical nature of the data by considering two levels: individual-level characteristics (level 1) and healthcare facility-level characteristics (level 2). Binomial logistic regression analyses were initially performed to explore the univariate relationships between LTFU and a range of maternal and healthcare-related characteristics (Model 1). Building on these findings, two multivariable logistic regression models were developed to further examine these associations. The first (Model 2) focused exclusively on individual-level variables, while the second (Model 3) included both individual- and healthcare facility-level factors to account for influences attributable to ANC quality of care. To highlight the contribution of healthcare-level factors to the observed outcomes, the proportion of variance attributable to the clustering effect was estimated. The selection of variables for inclusion in the multivariable models (both Model 2 and Model 3) was guided by a stepwise approach. This approach considered (1) variables that were statistically significant in univariate analyses, (2) the theoretical importance of each factor based on existing literature and clinical relevance, and (3) model performance as assessed using the Akaike Information Criterion (AIC). The following null hypothesis (H0: OR=1) was tested with its alternative (Ha: OR≠1) considering 0.05 (type I error or α) significance level and (1-α) % confidence intervals. OR >1 meant reciprocal association between response and explanatory or control variables, whereas OR <1 meant that this relationship was non-reciprocal. Lastly, OR=1 meant no association (null effect). Statistical analysis was conducted using RStudio software (version 2024.04.2+764).

RESULTS

The cohort study included 1,558 pregnant women. The mean age at enrollment was 25 years (SD 5.67). Overall, 1,266 women (81.2%) had attained primary education, 261 (16.7%) had completed secondary education or higher, and 29 (1.9%) had no formal education. Only 7.1% of participants were formally employed, with farming being the predominant occupation (69.4%). A high percentage of participants were married (94.7%).

Among the included women, 22% (n=344) were primigravidae, while 19.7% (n=307) were multiparous (having four or more pregnancies). The mean gestational age at recruitment was 25.7 weeks (SD 6.98), indicating that participants were enrolled in the mid to late stages of pregnancy. A total of 84 women (5.4%) were living with HIV. More than 45% (n=703) of the women experienced anemia during pregnancy, 442 (29.7%) had at least one episode of uncomplicated malaria, and 172 (11%) had at least one episode of severe malaria (*Table 1*).

Healthcare-related characteristics showed significant variability. A total of 955 participants (61.3%) were enrolled at Aber Hospital, 385 (24.7%) at Aboke Health Center, and 218 (14%) at Atipe Health Center. The mean duration of follow-up from recruitment to delivery was 12.6 weeks (SD 7). High coverage of intermittent preventive treatment in pregnancy (IPTp) was observed (82.1%), reflecting a strong commitment to malaria prevention. Additionally, 94.3% of participants adhered to the malaria screening protocol during antenatal care (ANC) visits.

The overall loss-to-follow-up (LTFU) at delivery was notably high, reaching 55.9% (n=871). Among those lost to follow-up for whom information was available, 5.9% delivered at home. To minimize the impact on research outcomes, various strategies were implemented to recover delivery data, reducing the percentage of missing data among the LTFU by 29.1%. Among the 72 pregnant women lost to follow-up who were successfully contacted via phone calls or active tracing, the main reasons for not delivering at the study center included lack of transportation (29.2%) (*Table 2*), precipitous labor (22.2%), and relocation into another area (11.1%).

Univariable and multivariable logistic regression analyses identified several individual- and healthcare-level predictors of LTFU (*Table 3*). In univariable analysis, having attained at least a secondary education (OR=0.73, 95% CI: 0.55-0.95) was protective against LTFU; however, this association lost significance after adjusting for cofactors. Conversely, after controlling for both individual- and healthcare-level

Table 1 – *General characteristics of the population.*

	Overall (N=1558)
Participant-level factors	
Age at enrolment	
Mean (SD)	25.0 (5.67)
Missing	2 (0.1%)
Educational level	
No education	29 (1.9%)
Lower primary	714 (45.8%)
Upper primary	552 (35.4%)
Lower secondary	159 (10.2%)
Upper secondary	50 (3.2%)
Tertiary	52 (3.3%)
Missing	2 (0.1%)
Occupation	
Employed	110 (7.1%)
Farming	1082 (69.4%)
Housewife	268 (17.2%)
Tailor	97 (6.2%)
Missing	1 (0.1%)
Religion	
Anglican/protestant	435 (27.9%)
Catholic	961 (61.7%)
Muslim	11 (0.7%)
Other	148 (9.5%)
Missing	3 (0.2%)
Marital status	
Never married	58 (3.7%)
Married	1476 (94.7%)
Divorced	23 (1.5%)
Missing	1 (0.1%)
Gravidity	
≥ 4	307 (19.7%)
1-3	890 (57.1%)
Primigravida	344 (22.1%)
Missing	17 (1.1%)
Gestational age at recruitment, mean (SD)	25.7 (6.98)
Syphilis during pregnancy	8 (0.5%)
Self-reported alcohol consumption	14 (0.9%)
HIV status	
HIV NEGATIVE	1474 (94.6%)
PLWH*	84 (5.4%)
Anemia (Hb < 11 g/dl) during pregnancy	703 (45.1%)
At least one episode of malaria during pregnancy	462 (29.7%)
Missing	3 (0.2%)
At least one episode of severe malaria during pregnancy	172 (11.0%)
Healthcare-level factors	
Study center	
Aber	955 (61.3%)
Aboke	385 (24.7%)
Atipe	218 (14.0%)
Duration of follow-up	
Mean (SD)	12.6 (7.00)
Missing	400 (25.7%)
Folic acid administration	
Always administered	1059 (68.0%)
Always taken	234 (15.0%)
Otherwise	265 (17.0%)
Ferrous sulfate administration	
Always administered	51 (3.3%)
Always taken	1425 (91.5%)
Otherwise	82 (5.3%)
IPTp* administration	
Always administered	1279 (82.1%)
Always skipped	0 (0%)
Otherwise	279 (17.9%)
Blood stain performed at every ANC	1469 (94.3%)
Outcome data	
Lost to follow up at delivery	871 (55.9%)
Home birth	51/871 (5.9%)
Missing	338/871 (38.8%)
Known reason for loss to follow-up	7 /1558 (4.6%)
Lack of transportation	21/72 (29.2%)
Precipitate labour	16/72 (22.22%)
Relocation	8/72 (11.11%)
Economic constraints	2/72 (2.78%)
Other	22/72 (30.56%)

PLWH= people living with HIV; IPTp = Intermittent preventive treatment; ANC = antenatal clinic.

factors, primigravid women were 27% less likely to be LTFU compared to those with at least two prior pregnancies (aOR=0.73, 95% CI: 0.56–0.97).

When considering only individual-level factors, unemployment was identified as a risk factor for LTFU (aOR=1.65, 95% CI: 1.01–2.71, p=0.0447). However, this effect lost significance when healthcare-level factors were included in the analysis (Model 3). Interestingly, experiencing malaria during pregnancy emerged as a protective factor against LTFU (aOR=0.61, 95% CI: 0.48–0.78; p<0.0001) in all 3 models.

Table 2 – *Strategies used to recover data of LTFU mothers.*

Outcome Mothers which outcome data were recovered	454/871 (29.1%)
Strategy adopted (N= 454)	
Active contact tracing	3/454 (0.7%)
Health center delivery register consultation	56/454 (12.3%)
Phone call	5/454 (1.1%)
Study center delivery register consultation	375/454 (82.6%)
Other strategy	1/454 (0.2%)
Missing	15/454 (3.3%)

Table 3 – *Predictors for being Lost to Follow Up.*
Lost to follow up was defined as not having cohort outcome data 30 days after the expected data of delivery. The variable severe malaria has been excluded because it was collinear with the variable malaria (any episode). Multivariable models have been built through stepwise approach, comparing them based on lowest Akaike Information Criterion. The proportion of variance attributable to the healthcare level factors, when compared with the model containing only individual-level variables is 7.8% (p<0·0001).

	Univariable logistic regression		*Multivariable logistic regression*			
			Individual-level		*Individual and healthcare level*	
	OR (95%CI)	*P value*	*aOR (95%CI)*	*P value*	*aOR (95%CI)*	*P value*
Individual level factors						
Age, (years)						
20-30	1	NA				
<20	0.96 (0.76-1.22)	0.7607				
>30	0.97 (0.73-1.28)	0.8204				
Education						
Primary	1	NA	1	NA	1	NA
Secondary or above	0.73 (0.55-0.95)	*0.0183*	0.78 (0.57-1.05)	0.1001	0.75 (0.54-1.03)	*0.0798*
No education	1.67 (0.78-3.89)	0.2036	1.77 (0.78-4.36)	0.1878	1.83 (0.78-4.6)	0.1762
Occupation						
Other	1	NA	1	NA	1	NA
Farming	1.46 (0.98-2.16)	0.0602	1.4 (0.89-2.19)	0.1443	1.05 (0.65-1.67)	0.8537
Tailor	1.01 (0.58-1.74)	0.9828	0.97 (0.55-1.72)	0.9138	1.01 (0.56-1.82)	0.9849
Not occupied	1.63 (1.04-2.55)	*0.0327*	1.65 (1.01-2.71)	*0.0447*	1.28 (0.76-2.16)	0.3623
Marital status						
Married	1	NA	1	NA	1	NA
Divorced	1.78 (0.76-4.66)	0.2045	0.85 (0.65-1.12)	0.2576	1.03 (0.77-1.37)	0.8413
Never married	0.59 (0.35-1)	0.0519	0.86 (0.67-1.12)	0.2651	0.73 (0.56-0.97)	0.0275
Gravidity						
1-3	1	NA	1	NA	1	NA
>4	0.99 (0.76-1.29)	0.9270	0.92 (0.66-1.29)	0.6336	1.03 (0.77-1.37)	0.8413
Primigravida	0.78 (0.61-1)	0.0518	0.82 (0.61-1.1)	0.1813	0.73 (0.56-0.97)	*0.0275*
Gestational age at recruitment	1 (0.98-1.01)	0.5713				
Syphilis during pregnancy	2.38 (0.55-16.25)	0.2902				
PLWH	0.95 (0.61-1.49)	0.8283				
Self-reported alcohol intake	2.92 (0.91-12.93)	0.1014				
Gestational anemia	0.93 (0.76-1.14)	0.4721				
Malaria in pregnancy (any)	0.56 (0.45-0.7)	*>0.0001*	0.54 (0.43-0.68)	*>0.0001*	0.61 (0.48-0.78)	*0.0001*
Severe malaria in pregnancy	0.36 (0.2-0.63)	*0.0003*				
Healthcare-level factors						
Duration of follow-up	1 (0.99-1.02)	0.7693				
Study center						
Aber	1	NA			1	NA
Atipe	1.43 (1.06-1.92)	*0.0179*			1.04 (0.65-1.65)	0.8731
Aboke	6.07 (4.54-8.23)	*>0.0001*			5.57 (4.08-7.71)	*>0.0001*
Folic acid administration						
Skipped at least once	1	NA			1	NA
Always administered	1.46 (1.1-1.95)	*0.0097*			1.32 (0.85-2.07)	0.2165
Fe SO4 administration						
Skipped at least once	1	NA			1	NA
Always administered	0.86 (0.59-1.22)	0.3965				
IPTp administration						
Skipped at least once	1	NA			1	NA
Always administered	0.72 (0.55-0.94)	*0.0167*			0.82 (0.61-1.11)	0.2038

Furthermore, women attending Aboke HC IV were more than five times as likely to be LTFU compared to those attending Aber Hospital (aOR=5.57, 95% CI: 4.08–7.71; p<0.0001). The proportion of variance in LTFU outcomes attributable to healthcare-level factors was 7.8% (p<0.0001), underscoring the importance of addressing facility-specific barriers to improve retention.

DISCUSSION

In our cohort of 1,558 pregnant women living in Northern Uganda, the lost-to-follow-up rate was extremely high (55%). The individual characteristics that showed the greatest impact on being LTFU were educational level, occupation, number of previous pregnancies, and experiencing at least one episode of malaria during pregnancy.

Being primigravida, a well-recognized risk factor for malaria in pregnancy (Desai *et al.*, 2018), has been shown to increase retention in antenatal care. This finding is likely a result of different healthcare-seeking behaviors in accordance with gravidity and delivery outcomes. These variations in healthcare-seeking behaviors may be influenced by factors such as age and past experiences, along with a higher unpaid workload in the household and negative past interactions with the healthcare system that might have influenced perceptions (Segala *et al.*, 2023), such as previous failure in expected service delivery, mistreatment and abuse (Finlayson & Downe, 2013).

In the subset of women for whom the data on the LTFU reason are available, financial barriers and lack of transportation played the biggest role. This is in line with other studies which consistently show that, among pregnant women, economic constrains are the key driver for ANC utilization (Ahinkorah *et al.*, 2021; Ameyaw, 2022). Indeed, limited financial resources can hinder access to healthcare in multiple ways, including the inability to afford transportation to health facilities, out-of-pocket expenses for medical consultations, and indirect costs such as lost wages or childcare (Marotta *et al.*, 2020). For women, these effects are compounded by a gender-based lack of personal agency, both in economic and health decision making. Indeed, treatment seeking for women affected by malaria is often a result of complex dynamics of intra-household negotiation (Ewing *et al.*, 2016). The effect of loss of personal agency in determining pregnancy outcomes among African women has been widely described in the literature (Gage, Wood & Akilimali, 2021; Perrykkad, O'Neill & Jamadar, 2024), but evidence is emerging that empowering women could also have substantial effects in improving malaria control efforts. A recent review conducted by the Gender Equality Toolbox group (Gender Equality Toolbox, 2020) highlighted that addressing gender inequalities in malaria endemic settings has the potential to accelerate burden reduction and disease elimination by integrating malaria care into ANC and designing gender-specific malaria control interventions.

Experiencing malaria, either uncomplicated or severe, emerged as a protective factor, probably reflecting, on the participant level, higher healthcare engagement, higher awareness and adherence to the study protocol. However, it might also reflect a higher commitment of the study personnel in ensuring adequate participant follow-up with increased attention to achieve complete collection of outcome data. In addition, being screened and treated for malaria may have strengthened these women's trust in the healthcare system and the research team, creating positive feedback that improved retention until delivery (Ward, 2017).

Notably, healthcare-level factors accounted for 7.8% of the variance in LTFU outcomes, highlighting the need to address facility-specific barriers to improve retention. Women recruited at Aboke Health Centre had more than five times the risk of being LTFU. It is important to note that this facility was the most distant from the main study center. During the study period, monitoring visits in Aboke were challenged by more frequent data collection gaps than at the other two study centers, suggesting that the higher LTFU rate may reflect reduced engagement from the research team rather than differences in individual healthcare-seeking behavior. Boosting research staff engagement with continuous training and investment in human resources should be considered in further research, especially in rural contexts with little or no previous experience in operational research, such as in Aboke. For this purpose, community and village health team workers can play a pivotal role in bridging gaps in continuity of care by tracking patients, providing health education and ensuring adherence to follow-up protocols (Wang *et al.*, 2024). Ensuring the completion of the antenatal care (ANC) schedule – particularly the delivery of at least four doses of intermittent preventive treatment in pregnancy (IPTp) – remains one of the most vulnerable aspects of maternal health services. This challenge becomes even more pronounced during unexpected health crises, such as the COVID-19 pandemic, highlighting the need for sustained and targeted resource allocation (Segala *et al.*, 2024).

Loss-to-follow-up (LTFU) has significant implications for both individual health outcomes and broader public health efforts. At the individual level, pregnant women lost to follow-up are at increased risk of severe maternal anemia, preterm delivery, low birth weight, and neonatal mortality. In high malaria-endemic settings, it is crucial to raise awareness among pregnant women regarding the risks of *Plasmodium falciparum* infection, while emphasizing the importance of adhering to local antenatal care (ANC) protocols. At the

systemic level, LTFU disrupts the ability to generate accurate estimates of disease prevalence and incidence which, in turn, affects resource allocation, program design, and policy development. Future research should use longitudinal designs to better assess the long-term impact of LTFU on maternal and neonatal health. Given the significant role of healthcare system factors in contributing to LTFU, efforts should focus on strengthening malaria and ANC services, alongside targeted training for healthcare personnel.

Several limitations should be acknowledged. The retrospective cohort design may have introduced biases related to incomplete or missing data. Although significant efforts were made to recover LTFU data through delivery registers, phone calls, and community health worker engagement, the reliance on retrospective data collection may have limited the accuracy and completeness of certain variables. Certain variables, such as occupation, education level, and reasons for LTFU, relied on self-reported data, which is subject to recall bias and social desirability bias. The healthcare facility-specific findings, such as the higher risk of LTFU at Aboke Health Center IV, may be influenced by unmeasured facility-level factors like staffing, infrastructure, or community perceptions, which were not assessed in this study.

CONCLUSIONS

In this cohort study conducted among pregnant women living in Northern Uganda, loss-to-follow-up rates were high. Our findings highlight the urgent need for targeted interventions that address individual, systemic, and structural barriers in malaria screening studies conducted in low- and middle-income countries (LMICs). Strengthening community-based support, improving healthcare infrastructure, and integrating malaria prevention into comprehensive maternal health services are key strategies to enhance retention in care. Future research should investigate the determinants of loss-to-follow-up and evaluate the effectiveness of interventions aimed at reducing it.

Author Contributions

JI, FVS, FDG, PL: Conceptualization; RN, NO, GP, RP, GA, VT, LO, EdV, JA: Data collection and data curation; FVS and ML: data analysis; SO, GDO, GP, AS, PL: Funding acquisition, JI, GDO, PL and GP: project administration; FDG, PL, AS and JI: Supervision and Validation; FVS and RN: writing – original draft, FVS and RP: Writing - review & editing.

Declaration of interest

The Authors have no conflicting interests to declare.

Funding source

The present study was funded by the Italian Agency for Development Cooperation (Agenzia Italiana per la Cooperazione e lo Sviluppo, AICS, Determina no 292, 21/10/ 2021). For this study, funders gave compensation for the contribution of part of the researchers listed as co-authors of the study. The funding body had no role in the design of the study, in the collection, analysis, and interpretation of data, and in the writing of the manuscript.

Ethical Statement

The study was conducted in accordance with the ethical principles outlined in the Declaration of Helsinki and adhered to all applicable local and international guidelines for human research. Ethical approval was obtained from the Lacor Hospital Research and Ethics Committee (Protocol No. LACOR-2022-95). All participants provided written informed consent prior to enrollment. For participants under the age of 18, consent was obtained from a parent or legal guardian in accordance with Ugandan national research guidelines. Confidentiality of participants' data was maintained throughout the study, and all data were anonymized prior to analysis. The study was registered in the ClinicalTrials.gov database (Identifier: NCT05348746).

Data statement

All data used to conduct this study will be made available by the corresponding author upon reasonable request.

References

Ahinkorah B.O., Ameyaw E.K., Seidu A.-A., Odusina E.K., Keetile M., Yaya S. (2021). Examining barriers to healthcare access and utilization of antenatal care services: evidence from demographic health surveys in sub-Saharan Africa. *BMC Health Serv Res*. **21** (1), 125.

Ameyaw E.K. (2022). Uptake of intermittent preventive treatment of malaria in pregnancy using sulfadoxine-pyrimethamine (IPTp-SP) in Uganda: a national survey. *Malar J*. **21** (1), 285.

Bangirana P., Conroy A.L., Opoka R.O., Semrud-Clikeman M., Jang J.H., Apayi C., et al. (2023). Effect of Malaria and Malaria Chemoprevention Regimens in Pregnancy and Childhood on Neurodevelopmental and Behavioral Outcomes in Children at 12, 24, and 36 Months: A Randomized Clinical Trial. *Clin Infect Dis*. **76** (4), 600-608.

Desai M., Hill J,. Fernandes S., Walker P., Pell C., Gutman J., et al. (2018). Prevention of malaria in pregnancy. *Lancet Infect Dis*. **18** (4), e119-e132.

Desai M., ter Kuile F.O., Nosten F., McGready R., Asamoa K., Brabin B., et al. (2007). Epidemiology and burden of malaria in pregnancy. *Lancet Infect Dis*. **7** (2), 93-104.

Ewing V.L., Tolhurst R., Kapinda A., Richards E., Terlouw D.J., Lalloo D.G. (2016). Increasing understanding of the relationship between geographic access and gendered decision-making power for treatment-seeking for febrile children in the Chikwawa district of Malawi. *Malar J*. **15** (1), 521.

Finlayson K., Downe S. (2013). Why Do Women Not Use Antenatal Services in Low- and Middle-Income Countries? A Meta-Synthesis of Qualitative Studies. *PLOS Med*. **10** (1), e1001373.

Flegg J.A., Humphreys G.S., Montanez B., Strickland T., Jacome-Meza Z.J., Barnes K.I., et al. (2022). Spatiotemporal spread of Plasmodium falciparum mutations for resistance to sulfadoxine-pyrimethamine across Africa, 1990-2020. *PLOS Comput Biol*. **18** (8), e1010317.

Frallonardo L., Vimercati A., Novara R., Lepera C., Ferrante I., Chiarello G., et al. (2023). Use of Sotrovimab in a cohort of preg-

nant women with a high risk of COVID 19 progression: a single-center experience. *Pathog Glob Health*. **117** (5), 513-519.

Gage A.J., Wood F.E., Akilimali P.Z. (2021). Perceived norms, personal agency, and postpartum family planning intentions among first-time mothers age 15-24 years in Kinshasa: A cross-sectional analysis. *Plos One*. **16** (7), e0254085.

Gender Equality Toolbox (2020). Gender and Malaria Evidence Review. (https://www.gatesgenderequalitytoolbox.org/malaria/, accessed 3 April 2025).

Marotta C., Pisani L., Di Gennaro F., Cavallin F., Bah S., Pisani V., et al. (2020). Epidemiology, Outcomes, and Risk Factors for Mortality in Critically Ill Women Admitted to an Obstetric High-Dependency Unit in Sierra Leone. *Am J Trop Med Hyg*. **103** (5), 2142-2148.

Obase B.N., Bigoga J.D., Nsagha D.S. (2023). Malaria and HIV Co-Infection among Pregnant Women in Africa: Prevalence, Effect on Immunity and Clinical Management: Review. *Int J Transl Med*. **3** (2), 187-202.

Perrykkad K., O'Neill R., Jamadar S.D. (2024). Sense of self in first-time pregnancy. *Npj Womens Health*. **2** (1), 1-13.

Segala F.V., Di Gennaro F., Ictho J., L'Episcopia M., Onapa E., Marotta C., et al. (2022). Impact of antimalarial resistance and COVID-19 pandemic on malaria care among pregnant women in Northern Uganda (ERASE): protocol of a prospective observational study. *BMC Infect Dis*. **22** (1), 668.

Segala F.V., Ictho J., L'Episcopia M., Olal L., Patti G., Bingom C., et al. (2024) Impact of the COVID-19 pandemic on malaria in pregnancy indicators in Northern Uganda: a joinpoint r. *Pathog Glob Health*.

Segala F.V., Patti G., Olal L., De Vita E., Olung N., Papagni R., et al. (2023). COVID Perceptions among Pregnant Women Living in a Malaria Hyperendemic Rural Region in Uganda: A Cross-Sectional Study. *Am J Trop Med Hyg*. **109** (6), 1363-1367.

Uganda National Malaria Control Division (NMCD), Uganda Bureau of Statistics (UBOS), and ICF (2020). Uganda Malaria Indicator Survey 2018-19.

Wang Y., Wang X., Gurbaxani B., Gutman J.R., Keskinocak P., Smalley H.K., et al. (2024). Modeling the Impact of Proactive Community Case Management on Reducing Confirmed Malaria Cases in Sub-Saharan African Countries. *Am J Trop Med Hyg*. **111** (3), 490-497.

Ward P.R. (2017). Improving Access to, Use of, and Outcomes from Public Health Programs: The Importance of Building and Maintaining Trust with Patients/Clients. *Front Public Health*. **5**: 22.

World Health Organization (2024a). World malaria report 2024. (https://www.who.int/teams/global-malaria-programme/reports/world-malaria-report-2024, accessed 11 December 2024).

World Health Organization (2024b). Global Malaria Programme operational strategy 2024-2030. (https://www.who.int/publications/i/item/9789240090149, accessed 3 April 2025).