Travel Medicine and Infectious Disease 71 (2026) 102976

Contents lists available at ScienceDirect

Travel Medicine and Infectious Disease

journal homepage: www.elsevier.com/locate/tmaid

Knowledge, attitudes and practices of malaria control and prevention in a high-exposure occupational group: A cross-sectional survey of mining workers in Haut-Katanga Province in the Democratic Republic of Congo

Cheng Liang [a], Yanqiu Du [b], Gasto Frumence [d], Xuedan Ke [a], Papy Musas Kasombo [e], Johnny Malu Mukolo [f], Yaping Gu [a], Huayun Zhou [a], Guoding Zhu [a,c], Jiayan Huang [b,*], Jun Cao [a,b,c,**]

[a] National Health Commission Key Laboratory of Parasitic Disease Control and Prevention, Jiangsu Provincial Key Laboratory for Parasite and Vector Control Technology, Jiangsu Provincial Medical Key Laboratory, Jiangsu Institute of Parasitic Diseases, Wuxi, Jiangsu, China
[b] School of Public Health, Global Health Institute, Fudan University, Shanghai, China
[c] Center for Global Health, School of Public Health, Nanjing Medical University, Nanjing, Jiangsu, China
[d] Department of Development Studies, School of Public Health and Social Sciences, Muhimbili University of Health and Allied Sciences, Dar es Salaam, Tanzania
[e] Department of Disease Control, National Public Health Institute, Kinshasa, Democratic Republic of the Congo
[f] Department of Population Health Observatory, National Public Health Institute, Kinshasa, Democratic Republic of the Congo

ARTICLE INFO

Keywords:
Malaria
Mining workers
Knowledge
Attitudes
Practices
Questionnaire

ABSTRACT

Background: Mining workers represent a high-risk occupational population for malaria in the Democratic Republic of Congo. This study aimed to assess the knowledge, attitudes and practices regarding malaria control and prevention among mining workers to inform targeted interventions.

Methods: A cross-sectional survey was conducted among 606 mining workers in Haut-Katanga Province. Data on socio-demographics and KAP regarding malaria were collected using a structured questionnaire. Multivariate logistic regression was employed to explore potential independent determinants of adequate knowledge and poor practice. *P* values less than 0.05 were considered statistically significant.

Results: Totally 485 valid questionnaires were collected, and 365 mining workers (75.3%) were considered to possess adequate knowledge. Multivariate analysis revealed that middle school education level (adjusted OR = 0.37; 95% CI: 0.22–0.64; $p < 0.01$) and working in the early morning or evening shifts were significant barriers to achieving adequate knowledge (adjusted OR = 0.46; 95% CI: 0.24–0.90; $p = 0.02$). For attitudes, most workers were willing to use insecticide-treated bed nets (99.3%) and spray insecticides indoors (94.7%). Highest self-reported preventive practices were wearing long-sleeved clothing (99.3%) and the use of insecticide-treated bed nets (91.1%).

Conclusions: Although majority of mining workers demonstrates adequate knowledge of malaria, a significant "knowledge-practice gap" still exists, enhancing the need to promote acceptance and sustained adoption of preventive practices. Corporate policies should move beyond general education toward visual-based training tailored for miners and subsidized preventive tools at home. The implementation of malaria-specific paid sick leave will also be essential to translate positive attitudes into prompt health-seeking behaviors by removing financial disincentives.

1. Background

Malaria remains a major public health challenge worldwide, with an estimated 263 million cases globally in 2023 by the World Heath Organization (WHO). Sub-Saharan Africa bears the overwhelming majority of this disease burden, and the Democratic Republic of Congo (DRC)

* Corresponding author.
** Corresponding author. National Health Commission Key Laboratory of Parasitic Disease Control and Prevention, Jiangsu Provincial Key Laboratory for Parasite and Vector Control Technology, Jiangsu Provincial Medical Key Laboratory, Jiangsu Institute of Parasitic Diseases, Wuxi, Jiangsu, China.
E-mail addresses: jiayanhuang@fudan.edu.cn (J. Huang), caojuncn@hotmail.com (J. Cao).

https://doi.org/10.1016/j.tmaid.2026.102976
Received 9 October 2025; Received in revised form 16 March 2026; Accepted 27 March 2026
Available online 31 March 2026

is among those countries with highest malaria incidence, reporting over 33 million in recent years [1]. Despite sustained control efforts, malaria transmission remains intense in many regions of the DRC, particularly among those populations living in rural areas [2].

Malaria transmission occurs through the bite of a female *Anopheles* mosquito that carries *Plasmodium*, with exposure risk peaking during evening and early morning hours [3,4]. Preventive measures recommended by the WHO, including long-lasting insecticidal nets (LLINs) and indoor residual spraying (IRS), primarily aim to reduce the density of mosquitoes or human-mosquito contact [5]. Individuals who have more contact opportunities with female *Anopheles* can be recognized as a high-exposure population [6,7].

Mining workers act as a high-exposure occupational population for malaria infection [8]. With the rapid expansion of mining industries in Africa, large number of workers are employed in open-pit or semi-open mining environments, often under 24-h shift systems that require work during peak mosquito biting times. These occupational conditions, combined with frequent population mobility and limited access to tailored health services, place them at an increased risk of infection. For instance, one study have shown that compared to other regions in the DRC, areas with mining and logging workers do have higher prevalence of malaria [9]. Nonetheless, malaria studies on population-based interventions have mainly focused on the general population or biologically vulnerable groups, especially children [10] and pregnant women [11], while high-exposure occupational populations have received relatively little attention [12].

Understanding how mining workers perceive malaria risk and prevention is essential for designing effective, context-specific interventions. Knowledge, attitudes, and practices (KAP) surveys are widely used to identify awareness, behavioral barriers, and opportunities for improving uptake of preventive measures. Although malaria-related KAP studies have been conducted in various endemic countries [13–15], data on mining workers in the DRC remain scarce. Particularly, little is known about how occupational factors such as working environment and shift patterns influence malaria-related knowledge and preventive behaviors in this population.

To address this gap, this present study assessed malaria-related knowledge, attitudes and practices among mining workers in the DRC. Specifically, we aimed to: (1) evaluate the level of KAP regarding malaria control and prevention in this high-exposure occupational group; and (2) identify factors associated with malaria knowledge and practices to inform targeted workplace-based interventions and recommendations.

2. Methods

2.1. Study site and population

The study was conducted in Haut-Katanga Province, which is among the most economically developed regions in the DRC, with extensive mining activity. Kambove, 30 km northwest of Likasi City, is a town with a population of approximately 36,000 and is located in the northwestern part of Haut-Katanga Province. This town is the centre of the Kambove mines region (Fig. 1). Malaria is the most severe infectious disease prevalent in Kambove, and local health officials stated that the predominant parasite species is *Plasmodium falciparum*. In DRC, malaria prevention primarily relies on the distribution of LLINs, and data shows that the overall proportion of households with at least one LLIN is approximately 70% in 2014 [16].

The mining company closest to the settlement in Kambove town was chosen with the reasons of the largest population of mining workers in the region, 24-h shift systems and high-exposure open-pit environments. The mining company was a Chinese foreign joint venture enterprise, including both DRC and Chinese employees. All 606 Congolese employees in the company were invited to participate in this study.

2.2. Study design and implementation

This study adopted a descriptive cross-sectional design using questionnaire survey in September 2019.

Firstly, a structured questionnaire was drafted in Chinese based on the KAP framework. After review and revision, the draft version was translated into French, pretested with two local medical staff members, back-translated into Chinese by an independent professional translator to ensure semantic equivalence, and revised accordingly. The final questionnaire encompassed five main parts: informed consent letter, sociodemographic characteristics, and KAP related to malaria control and prevention. There were 14 questions on knowledge of malaria symptoms, diagnosis, treatment, vectors, and prevention measures; 6 questions on attitudes towards control and prevention; and 8 questions on practices regarding malaria.

Before the investigation, there was a meeting held to inform all

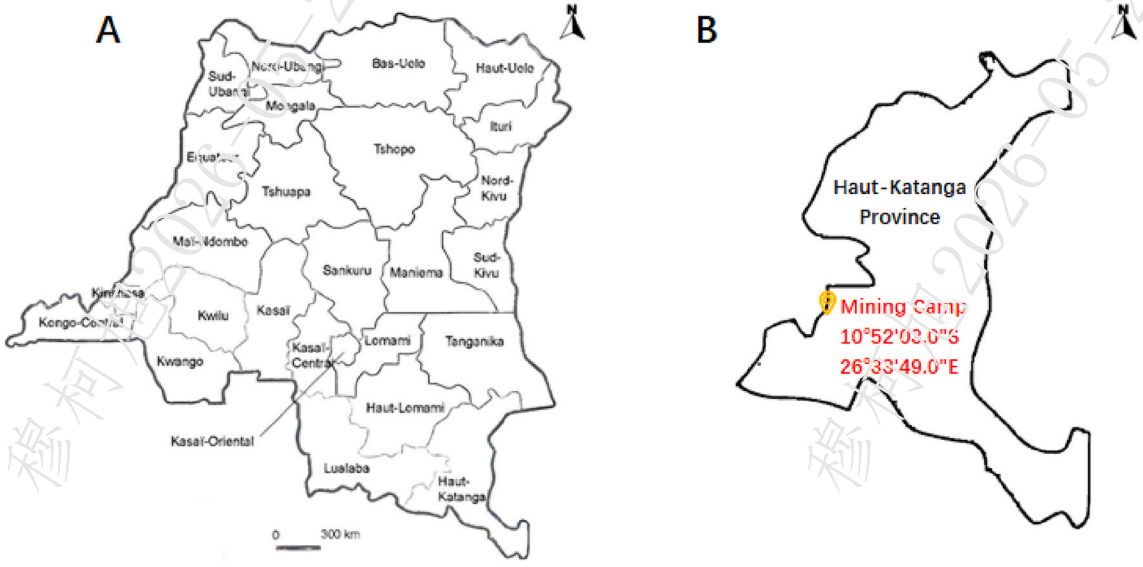

Fig. 1. Schematic diagram of the study site
Shown in panel A is a map of DRC. Shown in panel B is the mine camp where the study site locates in.

mining workers. Then the questionnaire was distributed by each department and collected after completion.

2.3. Data analysis

The exclusion criteria included unsubmitted questionnaires after distribution, and invalid questionnaires with only basic information such as names.

The knowledge segment totally comprised 14 questions. Each correct response was scored as 1 point, and incorrect response as 0 point, resulting in a cumulative knowledge score of 0-14. Following a Bloom's cut-off point of 60% [17], participants with a score of >8.4 were defined as "adequate knowledge". Attitude level was measured on a 5-point Likert scale, ranging from strongly agree, agree, neither agree nor disagree, disagree, to strongly disagree. For 8 items of practices, each positive practice was scored as 1 point, and other practices as 0 point. Similarly to the knowledge segment, with a 60% cut-off point, those scoring <4.8 were defined as "poor practice".

Data were entered into EpiData (version 3.1, Jens M. Lauritsen, Odense, Denmark) and exported into SPSS (version 20.0, SPSS Inc., Chicago, IL, USA) for analysis. Categorical variables were presented as counts and percentages (n%) and were compared using Pearson's chi-square test. When any expected cell count was less than 5 or when the contingency table was sparse, Fisher's exact test (2×2 tables) or the Monte Carlo method (larger tables) was used. To examine the associations between participant characteristics and outcomes, we conducted two-stage logistic regression analyses. Univariate logistic regression models were initially fitted for each candidate predictor to estimate crude odds ratios (ORs) and 95% confidence intervals (CIs), and variables with $p < 0.20$ alongside predefined factors of interest were entered in the multivariable logistic regression model. If none of the variables reached the predefined screening threshold in univariate analysis, a multivariable logistic regression model was constructed based on a priori epidemiological considerations. Specifically, age and sex were included as predefined confounders, and other key variables of theoretical relevance were retained to evaluate their independent associations with the outcome. Multicollinearity was assessed using variance inflation factors (VIF), with values exceeding 5 evaluated for potential redundancy. The final multivariable model was refined through backward stepwise selection ($p < 0.05$ for retention). p values < 0.05 were considered statistically significant.

2.4. Ethical approval

The study protocol was approved by the Institutional Review Boards of Jiangsu Institute of Parasitic Diseases (No. IRB00004221) and reviewed and approved by relevant departments of the mining company. Mining workers may choose not to participate in the survey or may decline to answer certain questions. Each survey respondent provided written informed consent.

3. Results

3.1. Basic characteristics of the study participants

From 606 participants surveyed, we received 555 questionnaires, of these, 70 questionnaires were excluded because they only contained the participants' names without any responses. Finally, 485/606 (80.03%) valid questionnaires were included in the analysis. Demographic characteristics of the study participants are shown in Table 1. Most of the participants were male (95.5%) and aged between 18 and 40 years old (80.4%). 277/485 (57.1%) and 171/485 (35.3%) lived in Kambove town and Likasi city, respectively. Most of the participants (93.2%) had a middle school education or above. In terms of exposure, 286/485 (59.0%) reported that their working environment was located in outdoor, open, or semi-open buildings, and 371/485 (76.5%) said that they needed to work in the early morning or evening. In terms of malaria infection history, 219/485 (45.2%) reported to have been diagnosed with malaria by a doctor within the past year.

Table 1
Socio-demographic characteristics of the study participants.

Items	n (N = 485)	%
Age		
18–29 y	137	28.2
30–39 y	253	52.2
≥40 y	74	15.3
Missing data	21	4.3
Sex		
Male	463	95.5
Female	13	2.7
Missing data	9	1.9
Residential location		
Likasi city	171	35.3
Kambove town	277	57.1
Other area in Haut-Katanga Province	24	4.9
Missing data	13	2.7
Education Level		
Primary school and below	11	2.3
Middle school	259	53.4
Senior high school	37	7.6
College and above	156	32.2
Missing data	22	4.5
Is the work environment located outdoors or in an open or semi-open building?		
Yes	286	59.0
No	131	27.0
Missing data	68	14.0
Do you need to work early in the morning or in the evening?		
Yes	371	76.5
No	61	12.6
Missing data	53	10.9

3.2. Knowledge level about malaria control and prevention

Most participants (93.7%) of participants reported that taking medicines could cure malaria. A majority (90.4%) understood that DRC is a high-risk area for malaria transmission. For symptoms and diagnosis, over half of them correctly identified about diagnostic techniques, including microscopy (76.3%) and rapid diagnostic testing (RDT) (55.8%). Only 25.5% of the participants knew that fever and chills are common symptoms after malaria infection. Only 2.9% knew that *Plasmodium falciparum* is most common type of malaria in the DRC (Table 2).

3.3. Adequate knowledge of malaria in the study participants

The cumulative knowledge scores of the participants regarding malaria control and prevention were calculated. In total, 365 participants who achieved a cumulative score of 8.4 or higher were considered to possess "adequate knowledge". The adequate knowledge rate ranged from 9.1 to 84.2%. Table 3 shows that education level and working time were significantly associated with adequate knowledge (both $p < 0.05$).

3.4. Independent determinants of adequate knowledge

In univariate logistic regression analyses, most sociodemographic and occupational characteristics were not significantly associated with adequate knowledge. Age group, residential location, education level, and working environment showed no statistically significant associations (all p values > 0.20; crude ORs shown in Supplementary materials). Male sex showed a borderline association with adequate knowledge (crude OR = 2.85, 95% CI: 0.94–8.67; $p = 0.07$). In contrast, participants who needed to work early in the morning or in the evening had significantly higher odds of adequate knowledge compared with those who did not (crude OR = 1.99, 95% CI: 1.12–3.54; $p = 0.02$).

After adjusting for potential confounders, education level and

Table 2
Assessment of malaria-related knowledge among participants.

Question (Correct answer)	No. correct answers	No. participants who answered the question	Correct rate %[a]
1. Can taking medicines cure malaria? (Yes)	444	474	93.7
2. Is the DRC a high-risk area for malaria transmission? (Yes)	423	468	90.4
3. Which diagnostic techniques can be used to confirm the diagnosis of malaria? (Microscopy)	358	469	76.3
4. Can people contract malaria through physical contact with someone with malaria? (No)	356	467	76.2
5. Can malaria be prevented by taking medicine? (Yes)	319	467	68.3
6. Do mosquitoes only thrive in water? (Yes)	316	471	67.1
7. Do you know about rapid diagnostic testing (RDT) for malaria? (Yes)	258	462	55.8
8. Can all species of mosquitoes transmit malaria? (No)	211	474	44.5
9. What are the months with a relatively high risk of malaria infection in this region? (Months that alternate between dry and rainy seasons)	175	477	36.7
10. Does the disappearance of symptoms mean that malaria has been cured? (No)	151	470	32.1
11. What outdoor measures can prevent mosquito breeding? (Remove standing water around the house)	131	472	27.8
12. Which symptoms are most common after contracting malaria? (Fever and chills)	120	471	25.5
13. Can malaria be spread through blood transfusions? (Yes)	115	465	24.7
14. What is the most common species of malaria parasites in this region? (*Plasmodium falciparum*)	14	475	2.9

[a] Correct rate % = Number of correct answers/number of participants who answered the question.

Table 3
Adequate knowledge rate in the study participants.

Variables	No. participated	No. adequate[b]	Adequate rate/%	χ2	*p*
Age					
18–29 y	138	104	75.4	0.361	0.835
30–39 y	254	198	78.0		
≥40 y	76	59	77.6		
Missing data	17	-	-		
Sex					
Male	463	356	76.9	3.709	0.054
Female	13	7	53.9		
Missing data	9	-	-		
Residential location					
Likasi city	171	135	79.0	0.637	0.727
Kambove town	277	210	75.8		
Other area in Haut-Katanga Province	24	18	75.0		
Missing data	13	-	-		
Education level					
Primary school and below	11	9	9.1	22.099	<0.001[a]
Middle school	259	218	84.2		
Senior high school	37	25	67.6		
College and above	156	101	64.7		
Missing data	22	-	-		
Working area					
Need to work outdoors	286	220	76.9	0.649	0.421
No need	131	96	73.3		
Missing data	68	-	-		
Working time					
Need to working in the early morning or evening	371	289	77.9	5.588	0.018[a]
No need	61	39	63.9		
Missing data	53	-	-		

Data were analyzed using Pearson's chi-square.
[a] Significant difference.
[b] Adequate knowledge defined as a score >8.4.

working time remained significant predictors (shown in Table 4). Specifically, participants with a middle school education had significantly lower odds of adequate knowledge compared to those with a college education or higher (adjusted OR = 0.37; 95% CI: 0.22–0.64; $p < 0.01$). Individuals required to work during early morning or evening had lower odds of adequate knowledge (adjusted OR = 0.46; 95% CI: 0.24–0.90; $p = 0.02$).

3.5. Attitudes and practices towards malaria control and prevention

Regarding participants' attitudes toward malaria (Fig. 2), the vast majority of participants (98.9%) were willing to seek treatment from medical doctors when symptoms occurred. The use of insecticide-treated bed nets (99.3%) and indoor spraying (94.7%) was more accepcted regarding vector control. Only 75.4% of the participants expressed their willingness to wear long-sleeved clothing, while 81.3% of participants agree that drug prevention could be a better choice.

In practice, wearing long-sleeved clothing during the past week (99.3%) and the use of insecticide-treated bed net (91.1%) were reported to happen very frequently by most of the participants. However, the adherence to using a thermometer and installing curtains or screens in the residence was only 42.2% and 38.1%, respectively. With regard to malaria prevention, 81.7% and 77.6% of the miners reported that they learned relevant knowledge in the last year and could obtain information within an hour (Table 5).

3.6. Poor practice of malaria in the study participants

Similarly to adequate knowledge, the cumulative practice scores of the participants were calculated, and those scoring <4.8 were defined as "poor practice". Table 6 shows that education level and working time were significantly associated with adequate knowledge (both $p < 0.05$). We used univariate and multivariate logistic regression to predict the independent determinants associated with poor practice, no variable indicated statistical significance (Supplementary materials).

4. Discussion

This study provides the first comprehensive assessment of malaria-related KAP among mining workers in Haut-Katanga Province, DRC. In contrast to most prior research focusing on the general population, children, or pregnant women [18–20], our work specifically targeted miners, a group facing increased malaria risk due to occupational characteristics, thereby filling an important gap in malaria KAP research

Table 4
Multivariate logistic regression analysis of independent determinants for adequate knowledge.

Variables	β	SE	Wald	p-value	OR	95% CI	
						Upper	Lower
Age (ref = >33 y)[a]							
≤33y	−0.08	0.26	0.08	0.78	0.93	0.56	1.55
Sex (ref = Female)							
Male	−0.29	0.82	0.13	0.72	0.75	0.15	3.79
Residential location (ref = Other area in Haut-Katanga Province)							
Likasi city	−0.14	0.60	0.06	0.81	0.87	0.27	2.81
Kambove town	0.25	0.58	0.19	0.67	1.28	0.42	3.95
Education (ref = College and above)[b]							
Primary school and below	−1.4	1.09	1.66	0.20	0.25	0.03	2.08
Middle school	−0.99	0.27	13.17	<0.01[a]	0.37	0.22	0.64
Senior high school	−0.20	0.45	0.2	0.66	0.82	0.34	1.97
Is the work environment located outdoors or in an open or semi-open building? (ref = No)							
Yes	−0.34	0.28	1.49	0.22	0.71	0.42	1.23
Do you need to work early in the morning or in the evening? (ref = No)							
Yes	−0.77	0.34	5.21	0.02[a]	0.46	0.24	0.90

*Significant difference.
abased on the median age of subjects included in the model; b. subjects with no formal education were included in the primary school and below group.

for this population.

4.1. The knowledge-practice gap among miners

Our findings reveal that mining workers possess a generally high level of basic malaria knowledge, however, a profound "knowledge-practice gap" persists concerning specific biological and epidemiological details. For instance, whereas a study from rural Zambia found that 100% of caregivers identified fever as a key malaria symptom [15], far fewer participants in our study recognized common clinical signs. This discrepancy is likely attributable to two key factors: regular workplace health education in the study setting tends to prioritize general malaria awareness over the specific biological, clinical and epidemiological knowledge necessary to drive proactive self-protective behaviors. Meanwhile, limited functional health literacy among some miners, stemming from educational backgrounds and pre-existing personal knowledge, hinders their ability to absorb and apply detailed malaria prevention and recognition information from existing forms and contents of health education. Given that higher levels of knowledge are linked to greater motivation to protective behaviors [21–23], future health education campaigns should prioritize these "blind spots" using more intuitive and inclusive formats such as images, videos or demonstrations [24,25].

4.2. Educational and occupational determinants of knowledge

A striking observation is that both lower education level and night-shift work significantly hinder malaria knowledge. This aligns with evidence from Cameroon [13], where education levels act as a primary driver of malaria KAP. Notably, our study identifies "night-shift system" as a distinct occupational barrier to malaria knowledge among miners, a finding that adds a critical occupational dimension to existing KAP literature. Unlike seasonal slash and burn cultivators in Bangladesh, whose exposure is varies with harvest cycles but who have consistent access to community health education [26], some miners in the DRC operate on 24-h shift systems that often prevent attendance at scheduled health sessions. Early morning and evening shifts, which overlap with the peak biting periods of *Anopheles* mosquitoes, not only elevate infection risk but also restrict participation in health education. This creates a structural paradox where the workers at highest risk of malaria are the least likely to access knowledge needed to mitigate their vulnerability. These results confirm that a uniform, "one-size-fits-all" educational approach is ineffective for high-exposure occupational groups with irregular working hours, and calls for schedule-adaptive outreach strategies that accommodate shift work patterns.

4.3. Behavioral drivers in occupational mining settings

Preventive practices among this mining population are largely driven by company-enforced policies, amounting to a pattern of "policy-driven adherence" that has ensured high compliance in visible behaviors such as wearing long-sleeved clothing. This contrasts with household-based surveys in Sierra Leone and Senegal [19,27], where individual beliefs and bed net availability act as primary motivators. This highlights a key distinction in malaria prevention drivers between community and high-risk occupational settings: for miners, institutional enforcement proves more directly effective at driving consistent

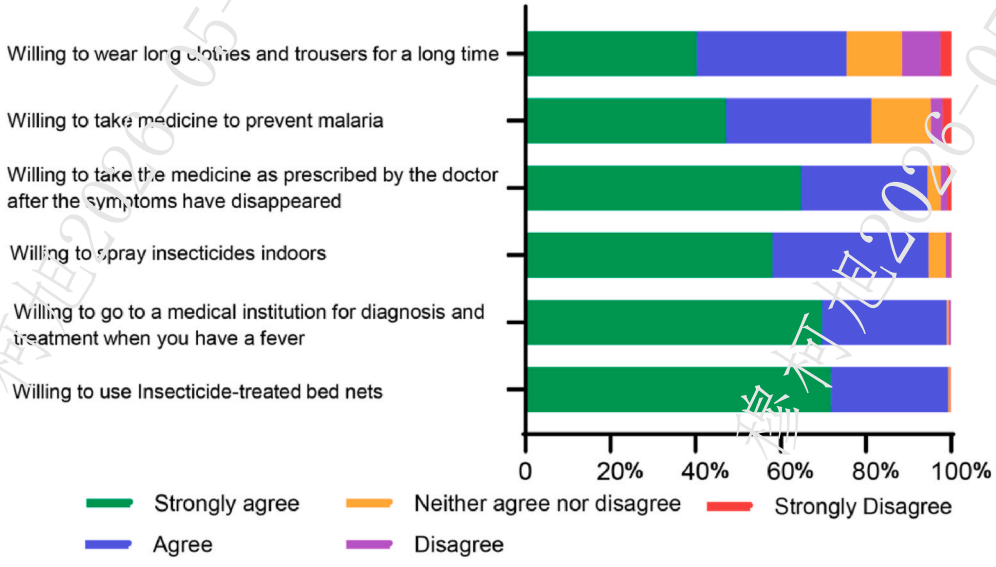

Fig. 2. Responses to attitudes towards malaria.

Table 5
Self-reported practices related to malaria control and preventive measures.

Practices related to malaria (positive practices)	Number	Positive practice rate %[a]
How often do you wear long-sleeved clothing for extended periods during the past week? (≥ 1 day)		**99.3**
7 days	401	
5-6 days	23	
3-4 days	24	
1-2 days	8	
Never	3	
Missing data	26	
Do you use insecticide-treated bed nets at night? (Yes)		**91.1**
Yes	418	
No	41	
Missing data	26	
Did you learn about malaria prevention information through public channels in the past year? (Yes)		**81.7**
Yes	375	
No	84	
Missing data	26	
Can you obtain malaria information within an hour? (Yes)		**77.6**
Yes	356	
No	103	
Missing data	26	
Do you possess any form of mosquito repellents? (Yes)		**77.1**
Yes	354	
No	105	
Missing data	26	
Did you seeking medical treatment at a medical institution after a recent fever? (Yes)		**73.6**
Yes	285	
No	102	
No fever in the past year	72	
Missing data	26	
Do you use a thermometer to measure body temperature? (Yes)		**42.2**
Yes	194	
No	265	
Missing data	26	
Do you install curtains or screens in the residence? (Either or Both)		**38.1**
Only curtains	16	
Only screens	64	
Both	95	
No	284	
Missing data	26	

[a] Positive practice rate % = Number of positive practice/number of participants who answered the question.

preventive behavior than mere individual-level health education, a finding that reinforces the value of workplace policy levers for protecting occupationally vulnerable populations. Over-reliance on company mandates, however, creates a false sense of security, particularly when miners return back to residential settings where such policies are absent. In our study, while mosquito net usage is high, which is due to passive distribution, active behaviors including installing curtains or screens remain markedly low. This reflects a lack of personal investment when institutional or governmental subsidies are unavailable. Conversely, this residential protection gap weakens the effectiveness of workplace-based malaria control control efforts, perpetuating ongoing transmission risk for this group and highlighting the need for cross-setting prevention strategies to truly transform "workplace requirement" into "life habit".

4.4. Economic barriers to Healthcare seeking

Beyond preventive practices, economic barriers emerge as a critical obstacle to timely care-seeking for suspected malaria. A national survey in the DRC reported that only 37.8% of people with suspected malaria sought care at medical institutions [28], a rate that may be even lower in some settings. This "economic-prevention paradox" is similar to observations from Thailand, where financial constraints often delayed health-seeking behaviors [29]. In both contexts, the immediate economic loss associated with sick leave may outweigh the perceived benefits of early diagnosis, leading to a pattern of "working through illness" among different populations. For miners, this not only affects individual health but also sustains parasite reservoirs within the camp, potentially undermining even well-structured corporate malaria control programs. Notably, an innovative approach in French Guiana, the Malakit project, which distributes malaria diagnostic tests and ACT to clandestine gold miners, has shown positive impacts on malaria-related KAP [30]. The success of this model highlights an important implication of our study. Implementing policies such as malaria-specific paid sick leave and expanding the accessibility of on-site diagnosis and treatment services, are not only individual-focused health interventions, but also crucial components of comprehensive malaria control based on the workplace.

4.5. Practical implications and recommendations

(i) Tailored health campaigns should transition from text-heavy lectures to visually oriented, interactive formats, with content prioritizing the identified knowledge gaps. (ii) The high compliance with long-sleeved clothing, a company mandated policy, suggests that integrating additional preventive tools into its safety standards could be effective. (iii) The implementation of paid malaria-specific sick-leave policy and providing on-site RDTs will help to improve timely care-seeking and address the low usage of diagnostic tools. (iv) To bridge the protection gap between workplace and residence, enterprises should collaborate with local government to distribute screens and LLINs to this occupational group.

5. Limitations

There were some limitations in this study. First, due to the specificity

Table 6
Poor practice rate in the study participants.

Variables	No. participated	No. Poor practice	Poor practice rate/%	$\chi 2$	*p*
Age					
18–29 y	122	44	36.1	1.475	0.478
30–39 y	213	88	41.3		
≥40 y	64	22	34.4		
Missing data	88	-	-		
Sex					
Male	399	155	38.9	0.215[a]	0.643
Female	11	3	27.3		
Missing data	75	-	-		
Residential location					
Likasi city	153	49	32.0	4.249	0.12
Kambove town	231	98	42.4		
Other area in Haut-Katanga Province	22	8	36.4		
Missing data	79	-	-		
Education level					
Primary school and below	8	4	50.0	2.452[a]	0.484
Middle school	218	91	41.7		
Senior high school	30	12	40.0		
College and above	143	49	34.3		
Missing data	86	-	-		
Working area					
Need to work outdoors	253	104	41.1	3.223	0.073
No need	115	36	31.3		
Missing data	117	-	-		
Working time					
Need to working in the early morning or evening	323	128	39.6	4.429	0.035[a]
No need	53	13	24.5		
Missing data	109	-	-		

*Significant difference.
[a]Chi-square test for continuity correction.

of mining workers (95.46% of participants were male), our results may have limited reference value and spillover effects for other occupational groups. However, from another perspective, this limitation made this study more accurate as a reference for other groups with similar characteristics regarding malaria control and prevention, such as logging workers. Second, only Congolese employees were included, which missed an opportunity for a comparative analysis between local and foreign workers. Third, a 20% non-response rate and a single mining enterprise might not broadly representative of mining workers. However, the standardized operational structure of the selected site provided a valuable proxy for large-scale industrial mining population in DRC and even sub-Saharan Africa. Meanwhile, our study would have benefited from the inclusion of more knowledge modules (such as malaria treatment) and conducting qualitative probing through focus group discussions to further elucidate themes arised. Despite these limitations, our findings do provide initial insight on malaria KAP where previous studies have not been performed, and thus can guide robust KAP studies for high-risk populations in the future.

6. Conclusion

The majority of mining workers in Haut-Katanga Province, DRC achieved scores categorized as “adequate” in general malaria knowledge. However, there remains a significant gap between knowledge and practices, alongside critical deficiencies in disease-specific knowledge, especially in the recognition of core clinical malaria symptoms and the adoption of household-initiated preventive measures. Education level and working shifts are identified as key independent determinants of knowledge deficiency. To address these gaps, it is necessary to adopt optimized forms of health education, formulate specific policies such as subsidizing residential preventive measures and implementing paid leave for malaria, and combine corporate health regulations with community-based support to improve malaria KAP and alleviate high burden within this occupationally vulnerable population.

CRediT authorship contribution statement

Cheng Liang: Writing – original draft, Project administration, Methodology. **Yanqiu Du:** Formal analysis, Data curation. **Gasto Frumence:** Conceptualization. **Xuedan Ke:** Methodology. **Papy Musas Kasombo:** Resources. **Johnny Malu Mukolo:** Resources, Project administration. **Yaping Gu:** Methodology, Investigation. **Huayun Zhou:** Methodology, Investigation. **Guoding Zhu:** Validation, Conceptualization. **Jiayan Huang:** Writing – review & editing, Methodology, Funding acquisition. **Jun Cao:** Writing – review & editing, Resources, Funding acquisition, Conceptualization.

Availability of data and materials

All data generated or analyzed during the study are included in this article; please contact the author with data requests.

Ethics approval and consent to participate

This study was approved by the Ethics Committee of Jiangsu Institute of Parasitic Diseases, Wuxi, China. This survey was voluntary, and the submission of the responses to the questions implied willingness to participate in the survey.

Consent for publication

Not applicable.

Funding

This work was supported by the Jiangsu Province Capability Improvement Project through Science, Technology and Education (No. ZDXYS202207) and the Major Program of National Social Science Fund (No. 20VMG027).

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements

We gratefully acknowledge the respondents who volunteered to participate in the survey, thanks for their helpful reply and suggestions.

Abbreviations

DRC	Democratic Republic of Congo
WHO	World Health Organization
KAP	Knowledge, attitudes, and practices
IRS	Indoor residual spraying
RDT	Rapid diagnostic testing
LLINs	Long-lasting insecticidal nets

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.

org/10.1016/j.tmaid.2026.102976.

References

[1] WHO: **Worwd Malaria report 2024**. 2024.
[2] Deutsch-Feldman MPJ, Keeler C, Brazeau NF, Goel V, Emch M, Edwards JK, Kashamuka M, Tshefu AK, Meshnick SR. The burden of malaria in the Democratic Republic of the Congo. J Infect Dis 2021;223:1948–52.
[3] Rodriguez-Barraquer I, Arinaitwe E, Jagannathan P, Boyle MJ, Tappero J, Muhindo M, Kamya MR, Dorsey G, Drakeley C, Ssewanyana I, et al. Quantifying heterogeneous malaria exposure and clinical protection in a cohort of Ugandan children. J Infect Dis 2016;214:1072–80.
[4] Sherrard-Smith E, Skarp JE, Beale AD, Fornadel C, Norris LC, Moore SJ, Mihreteab S, Charlwood JD, Bhatt S, Winskill P, et al. Mosquito feeding behavior and how it influences residual malaria transmission across Africa. Proc Natl Acad Sci U S A 2019;116:15086–95.
[5] WHO: **Glogal technical strategy for malaria 2016-2030**. 2015.
[6] Moreno JE, Rubio-Palis Y, Páez E, Pérez E, Sánchez V. Abundance, biting behaviour and parous rate of anopheline mosquito species in relation to malaria incidence in gold-mining areas of southern Venezuela. Med Vet Entomol 2007;21:339–49.
[7] Barbieri AF, Sawyer DO. Heterogeneity of malaria prevalence in alluvial gold mining areas in Northern Mato Grosso State, Brazil. Cad Saúde Pública 2007;23:2878–86.
[8] Shanks GD, Wongsrichanalai C. Mining-Associated malaria epidemics. Am J Trop Med Hyg 2021;106:33–7.
[9] Mitchell CL, Janko MM, Mwandagalirwa MK, Tshefu AK, Edwards JK, Pence BW, Juliano JJ, Emch M. Impact of extractive industries on malaria prevalence in the Democratic Republic of the Congo: a population-based cross-sectional study. Sci Rep 2022;12:1737.
[10] Nundu SS, Arima H, Simpson SV, Chitama BA, Munyeku YB, Muyembe JJ, Mita T, Ahuka S, Culleton R, Yamamoto T. Low prevalence of Plasmodium falciparum parasites lacking pfhrp2/3 genes among asymptomatic and symptomatic school-age children in Kinshasa, Democratic Republic of Congo. Malar J 2022;21:126.
[11] Gontie GB, Wolde HF, Baraki AG. Prevalence and associated factors of malaria among pregnant women in Sherkole district, Benishangul Gumuz regional state, West Ethiopia. BMC Infect Dis 2020;20:573.
[12] Ueno T, Lima L, Sardinha DM, Rodrigues YC, Souza HUS, Teixeira PR, Guimarães R, Lima KVB, Ventura A. Socio-Epidemiological features and spatial distribution of malaria in an area under mining activity in the Brazilian amazon region. Int J Environ Res Publ Health 2021;18.
[13] Kala Chouakeu NA, Ngingahi LG, Bamou R, Talipouo A, Ngadjeu CS, Mavi MPA, Kopya E, Awono-Ambene P, Tchuinkam T, Antonio Nkondjio C. Knowledge, attitude, and practices (KAP) of human populations towards malaria control in four ecoepidemiological settings in Cameroon. J Trop Med 2021;2021:9925135.
[14] Ravi N, Holsted E, Kadiebwe B, Salthouse A, Sattar A. A malaria knowledge, attitudes and practice survey in a rural community in Guinea. Malar J 2022;21:329.
[15] Jumbam DT, Stevenson JC, Matoba J, Grieco JP, Ahern LN, Hamainza B, Sikaala CH, Chanda-Kapata P, Cardol EI, Munachoonga P, Achee NL. Knowledge, attitudes and practices assessment of malaria interventions in rural Zambia. BMC Public Health 2020;20:216.
[16] Levitz L, Janko M, Mwandagalirwa K, Thwai KL, Likwela JL, Tshefu AK, Emch M, Meshnick SR. Effect of individual and community-level bed net usage on malaria prevalence among under-fives in the Democratic Republic of Congo. Malar J 2018;17:39.
[17] Kuguyo O, Mukona DM, Chikwasha V, Gwanzura L, Chirenda J, Matimba A. Prevalence and risk factors for diabetic foot complications among people living with diabetes in Harare, Zimbabwe: a cross-sectional study. BMC Public Health 2024;24:677.
[18] Bamou R, Tchuinkam T, Kopya E, Awono-Ambene P, Nikokou F, Mwangangi J, Antonio-Nkondjio C. Knowledge, attitudes, and practices regarding malaria control among communities living in the south Cameroon forest region. IJID Reg 2022;5:169–76.
[19] Wang L, Yin J, Zheng C, Smith SJ, Ngegba E, Huang X, Kamara A, Chen X, Wang X, Luo W, Kan B. A Household-based cross-sectional survey of knowledge, awareness and practice regarding malaria in Western area rural district, Sierra Leone. Front Public Health 2021;9:664971.
[20] Manga IA, Gaye A, Dia A, Kouevidjin E, Dos Reis MR, Niang AS, Fall AN, Anquetil CM, Ndiaye JLA. Knowledge, attitudes and practices (KAP) to assess the impact of school children's awareness of malaria using the MOSKI KIT® tool: study case of some Dakar schools in Senegal. Malar J 2021;20:310.
[21] Pourkazemi A, Ghanbari A, Khojamli M, Balo H, Hemmati H, Jafaryparvar Z, Motamed B. Diabetic foot care: knowledge and practice. BMC Endocr Disord 2020;20:40.
[22] Dwiartama A, Nirbayati WF, Ciri-Rachman EA, Niloperbowo W, Tan MI, Amin A. Knowledge, attitude, and practice towards hepatitis B infection prevention and screening among Indonesians. Int J Environ Res Publ Health 2022;19.
[23] Lee M, Kang BA, You M. Knowledge, attitudes, and practices (KAP) toward COVID-19: a cross-sectional study in South Korea. BMC Public Health 2021;21:295.
[24] Mutanda JN, Waiswa P, Namutamba S. Community-made Mobile videos as a mechanism for maternal, newborn and child health education in rural Uganda; a qualitative evaluation. Afr Health Sci 2016;16:923–8.
[25] Tuong W, Larsen ER, Armstrong AW. Videos to influence: a systematic review of effectiveness of video-based education in modifying health behaviors. J Behav Med 2014;37:218–33.
[26] Saha A, Sarker M, Kabir M, Lu G, Müller O. Knowledge, attitudes, and practices regarding malaria control among the slash and burn cultivators in Rangamati Hill tracts of Bangladesh. Malar J 2019;18:216.
[27] Tairou F, Nawaz S, Tahita MC, Herrera S, Faye B, Tine RCK. Malaria prevention knowledge, attitudes, and practices (KAP) among adolescents living in an area of persistent transmission in Senegal: results from a cross-sectional study. PLoS One 2022;17:e0274656.
[28] Ntamabyaliro NY, Burri C, Lula YN, Ishoso D, Engo AB, Ngale MA, Liwono JY, Mukomena ES, Mesia GK, Mampunza SM, Tona GL. Knowledge of antimalarials and health seeking behaviour of households in case of suspected malaria in democratic Republic of the Congo. Trop Med Infect Dis 2021;6.
[29] Naing SHH, Isaramalai SA, Sukmag P. Policy literacy, barriers, and gender impact on accessibility to healthcare services under compulsory migrant health insurance among Myanmar migrant workers in Thailand. J Environ Public Health 2020;2020:8165492.
[30] Longchamps C, Galindo MS, Lambert Y, Sanna A, Mutricy L, Garancher L, Adenis A, Nacher M, Suarez-Mutis M, Cairo H, et al. Impact of Malakit intervention on perceptions, knowledge, attitudes, and practices related to malaria among workers in clandestine gold mines in French Guiana: results of multicentric cross-sectional surveys over time. Malar J 2022;21:397.