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Community pharmacists' knowledge and experience regarding malaria management: a cross-sectional study in Hodeida, Yemen

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Abstract

Background Malaria remains a significant public health concern in Yemen, ranking fourth in incidence within the Eastern Mediterranean Region. Community pharmacists play a pivotal role in malaria management and often dispense anti-malarial medications without prescriptions. However, little is known about their knowledge and adherence to the National Policy for Antimalarial Drugs. This study aimed to evaluate pharmacists' knowledge, experience, and perceived barriers regarding malaria management in Hodeidah, Yemen.

Methods A cross-sectional study was conducted between May and August 2023 across 320 community pharmacies in 16 districts of Hodeidah governorate. A validated questionnaire was used to assess pharmacists' knowledge, experience, and perceived barriers to effective malaria management. Descriptive statistics and logistic regression analysed the associations between sociodemographic factors and pharmacists' knowledge and experience.

Results Of the 304 respondents, 10 were excluded due to incomplete data, yielding a valid response rate of 91.9% (294). Most pharmacies were independent (74.8%), and 51.4% were located in Hodeidah city. The majority of the pharmacists were male (92.2%), aged 19–30 years (50.3%), and held a pharmacy diploma (69%). Poor knowledge of malaria management was observed in 76.5% of respondents (mean: 9.96, SD 3.47), with only 34.4% and 43.2% accurately identifying first-line treatments for uncomplicated and complicated malaria, respectively. Additionally, 60.9% were aware of the prevalent malaria species, and 53.1% knew the correct diagnostic methods. However, only 17.0% recognized high-risk groups for complicated malaria, 18.4% identified causes of treatment failure, and 7.8% understood the consequences of malaria during pregnancy. In terms of experience, 76.2% of the participants reported inadequate experience related to anti-malarial medications (mean: 56.71, SD 7.32), with the main barriers being lack of training (78.9%) and insufficient knowledge (73.5%). Multivariable logistic regression revealed that older age (AOR: 6.827, $p=0.020$), holding a pharmacy diploma (AOR: 2.555, $p=0.036$), and fewer perceived barriers (AOR = 3.830, $p<0.001$) were predictors of poor knowledge, whereas practicing in Hodeidah city (AOR = 1.865, $p=0.043$) predicted inadequate experience.

Conclusion Community pharmacists in Hodeidah demonstrate significant gaps in knowledge and experience related to malaria management. Urgent educational interventions are needed to enhance pharmacists' competency, ensure effective malaria treatment, and prevent the emergence of drug resistance in Yemen.

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Keywords Community pharmacists, Malaria management, Knowledge, Experience, Barriers, National Policy for Antimalarials, Hodeidah city

Background

Malaria remains a leading cause of morbidity and mortality, particularly in resource-limited settings, where healthcare infrastructure is weak and socioeconomic challenges hinder effective disease management [1]. In Yemen, which is classified as a high-endemic zone by the World Health Organization (WHO), the burden of malaria is severe, with the country ranking fourth in malaria incidence in the Eastern Mediterranean Region. Approximately 68% of Yemen's population is at high risk of malaria, and 155,127 confirmed cases were reported in 2022, primarily attributed to *Plasmodium falciparum* [1, 2]. The ongoing conflict and political instability in Yemen have exacerbated healthcare disruptions, leading to increased misdiagnosis, inappropriate treatment, and increased drug resistance [3–5].

The Hodeidah governorate, the most affected region, accounts for 80% of the malaria cases reported in the Tehama region and 66% of the total cases reported in the country [6]. In such high-risk regions, community pharmacists play a critical role in managing malaria due to their accessibility and the high prevalence of self-medication [7, 8]. Many patients seek malaria treatment directly from pharmacies, often without prescriptions or laboratory confirmation [9, 10]. The private sector manages approximately 75% of malaria cases in Yemen, emphasizing the significant role of community pharmacists in malaria control efforts [11].

Historically, chloroquine was the first-line treatment for malaria in Yemen until 2006, when its declining efficacy prompted its replacement with artesunate combined with sulfadoxine-pyrimethamine for uncomplicated *P. falciparum* infections [12–14]. However, procurement challenges led to a policy change in 2017, establishing artemether-lumefantrine as the first-line treatment [15]. These evolving national guidelines require community pharmacists to stay updated with the latest treatment protocols to ensure effective malaria management.

Despite the central role of community pharmacists, there has been no formal evaluation of their knowledge, experience, or the barriers they face in adhering to national malaria management guidelines, particularly in regions heavily burdened by the disease. This study aimed to assess the knowledge, experience, and perceived barriers of community pharmacists regarding malaria management in Hodeidah. The findings are expected to inform the development of targeted educational interventions and policies to increase the effectiveness of community pharmacists in primary healthcare services.

Methods

Study design and setting

This cross-sectional study was conducted from May to August 2023 among community pharmacies in the Hodeidah governorate. A structured, validated questionnaire was employed to assess pharmacists' knowledge, experience, and perceived barriers related to malaria management. Hodeidah was chosen as the study site because of its high malaria burden, representing the most malaria-affected region in Yemen.

Study population and participation criteria

This study targeted community pharmacists in Hodeidah city and surrounding districts who held qualifications in clinical pharmacy, a bachelor of pharmacy, or a pharmacy diploma, and who actively dispensed anti-malarial medications, either by prescription or over-the-counter. In Yemen, diploma holders have similar responsibilities to those with bachelor's degrees, including medication dispensing and patient counseling [16]. Pharmacists who primarily dealt with cosmetic or paramedical products, or those working in hospital pharmacies, were excluded to ensure relevance to anti-malarial dispensing. Those who declined to participate were also excluded.

Sample size calculation and sampling method

According to recent data from the Director of Pharmacy at the Hodeidah Health Office, the governorate contains 833 pharmacies and drug stores. The required sample size was calculated via the following formula for finite populations [17]:

$n = \frac{NZ^2P(1-P)}{E^2(N-1)+Z^2P(1-P)}$ where n is the minimal required sample size, N is the population size (833 in this case), Z is the Z score (1.96 for a 95% confidence level), P is the estimated proportion (0.5), and E is the margin of error (0.05). With these parameters, the minimum required sample size was 263. To account for a potential nonresponse rate, a 10% increase was applied, resulting in an adjusted sample size of 292. Ultimately, 320 pharmacies and drug stores were visited, with one pharmacist recruited per location to ensure broad representation. A convenience sampling method was employed for data collection.

Research tool development

The questionnaire was developed following a comprehensive review of the updated National Policy for Antimalarial Drugs (NPAD), WHO guidelines, and relevant literature [1, 18–20]. The final tool consisted of 67 questions and statements divided into five sections (Supplementary File). The first section collects demographic data from pharmacists and pharmacy technicians through nine questions. The second section assesses the physical environment of the pharmacy premises with 12 questions. The third section evaluates general knowledge about malaria through six multiple-choice questions. The fourth section covers malaria treatment guidelines through 20 multiple-choice questions on malaria etiology, risk factors, clinical presentations, diagnosis, and recommended antimalarial medications for complicated and uncomplicated cases across different age groups, including considerations for pregnant women. The fifth section assesses the experience of pharmacists and pharmacy technicians in dispensing antimalarial medications through 16 questions using a 5-point Likert scale (from "never" to "always"). This section also included four statements to assess perceived barriers to effective malaria treatment by pharmacists.

Validation

The questionnaire underwent a rigorous validation process. Content validation was performed by 12 experts from various fields, including community medicine, pharmacology, parasitology, paediatrics, and clinical pharmacy. They assessed the items' relevance and representation to the measured domain. Their feedback was incorporated into the questionnaire, yielding content validity index (CVI) scores of 0.99 for general knowledge, 0.85 for malaria management, and 0.82 for experience, exceeding the satisfactory threshold of 0.8 [21]. The questionnaire was translated into Arabic via a forward–backward translation method performed by a licensed linguist and a bilingual healthcare researcher while reconciling the discrepancies in the final version.

Face validation was conducted with ten final-year clinical pharmacy students, who provided feedback on the clarity and comprehensibility of the questionnaire items [22]. Their feedback was incorporated into the final version. Their suggestions were incorporated, resulting in face validity index (FVI) scores of 0.83 for general knowledge, 0.90 for malaria management, and 1.0 for experience [23].

A pilot test with 31 community pharmacists confirmed the reliability of the questionnaire, yielding Cronbach's alpha values of 0.810 for the knowledge domain and 0.811 for the experience domain. Following the pilot phase, the questionnaire was deemed clear and required no changes.

Study variables and scoring system

The study assessed knowledge and experience using the 75th percentile as a cutoff [24, 25]. Knowledge was scored by coding correct answers as 1 and incorrect or "I am not sure" answers as 0, resulting in a knowledge score ranging from 0 to 26. Scores above 12 were considered "good knowledge," whereas scores of 12 or below were classified as "poor knowledge." Experience was evaluated via 16 questions on a five-point Likert scale, with scores ranging from 16 to 80. Scores above 62 indicated "adequate experience," whereas scores of 62 or below indicated "inadequate experience".

Data collection

Data collection took place during morning hours to minimize interference with pharmacy operations. Two researchers with master's degrees in clinical pharmacy and pharmacology visited 320 pharmacies and drug stores in 16 districts of Hodeidah, covering 95% of the pharmacies in the governorate. The researchers explained the study objectives and emphasized the confidentiality and anonymity of the participants' responses. Verbal informed consent was obtained from each participant before they completed the self-administered questionnaire. In cases where multiple pharmacists were present, the pharmacist in charge was selected to complete the survey. On average, the questionnaire took 20 min to complete, after which it was returned to the researchers.

Statistical analysis

The data were entered, checked and analysed via IBM SPSS Statistics version 27.0 for Windows® (IBM Corp., Armonk, NY, USA). Descriptive statistics were used to summarize categorical variables, with results presented as frequencies and percentages.

The knowledge and experience scores were dichotomized on the basis of the 75th percentile cutoff points. Univariate logistic regression was conducted to assess associations between sociodemographic variables and knowledge/experience scores. Variables with P values less than 0.25 in the univariate analysis were included in a multivariable logistic regression model to identify independent predictors of knowledge and experience. Odds ratios (ORs) with 95% confidence intervals (CIs) were calculated to quantify the strength of these associations. Statistical significance was set at $P < 0.05$ for all analyses.

Results

Of the 320 surveyed pharmacies, 304 questionnaires were collected. After excluding 10 incomplete responses, the valid response rate was 91.9% (294). Among the respondents, 48 (16.3%) held PharmD degrees, 43 (14.6%) held B.Pharm. degrees, and 203 (69.0%) were pharmacy technicians.

The majority of the participants were male (92.2%) and aged between 19 and 30 years (50.3%). Over half (55.8%) had graduated from private institutions, whereas 44.2% had graduated from public institutions. In terms of professional experience, 36.7% had less than five years of experience, 28.2% had 5–9 years, and 35.0% had 10 or more years (Table 1).

With respect to education and training on malaria management, 53.4% had received malaria-related training, mainly through online platforms (38.1%). Most (86.4%) had studied malaria-related material during their education. With respect to the awareness of NPAD, only 14.6% had read the full report.

Table 1 Sociodemographic data of community pharmacists in Hodeidah governorate (n = 294)

Age (years)	Count	(%)
19–30	148	(50.3)
31–40	116	(39.5)
> 40	30	(10.2)
Gender		
Male	271	(92.2)
Female	23	(7.8)
Education sector		
Public sector	130	(44.2)
Private sector	164	(55.8)
Qualification		
Clinical pharmacy	48	(16.3)
Bachelor of pharmacy	43	(14.6)
Diploma	203	(69.0)
Experience (year)		
< 5 years	108	(36.7)
5–9 years	83	(28.2)
≥ 10 years	103	(35.0)
Received training about malaria		
Yes	157	(53.4)
No	137	(46.6)
Training provider		
National Malaria Control Program	36	(21.4)
Ministry of Health	34	(20.2)
Online platform	64	(38.1)
Other	34	(20.2)
Studied malaria-related topic		
Yes	254	(86.4)
No	40	(13.6)
Awareness of national antimalarial policy		
Not aware at all	65	(22.1)
Aware of existence, not contents	94	(32.0)
Aware of some content, not full	92	(31.3)
Read the full report	43	(14.6)

Pharmacy premise characteristics

Table 2 shows the characteristics of the Pharmacy Premises in Hodeidah Governorate. Among the surveyed pharmacies, 151 (51.4%) were located in Hodeidah city, and 143 (48.6%) were located in other districts. The majority of pharmacies were independent (220, 74.8%), with only 74 (25.2%) being chain pharmacies. In terms of staffing, 39.8% of pharmacies had one pharmacist per shift, whereas 33.0% were operated solely by pharmacy technicians. Approximately 58.8% of the pharmacies had computers, 85.4% were air-conditioned, and 54.6% had internet access. Only 27.9% of pharmacies provided private counseling, and 21.4% maintained patient records. Drug references for anti-malarial medications were found in 45.6% of the pharmacies, with mobile apps being the most common source (39.9%).

Services available in community pharmacies

Figure 1 presents the services commonly available in community pharmacies. The most frequently offered services include blood pressure measurements (106 pharmacies, 26.2%), blood glucose tests (94 pharmacies, 23.2%), body temperature measurements (74 pharmacies, 18.3%), body weight measurements (61 pharmacies, 15.1%), malaria rapid diagnostic tests (mRDTs) (50 pharmacies, 12.3%), and body height measurements (20 pharmacies, 4.9%).

Pharmacists' knowledge of malaria diagnosis and management

Table 3 summarizes the knowledge of pharmacists regarding malaria diagnosis and management. The majority of the pharmacists (97.6%) correctly identified fever, chills, and headaches as key symptoms of malaria. Additionally, 60.9% recognized *P. falciparum* as the most prevalent species in Yemen. However, knowledge of parasitological diagnosis was less widespread, with only 53.1% recognizing that suspected cases should be confirmed through microscopy or rapid diagnostic tests. Knowledge of vulnerable groups,

Table 2 Characteristics of Pharmacy Premises in Hodeidah Governorate (n = 294)

	Count	(%)
Type and location of the pharmacy		
Pharmacy location		
Hodeidah city	151	(51.4)
Districts	143	(48.6)
Type of pharmacy		
Chain Pharmacy	74	(25.2)
Independent Pharmacy	220	(74.8)
Pharmacy staff per work shift		
Number of pharmacists		
None	97	(33.0)
One	117	(39.8)
Two	62	(21.1)
Three or more	18	(6.1)
Number of pharmacy technicians		
None	20	(6.8)
One	139	(47.3)
Two	108	(36.7)
Three or more	27	(9.2)
Pharmacy infrastructure		
Computer available		
Yes	173	(58.8)
No	121	(41.2)
Air conditioning		
Yes	251	(85.4)
No	43	(14.6)
Internet connection		
Yes	160	(54.6)
No	133	(45.4)
Private counseling area		
Yes	82	(27.9)
No	212	(72.1)
Telephone service		
Yes	210	(71.7)
No	83	(28.3)
Patient and drug information		
Patient medical record		
Yes	63	(21.4)
No	231	(78.6)
Drug reference for antimalarial medications		
Yes	134	(45.6)
No	160	(54.4)
Type of drug reference		
British National Formulary	15	(10.1)
Pharmacotherapy-related book	21	(14.2)
Pharmacology	24	(16.2)
NMCP	17	(11.5)
Mobile App	59	(39.9)
Others	12	(8.1)

including pregnant women and children, was low, with only 17.0% responding correctly.

Regarding malaria management, only 34.4% identified artemether-lumefantrine as the first-line treatment for uncomplicated *P. falciparum* malaria, and 24.8% identified artesunate plus sulfadoxine/pyrimethamine as an alternative. Fewer than half (46.3%) agreed on the use of primaquine to prevent transmission, although 60.9% correctly acknowledged that primaquine is not safe for pregnant women and infants under six months of age.

In severe malaria treatment, 43.2% of the pharmacists selected artesunate as the preferred treatment, while only 20.7% recognized intramuscular artemether as a second-line option. Supportive therapies, including antipyretics, fluids, and iron supplements, were well understood, with 71.1% correctly identifying their role in managing associated symptoms.

Pharmacists demonstrated limited knowledge of malaria prophylaxis, with only 3.1% identifying mefloquine as the recommended drug for travelers to endemic regions. Nearly half (49.3%) agreed that artesunate suppositories are appropriate for young children in remote areas before referral, but only 4.4% knew the correct dosage of primaquine for preventing P. vivax relapse in individuals with G6PD deficiency. The overall mean knowledge score was 9.96 (SD 3.47) out of 26, indicating that the majority of participants (76.5%) had poor knowledge, whereas only 23.5% demonstrated good knowledge.

Experience of community pharmacists toward antimalarial medications

Table 4 shows the experience of community pharmacists regarding antimalarial medications majority (73.5%) of pharmacists reported never advising patients to take antimalarial drugs on an empty stomach, while nearly half (49.0%) recommended taking them with food. However, 52.4% of pharmacists reported dispensing intravenous or intramuscular antimalarial drugs without a prescription for severe cases, and only 20.4% never dispensed oral antimalarials without a prescription. Additionally, 33.0% sometimes dispensed antibiotics alongside antimalarial drugs.

Regarding the clinical and laboratory findings, 17.3% of the pharmacists reported never using clinical features alone for treatment, 22.4% never used estimated body weight for dosing, and 26.5% never relied on thrombocytopenia for dispensing. Furthermore, 46.9% frequently advised patients to consult a physician or pharmacist regarding adverse effects. Overall, 76.2% (n = 224) of the pharmacists demonstrated "Inadequate experience," whereas 23.8% (n = 70) demonstrated "Adequate experience." The mean experience score was 56.71 (SD 7.32).

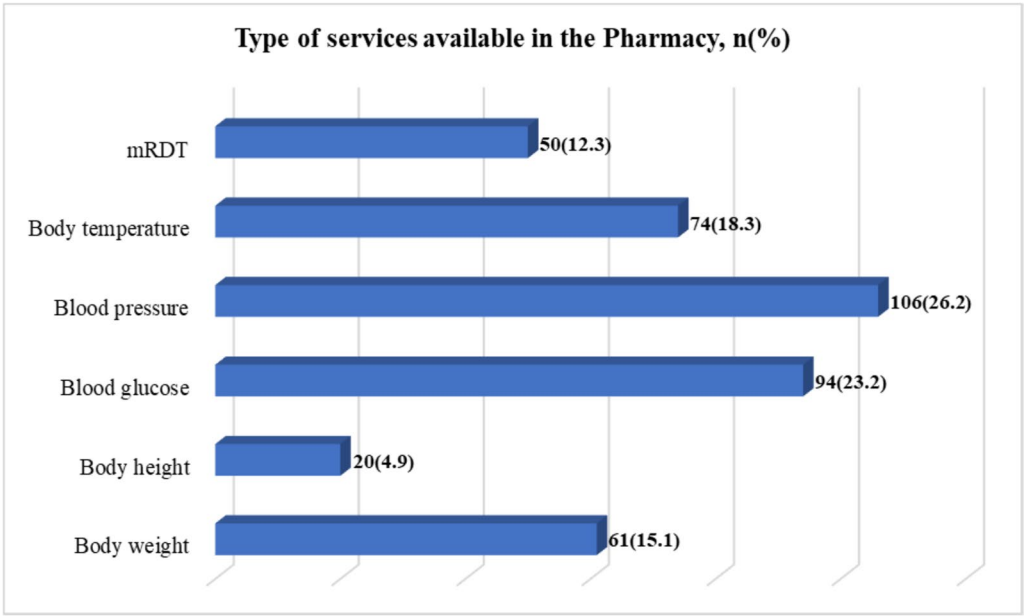

Fig. 1 Types of services available in the pharmacy

Figure 2 highlights the barriers preventing pharmacists from contributing effectively to malaria treatment. The identified barriers were insufficient training (78.9%), inadequate knowledge of malaria diagnosis and treatment (73.5%), lack of resources like medical records and guidelines (69.7%), and limited time for workshops (62.2%).

Predictors of poor knowledge of malaria among community pharmacists

Table 5 summarizes the predictors of poor malaria knowledge among community pharmacists, identified through univariate and multivariable logistic regression analyses. In the univariate analysis, pharmacists over 40 years old had significantly higher odds to have poor knowledge compared to those aged 19–30 years (COR = 6.314, 95% CI 1.443–27.630, p = 0.014). Additionally, graduating from the private sector, holding a diploma qualification, lacking training on malaria management, and being unaware of the NPAD were all significantly associated with increased odds of poor knowledge ($p < 0.05$). Moreover, pharmacists reporting fewer barriers to effective malaria management were more likely to exhibit poor knowledge (COR = 3.286, 95% CI 1.670–6.465, $p < 0.001$).

In the multivariable analysis, several factors remained significant. Pharmacists over 40 years old were more likely to have poor knowledge (AOR = 6.827, 95% CI 1.360–34.258, p = 0.020). Pharmacists with a diploma qualification had more than twice the odds of having poor knowledge compared to those with clinical pharmacy qualifications (AOR = 2.555, 95% CI 1.065–6.128, p = 0.036). Additionally, reporting fewer barriers to effective malaria management remained significantly associated with poor knowledge (AOR = 3.830, 95% CI 1.802–8.138, $p < 0.001$). The model explained 27.8% of the variance in malaria knowledge (Nagelkerke $R^2 = 27.8\%$) and demonstrated a good fit on the basis of the Hosmer and Lemeshow test (p = 0.878).

Predictors of inadequate experience among community pharmacists

Table 6 shows the predictors associated with inadequate malaria experience among community pharmacists. According to the univariate logistic regression analysis, pharmacists with a diploma qualification had significantly lower odds of inadequate experience than those with a clinical pharmacy qualification (COR = 0.394, 95% CI 0.159, 0.980, p = 0.045). Similarly, pharmacists who had not received training on malaria management (COR = 1.800, 95% CI 1.034, 3.134; p = 0.038) and those who had not studied malaria-related topics (COR = 3.160, 95% CI 1.083, 9.215; p = 0.035) were significantly more likely to exhibit inadequate experience. Additionally, pharmacists working in Hodeidah had significantly greater odds of inadequate experience than those working in district areas (COR = 1.827, 95% CI 1.058, 3.153, p = 0.030).

According to the multivariable logistic regression analysis, pharmacy location remained a significant predictor of inadequate experience of malaria management, with

Table 3 Pharmacists' correct response to Malaria diagnosis and management (n = 294)

		n	(%)
General knowledge about malaria with the correct answer			
Most prevalent species in Yemen: *P. falciparum*		179	(60.9)
Clinical signs/symptoms: Fever, chills, headache		287	(97.6)
Parasitological diagnosis before treatment: Microscopy or malaria mRDT		156	(53.1)
Vulnerable groups: Pregnant women, children, malnutrition		50	(17.0)
Severe clinical signs/symptoms: Chills, hypoglycemia, hypotension, reduced urine output		50	(17.0)
National Policy objectives: Early diagnosis, appropriate regimens, rational drug use, resistance prevention		44	(15.0)
Knowledge regarding malaria management			
First-line medication: Artemether-lumefantrine		101	(34.4)
Alternative drug: Artesunate + Sulfadoxine/Pyrimethamine		73	(24.8)
Primaquine as gametocide: Agree		136	(46.3)
Primaquine safety: Not safe for pregnant women and infants < 6 months		179	(60.9)
Cardiovascular side effects of antimalarials: Agree		124	(42.2)
Causes of treatment failure: Vomiting, low dose, resistance		54	(18.4)
Treatment for *P. ovale/P. vivax*: Artemether-lumefantrine/chloroquine + primaquine		122	(41.5)
Primaquine for G6PD deficiency: 0.75 mg/kg weekly for 8 weeks		13	(4.4)
Severe *P. falciparum* treatment (adults): Artesunate (2.4 mg/kg)		127	(43.2)
Alternative for severe *P. falciparum*: Artemether I.M		61	(20.7)
Lactating mothers treatment: Artemether-lumefantrine		145	(49.3)
First-trimester pregnancy treatment: Quinine + Clindamycin		37	(12.6)
Alternative in pregnancy: Artemether-lumefantrine		139	(47.3)
Severe malaria treatment in pregnant women: Artesunate		129	(43.9)
Artesunate suppositories for children: Agree		145	(49.3)
Supportive therapies: Antipyretic, fluid, iron		209	(71.1)
Prophylaxis for travelers: Mefloquine		9	(3.1)
Antibiotics for suspected bacterial infection: Agree		137	(46.6)
Pregnancy complications: Abortion, preterm delivery, congenital infection		23	(7.8)
Artemether-lumefantrine duration: Three days		200	(68.0)
Overall knowledge	Mean (SD)	9.96 (3.47)	
Knowledge classification	Poor knowledge	225 (76.5)	
	Good knowledge	69 (23.5)	

Correct answers are provided in bold text. Overall knowledge was classified based on the upper quartile

pharmacists in Hodeidah continuing to have higher odds of inadequate experience than those in district areas did (AOR = 1.865, 95% CI 0.900, 3.155, p = 0.043). However, other variables, such as qualifications, receiving malaria management training, and studying malaria-related topics, were no longer significant predictors of inadequate experience. The overall model accounted for 12.3% of the variance in experience adequacy (Nagelkerke R2 = 12.3%) and demonstrated a good fit on the basis of the Hosmer and Lemeshow test (p = 0.738).

Discussion

Malaria remains a critical public health issue in Yemen. Despite health authorities' efforts and the implementation of WHO-recommended interventions over the last decade, eliminating malaria has remained challenging [1, 18, 26]. Community pharmacists, as primary healthcare providers, play a critical role in malaria management. Their knowledge of diagnosis, treatment, and counseling is essential to the success of national interventions [27, 28]. Given that pharmacists are often the first point of contact for patients, ensuring that they are well-trained is crucial for effective malaria control.

This study highlights significant gaps in the knowledge and experience of community pharmacists in Hodeidah, the most malaria-affected governorate in Yemen [29]. Pharmacists exhibited notable deficiencies in their knowledge of the clinical aspects, diagnostic methods, and treatment protocols of malaria, as outlined by the NPAD guidelines. Age, qualifications, and perceived

Table 4 Experience of community pharmacists toward antimalarial medications (n = 294)

Experience question	Never	Rarely	Sometimes	Often	Always
How frequently do you dispense antimalarial drugs without a prescription?[a]	60 (20.4%)	48 (16.3%)	105 (35.7%)	52 (17.7%)	29 (9.9%)
How frequently do you dispense antimalarial drugs with prescription?	8 (2.7%)	14 (4.8%)	29 (9.9%)	79 (26.9%)	164 (55.8%)
How frequently do you dispense antimalarial drugs on patient's request with lab results?	19 (6.5%)	65 (22.1%)	119 (40.5%)	46 (15.6%)	45 (15.3%)
How frequently do you dispense antimalarial drugs on patient's request without lab results?[a]	97 (33.0%)	115 (39.1%)	46 (15.6%)	25 (8.5%)	11 (3.7%)
How frequently do you depend only on clinical features (presumptive diagnosis) as the basis for treating uncomplicated malaria?[a]	51 (17.3%)	93 (31.6%)	88 (29.9%)	50 (17.0%)	12 (4.1%)
How frequently do you use the actual body weight of the patient for determining the antimalarial dose?	62 (21.1%)	51 (17.3%)	66 (22.4%)	36 (12.2%)	79 (26.9%)
How frequently do you use the estimated body weight of the patient for determining the antimalarial dose?[a]	66 (22.4%)	64 (21.8%)	83 (28.2%)	58 (19.7%)	23 (7.8%)
How frequently do you depend on thrombocytopenia for dispensing antimalaria drugs?[a]	78 (26.5%)	53 (18.0%)	71 (24.1%)	42 (14.3%)	50 (17.0%)
How frequently do you advise the patient on oral antimalarial drugs for uncomplicated cases?	21 (7.1%)	43 (14.6%)	119 (40.5%)	56 (19.0%)	55 (18.7%)
How frequently do you advise the patient to take antimalarial drugs with food?	14 (4.8%)	32 (10.9%)	44 (15.0%)	60 (20.4%)	144 (49.0%)
How frequently do you advise the patient to take antimalarial drugs on an empty stomach? a	216 (73.5%)	39 (13.3%)	20 (6.8%)	14 (4.8%)	5 (1.7%)
How frequently do you advise the patient to repeat the antimalaria dose if vomiting occurs 30 min after drug ingestion?	96 (32.7%)	74 (25.2%)	43 (14.6%)	50 (17.0%)	31 (10.5%)
How frequently do you advise the patient to consult the physician or the pharmacist if they develop adverse effects?	12 (4.1%)	21 (7.1%)	44 (15.0%)	79 (26.9%)	138 (46.9%)
How frequently do you refer the patient to the healthcare center for IV injection and monitoring in case of frequent vomiting?	30 (10.2%)	31 (10.5%)	62 (21.1%)	64 (21.8%)	107 (36.4%)
How frequently do you dispense antibiotics besides antimalarial drugs for a suspected case of malaria? a	48 (16.3%)	72 (24.5%)	97 (33.0%)	61 (20.7%)	16 (5.4%)
How frequently do you dispense IV/IM antimalarial drugs without a prescription for a suspected case of severe malaria?[a]	154 (52.4%)	50 (17.0%)	47 (16.0%)	25 (8.5%)	18 (6.1%)
Overall experience	Mean (SD)			**56.71(7.32)**	
Experience classification	Inadequate experience			**224 (76.2)**	
	Adequate experience			**70 (23.8)**	

Overall experience were classified into "Inadequate experience " and "Adequate experience" on the basis of the upper quartile (75th percentile)

Items marked with (a) indicate reverse coding

barriers were identified as key predictors of poor knowledge, whereas pharmacists practicing in Hodeida exhibited inadequate experience.

The study revealed that 76.5% of the pharmacists in Hodeidah had poor knowledge regarding malaria diagnosis and treatment (mean score: 9.96, SD 3.47). This proportion is considerably higher than what has been reported in other regions, such as 52.5% in Cameroon[30], over 50% in Nigeria [31], and 66% in Sudan [20]. These differences may be attributed to varying levels of resources, training opportunities, and public health infrastructure.

In terms of symptom recognition, 97.6% of the pharmacists correctly identified fever, headache, and chills as common symptoms of malaria. This result is comparable to findings from Cameroon (95.5%)[32] and higher than that from Rwanda (73.8%) [33]. However, only 60.9% correctly identified *P. falciparum* as the dominant malaria species in Yemen, which is lower than the 86% reported in Sudan [20]. This knowledge gap could delay appropriate treatment and contribute to higher morbidity and mortality rates in Yemen.

Community pharmacists are often the first point of contact for malaria patients in community settings, making their knowledge and preparedness vital for effective malaria control. Their competency in four key areas, namely symptom recognition, accurate diagnosis, appropriate treatment, and timely reporting, plays a crucial role in case management [34, 35]. Timely recognition of febrile patients suspected of malaria enables early

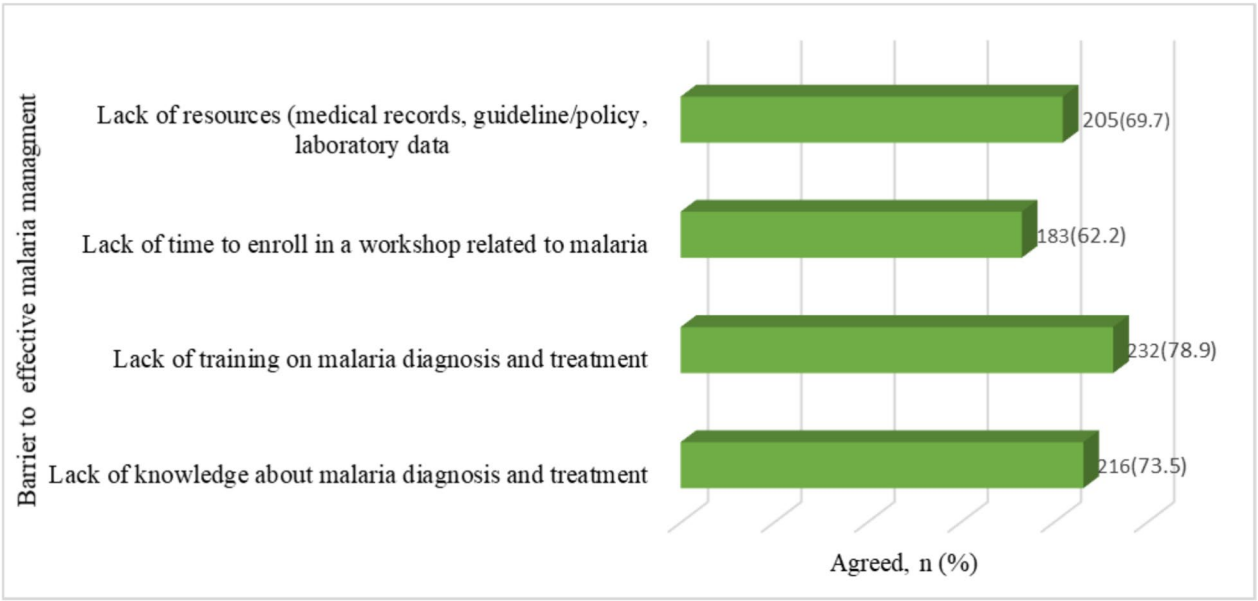

Fig. 2 Barriers to the effective contribution of pharmacists in malaria treatment

intervention, while urgent reporting within 24 h facilitates rapid public health responses to contain disease spread. In Yemen, where healthcare resources are limited, equipping pharmacists with the necessary knowledge and skills is essential for improving malaria outcomes.

Regarding the treatment of uncomplicated malaria, only 34.4% of the pharmacists correctly identified artemisinin-lumefantrine as the first-line treatment for *P. falciparum* malaria. This rate is lower than the 42.5% reported in Cameroon [30] and the 76% reported in Nigeria [36]. The knowledge gap may stem from the gradual transition in Yemen's anti-malarial treatment protocols, which have evolved from chloroquine to artesunate + sulfadoxine/pyrimethamine [12–14] and then to artemisinin-lumefantrine [1, 37]. This transition occurred without corresponding updates to pharmacist education and training, given that only 14.7% of community pharmacists reported that they had read the complete report of the NPAD, and only 29.7% correctly recognized its objectives. These findings underscore the pressing need for ongoing education and training for community pharmacists, who serve as the most accessible healthcare professionals.

In terms of severe malaria treatment, 43.2% of the pharmacists identified intravenous artesunate as the drug of choice, indicating better knowledge than in uncomplicated cases. Nevertheless, severe malaria symptoms were identified in only 17.0% of the patients. This deficiency could lead to delays in seeking appropriate care, potentially increasing mortality [38]. A similar finding was reported in Cameroon, where only 10% of pharmacists recognized severe malaria [30]. As frontline healthcare providers, pharmacists must be equipped to assess the severity of malaria and refer patients promptly to prevent complications [39, 40].

Only 46.3% of the pharmacists agreed on dispensing a single dose of primaquine for Plasmodium gametocidal activity, which is lower than that reported in India [39]. While 60.9% acknowledged primaquine's risks for pregnant women and infants, only 12.6% identified artesunate as the first-line treatment for severe malaria during pregnancy, and only 7.8% recognized the major complications that malaria poses to pregnancy. These knowledge gaps could negatively impact pregnancy outcomes, especially since uncomplicated malaria is often managed in community pharmacies. A recent study in Kenya highlighted better knowledge regarding malaria treatment during pregnancy [40], reinforcing the need for updated training.

Integrating these updates into pharmacy curricula and providing regular training sessions are essential for ensuring that community pharmacists remain well-informed about malaria diagnosis and treatment. Notably, on November 25, 2022, the WHO endorsed artemisinin-lumefantrine as the preferred treatment for uncomplicated malaria during all trimesters of pregnancy [41, 42]. In Yemen, health authorities updated the anti-malarial policy in the third quarter of 2023, designating artemisinin-lumefantrine as the drug of choice for uncomplicated malaria in all trimesters.

The study identified several predictors of poor knowledge, including being over 40 years old, working in the

Table 5 Predictors of poor malaria knowledge among community pharmacists (n = 294)

	n	Univariate logistic regression		Multivariable logistic regression	
		COR(95% C.I.)	*P* value	AOR(95% C.I.)	*P* value
Age					
19–30	148	Reference		Reference	
31–40	116	2.040 (1.134, 3.669)	**0.017***	1.270 (0.584, 2.757)	0.546
> 40	30	6.314 (1.443, 27.630)	**0.014***	6.827 (1.360, 34.258)	**0.020***
Gender					
Male	271	Reference		Reference	
Female	23	0.442 (0.183, 1.072)	0.071	0.828 (0.289, 2.372)	0.725
Sector					
Public sector	130	Reference		Reference	
Private sector	164	2.238 (1.291, 3.878)	**0.004***	1.356 (0.671, 2.741)	0.397
Qualification					
Clinical pharmacy	48	Reference		Reference	
Bachelor of pharmacy	43	2.377 (0.991, 5.698)	0.052	1.491 (0.516, 4.306)	0.461
Diploma	203	4.573 (2.327, 8.987)	**< 0.001***	2.555 (1.065, 6.128)	**0.036***
Experience (Year)					
< 5 years	108	Reference		Reference	
≥ 5	186	1.696 (0.980, 2.933)	0.059	0.966 (0.454, 2.055)	0.928
Have received training					
Yes	157	Reference		Reference	
No	137	2.233 (1.263, 3.949)	**0.006***	1.692 (0.842, 3.399)	0.139
Have studied malaria-related topic at the university					
Yes	254	Reference		Reference	
No	40	4.330 (1.292, 14.513)	**0.018***	2.828 (0.781, 10.241)	0.113
Awareness about the NPAD					
Yes	135	Reference		Reference	
No	159	2.208 (1.272, 3.833)	**0.005***	1.909 (0.998, 3.652)	0.051
Have a drug reference for antimalarial medications in the pharmacy					
Yes	134	Reference		Reference	
No	160	2.640 (1.510, 4.616)	**0.001***	1.480 (0.754, 2.903)	0.254
Pharmacy location					
District	143	Reference		Reference	
Hodeidah	151	0.958 (0.559, 1.644)	0.877		
Pharmacy type					
Chain pharmacy	74	Reference		Reference	
Independent pharmacy	220	0.869 (0.461, 1.638)	0.665		
Barriers to effective malaria management					
> 2 barriers	190	Reference		Reference	
≤ 2 barriers	104	3.286 (1.670, 6.465)	**< 0.001***	3.830 (1.802, 8.138)	**< 0.001***

The model has a classification table accuracy of 78.6%, a Hosmer and Lemeshow test value of 0.878, and a Nagelkerke R2 of 27.8%

Asterisks (*) and bold values indicate statistically significant p values (< 0.05)

private sector, holding a diploma, lacking malaria training, and being unaware of the NPAD. These findings align with other studies showing that training [20, 40, 43], access to malaria guidelines [43], age [44], and academic level [45] are key predictors of malaria knowledge. These results underscore the pressing need for ongoing education and training for community pharmacists, who serve as the most accessible healthcare professionals.

In terms of experience, only 76.2% of the pharmacists reported inadequate experience in malaria diagnosis and management, which is higher than the reported rates in Ghana [46] and Saudi Arabia [47]. This likely reflects a

Table 6 Predictors of inadequate experience among community pharmacists (n = 294)

	n	Univariate logistic regression		Multivariable logistic regression	
		COR (95% C.I.)	*P* value	AOR (95% C.I.)	*P* value
Age					
19–30	148	Reference		Reference	
31–40	116	0.763 (0.427, 1.363)	0.361	0.849 (0.413, 1.742)	0.655
> 40	30	0.439 (0.189, 1.021)	0.056	0.538 (0.197, 1.469)	0.227
Gender					
Male	271	Reference		Reference	
Female	23	2.190 (0.631, 7.600)	0.217		
Sector					
Public sector	130	Reference		Reference	
Private sector	164	0.797 (0.462, 1.376)	0.416		
Qualification					
Clinical Pharmacy	48	Reference		Reference	
Bachelor of Pharmacy	43	0.471 (0.155, 1.431)	0.184	0.576 (0.177, 1.867)	0.358
Diploma	203	0.394 (0.159, 0.980)	**0.045***	0.404 (0.152, 1.077)	0.070
Experience (years)					
< 5 years	108	Reference		Reference	
≥ 5	186	0.565 (0.313, 1.020)	0.058	0.717 (0.343, 1.500)	0.377
Received Training					
Yes	157	Reference		Reference	
No	137	1.800 (1.034, 3.134)	**0.038***	1.606 (0.863, 2.988)	0.135
Studied malaria-related topic					
Yes	254	Reference		Reference	
No	40	3.160 (1.083, 9.215)	**0.035***	2.727 (0.902, 8.245)	0.076
Awareness about the NPAD					
Aware about some/all content	135	Reference		Reference	
Not aware	159	1.067 (0.623, 1.827)	0.814		
Have a drug reference for Antimalarial medications					
Yes	134	Reference		Reference	
No	160	1.468 (0.857, 2.516)	0.162	1.685 (0.900, 3.155)	0.103
Pharmacy location					
District	143	Reference		Reference	
Hodeidah	151	1.827 (1.058, 3.153)	**0.030***	1.865 (0.900, 3.155)	**0.043***
Pharmacy type					
Chain pharmacy	74	Reference		Reference	
Independent pharmacy	220	0.541 (0.272, 1.075)	0.079		
Barriers to effective malaria management					
> 2 barriers	190	Reference		Reference	
≤ 2 barriers	104	1.374 (0.770, 2.450)	0.282		

The model has a classification table accuracy of 78.6%, a Hosmer and Lemeshow test p value of 0.738, and a Nagelkerke R2 of 12.3%. The upper quartile was used as the cutoff point to determine adequate experience (≥ 80%) [24, 25]

Asterisks (*) and bold values indicate statistically significant p values (< 0.05)

lack of training, as most pharmacists in this study identified insufficient knowledge and training as barriers to their effective contribution to malaria management. Furthermore, 79.6% of pharmacists reported dispensing antimalarial drugs without a prescription, exceeding the 59% rate reported in Sudan [20]. Additionally, 67% dispensed anti-malarials on the basis of patient requests without laboratory tests, similar to Ghana [46], but lower than in other sub-Saharan countries [48, 49]. These experience deviate significantly from the WHO and national

guidelines, which mandate malaria testing before antimalarials are dispensed. Such deviations may contribute to the development of anti-malarial resistance, ultimately complicating malaria control and elimination efforts.

In terms of patient advice, 49% of the pharmacists consistently advised taking anti-malarial drugs with food, comparable to Ghana (52.2%) [46] but lower than the 61.4% reported in Sudan [20]. Additionally, 73.5% advised not to take the medication on an empty stomach, representing an improvement over Tanzania, where many pharmacists were unaware of the importance of food for drug absorption [50]. However, only 18.7% consistently provided guidance on the use of oral anti-malarial drugs for uncomplicated malaria, which is significantly lower (59.7%) than that reported in Sudan [20].

Several factors were identified as predictors of inadequate experience, including qualifications, training, malaria-related topics studied, and pharmacy location. However, when controlling for other variables, only pharmacy location emerged as a significant predictor of pharmacists' experience adequacy. Specifically, pharmacists in Hodeidah city were 1.865 times more likely to exhibit inadequate experience than those working in the districts of Hodeidah. This finding is consistent with the higher prevalence of malaria in districts than in cities. In rural areas, conditions such as stagnant water in ponds and irrigation ditches are more conducive to mosquito breeding [51–53]. Consequently, pharmacists in these districts are likely more familiar with malaria cases than their urban counterparts are, where the incidence is lower, and healthcare centers are better equipped to manage both complicated and uncomplicated cases.

The study identified a lack of training and insufficient knowledge as major barriers to effective malaria management by community pharmacists. These findings, which are consistent with those of Elhag and Sulaiman [20], highlight the need for targeted educational initiatives to enhance pharmacists' competencies. Addressing these barriers is crucial for enabling community pharmacists to contribute meaningfully to patient care and public health, particularly in the fight against malaria. By equipping pharmacists with the necessary skills and knowledge, their role in the healthcare system can be optimized, ultimately supporting broader malaria eradication efforts.

Strengths and limitations of the study

This study has several strengths, including a relatively large sample size and a comprehensive exploration of factors influencing knowledge and experience. Moreover, it is the first to target community pharmacists across 16 districts of Hodeidah, where 95% of the pharmacies and drug stores in the governorate are located.

However, limitations include the cross-sectional design and the use of convenience sampling, which may introduce selection bias and limit the generalizability of the findings. Reliance on self-reported data may not fully reflect pharmacists' actual practices. Additionally, the tool did not address critical aspects of malaria management, such as urgent reporting to health systems, potentially overlooking key pharmacist roles in malaria control.

Future research should aim to address these limitations by employing longitudinal study designs to track changes in pharmacists' knowledge and experience over time and assess intervention impacts. Using simulated patients or direct observation methods could also provide more accurate insights into real-world practices and address areas like reporting to health systems.

Conclusion

This study highlights a significant knowledge gap regarding malaria among community pharmacists in Hodeidah city and its surrounding districts. Many participants demonstrated limited understanding of prevalent malaria species in Yemen, appropriate medication selection for complicated and uncomplicated cases, suitable anti-malarial options during pregnancy, and the implications of malaria in pregnant women. Factors such as age, training, type of pharmacy, and pharmacy location were found to influence pharmacists' knowledge and experience in malaria management.

To address these gaps, policymakers should integrate updated malaria protocols into pharmacy curricula, provide regular training, and involve pharmacists in national malaria control programs. Strengthening pharmacists' roles in early diagnosis, treatment, and patient counseling is crucial for advancing malaria elimination efforts in Yemen.

Abbreviations

AOR	Adjusted odds ratio
COR	Crude odds ratio
CI	Confidence interval
CVI	Content validity index
FVI	Face validity index
G6PD	Glucose-6-phosphate dehydrogenase
IV	Intravenous
IM	Intramuscular
NPAD	National Policy for Antimalarial Drugs
NMCP	National Malaria Control Programme
mRDT	Malaria Rapid Diagnostic Test
SD	Standard deviation
WHO	World Health Organization

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Author contributions
AMH led the conceptualization, methodology, data acquisition, formal analysis, visualization, validation, and original draft preparation and editing. SNH, SMSG, and SASS contributed to conceptualization, methodology, validation, and supervision and revised the draft. DAI, AAA, and FYA assisted with conceptualization, methodology, data interpretation, and critical revision of the manuscript. All the authors approved the final version.

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Data availability
The data are available from the corresponding author upon reasonable request.

Declarations

Ethics approval and consent to participate
The study was approved by the Ethical Committee of Medical Research at the University of Science and Technology, Yemen (Reference No: EAC/UST221), which also approved verbal informed consent, as the study posed no risk to participants and ensured anonymity. The protocol was additionally reviewed and approved by the Human Research Ethics Committee at Universiti Sains Malaysia (JEPeM Code: USM/JEPeM/PP/24020165). The study adhered to the ethical guidelines of the Declaration of Helsinki.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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