



Faculty of Science - University of Benghazi

Libyan Journal of Science &amp; Technology

journal home page: <https://journals.uob.edu.ly/LJST>

# A study on the prevalence of the malaria parasite in the city of Sebha among expatriate workers from neighboring countries.

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## Highlights

- About the extent of the spread of positive cases of malaria among those arriving from neighboring countries to the southern region of Libya.
- Using rapid diagnostic testing as an accurate method to detect cases of malaria.
- Attempts to study potential risk factors associated with malaria transmission.

## ARTICLE INFO

### Article history:

Received 04 January 2024

Revised 02 April 2024

Accepted 02 April 2024

### Keywords:

Malaria, Expatriates, Rapid Malaria Test, On-Site (Pf/Pan) antigen

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## ABSTRACT

Libya eliminated malaria in 1973. The majority of malaria cases reported in Libya are imported cases, that travelled abroad, especially to neighboring countries where malaria is endemic. Rapid diagnostic test (RDTs) was conducted to determine the possible risk of malaria among expatriates residing in different areas in Sebha City. The results of this study showed that out of 363 expatriates, 141 had an infection with malaria (38.8%). Infection of *Plasmodium falciparum* and *Plasmodium vivax* was reported among one hundred one (27.8%) and forty expatriates (11.01%) respectively. The infection rate was higher in males than females, reaching 39.2% and 31.2%, respectively. Infection of malaria was higher among expatriates who came from Chad (55.55%) and Niger (41.35 %). The correlation between the infection rate of malaria and the educational attainment of expatriates was substantially statistically significant ( $\chi^2 = 9.571$ ;  $P = 0.002$ ). This study confirms that the prevalence of malaria among expatriates is relatively high which may impose a high risk of re-introducing malaria to the southern regions of the country.

## 1. Introduction

Malaria is an acute febrile illness caused by *Plasmodium* parasites, which are spread to people through the bites of infected female *Anopheles* mosquitoes. Malaria occurs primarily in tropical and subtropical countries. Nowadays, malaria is the most severe protozoan infection globally, and it affects many people worldwide every year (Su *et al*, 2020). However, between 2000 and 2015, malaria incidence among populations at risk fell by 37% globally; and mortality rates decreased by 60% and 65% in children younger than five years (WHO, 2023). This parasite is also dominant in other malaria hotspots, including the WHO regions of South-East Asia, Eastern Mediterranean and Western Pacific (WHO, 2024). According to the World Health Organization's latest estimates, 228 million cases occurred globally in 2018, resulting in 405,000 deaths. Most cases (93%) were reported from the WHO African region (WHO, 2019). Africa has the highest burden of malaria with 81% of the cases and 91% of the deaths due to malaria globally (WHO, 2011). However, between 2000 and 2015, malaria incidence among populations at risk fell by 37% globally; and mortality rates decreased by 60% and 65% in children younger than five years (WHO 2020).

Malaria caused by *Plasmodium vivax* is widely distributed globally and rarely fatal. Infection with *Falciparum* malaria is comparatively rare and the most fatal species of malaria. In addition, co-infections between *P. falciparum* and *P. vivax* have been well-documented and have been reported to occur in up to 10–30% of patients living in areas where both parasites are prevalent (Im-mong *et al*, 2011 and Ginouves *et al*, 2015). Libya is free from local malaria transmission and the last case of malaria was reported in 1973 (WHO, 2011).

In non-endemic nations like Libya, the transmission of malaria from endemic nations poses a concern to public health. This potential risk manifests as a result of the sharp rise in labor migration to Libya from the developing nations. The majority of them come from Egypt, Sudan, Ghana, Niger, and Chad. In Africa, some countries in the North have achieved malaria elimination in the last 30 years, Libya in 1973 (Hamid *et al*, 2018), Tunisia in 1979 (Snow and Marsh 2010), and Morocco in 2010 (Snow *et al*, 2012). The majority of the region is largely regarded as malaria-free despite a few disputed residual foci in Algeria and Egypt (Hamid *et al*, 2018). Elimination, however, poses a major challenge in the majority of countries in Africa owing to the intrinsically high transmission intensity within each country's national borders (Snow and Marsh, 2010). There is no active transmission of malaria. The last local case was

reported in 1973. However, every year cases of malaria are reported in the country. The actual cause is unknown. There is a re-introduction of malaria in Libya through illegal immigration from neighboring sub-Saharan countries where malaria is endemic (Snow *et al*, 2012; Hamid *et al*, 2018; Mahanay *et al*, 2021). Moreover, improved roads lead to the movement of heavy load vehicles in neighboring regions (in or out), air traffic, and the receptivity to both, imported malaria and its vectors in many parts of Libya where subterranean sources of water are being used for development and irrigation (Ramsdale, 1990). Many Libyan oases, like those in other parts of the Sahara, have a history of occasional outbreaks of malaria involving *Plasmodium vivax* Grassi and Feletti and *P. falciparum* Welch. The latter species of malaria parasite has been eradicated from the Mediterranean basin but still predominates in Africa south of the Sahara (Ramsdale, 1990). In Libya, past exposure to relapsing malaria was measured by Gebreel *et al*, (1985). Moreover, imported clinical malaria has been reported in the southern region of Libya (Mahanay *et al*, 2021). With the challenges of immigration from neighboring endemic countries and increasing the volume of trade, the reintroduction of the disease in Libya is possible.

This study was conducted to investigate the prevalence of malaria-positive cases using rapid malaria diagnostic tests among expatriates coming from neighboring countries in the southern region of Libya. Attempts were also made to study possible risk factors associated with the transmission of malaria.

## 2. Materials and Methods

The study population consisted of expatriate workers from Libya's neighboring countries (Egypt, Sudan, Tunisia, Algeria, Chad and Niger), who came to the health care center in Sabah to obtain a health card to get a work permit in the institutions. A total of 1295 expatriate workers were registered during the period from 1/1/2020 until 6/24/2021. Of 1295 blood samples collected, 363 random samples were taken for the diagnosis of malaria. A standardized questionnaire was used which included information about age, gender, nationality, marital status, educational level and housing place of expatriates.

Two millilitres of venous blood samples were collected from each participant. All the samples were kept in clean, sterile plastic tubes designated for samples, containing anticoagulant Ethylene Diamine Tetra Acetic Acid (EDTA). These tubes are used for tests that rely on whole blood. The samples were arranged in cold storage and transported to the research laboratory at the Faculty of Science, Sebha University for examination using rapid diagnostic test strips (RDTs).

Rapid diagnostic test kit (RDTs) produced by CTK Biotech Inc, USA, was evaluated in this study. This device has the ability to detect Pan-specific lactate dehydrogenase (pLDH) and *P. falciparum*-specific HRP-II. A commercially available rapid diagnostic kit (On-Site Pf/Pan) from Hangzhou Biotest Biotech Co.Ltd. (Right Sign) was used for the diagnosis of malaria. The test was performed according to the instructions given in the kit of the test. If both LDH and HRP line and only HRP line is found then the experimental sample is considered as *P. falciparum* positive. Conversely, only LDH-positive samples were diagnosed as non-falciparum, exclusively *P. vivax* in this study.

Statistical analysis was carried out using the Statistical Package for the Social Sciences-20 (SPSS-20)—chi-square test to determine the significance of the relationship between variables. The differences were considered significant (statistically significant) when the P-value was less than 0.05.

## 3. Results

The ages of participants ranged from 15 to 70 years. The majority of expatriates were males (95.65%) compared to females (4.4%). There was no significant difference in the infection of malaria between both genders ( $\chi^2=0.406$ ,  $P=0.524$ ). The highest (35.6%) detection of malaria was noted among 15 to 25-year-

old participants. No, significant difference was found among different age groups ( $\chi^2=2.285$ ,  $P=0.683$ ). Infection of malaria among expatriates is presented in Table 1.

**Table1**

Infection of malaria among expatriate workers in Sebha City

<i>Plasmodium falciparum</i> * Pan*	<i>Plasmodium falciparum</i> * Pan*	<i>Plasmodium falciparum</i> * Pan*	<i>Plasmodium falciparum</i> * Pan*
141 (38.8)	40 (11.01)	101 (27.82)	222 (61.15)

\*Pan +=positive for *P.viva*\*and \*Pan-=negative for *P.vivax*

Results revealed that out of the 363 blood samples tested, 141 (38.8%) participants indicated the presence of *Plasmodium anti-gens* residing in Sebha City. Forty participants (11.01%) showed infection with *Plasmodiumvivax* (Pan+) and one hundred one participants (27.82%) were found exclusively positive for *P. falciparum* infection.

Table 2 shows the distribution of malaria according to nationality. Regarding malaria-positive cases, expatriates from Chad showed the highest infection (55.55%) followed by Niger (41.3%), Egypt (36.63%), Sudan (33.33%) and Tunisia (30.76). Statistically, no significant differences were found in the infection of malaria among the expatriates from different nationalities ( $\chi^2=5.661$ ,  $P=0.226$ )

**Table 2**

Infection of malaria among expatriate workers from different nationalities

Nationality	No. of samples examined	No. of sample infected (%)
Niger	162	67 (41.35)
Sudan	69	23 (33.33)
Tunisia	13	4 (30.76)
Chad	18	10 (55.55)
Egypt	101	37 (36.63)

**Table 3**

Risk factors associated with malaria among expatriate workers.

Factors		No. of samples examined	No. of sample infected (%)	Statistics
Gender	Males	347	136 (39.19)	$\chi^2=0.406$ , $P=0.524$
	Females	16	5 (31.25)	
Marital Status	Married	190	79 (41.57)	$\chi^2=0.619$ , $P=0.431$
	Unmarried	173	62 (35.83)	
Education Level	Educated	199	62 (31.15)	$\chi^2=9.571$ , $P=0.002^*$
	Uneducated	164	79 (48.17)	
Locality	Rural	178	71 (39.88)	$\chi^2=0.235$ , $P=0.628$
	Urban	185	70 (37.83)	

\* $P<0.05$  Significant

The infection of malaria among expatriates, according to their marital status, education level and residency is presented in Table 3. The highest infection rate of malaria (48.17%) was found among uneducated expatriates compared to 31.15% among educated expatriates. A significant difference was found between educated and uneducated participants ( $\chi^2=9.571$ ,  $P=0.002$ ). The marital status and residency of participants did not show significant differences.

## 4. Discussion:

Africa is often called the "heartland" of malaria and remains a major public health threat and impediment to economic development. As a result of the migration of expatriate workers, the spread of malaria infection in endemic African countries has begun to pose

a risk factor to public health in neighboring regions, such as Libya (Mahanay *et al.*, 2021). Malaria was endemic in Libya until 1973 when it was declared by WHO to be a country free of malaria (WHO, 1996). Libya is facing a continuous influx of expatriate workers and an increase in the volume of trade from neighboring endemic regions of malaria is still at risk of malaria spread in the region (Snow *et al.*, 2012, Hamid *et al.*, 2018). The information regarding mosquito-borne diseases in Libya is poor with few reports on malaria cases (Hamid *et al.*, 2018; Martelli *et al.*, 2015; Shaibi, 2017, Mahanay *et al.*, 2021).

In this study, a total of 363 samples were analyzed from 1295 participants suspected of malaria infection. The results of this study indicate that clinical malaria is prevalent (38.8%) among expatriates using the RDTs test (Pf/Pan). This infection rate was lower than the results of the study presented by Mahanay *et al.* (2021) using the Enzyme-Linked Immunosorbent Assay (ELISA) technique. They reported that 64.36% of illegal immigrants positive for malaria antibodies residing in Sebha City came from countries in sub-Saharan Africa. Similarly, thousands of imported malaria cases were reported in immigrants and travellers in European Union countries (ECDPC, 2019). An outbreak of *Plasmodium vivax* occurred in the coastal city of Zuara, involving 18 subjects and is believed to have been introduced by migrant workers (Gebreel *et al.*, 1985 and Snow *et al.*, 2012). Hamid *et al.*, (2018) determined the prevalence of malaria infection in the Fezzan region (south of Libya). They found that out of the 220 blood samples collected from 220 patients suspected of malaria infection, 43 samples (19.54 %) were positive. Out of 43 positive malaria patients, 41 were Libyans. It suggested that the presence of illegal labors from different African countries might be the cause of the infection (The Libyan Observer, 2015). The Fezzan region has a long history of epidemic malaria; with many outbreaks of *P. falciparum* brought in by carriers in caravans coming from the south and transmitted by local vectors. *P. vivax* was more prevalent near the coast. Most imported malaria now is of *P. vivax*, though there are some cases of *P. falciparum*. Moreover, most current parasite carriers quickly disperse from ports (airports); therefore, all parts of the country are equally vulnerable. The desert forms of *Anophelines* exist in Libya (Macdonald, 1982; Khalefa *et al.*, 2022) to be the principal vector species that are sufficiently prevalent to maintain malaria transmission in most of Libya (Ramsdale, 1980). Gebreel *et al.* (1985) applied an Indirect Fluorescent Antibody (IFA) test in order to determine the possible risk to Libyan communities of malaria, particularly relapsing forms, as a direct result of the presence of large teams of immigrant labour. Furthermore, new cases of Libyans infected with malaria have been detected on December 2018 (Hamid *et al.*, 2018). In the present study, 41.35%, 55.55 % and 33.33% infections of malaria were reported among the migrant workers arriving from Niger, Chad and Sudan respectively. However, Mahanay *et al.*, (2021) found high rates of infection among illegal immigrants arriving from Chad and Sudan in Libya reaching 100 % and 66.67 % respectively. Our study also recorded a higher rate of malaria (41.35 %) among expatriates from Niger compared to the report of Mahanay *et al.*, (2021), where the infection of malaria reached 16.2 % among workers from Niger. Hamid *et al.*, (2018) studied the spread of malaria infection in the Fezzan region (Southern Libya) using microscopic examination and RDTs (Pf/Pan), and found 19.54% infection among patients from different places in south Libya (Sebha, Murzug, Gaat and Um-alaranib). Moreover, a study in Saudi Arabia showed a higher rate of malaria (63.3%) among the workers arriving from endemic countries of malaria (Hawas *et al.*, 2019) and agreed with our study that international borders represent a major challenge for countries seeking to eliminate malaria. In agreement with this observation, neighboring countries showed the infection rate is high in Niger and Egypt. Furthermore, it suggested that people coming from endemic areas of malaria pose a risk of re-introduction of malaria in the region which is likely reported in Europe (Bisoffi *et al.*, 2003 and Kassir *et al.*, 2014).

This study concluded that the age group of 15-24 years has the highest number of cases at 50.1% (182 cases) and an infection rate of 41.8% compared to other groups. The study also showed the highest infection with all four parasites (Pf + Pan) in the age group 15-24 years (11.6%). This may be because this is the most preferred age by employers and this is why they leave their countries for employment in overseas.

Our study showed that the infection rate of malaria in the unmarried was low compared to married people but the difference was statistically insignificant ( $\chi^2=0.619$ ,  $P=0.431$ ). This study differed from the study of Al-Haddad & Elsalem (2022) in Libya to study the spread of the malaria parasite among expatriate workers in Sebha using a rapid diagnostic test, which showed that the infection rate for the unmarried category was the highest and amounted to 22.7% compared to the category of married people, which amounted to 8.2% and the difference was significant ( $\chi^2=16.74$ ,  $P=0.00$ ). This difference in results is probably due to the sample size in the two study groups.

This study examined the educational level as one of the risk factors for the spread of malaria. The study sample showed that the rate of infection with the parasite in general among the uneducated group was significantly higher ( $\chi^2=9.571$ ,  $P=0.002$ ) than that of the educated group, which amounted to 48.2% and 31.2%, respectively. The high incidence of infection among the uneducated group may be attributed to several reasons, including the lack of health knowledge, especially knowledge about methods and measures to prevent malaria, acceptance and implementation of safe practices and lack of knowledge of government health centers that provide diagnosis and group treatment in their countries. These are all risk factors that contribute to accelerating the transmission of malaria. The study of Dayanand *et al.*, (2017) in India agreed with this study, as it showed that the educational level was a risk factor, and the incidence of malaria among uneducated immigrants was high, reaching 83% of the total cases of infection, while the study of Tilaye *et al.*, (2021) in Ethiopia also showed that the educational status of migrant workers was associated with malaria infection. A study in Sudan reported that educational level did not show a significant association with the incidence of malaria (Eshaget *et al.*, 2020).

Our study examined the place of residence as a risk factor, as it showed that individuals who live in villages have a higher infection rate than those who live in the city, where the percentage was 39.9% and 37.9%, respectively. The results of this study showed that malaria infection among rural residents was higher, at a rate of 39.88 %, while in urban areas it was 37.80 %. These results agreed with the study presented by Tadesse *et al.*, (2018) in Ethiopia. This study also showed no statistically significant relationship between the infection rate and place of residence ( $\chi^2= 0.92$ ,  $P=0.62$ ).

## 5. Conclusion:

The result of this study confirms that the prevalence of malaria among expatriate workers arriving in Southern Libya from neighbouring regions is relatively high. On-site (Pf/Pan), newly available RDTs appeared to be useful in identifying both *P. falciparum* and *Plasmodium vivax* infections. It can be utilized for the diagnosis of symptomatic malaria as well as to discriminate between falciparum malaria infection and vivax malaria in endemic areas and during outbreaks. The significant increase in the entry of expatriate workers into the country and the parasitic infection they carry with malaria and what may result in re-introducing the disease into the country requires further studies to be conducted.

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