

Original Article

Epidemiological trends of malaria in the Western regions of Saudi Arabia: a cross sectional study

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Abstract

Introduction: Saudi Arabia has successfully reduced malaria cases to be constrained largely in the western regions. This study aimed to determine the epidemiological trends of malaria infection in five western regions of Saudi Arabia.

Methodology: A retrospective analysis was conducted to investigate the epidemiological trends of malaria infection in the western regions, based on the published registry of the Saudi Ministry of Health, during the period from 2014 to 2017 using the appropriate statistical tools.

Results: A total of 8925 confirmed cases of malaria were reported in the western regions during the period from 2014 to 2017 with the mean of 2231 malaria cases per year. The minimum (n = 1097) and maximum (n = 4075) number of cases were reported in 2014 and 2016 respectively. The highest (n = 5919, 66.3%) number of cases were reported from Jazan region, while lowest (n = 86, 1.0%) number of cases were reported from Al-Bahah region. *Plasmodium falciparum* was the most frequently reported species with 7485 (83.9%) cases, while *Plasmodium vivax* accounted 1386 (15.5%) cases. *Plasmodium malariae* and mixed infections were insignificant and accounted 0.5% (n = 48) and 0.1% (n = 6) cases respectively. In relation to malaria infection and age group, malaria was predominant in > 15 age group. The highest number of malaria cases in almost all years was observed from January until March and the lowest number was reported from May until July.

Conclusions: *Plasmodium falciparum* was the most dominant species in this survey and Jazan was the most affected region.

Key words: Malaria; epidemiological trends; Western region; Saudi Arabia; cross sectional study.

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Introduction

Malaria is a serious and sometimes fatal disease caused by protozoan parasites from genus *Plasmodium*. The four main different species of malaria parasites which infect human are; *Plasmodium falciparum*, *Plasmodium malariae*, *Plasmodium ovale* and *Plasmodium vivax*. Female *Anopheles* mosquitoes are the vectors of these parasites and the infection occurs during the feeding of mosquitoes on the human blood. Malaria is a great challenge for global health and considered a public health concern in many countries [1]. Over 100 countries are endemic with malaria and around half of the global population is at risk; approximately one million people die from malaria annually [2]. In 2017, 219 million cases of malaria occurred worldwide; of these, African countries bear the largest burden of malaria morbidity with 200 million cases (92%), followed by South-East Asian

(5%) and Eastern Mediterranean countries (2%) [3]. Nearly 80% of all malaria deaths were concentrated in 15 countries, most of them in the African region [2]. In the Arabian Peninsula, malaria has been recognized since the pre-Islamic era and many travelers have mentioned it as a prevailing disease [4]. A remarkable variety of infectious and contagious diseases, including malaria, was reported in countries surrounding the Arabian Gulf [5]. In Saudi Arabia, preliminary studies for malaria were carried out in the Eastern Province by ARAMCO in 1941 [4] and by Marett [6] who revealed that malaria was the most significant health hazard in Al-Hassa and Qatif. Daggy [7] described the malaria occurring in oases areas in detail. Magzoub [8] reported the results of malaria surveys carried out in different provinces of Saudi Arabia. Al-Seghayer and Sebai [9] and [4] reassessed and comprehensively discussed the malaria situation and its control in the kingdom.

Recently, Musa *et al.* [10] presented a retrospective analysis for imported malaria at Buraidah Central Hospital in Qassim region. Al-Mohammed and Ferchichi [11] studied the epidemiological trends of malaria in Al-Ahsa province. El Hassan *et al.* [12] reviewed the progress towards malaria elimination in the province of Jazan between 2000 and 2014. Alshahrani [13] studied the risk associated with malaria infection in Asir region. Hawash *et al.* [14] described comprehensively the transmission of malaria in Jazan province. Many factors affect the process of malarial transmission. It highly depends on temperature, humidity, and rainfall [15]. Despite these climatic factors, transmission of malaria infection is also determined by the socioeconomic conditions and access to malaria prevention tools as well as healthcare services [16]. In Saudi Arabia, the climate is hot and dry and rainfall is irregular, mostly occurring from October to April. In addition, there are no rivers or lakes; however, several wells and springs in the oases of the eastern and northwestern parts provide proper breeding sites for the mosquito vectors of malaria [17]. The current study aims to highlight the epidemiological trends of malaria infection in the western regions of Saudi Arabia.

Methodology

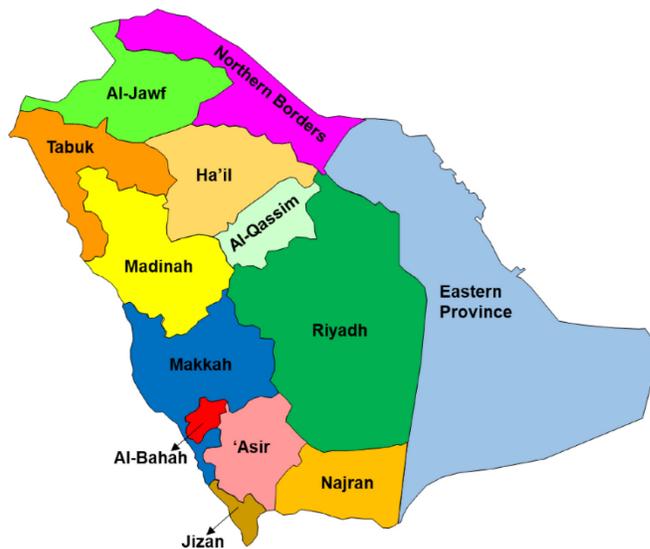
Study Area

This study focused on five administrative regions (Al-Bahah, Asir, Madinah, Makkah and Jazan) located in the west of Saudi Arabia (Figure 1). The area and population (census, 2017) of these regions is as follows: Al-Bahah (9.92 km², 476,172), Asir (76.69 km², 2,211,875) Madinah (151.99 km², 2,132,679), Makkah (153.13km², 8,557,766), and Jazan (11.67 km², 1,567,547). The average rainfall for all these regions is as follows: Al-Bahah (12 mm), Asir (10 mm), Madinah (3 mm), Makkah (9 mm), and Jazan (9 mm) (Table 1).

Study design

The study was conducted to determine the 4-year trend prevalence of malaria in five western regions of Saudi Arabia by reviewing the published data of the Saudi ministry of health [18].

Figure 1. Map of Kingdom of Saudi Arabia showing the regions of study area.



Data collection

Four-year malaria data was obtained from the registry of the ministry of health during the period 2014–2017. Microscopy was used as the gold standard method to confirm *Plasmodium* parasite presence in stained peripheral blood smear films, as per the World Health Organization protocol. The available data (Regions, No. of examined patients, No. of infected patients, infection per month per year and age group) were collected and checked for completeness before analysis; however, some important data (sex and nationality) were not provided.

Data analysis

Data were entered and analyzed using SPSS (Statistical Package for Social Sciences, version 24.0 California, USA) software. Crosstab was used for determining the frequency distribution of both dependent and independent variables. Finally, the data were presented using appropriate figures and tables.

Table 1. The amount of rainfall in different regions during the period from 2014-2017.

Region	2014	2015	2016	2017	Total average of rainfall (mm)
Al-Bahah	8	4.5	16	19.7	12
Asir	6	4.3	23	5.6	10
Madinah	4	2.1	3	1.2	3
Makkah	8	7.3	4	17.3	9
Jazan	7	9.2	16	3.2	9

Results

For the last 4 years (2014 to 2017), a total of 8925 confirmed malaria cases were reported in the western region of Saudi Arabia, with the mean of 2231 malaria cases per year. From 2014 to 2017, there was a fluctuating trend of malaria, with the minimum (n = 1097) and maximum (n = 4075) number of cases being reported in 2014 and 2016 respectively (Figure 2). Of the 8925 cases reported in these 4 years, the highest (n = 5919, 66.3%) number of cases were reported from Jazan region, whereas the lowest (n = 86, 1.0%) number of cases were reported from Al-Bahah region. The regions of Madinah, Makkah, and Asir accounted for 1481 (16.6%), 778 (8.7%), and 661 (7.4%) cases, respectively (Table 2). Concerning *Plasmodium* species, *P. falciparum* was the most frequently reported species and accounted for 7485 (83.9%) cases, whereas *P. vivax* accounted for 1386 (15.5%) cases. *P. malariae* and mixed infections were insignificant and accounted for 48 (0.5%) and 6 (0.1%) cases, respectively (Figure 3 and Table 3). When comparing the distribution of *Plasmodium* species across different regions, *P. falciparum* was the most prevalent species in all regions, except Al-Bahah, where *P. vivax* was more prevalent. In Jazan, 96.8% of the reported cases were *P. falciparum* whereas only 3.1% were *P. vivax*. In Asir, 74.7%, cases were *P. falciparum* and 19.5% cases were *P. vivax*. In Makkah, 56.3%, cases were *P. falciparum* and 42.9% cases were *P. vivax*. In Medinah, 52.7%, cases were *P. falciparum* and 47.2% cases were *P. vivax*. Al-Bahah was the only region where *P. vivax* (81.4% cases) was more predominant than *P. falciparum* (18.6% cases) (Table 3). Overall, the number of cases reported for *P. falciparum* and *P. vivax*

Figure 2. Trend of malaria cases in Saudi Arabia from 2014 to 2017.

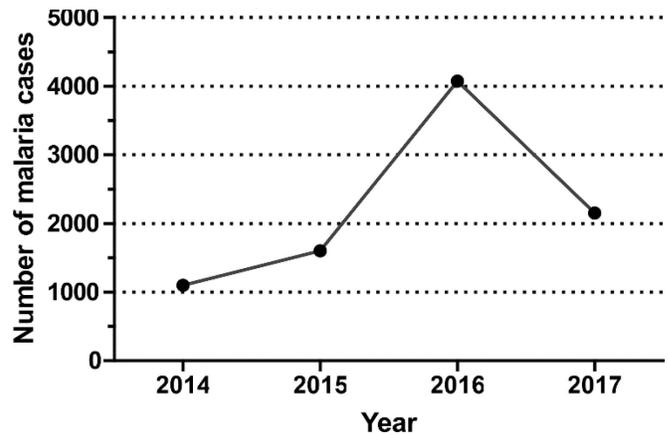


Figure 3. Trend of Plasmodium species from 2014-2017.

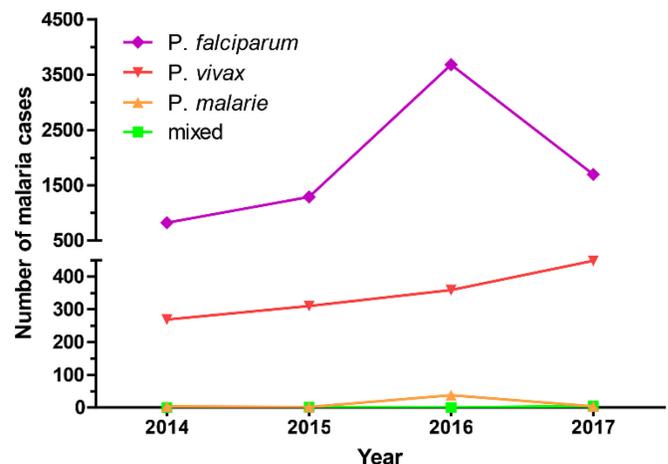


Table 2. The distribution of malaria cases in different regions from 2014-2017.

Region	Malaria cases per year -- n (%)				
	2014	2015	2016	2017	TOTAL
Al-Bahah	19 (1.7%)	34 (2.1%)	18 (0.4%)	15 (0.7%)	86 (1.0%)
Asir	89 (8.1%)	112 (7.0%)	267 (6.6%)	193 (9.0%)	661 (7.4%)
Madinah	218 (19.9%)	182 (11.4%)	177 (4.3%)	201 (9.3%)	778 (8.7%)
Makkah	272 (24.8%)	290 (18.1%)	456 (11.2%)	463 (21.5%)	1481 (16.6%)
Jazan	499 (45.5%)	984 (61.4%)	3157 (77.5%)	1279 (59.5%)	5919 (66.3%)

Table 3. The distribution of *Plasmodium* species in different regions from 2014-2017.

Region	Malaria cases per Species -- n			
	<i>P. falciparum</i>	<i>P. vivax</i>	<i>P. malariae</i>	mixed
Al-Bahah	16	70	0	0
Asir	494	129	38	0
Madinah	410	367	1	0
Makkah	834	635	8	4
Jazan	5731	185	1	2
Total	7485	1386	48	6

Table 4. The distribution of malaria cases by Age group in different regions from 2014-2017.

Region	Malaria cases per Age Group -- n			
	Age <5	Age 5-9	Age 10-14	Age >15
Al-Bahah	1	0	0	85
Asir	27	53	53	528
Madinah	12	13	5	748
Makkah	14	21	16	1430
Jazan	118	160	186	5455
Total	172	247	260	8246

from 2014 to 2017 have increased. The number of cases with *P. falciparum* peaked in 2016 (n = 3678) and then decreased by 53.9% in 2017. However, compared to 2014, the number of *P. falciparum* cases increased by 105.6% in 2017. For *P. vivax*, 359 cases were reported in 2016, which increased by 24.8% in 2017 (Figure 3). In relation to malaria infection and age group, malaria was predominant in the > 15 years age group. Of all the 8925 cases reported from 2014-2017, 8246 (92.5%) cases belonged to the > 15 years age group, followed by the 10–15 years age group with 260 (2.9%) cases, 5–9 years age group with 247 (2.8%) cases, and the <5 years age group with 172 (1.9%) cases (Figure 4 and Table 4). Jazan reported the highest (n = 5455) number of cases, whereas Al-Bahah reported the lowest (n = 85) number of cases in the > 15 years age group. Asir, Madinah, and Makkah reported 528, 748, and 1430 cases, respectively in the > 15 years age group (Table 4). The 4-year monthly trend of malaria showed that the highest number of malaria cases in almost all years was observed from January to March and the lowest were reported from May to July (Figure 5). However, the

region-wise trend showed that for Makkah and Madinah, the highest number of cases were reported from August to October.

Discussion

Many studies have addressed various aspects of malaria in different regions of Saudi Arabia including malaria transmission and control strategies [12,19,20]

Figure 4. Trend of malaria cases by Age group from 2014-2017.

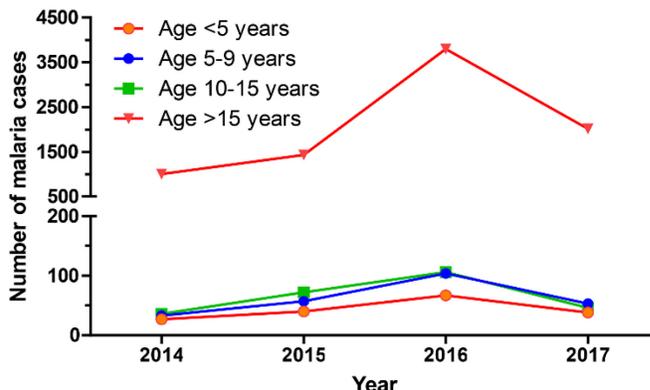
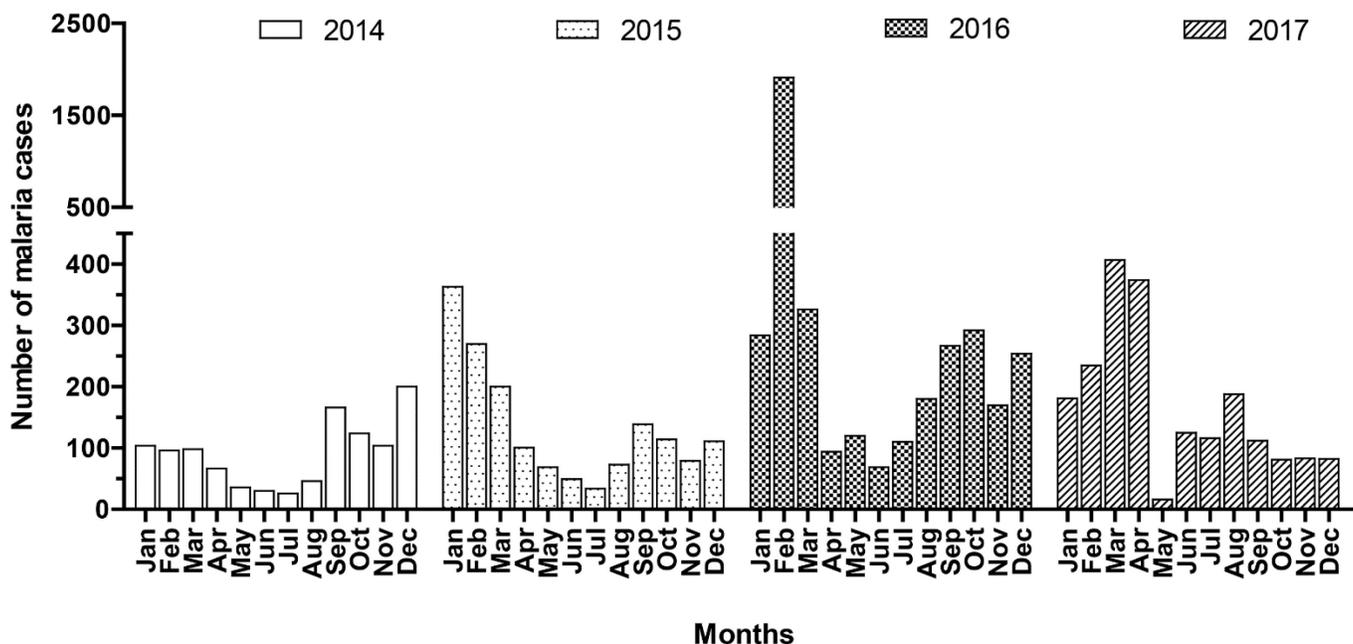


Figure 5. 4-year monthly trend of Plasmodium species from 2014-2017.



and the distribution and prevalence of malaria [10, 11,13]. The current study describes the epidemiological trends of malaria in five administrative regions (Al-Bahah, Asir, Madinah, Makkah, and Jazan) located at the west of the kingdom of Saudi Arabia. These regions are considered the most affected throughout the kingdom [11,12,17,20,21]. As shown in Figure 2, there was a fluctuating trend in the number of malaria cases during the period of the study (2014–2017), where the highest number was recorded in 2016, and the lowest number was recorded in 2014. This finding might be attributed to some climatic factors (humidity, temperature, and rainfall) that determine the prevalence of the insect vectors in the areas of infection; this finding also is in accordance with a previous study in Saudi Arabia [17] and two studies in Ethiopia [22,23]. Moreover, some human factors might affect the fluctuation trend of infection including community misconceptions for malaria prevention and control, poor community education, effectiveness of national strategies for malaria control and prevention, and laboratory personnel performance differences in malaria parasite detection [22,23]. The total number and percentage of malaria cases in the study regions (Table 2) revealed that the maximum number of cases was recorded in Jazan (5919, 66.3%), whereas the lowest number was recorded in Al-Bahah (86, 1%). This result might be due to the climatic factors and endemicity of malaria in the study regions, particularly in Jazan. This finding is also consistent with that of AL-Seghayer *et al.* [17]. Overall, infection by *P. falciparum* was the highest (n = 7485) among the study regions, followed by *P. vivax* (n = 1386), *P. malariae* (n = 48), with mixed infection showing the least occurrence (n = 6). This may be attributed to the predominance of the *Anopheles* mosquito species, which transmit these parasites. In addition, this result is in line with previous studies in Saudi Arabia [11,17,24]. Regarding malaria infection and patient age groups, the highest number (n = 8246) of cases were reported in the > 15 years age group and the lowest number (n = 172) was recorded in the < 5 years age group. This may be attributed to the fact that the > 15 years age group is the most productive and these individuals are actively involved in different activities, particularly agricultural activities, thus increasing the chances of this group being bitten by *Anopheles* mosquitoes. This finding is in accordance with the previous results in Saudi Arabia [11] and Ethiopia [22,23]. In the study regions, the number of malaria cases peaked during the period from January to March, whereas the lowest number of cases was observed during the period from May to July. These

months were the highest and lowest transmission periods in the western regions of Saudi Arabia, respectively. The highest transmission period may be due to the season of rainfall in Saudi Arabia, which usually starts in October and continues until April. This season provides a suitable environment for the breeding of malaria insect vectors (*Anopheles* mosquitoes). The lowest transmission period results from the lack or shortage of rains from May to July. This result agrees with a previous study in the Kingdom [17]. Although malaria transmission is usually associated with rainy season, the current study reported a high increase in the number of malaria cases in Makkah and Madinah from August to October. This finding might be due to the huge number of pilgrims from Islamic countries who visit these two holy places during this period [25], beside the laborers who come to work in the kingdom from malaria-endemic countries [26,27]. The main limitations of the current study are as follows; first, there is a lack of data for sex and nationality and so, we could not present any information regarding the number and percentage of malaria cases in males and females or in expatriates and Saudis. Second, the clinical correlation could not be determined, as we did not have adequate data regarding the clinical presentation of the positive cases. Third, the patients' history regarding the acquisition of the disease was limited and therefore, we could not confirm whether all the cases were imported or autochthonous. Finally, information on the treatment details was lacking.

Conclusion

Despite the efforts exerted for controlling malaria, it remains one of the major public health concerns in Saudi Arabia. *P. falciparum* was the predominant type of malaria in the study area and Jazan, Makkah, and Madinah were the most affected regions during the period of the study. The > 15 years age group was the most vulnerable and the period from January to March was the highest in malaria infection. Control activities should thus be continued in the study area with special emphasis on Jazan region. Moreover, there is a need for regular epidemiological reviews of the endemic regions to monitor the status of malaria infection.

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Conflict of interests: No conflict of interests is declared.