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Malaria in Saudi Arabia in the last six years [2011-2016]

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Abstract: Introduction: Kingdom of Saudi Arabia (KSA) suffered an outbreak of malaria in 1998, Effective strategies to shrink the malaria map were carried out. Aim: to through light on recent reports of malaria disease in KSA from 2011 till 2016.Methodology: The present study searched the previous publications in the last five years from 2011 till 2016 about malaria in the KSA. Then the collected data were arranged accordingly into:1 The geographical distribution and prevalence of malaria in Saudi Arabia. 2. The species of Plasmodium present. 3. Clinical presentation in different areas in the kingdom 4. Methods of diagnosis used. 5. Methods of treatment in kingdom. 6. Methods used to control malaria in KSA. Study design: Review article , Peroid of time: Four months. Data Source: Data for this review were identified by literature searches of PubMed and general searches using the Google and WHO search engines. Also, National Library of Medicine via the PubMed and MEDLINE were used for research articles, reviews, books, and other reports. We searched by using key word searches such as "malaria" and "Saudi Arabia". Results: The number of malaria cases in Saudi Arabia decreased between 2011 and 2016.. Incidence continued to be reported at low levels (between 0.01 and 0.1 per 1,000 of the population) with: P. falciparum predominantly, remainder was P. vivax .species. Artesunate plus sulfadoxine-pyrimethamine were the first line treatment. Chloroquine showed resistance. Chemoprophylaxis and mosquito avoidance were recommended. Conclusion: Malaria control has reduced the incidence of disease over the last 15 years, there are only few cases in rural areas of Jeddah, Al Jouf and Jizan emirates by border of Yemen, reported in 2016. Saudi Arabia is on the way to eradicate malaria.

Keywords: Malaria - Saudi Arabia - Plasmodium falciparum.

1.Introduction

Malaria is one of the most common infectious diseases and a great public health problem worldwide, particularly in Africa and south Asia. About 3.2 billion people – almost half of the world's population – are at risk of malaria. Patients often experience fever, chills, and flu-like illness. If left untreated, they may develop severe complications and die [(1)]. It is vital to monitor malaria trends to see if malaria control campaigns are being effective, and to make improvements. Malaria is a mosquito-borne disease caused by a protozoan parasite. There are four species that can infect humans: *P. falciparum, P. vivax, P. malariae, and P. ovale, only P. vivax* and *P. ovale* can develop dormant liver stages that can be reactivated after symptomless intervals of up to 2 (*P. vivax*) to 4 years (*P. ovale*) [(2)]. An experienced laboratory technician or pathologist can distinguish between *P. falciparum, P. vivax, P. malariae, and P. ovale* based on the appearance of the parasites and infected blood cells [(3)]. Increasingly reference diagnostic

tools like PCR are employed to confirm malaria infection and to determine definitively which species are involved [(4)]. Resistance to antimalarial medicines is a recurring problem. Resistance of *P. falciparum* to previous generations of medicines, such as chloroquine and sulfadoxine-pyrimethamine (SP), became widespread in the 1970s and 1980s, undermining malaria control efforts and reversing gains in child survival. [(5)]

Problem Statement / Importance of the Study:

Malaria is a major vector-borne disease. Based on vast geographic areas with associated topographic and climatic diversity, the variable malaria epidemiology in Saudi Arabia is associated with parasite genetic diversity and rapidly evolving drug resistance, differential distribution of vector species and emerging insecticide resistance and underlying human genetic diversity and past evolutionary histories.[(1-5)] Estimates of the disease burden caused by malaria are crucial for informing malaria control programmes.

1.1. Aims:

The present review article aimed at collection of reports in the last 5 years [2011-2016] about

1. To determine the geographical distribution and prevalence of malaria in Saudi Arabia from 2011 till 2016.
2. To estimate the *Plasmodium spp* found in KSA.
3. To find out clinical criteria and methods used to diagnose the new cases of Malaria in Saudi Arabia hospitals.
4. To find out the treatment strategies.
5. To find out the implanted programs used to control spread of disease in KSA.

1.2 Methods and materials:

-Bibliographic databases:

PubMed ID (PMID), Medical Subject Headings (MeSH) and EMtree collections of keywords utilised by Medical Literature Analysis and Retrieval System Online (MEDLINE; US National Library of Medicine) and EMBASE (Elsevier).

-Selection Criteria:

Reports and articles published in the last five years [2011-2016].

-Number of studies screened: 36

-Number of studies included: 28

Methodology:

The present article searched the previous publications in the last five years [(2-11),] 2011 till 2016 about malaria in the KSA. Then the collected data were arranged and designed accordingly into:

1. Data about the geographical distribution and prevalence of malaria in Saudi Arabia.

2. Data about the species of Plasmodium present and reported in the kingdom.
3. Reports about the clinical presentation in different areas in the kingdom
4. Published data about the methods of diagnosis used.
5. Reported methods of treatment in kingdom.
6. The methods used to control malaria in KSA.

2.The prevalence of malarial cases in different regions in KSA from 2011 to 2016:

MOH in 2011 in KSA [6] reported that out of 1062827 examined cases positive cases of malaria were 2788 , of which 1045 (37.5%) were a malignant malaria (*Plasmodium falciparum*) , 1719 (61.7%) were a benign(*Plasmodium vivax*) , 19 (0.2%)were a Quartan and 5 (0.2%) were a mixed .Out of these cases, 69 were a local , Imported from inside was 0 and outside were 2717(97.45%) , and two cases were Relapse . Cases of less than 5 years were 33 (2.63 %) , the cases between 5-9 years were 59 (4.71%) and the cases more than 10 years were 1161 (92.66%).The highest prevalence was in February 2011 (243 cases), while the least was in June (46 cases) .[6]**. (Table I)**

MOH in 2012 in KSA [7] found that out of1,186,179 examined cases positive cases of malaria were 3,406 (0.29%) , of which 37.29% were a malignant malaria (*Plasmodium falciparum*) , 61.57% were a benign tertiary (*Plasmodium vivax and Plasmodium ovale*) , 1.03%were a Quartan and 0.12% were a mixed . Cases of less than 5 years were 53, the cases between 5-9 years were 77 and the cases more than 10 years were 1334 . The highest prevalence was in February 2012 (310 cases) , while the least was in December (30 cases) .[7]**(Table I)**

MOH in 2013 in KSA [8] reported that out of 1,309,783 examined cases positive cases of malaria were 2,513 (0.19%) , of which 38.76% were a malignant malaria (*Plasmodium falciparum*) , 60.67% were a benign tertiary (*Plasmodium vivax and Plasmodium ovale*) , 0.24% were a Quartan and 0.24% were a mixed . Cases of less than 5 years were 29 , the cases between 5-9 years were 86 and the cases more than 10 years were 975 . The highest prevalence was in February 2013 (216 cases) , while the least was in June (30 cases). [8] **(Table 1) .**

MOH in 2014 in KSA [9]found that of1,249,752 examined cases positive cases of malaria were 2,305 (0.18%) , of which 1155 were a malignant malaria (*Plasmodium falciparum*) , 1144 were a benign tertiary (*Plasmodium vivax and Plasmodium ovale*) , 6 were a Quartan and 0 were a mixed . Cases of less than 1 year were 0 (0.00%) , the cases less than 5 years were 27 (2.46%) , the cases between 5-9 years were 33 (3.01%) , the cases more than 10-14 years were 36 (3.28%) and 15 years and more were 1001 (91.25%) .

The highest prevalence was in December 2014 (200 cases) , while the least was in July (26 cases) [9] **(Table I)** .

MOH in 2015 in KSA [10] report that out of1,306,700 examined cases positive cases of malaria were 2620 (0.20%) , of which 1444 were a malignant malaria (*Plasmodium falciparum*) , 1164 were a benign tertiary (*Plasmodium vivax and Plasmodium ovale*) , 10 were a Quartan and 2 were a mixed . Cases of less than 1 year were 5 (0.31%) , the cases less than 5 years were 35 (2.18%) , the cases between 5-9 years were 57 (3.56 %) , the cases more than 10-14 years were 72 (4.49 %) and 15 years and more were 1433 (89.45 %) . The highest prevalence was in January 2016 (363 cases) , while the least was in July (34 cases)[10] **(Table I).**

MOH in 2016 in KSA found that of 1,267,933 examined cases positive cases of malaria were 5,382 (0.42%) , of which 3,922 were a malignant malaria (*Plasmodium falciparum*) , 1,420 were a benign tertiary (*Plasmodium vivax and Plasmodium ovale*) , 40 were a Quartan and 0 were a mixed . Cases of less than 1 year were 0 (0.00%) , the cases less than 5 years were 67 (1.64%) , the cases between 5-9 years were 104 (2.55%) , the cases more than 10-14 years were 106 (2.60%) and 15 years and more were 3798 (93.20%) . The highest prevalence was in February 2016 (1909 cases) , while the least was in June (69 cases). **(Table I)**

In Yemen, the prevalent spp. was reported to be *P. falciparum (100%)[12] and the incidence showed an* increase in 2015. The may be due to the local events there, that leaded to decrease in health care activities [12]. Also, there is a high burden of malaria-related morbidity and mortality in Sudan. However, the national malaria control programme, with WHO's support, has reduced the number of malaria cases from more than four million in 2000 to less than one million in 2010. [13].

The mortality ratio among children under 5 years has significantly declined in the Kingdom from 44 deaths per thousand in 1990 to 18.7 deaths per thousand in 2012. In addition, the babies' mortality ratio declined from 34 deaths per thousand in 1990 to 16.2 deaths per thousand in 2012. [14,15]. MOH efforts were to be added to accelerating development by 2015 and beyond. [16].

Table 1: Prevalence % of malaria cases reported in different regions in KSA from 2011-2016 (R)

	2011 [6]	2012[7]	2013[8]	2014[9]	2015[10]	2016
Riyadh	0.19%	0.20%	0.06%	0.07%	0.07%	0.06%
Makkah	0.44%	0.68%	0.27%	0.29%	0.41%	0.63%
Jeddah	1.54%	-	3.00%	2.18%	2.71%	6.47%
Ta`if	0.40%	-	0.11%	0.29%	0.17%	0.21%
Medinah	0.12%	0.21%	0.12%	0.18%	0.14%	0.15%
Eastern	0.34%	0.31%	0.16%	0.22%	0.17%	0.22%
Al - Ahsa	0.19%	-	1.51%	0.13%	0.10%	0.12%
Hafr Al - Baten	0.03%	-	0.21%	0.74%	19.75%	0.49%

Qaseem	0.46%	0.34%	0.27%	0.21%	0.16%	0.24%
Aseer	0.11%	0.16%	0.18%	0.24%	0.38%	0.76%
Bishah	0.03%	-	0.05%	0%	0%	0%
Tabouk	0.02%	0.09%	0.05%	0%	0.02%	0.01%
Ha`il	0.11%	0.20%	0.05%	0.07%	0.16%	0.13%
Northern	0.02%	0.30%	0.12%	0.05%	0.03%	0.11%
Jazan	0.51%	0.46%	0.31%	0.23%	0.48%	1.54%
Najran	0.23%	0.27%	0.19%	0.20%	0.16%	0.33%
Al - Bahah	0.02%	0.05%	0.05%	0.05%	0.11%	0.07%
Al - Jouf	0.02%	0.03%	0.03%	0.05%	0.03%	6.17%
Qurayyat	0%	-	0.01%	0.03%	0.12%	0%
Qunfudah	1.01%	-	1.09%	1.96%	0.89%	2.23%

3.The clinical picture of Malaria in Saudi Arabia

In general, the clinical aspects of malaria appear after the incubation period which differs according to the parasite species. As a matter of fact, the clinical signs and symptoms may not be specific to any type of malaria, suggestive of sepsis. [17]

The symptoms begins with rigors for one to two hours followed by high grade fever more than 38^0cand, nausea, vomiting ,headache, diaphoresis ,arthralgia ,myalgia ,cough ,abdominal pain ,backache ,diarrhea ,fatigue ,loss of appetite , convulsions and in some cases it may be accompanied by urticarial rash [15, 16]

In severe cases the disease can be complicated with hepatomegaly, spleenomegaly, jaundice, thrombocytopenia, heamoglobinemia, anemia, acute renal failure, cerebral malaria and disseminated intravascular coagulation. Also, the presence of retinopathy is associated with bad prognosis [17]

Patients who are infected with *P.falciparum* have a high risk for bacteremia and in some mild to moderate cases of *P.vivax* hypoglycemia with respiratory distress syndrome have been reported[18] .

To recapitulate, the sever signs and complications and deaths were related to the malignant type P. *falciparum* [19].

4.Diagnosis of Malaria

Accurate and early malaria diagnosis is essential in all aspects, as misdiagnosis can lead to significant morbidity and mortality. As WHO recommends prompt malaria diagnosis either by microscopy or malaria rapid diagnostic test (RDT) in suspected cases before treatment is administered because accurate diagnosis improves the management of cases with febrile illnesses, help to reduce the emergence and spread of drug resistance by reserving antimalarials for confirmed cases [20].

The main malaria diagnostic test which still used today in most hospitals and health clinics is microscopy although the quality of its diagnosis is frequently inadequate. Malaria rapid diagnostic tests

improve management of malaria cases, especially in remote regions where the access to microscopy services is limited. Nucleic acid amplification-based diagnostics which can detect low density malaria infections is recommended by WHO to be considered only for epidemiological researches and surveys mapping submicroscopic infections [21].

Kasetsirikul et al (2016) [16] mentioned that the researchers around the world are looking for new diagnostic tests because the conventional microscopic examination of blood smears, molecular biology-based diagnosis and antigen-based rapid test have some limitations for effective employment in low-resource setting areas. Dielectrophoretic and magnetophoretic principles among various techniques have recently became attractive possibilities for malaria diagnosis due to the unique differences between the electrical and magnetic properties of infected RBCs and healthy RBCs. Moreover, cell morphology and deformability as alternative techniques, have been proposed to be suitable biomarkers for the future. Although the knowledge of parasite biological properties is critical, also the development of an engineering system is an important factor and should be studied in parallel. One example is a magnetic-field generating system that could create a high magnetic field gradient over a large area. Another solution might be a combination of two or three detection techniques, which might be able to increase the specificity to infected RBCs and so enhance the ability for malaria detection or infected erythrocyte separation.

4.1. Diagnosis of malaria in KSA:

As mentioned in KSA ministry of health website, on the emergence of malaria symptoms a blood specimen should be examined by the microscope [12]. Bin Dajem (2015) [17] concluded that mixed malaria infections are currently overlooked when using microscopy. He added that the PCR assays were essential complementary techniques and should be used with microscopic examination of blood smears. Hassan et al (2015) [18] reported that Jazan province was poised to achieve malaria elimination. They added that there was a need to change from a policy of passive case detection to reactively and proactively detecting infectious reservoirs that require new approaches to surveillance. These should be combined with advanced epidemiological tools to improve the definitions of epidemiological receptive and hotspot malaria risk mapping. The single largest threat currently remains the risks posed by imported infections from Yemen. Hassona et al (2016) [19] used blood smears for diagnosis and also observed in their study that there was significant reduction in erythrocyte, leucocyte, hemoglobin and platelet count levels in infected patients compared with those of healthy control subjects. They added that the percentage of neutrophil cells in the infected patients was significantly higher than in the healthy group. The percentage of lymphocytes in the infected subjects was significantly lower than in the healthy group and they concluded that the blood was the most simply manageable diagnostic tissue and hematological changes were the most common complications in malaria and they showed a main role in malarial pathology. The hematological evaluation could help in prompt and accurate diagnosis and prevent disease progression by facilitating physicians in

clinical correlation for better drug management. Also, they mentioned that most of the noticed malaria cases in Hail area were among expatriates while the predominant species were *P. vivax*[19].

4.2. Screening of malaria in KSA:

Al Gharawi et al (2016) [20] found that the current methods of malaria screening in blood donors was not suitable for screening low-level parasiotemia. Adding the immunoassay and molecular screening methods was suggested.

5.Treatment of Malaria in The Kingdom of Saudi Arabia

In this review, we have summarized our current knowledge on the efficacy and resistance patterns of currently used antimalarials. Alternative treatments that could be used against malaria in the Kingdom are also discussed. [21]

The malaria parasite has an intrinsic ability to quickly develop resistance against antimalarials [21]. As a result, the World Health Organization (WHO) recommended that antimalarial treatment be based on the use of combinations of 2 drugs that have different modes of action, as a strategy to delay or slow down the onset of resistance [21]. Artemisinin has been selected as the drug of choice in such combinations, and these are now known as artemisinin based combinations, ACTs [22]. The ACTs have been adopted by the Saudi Ministry of Health. The combinations of pyrimethamine/ sulfadoxine/artesunate (PM/SD/ART) and lumefantrine/artemether (LM/ATM), also known as Coartem, have been selected as first and second lines of treatment for uncomplicated falciparum malaria, and quinine and artesunate are used for the management of severe malaria due to *P. falciparum* [23].

On the other hand, *P. vivax* malaria is treated with the combination of chloroquine (an old antimalarial used to treat *P. falciparum malaria,* which is also active against the *P. vivax* blood stage) and primaquine. [24]

Plasmodium vivax is characterized by the existence of dormant forms in the liver of the host, and these forms are effectively cleared by primaquine, hence, the use of the combination of chloroquine and primaquine [25]. However, resistance of *P. vivax* against chloroquine is now emerging in Asia, threatening the treatment of *P. vivax*.[26]

Since the bulk of malaria cases in KSA are imported, most parasites might have been exposed to antimalarials prior to coming to KSA. Thus, knowledge of the pattern of resistance to these drugs outside KSA could contribute to better management of the disease. [21]

In our review, we have summarized the current knowledge on both efficacy and resistance patterns for antimalarials which used in the KSA (PM/SD, artemisinin, Coartem® and quinine). Also discussed,alternative treatments which could be introduced in the Kingdom. Table II summarizes the current drugs used in treatment of malaria, Table III presents information of the mechanism of antimalarial resistance, and Table IV provides the main dosages and side effects of antimalarials drugs.

Current malaria treatments in 2016 are based on the use of artemisinin based combinations. In the Kingdom of Saudi Arabia, the combination of pyrimethamine/ sulfadoxine/artesunate is the first line of treatment of uncomplicated malaria, while lumefantrine/ artemether (Coartem®) is used as a second option. The treatment of severe malaria rests on the use of quinine or artesunate. [21]

Malaria chemotherapy in Saudi Arabia

Table II - Drugs used in the treatment of malaria. [21]

Antimalarials	General remarks	Saudi Arabia
Uncomplicated falciparum malarial PM/SD/ART	PM/SD is an old drug that has been combined with ART	**1st line of treatment**
LM/ATM)( )®Coartem(	The first artemisinin drug combination	**2nd line of treatment**
PYR/ART	New drug combination	--
PQP/DHA	New drug combination	--
Severe falciparum malaria Quinine	The oldest antimalarial	**1st line treatment**
Artesunate	New evidence showing its efficacy	**2nd line treatment**
Vivax malaria CQ + PMQ	Old drug combination	**1st line treatment**
PM/SD/ART	Evidence that it could be used against vivax, but cannot clear hypnozoite forms of vivax	--
LM/ATM)( )®Coartem(	Evidence that it could be used against vivax, but cannot clear hypnozoite from of vivax	--
PQP - Piperaquine, SD - sulfadoxine, ART - artesunate, PYR - Pyronaridine, DHA - dihydroartemisinin, PM- pyrimethamine, CQ- chloroquine, LM - Lumefantrine, ATM - artemether, PMQ- primaquine		

Table III - Proposed mechanisms of resistance to commonly used antimalarials.[21]

Antimalarial	Mechanisms of resistance
Uncomplicated falciparum malaria	
PM/SD/ART	**Point mutations in dhfr and dhps genes for PM and SD. Not defined yet but single polymorphism in chromosomes 10,13,14 for artemisinin has been reported.**
LM/ATM)( )®Coartem(	**Presence of wild type Pfmdr1 and Pfcrt. Single polymorphism in chromosomes 10,13,14 for artemisinin has been reported**

PYR/ART	**Not defined yet for PYR. Single polymorphism in chromosomes 10,13,14 for artemisinin has been reported**
PQP/DHA	**Not defined yet for PQP. Single polymorphism in chromosomes 10,13,14 for artemisinin has been reported**
Severe falciparum malaria	
Quinine	**PfNHE-1 polymorphism**
Artesunate	**Single polymorphism in chromosomes 10,13,14 for artemisinin has been reported**
Vivax malaria	
CQ+ PMQ	**Pvcrt and Pvmdr1 in vivax for CQ. Not defined yet for PMQ**
PM/SD/ART	**Point mutations in dhfr and dhps genes for PM and SD**
LM/ATM)( )®Coartem(	**Not defined yet.**
dhfr - dihydrofolate reductase gene, dhps - dihydropteroate synthase, Pfmdr1 - Plasmodium falciparum multidrug resistant protein 1, Pfcrt - Plasmodium falciparum chloroquine resistance transporter, PfNHE-1 - Plasmodium falciparum sodium hydrogen exchanger -1, Pvcrt - Plasmodium vivax chloroquine resistance transporter, Pvmdr1 - Plasmodium vivax multidrug resistant protein 1, PM - Pyrimethamine, PQP - Piperaquine, SD - sulfadoxine, ART - artesunate, PYR - Pyronaridine, PQP - Piperaquine, DHA - Dihydroartemisinin, LM - Lumefantrine, ATM - artemether, CQ - Chloroquine, PMQ - primaquine	

Table IV - Antimalarial combinations used to treat malaria, their dosage and their major side effects. [21]

Type of malaria disease	Antimalarials	Dosage	Most common side effects
Uncomplicated falciparum malaria	PM/SD/ART	Single administration PM/SD (1.25/25 mg base/Kg bw) on day 1 ART 4mg/Kg bw per day for 3 days	**Nausea, vomiting, anorexia and diarrhea, cutaneous manifestations can be severe and include pruritus, photosensitivity reactions, exfoliative dermatitis, erythema nodosum, toxicepidermal necrolysis and Stevens-Johnson syndrome**

	LM/ATM)®Coartem(	Tablet of 120 mg LM and 20mg ATM. Tablets are given by weight: 1 for 5-14 kg/2 for 14-24 Kg/3 for 24-34Kg/4 for >34Kg	**Mild nausea, abdominal discomfort, headache and dizziness**
	PYR/ART	One tablet containing 180 mg of PYR and 60 mg of ART per day for 3 days (adult dose)	**Anaemia, headache, heart rhythm disturbances (ECG changes or noticing unusually fast heart beats or palpitations), fever, general weakness**
Severe falciparum malaria	Quinine	20 mg/Kg loading dose over 4 hours followed by 10mg/Kg over 4 hours /8 hours (maximum dose 1800mg) for 7 days. Complete cure is obtained with a dose of 200mg doxycycline, followed by daily doses of 100mg for 7-10 days (adult dose(	**Tinnitus, impaired high tone hearing, headache, nausea, dizziness and dysphoria, visual disturbances. Hypoglycemia is common in the treatment of severe malaria.**
	Artesunate	2.4 mg/Kg intravenous or intramuscular on day 0, and then at 12 hours and 24 hours, then once a day until patient is able to tolerate oral medication	**Mild gastrointestinal disturbances, dizziness, tinnitus, reticulocytopenia, neutropenia, elevated liver enzyme values, and electrocardiographic abnormalities**
Vivax malaria	CQ+ PMQ	10 mg base/kg orally at once, followed by 5 mg base/kg at 6, 24, and 48 hours, combined with 0.25mg/Kg of PMQ taken daily with food for 14 days	**The most important adverse effect is hemolytic anemia in patients with Glucose-6 phosphate dehydrogenase deficiency (G6PD) deficiency due to PMQ. Mild dizziness, nausea, vomiting, abdominal pain and itching can also be observed**
	PM/SD/ART	Single administration PM/SD (1.25/25 mg base/Kg bw) on day 1, and ART 4mg/Kg bw per day for 3 days	**Same as in Plasmodium vivax**

	LM/ATM)®Coartem(	Tablet of 120 mg LM and 20mg ATM. Tablet are given by weight: 1 for 5-14 kg/2 for 14-24 Kg/3 for 24-34Kg/4 for > 34Kg	**Same as in Plasmodium vivax**
PM - Pyrimethamine, PQP - Piperaquine, SD - sulfadoxine, ART - artesunate, PYR - Pyronaridine, PQP - Piperaquine, DHA - Dihydroartemisinin, LM - Lumefantrine, ATM - artemether, CQ - Chloroquine, PMQ - primaquine			

6.Control of Malaria in KSA

The draft Global Technical Strategy for malaria 2016–2030 aims to eliminate malaria from at least 10 countries by 2020[18]. Over the last 50 years, systematic efforts to control malaria in the Kingdom of Saudi Arabia has successfully shrunk the extent of *Plasmodium falciparum* and *Plasmodium vivax* risks. Starting with the oil rich areas in the Eastern region, the use of annual indoor residual house spraying (IRS) with dichlorodiphenyl-trichloroethane (DDT) and dieldrin, between 1948 and 1957, led to a dramatic decline in malaria case incidence and local transmission was interrupted by 1975. From 1956, significant progress was made in reducing the malaria risks maintained by *Anopheles superpictus* through the application of DDT IRS and larvicides in the northern borders with Jordan and Iraq. Active transmission of malaria in the northern regions was interrupted in the 1970s.

The hardest areas to control were located along the Red Sea, where *Anopheles sergentii* and *Anopheles arabiensis* sustained transmission. The pilgrimage routes used by those on the Hajj were protected through Abate® larviciding and DDT IRS in rural households through the 1970s. Small residual foci remained in the lower reaches of the Hijaz mountains and persistent *An. arabiensis* foci in the foothills of Mecca. Malaria control activities in the south-western regions of the Kingdom did not start until 1972. In 2009, only 61 autochthonous cases were reported and all came from foci in Jazan and Asir .[18]

Yemen and Saudi Arabia remain the last two countries on the Arabian Peninsula to achieve elimination global progress in malaria control over the last 15 years is nothing short of remarkable. The effectiveness of insecticide-based vector control is threatened by malaria mosquitoes developing resistance to the insecticides used. Malaria control activities were started in 1948 in the Eastern Province around the oil fields by ARAMCO oil company. Over the last 50 years, systematic efforts to control malaria in the Kingdom of Saudi Arabia has successfully reduced malaria cases to a point where malaria is now constrained largely to Jazan Province, the most south-western area along the Red Sea.[18] .In Sudan, WHO worked in close collaboration with the national malaria control programme to implement appropriate and cost-effective malaria control interventions. These include the distribution of artemisinin-based

combination therapy treatments, rapid diagnostic tests and long-lasting insecticidal nets, and the introduction of the home-based management of malaria strategy.

The Saudi Government are fully committed to the malaria elimination end game committing US$ 30 million per year to this ambition, where more than 35 % of this budget is allocated for malaria control programme in Jazan. To achieve elimination will require a substantial increase in the use of epidemiological methods to predict, prevent, detect and contain new infections in the province. [27, 28]

7. Conclusion

In conclusion, the low incidence of malaria seen in the KSA is a valuable evidence of the success of malaria eradication programs. The eradication measures should be consolidated, with an adequate control of the vectors, Also the surveillance system in all the regions of Saudi Arabia should be continuously monitored for accuracy, timeliness, and completeness of all records. Health workers should consider malaria as the first line of suspicion for pilgrims from Far east and Africans with febrile illness.

8. Recommendations:

Out of the published studies, it was recommended to pay more efforts to eradicate and eliminate malaria through adequate control of mosquitoes especially in the areas near Yemen and Sudan. Carefully inspecting the pilgrims was also recommended. Cooperative work of ministry of health and ministry of agriculture will achieve the goal of malaria eradication.

9. Acknowledgment:

The participating authors thanked and admired all the participating efforts in the KSA to eliminate malaria from different areas in the kingdom. Also we appreciate all the published papers and reports which through light on the scope of malaria in Saudi Arabia.

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