MALARIA IN THE KINGDOM OF SAUDI ARABIA: EPIDEMIOLOGY AND CONTROL

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ABSTRACT

In this paper, the present status of malaria and its control is discussed compared to the previous situation in almost 50 years. Malaria in Saudi Arabia has been documented since 1941 as a major health problem in the eastern oases. Today, malaria is highly endemic in the Southwest (Gazan and Asir) where 83%, 92% and 96%, respectively of the Kingdom total-, indigenous- and malignant cases are reported and transmitted by *An. arabiensis* and *An. sergentii*. The central part is free of malaria, northern and eastern parts are with no transmission while the northwestern part has low endemicity. Of the four parasites, *P. falciparum* is dominating representing 87% of the cases. Over two decades, malaria showed periodical peaks every 4 to 5 years. Transmission generally occurs from October to April and with perennial pattern in the South. The antimalaria programme (started in 1948) has two major achievements during 1970's: (a) interruption of transmission in the eastern and northern parts, in the major cities and most of the coastal plain in the western part and in some valleys of Asir Plateau and (b) maintaining the central part and pilgrimage areas free of malaria. Imported cases, border malaria, *P. falciparum* resistance to chloroquine, vector resistance to insecticides are the main problems facing the antimalaria activities. The programme is now being intensified to overcome such problems.

INTRODUCTION

In the Arabian Peninsula, malaria is known since the pre-Islamic era and was mentioned earlier by many travellers as a prevailing disease (Sebai,1987). Recently, Baker and Strunk (1991) reported that countries surrounding the Persian Gulf are remarkable for the variety of infectious and contagious diseases (including malaria) that will affect those deployed to the area.

The Kingdom of Saudi Arabia occupies about 80% of the Arabian Peninsula with an area of 2,235,000 sq. Km. and has a population of 18,855,494 of which 4,624,734 are expatriate workforce (MOH Statistical Department). The climate is basically hot and dry. Rainfall is irregular, unpredictable and occurs mostly from October to April (70-550 mm. / year). There are no rivers or lakes. However, numerous wells and springs in the oases at the eastern and northwestern parts and upstream of valleys inside the coastal mountain range along the Red Sea provide suitable breeding sites for mosquito vectors of malaria. Administratively, the Kingdom is divided into 13 Provinces (Fig. 1) but for the purpose of this work we will consider the 5 major Provinces of the old division namely: The Central (Najd), Eastern (Al-Hassa), Western (Hijaz), Southern (Asir) and Northern frontier.

Inspite of its long history, few published reports are available on malaria in Saudi Arabia. The first studies were carried out in the Eastern Province by ARAMCO (Arabian American Oil Company) in 1941 (Sebai, 1987) and by Marret (1953) which indicated that malaria was the most significant health hazard in two major oasis (Al-Hassa and Qatif) and followed by that of Daggy (1958) who described in details the "oases malaria" in this area. Magzoub (1980), presented results of the malaria surveys carried out in different Provinces.

Al-Seghayer (1983) and Sebai (1987) reviewed and discussed the general malaria situation and its control in the kingdom. Other reports (Afridi, 1987; Mulla, 1989; Najera-Morrondo, 1996) focused on evaluating the kingdom antimalaria programme.

The objective of this paper is to discuss the present status of malaria and its ongoing control activities. Historical background of the control programme, its constraints and its achievements gained during the past fifty years were also presented. The data showed here were based on the survey results of the various malaria control services of the Ministry of Health (MOH) reported to the Headquarters (HQ) in Riyadh where analysis and interpretation for theses results were carried out.

MALARIA EPIDEMIOLOGY

1. THE PARASITES

Three common species of *Plasmodium (P)* occur in the kingdom: *P. falciparum*, *P. vivax* and *P. malariae* in that order of frequency. Very few and sporadic cases of *P. ovale* also exist. Of 233,026 malaria infections reported in the kingdom (1980-1996), 87% (75-94%) were *P. falciparum* with a relative frequency of malignant tertian-, benign tertian- and quartan malaria approximately in the ratio of 86:12:1, respectively. This contrasts with the pre-control data (1947) from the Eastern Province (Daggy, 1958) which showed a slight predominance of *P. falciparum* (35.5%) over *P. vivax* (27.4%) or *P. malariae* (14.2%). Such predominance of *P. falciparum* is a characteristic of malaria transmitted by *Anopheles arabiensis* in the Southern Province as for example, 82% of *P. falciparum* cases reported in the Kingdom (1994-1996) were from this area (Table1).

Table (1). Relative abundance of the malaria Plasmodium species in the Southern and Western Provinces compared to the other parts of Saudi Arabia (1994 - 1996).

Plasmodium species	Positive slides No. %	Southern Prov. %	Western Prov. %	Others %
P. falciparum	43419 100.00	82.34	14.03	3.63
P. vivax	6134 100.00	7.47	38.75	53.78
P. malariae	146 100.00	16.44	5.48	78.08
P. ovale	3 100.00	0.00	0.00	100.00
Total +ve slides*	49790 100.00	72.77	17.03	10.20

* Including the mixed parasite infections.

2. THE ANOPHELINE VECTORS

Fifteen indigenous *Anopheles* mosquito species are known to exist in the Kingdom (Leeson, 1948; Mattingly and Knight, 1956; Daggy, 1958) of which only four are primary malaria vectors namely, *An. arabiensis* (Southern Province), *An. sergentii* (Western Province), *An. stephensi* (Eastern Province) and *An. superpictus* (Northern Province). In

addition, *An. fluviatilis* (Eastern Province) and *An. sergentii* (Eastern and Southern Provinces) are considered as secondary vectors (Daggy, 1958; MOH, 1983). Two other species are of importance in malaria transmission in other countries but their role in Saudi Arabia needs to be investigated, these are *An. pharoensis*, the main vector in Egyptian Delta (Kenawy, 1988) and *An. multicolor,* a suspected oases vector in Egypt (Kenawy *et al.*, 1986) and North Africa (Zahar, 1974).

Table (2) shows the relative abundance of the commonly occurring anopheline species in the Kingdom. Generally, with the exception of *An. superpictus* and *An. fluviatilis*, the other vectors are the most common species in their respective areas of distribution.

Table (2). Relative abundance of *Anopheles (= An. / Ano.) mosquito adults in Saudi Arabia (1990 - 1992).*

Species*	% of collected adults** Western Province	Southern Province	Eastern Province	Northern Province
Anopheles (Ano.) tenebrosus Doenitz			1.2	
An. (Cellia) arabiensis Patton	31.0	54.6		
An. (Cel.) d'thali Patton	20.6	22.6		
An. (Cel.) fluviatilis James			6.2	
An. (Cel.) multicolor Cambouliu	17.3	6.9	49.1	
An. (Cei.) pulcherrimus Theobald			3.2	
An. (Cel.) rhodesiensis rupicolus Lewis			6.0	2.6
An. (Cel.) sergentii (Theobald)	24.9	12.0	14.2	30.6
An. (Cel.) stephensi Liston			78.4	
An. (Cel.) superpictus Grassi			17.1	
An. (Cel.) turkhudi Liston			0.2	1.3
Total collected	2110	5088	19061	222

* Four other species: *An. (Ano.) coustani* Laveran , *An. (Cel.) pharoensis* Theobald , *An. (Cel.) cinereus* Theobald and *An. (Cel.) pretoriensis* (Theobald) also exist.

** From indoor resting sites by the day-time space spraying.

3. INCIDENCE AND PRESENT SITUATION

Surveys in Saudi Arabia over the last 20 years (1977-1996) indicated that although there was a noticed decrease in malaria incidence in several areas, the disease however, has generally shown a more or less stable trend (Fig. 2), for example, the morbidity rates were 2.66, 2.41 and 2.85 % in 1977, 1986 and 1996, respectively. Higher rates occurred periodically every 4 to 5 years affected by the situation mainly the rainfall in the southwestern part where malaria remains endemic. In 1996, 83% of all- and 92% of indigenous malaria cases reported in the Kingdom were from the Southwest (Table 3) which shows the influence of this part on the general malaria situation in the country.

Table (3). Indigenous malaria cases reported in the southwestern part of Saudi Arabia (1996)

Sector	Reported cases Number	%	Indigenous cases Number	%
Makkah	821	3.91	168	1.10
Qunfudah	339	1.61	264	1.73
Asir	3376	16.07	2940	19.32
Baha	812	3.87	769	5.05
Najran	284	1.35	10	0.07
Gazan	11748	55.92	9908	65.09
Total of the Southwest	17380	82.73	14059	92.37
Rest of the Country	3627	17.27	1162	7.63
Total	21007	100.00	15221	100.00

According to the present malaria situation, the Kingdom can be divided into non-malarious and malarious areas (Fig. 1):

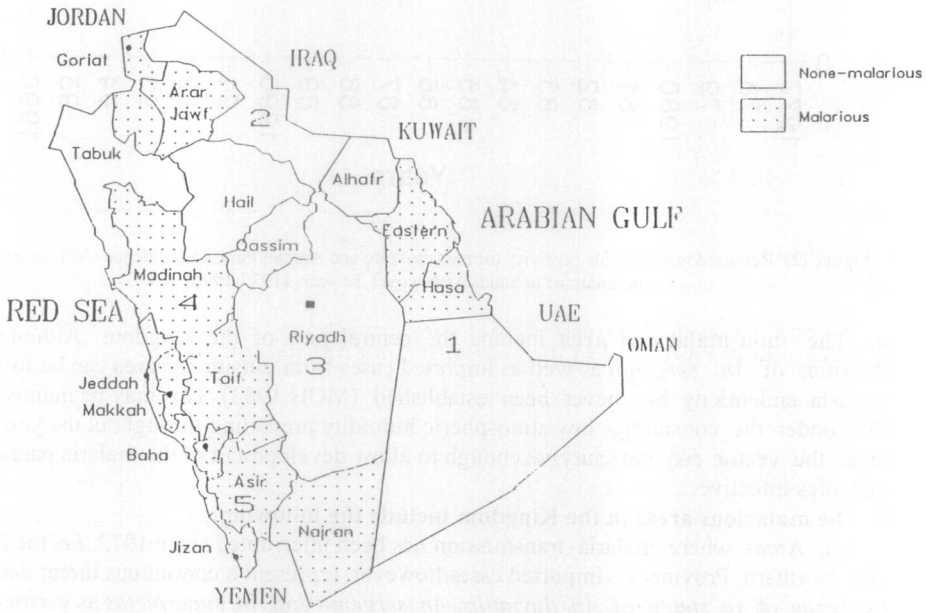

Figure (1). A map of Saudi Arabia showing the old administrative division into 5 major Provinces (Eastern :1, Northern :2, Central :3, Western :4 and Southern :5) and the malarious areas.

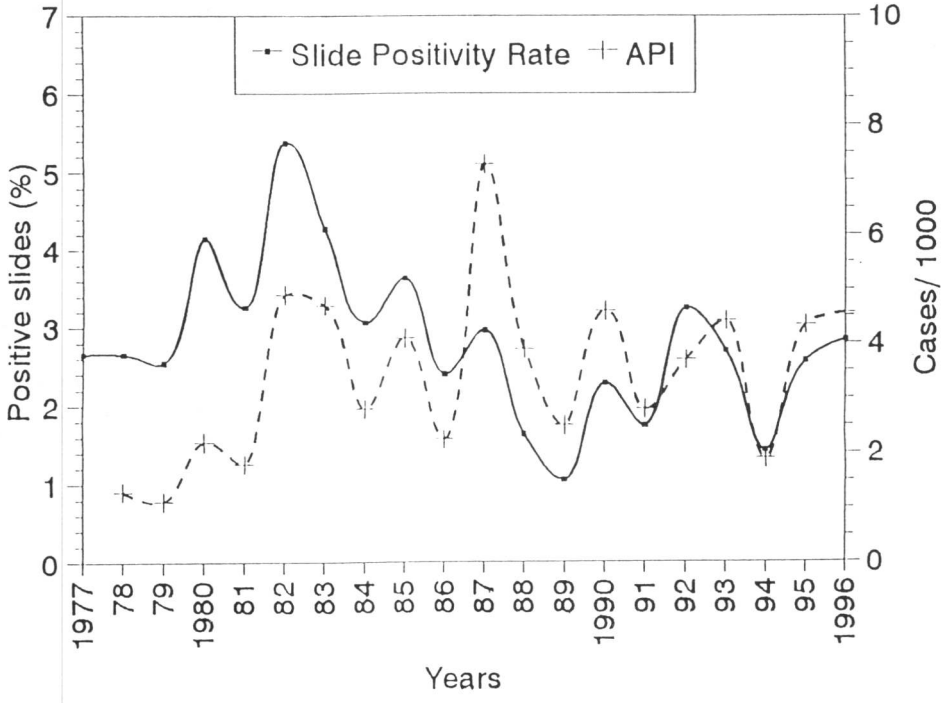

Figure (2). Reported malaria slide postivity (or parasite) rate and Annual Parasite Incidence (API, cases / 1000 population) in Saudi Arabia over 20 years (1977-1996).

a. The non-malarious area include the central part of the kingdom. Although low densities of *An. sergentii* as well as imported cases from outside the area can be found but malaria endemicity has never been established (MOH,1983). This may be mainly due to that under the constantly low atmospheric humidity prevailing throughout the year in this area, the vector can not survive enough to allow development of the malaria parasite and becomes infective.

b. The malarious areas in the Kingdom include the following:

i. Areas where malaria transmission has been interrupted since 1972, *i.e.* the Eastern and Northern Provinces. Imported cases however, represent a continuous threat due to the existence of *An. stephensi, An. fluviatilis, An. sergentii* and *An. superpictus* as vectors and a large number of non-immune humans.

ii. Areas with low endemicity in the Western and Southern Provinces where malaria transmission has been interrupted by 1980 in the major cities (Makkah, Jeddah, Taif, Medinah, Najran, Bisha and Abha) but having residual foci in the remote valleys maintained by *An. arabiensis* and *An. sergentii.* The immensity of anopheline breeding habitats and Bedouin nomads coming from the endemic parts outside these areas (mainly

during the harvest season of palm dates) are the main causes for maintenance of such malaria foci.

iii. Areas with high endemicity including foothills and lowlands of Tihama in the southern and southwestern parts of the Kingdom along the Red Sea, starting from just south of Jeddah-Makkah area outskirts down to the border of Yemen and with about 600 km. long and 60-70 km. width. These are considered as the most endemic part in the Kingdom, being hyperendemic on the foothills and lowlands along the valleys and meso- to hypoendemic on the coastal plain. *Plasmodium falciparum* is dominant, transmitted primarily by *An.arabiensis* and secondarily by *An. sergentii*. The high rates of rainfall, high vector potential of *An. arabiensis* (MOH, 1983) and the low socio-economic level are the main factors for persistence of such high endemicity.

4. TRANSMISSION SEASON

In general, malaria in the Kingdom exhibits seasonality associated with the variation in vector density (Fig. 3) with peaks toward the end of each year and beginning of the next year. At present, malaria transmission season can not be predicted in the Northern and Eastern Provinces due to lack of local transmission . In the Eastern Province, Daggy (1958) observed peak rates of malaria morbidity in spring (May) and fall (November). In other parts (Al-Seghayer, 1983), transmission season varies depending on rainfall but generally extends from October to April or early autumn to late spring. Perennial transmission, however is observed in the Southern Province as in Gazan (Fig. 4) where infections are detected throughout the year in children of less than one year old.

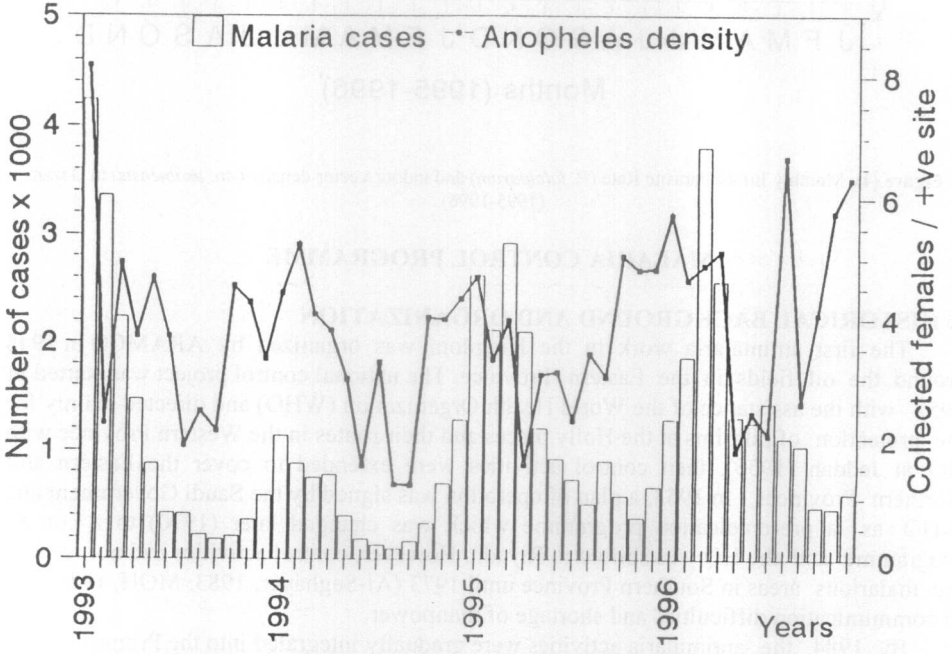

Figure (3). Monthly variation in the reported malaria cases and indoor resting density of the *Anopheles* mosquito adults (No. of collected females per positive site: bed room or animal shed) in Saudi Arabia (1993-1996).

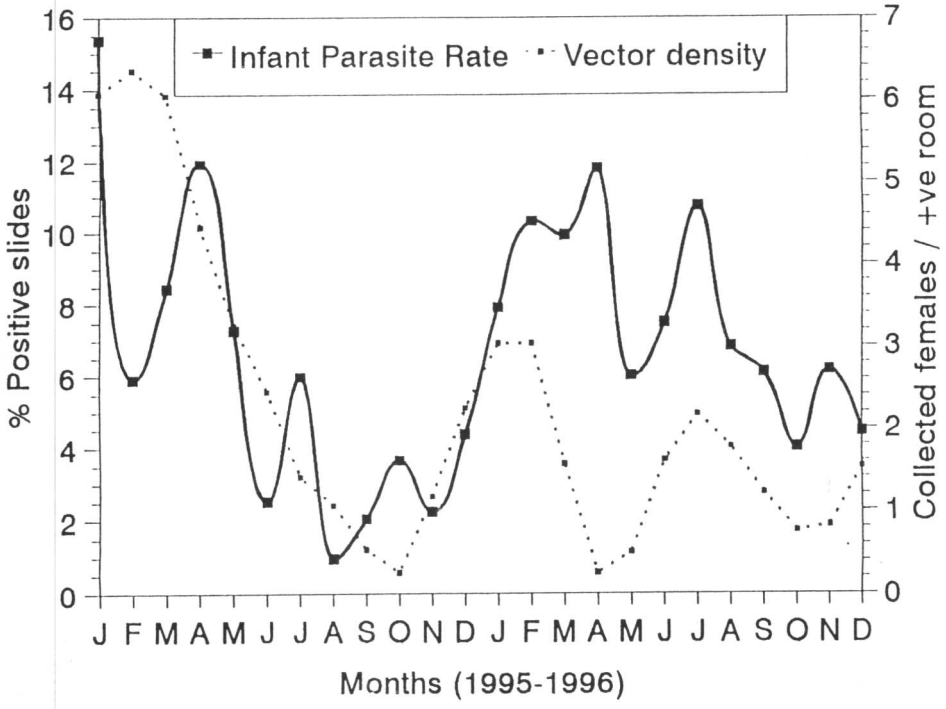

Figure (4). Monthly Infant Parasite Rate (*P. falciparum*) and indoor vector density (*An. arabiensis*) in Gazan (1995-1996).

MALARIA CONTROL PROGRAMME

1. HISTORICAL BACKGROUND AND ORGANIZATION

The first antimalaria work in the Kingdom was organized by ARAMCO in 1948 around the oil fields in the Eastern Province. The national control project was started in 1952 with the assistance of the World Health Organization (WHO) and directed mainly for the protection of pilgrims at the Holly places and their routes in the Western Province with HQ at Jeddah (1956), then control activities were extended to cover the Eastern and Northern Provinces. In 1963, a plan of operation was signed by the Saudi Government and WHO as a pre-eradication programme which was changed later (1970) to a control programme and the HQ was shifted to Riyadh. However, control activities had not reached the malarious areas in Southern Province until 1973 (Al-Seghayer, 1983; MOH, 1983) due to communication difficulties and shortage of manpower.

By 1984, the antimalaria activities were gradually integrated into the Primary Health Care (PHC) services. The number of malaria control units progressively increased from 12 malaria stations (MS) and 11 substations (MSS) in 1982 (MOH, 1983) to 22 MS and 25 MSS at present (1996) with an overall manpower of 3445 compared to 1047 in 1982.

Today, malaria control activities cover all areas in the kingdom and carried out by the MS, MSS and PHC centers which administratively belong to their respective provincial Health Affairs Directorates (HAD: 13 General Directorates and 8 Directorates all over the kingdom). The malaria HQ at Riyadh is responsible for technical supervision, planning, evaluation , training and reporting for such activities.

2. CONTROL MEASURES

The current malaria control programme depends on the combination of the following measures:

a. Antiparasite measures "Chemotherapy"

The treatment of malaria parasites in the Kingdom follows a policy and guidelines formulated by the Malaria Department, Preventive Medicine, MOH (MOH, 1994; Al-Seghayer and Tamim, 1996) which have been adopted from those of WHO (1990) and Warrell *et al.* (1990). Such policy aims at: early treatment of the documented malaria cases, prevention or delay introduction of *P. falciparum* resistance to chloroquine, prevent resumption of transmission in areas free of it and prevent relapses in *P. vivax* and *P. ovale* infections. In brief, the ongoing treatment regime includes:

i. Radical treatment of all malaria cases (regardless of species and whether clinically suspected or microscopically confirmed) with a dose of 1500 mg. chloroquine (10 tablets of 150 mg. active ingredient, a.i.) and 45 mg. primaquine (3 tablets of 15 mg. a.i.) over 3 days. For *P. vivax* or *P. ovale* an additional dose of 15 mg. primaquine is administered daily for 11 days.

ii. Treatment of *P. falciparum* resistant to chloroquine, for local patients and expatriates or pilgrims coming from countries where resistant strains are documented, is achieved by giving a single dose of 3 Fansidar tablets (500 mg. sulfadoxine / 25 mg. pyrimethamine) and 45 mg. primaquine or other suitable antimalarial drug (mefloquine or quinine) according to the response of the case.

iii. Chloroquine prophylaxis "300 mg. weekly" is usually given to the malaria field workers (if required) , people asking for it and non immunes traveling to endemic areas.

b. Antivector measures include the following activities:

i. Weekly larviciding of the breeding places with Temephos EC (Emulsifiable Concentrate) applied in all Provinces.

ii. House spraying with residual insecticides was the main control measure in the Kingdom till 1984 when encouraging results were obtained by larviciding, but still continuously applied focally in the highly endemic areas in the South. At the beginning of the control programme DDT was used, followed by Dieldrin (DLD) and then replaced later by Fenitrothion and other insecticides when *An. arabiensis* developed resistance to it (1986). During 1996, one cycle of focal residual spraying was carried out in the Southern Province (Gazan, Abha, Mohayel, AL-Farshah and Gelwa) through which 39,442 houses were treated giving a protection for 91.83% (218,868) of the targeted population at risk.

iii. Space spraying of the outdoor and indoor resting places of the mosquito vectors with synthetic pyrethroide insecticides using the Ultra Low Volume (ULV) or Fog-producing equipments. It is used as a supplementary measure to reduce the density of the vector adults usually during the transmission season. In 1996, ULV has been applied in 6,967 villages with 301,319 houses and 1,688,909 population in the Western and Southern Provinces.

c. Other control activities includes mainly:

i. Geographical Reconnaissance (GR) to obtain or update topographic and demographic information of the villages under control or planned to be controlled.

ii. Health education of the Public to encourage and enhance community participation in control activities.

iii. Continuous training of malaria field and laboratory personnel to improve and upgrade their Knowledge and skills.

3. METHODS OF EVALUATION

To assess the impact of the control measures upon malaria morbidity and prevalence in the Kingdom, the following activities are currently in use:

a. Parasitological activities

i. Passive Case Detection (PCD) in which all hospitals, PHC centres and dispensaries are obliged to report to their respective malaria control service and send a blood film of every suspected case. This method is now being the main source of blood samples (Table 4). Out of 4,697,627 blood slides examined in the Kingdom during 1990-1996, 90% were collected through PCD giving 95% of the all positive slides (113,430) detected in the same period..

Table (4). Examined and positive blood slides obtained by three main methods: Passive Case Detection (PCD), Epidemiological Contact Survey (ECS) and Mass Blood Survey (MBS) in Saudi Arabia (1977 - 1996).

	Examined slides				Positive slides			
Year	Total No.	PCD %	ECS %	MBS %	Total No.	PCD %	ECS %	MBS %
1977	112113	36.2	14.2	49.4	2987	60.7	4.6	34.7
1978	125888	57.8	2.6	39.6	3344	61.0	3.2	35.8
1979	124966	62.4	4.6	33.0	3192	63.8	6.3	30.0
1980	156421	74.3	4.8	20.9	6949	86.5	2.7	10.8
1981	169548	81.8	6.8	11.3	5543	87.6	8.2	4.2
1982	281792	88.5	9.9	1.6	15167	94.5	4.6	1.0
1983	419713	67.1	3.8	29.1	17956	91.3	1.7	7.0
1984	361598	57.8	10.4	31.8	11091	89.1	7.2	3.7
1985	452077	64.6	2.5	32.9	16457	85.5	1.9	12.6
1986	537955	62.4	2.2	35.4	12975	88.9	2.8	8.4
1987	594166	88.4	2.0	9.6	17648	98.0	1.7	0.4
1988	598400	69.7	2.1	28.3	9797	92.0	2.7	5.3
1989	608503	72.4	1.4	26.3	6475	90.9	5.2	4.9
1990	682649	94.4	1.5	4.1	15666	95.4	2.7	1.9
1991	570551	85.2	9.6	5.3	9962	92.9	5.6	1.5
1992	601847	86.3	8.6	5.1	19623	93.8	4.9	1.3
1993	679254	88.0	8.1	3.9	18380	92.4	6.1	1.5
1994	697960	90.2	6.5	3.4	10032	94.6	3.7	1.7
1995	727307	91.8	6.2	2.0	18751	95.0	4.1	1.0
1996	738059	92.9	3.6	3.5	21007	97.2	1.6	1.3

ii. Epidemiological Contact Survey (ECS) is the most important activity in the malaria-free areas (Central Province) and those where malaria transmission has been ceased

(Eastern and Northern Provinces) to clarify the source of infection for any detected positive case. In the Western and Southern Provinces however, ECS is rather difficult to conduct due to the continuous movement of inhabitants.

iii. Mass Blood Survey (MBS) for all inhabitants is applied at present only for new settlement areas to examine the possibility of introducing malaria brought by new comers or foreign workers.

iv. Malariometric Survey is applied to measure malaria prevalence in the highly endemic areas where school children (6-9 years old) of selected indicator villages are examined for malaria infection and spleen enlargement usually before and at the end of the transmission season.

v. Infant Parasite Survey (IPS) is also carried out either in selected indicator villages of endemic areas to detect the new malaria infections and to examine the transmission season or in other areas to verify cessation of the local transmission. Blood specimens are taken monthly from all newborn of less than one year old and examined for malaria parasites.

vi. Periodical monitoring of *P. falciparum* susceptibility to chloroquine mainly in Gazan.

b. Entomological activities

Entomological surveys are carried out mainly to examine the densities of both larvae and adults (by the day-time space spraying in houses and other resting shelters) as parameters to evaluate the control operations. The susceptibility of the malaria vectors to insecticides is continuously monitored to examine the effectiveness of the insecticides in use and to decide upon the alternative ones.

4. CONTROL STRATEGY IN MALARIOUS AREAS

The areas in the South of the Kingdom where *An. arabiensis* is the main vector are now given a full support. As to the plan of operation, these areas are epidemiologically stratified into 4 categories based on the Annual Parasite Incidence (API, *i.e.* cases / 1000 population). The different control and evaluation measures applied in these 4 area categories are shown in table (5).

Table (5). Epidemiological stratification and applied control and evaluation measures for the malaria endemic areas in the Southwest of Saudi Arabia.

Applied measures	API (Casses / 1000) / Malaria endemicity** 0- Non- malarious	>1-<3- Hypo- endemic	>3-<10- Meso- endemic	>10- Hyper- endemic
Control: Larviciding	•	•	•	•
Residual house spraying		•		
Space spraying*			•	•
Chemotherapy			•	•
Evaluation: Passive Case Detection (PCD)			•	•
Epidemiological Contact Survey (ECS)		•	•	
Infant Parasite Survey (IPS)		•	•	

* A supplementary measure in the case of increasing malaria cases and vector density.
** API : Annual Parasite Incidence.

5. ACHIEVEMENTS

Over the last 50 years since the beginig of the antimalaria activities in the Kingdom, the followings are the major achievements:

a. Interruption of malaria transmission in the following areas:

i. Eastern Province: After having a long history of oasis malaria and malaria associated with oil drilling, transmissioin has been ceased since 1972 as a result of well planned and repeated attacks aganist vectors, detection and surveillance of indigenous and imported cases and drug administration to the suspected and parasitologically confirmed patients. The antivector activities included: house residual spraying (DDT and DLD), larviciding and source reduction through environmental sanitation and water management mainly: drainage of ponds and swamps, filling of shallow wells and borrow pits and improving the agricultural drainage.

ii. Northern Provinces where oasis malaria was also endemic, continuous application of larvicides (Diesel oil, Paris green and DDT) during 1960's led to the disappearance of the main vector, *An. superpictus* (MOH, 1983) and subsequent cessation of malaria transmission by 1972. The vector however, reappeared again (1982) in the area (MOH, 1984) but with intensified larviciding, construction of a large scale drainage system (1983) and improving PCD, no malaria resurgence was observed.

iii. Big cities and most of coastal parts in the Western Province since 1970 through repeated application of house residual spraying with DDT, intensified case detection and radical treatment.

iv. Some valleys in Asir Plateau (Ranya, Tabala, Bisha, Najran and Habouna) since 1980 after three consecutive annual rounds of house residual spraying (DDT started in 1978) and case finding and treatment.

b. Maintaining the Central Province and pilgrimage areas and their routs free of malaria.

6. PROBLEMS

a. Imported malaria

Imported malaria whether from abroad or from endemic areas within the country always pause a threat of introducing the disease into the malaria- free areas or those with no local transmission especially with the continuous presence of the vectors. During 1990-1996, data from Al-Hassa (Eastern Province) showed a small number of imported cases among Saudis (160) compared to 1741 cases among non-Saudis. The number of Saudi cases increased considerably during 1992, a year of high rains in the South, the area where most of the cases were contracted. The newly arriving foreign labourers from malarious countries are compulsory examined for malaria parasites before obtaining their residency licence. However, they are usually examined after passage of sometime in the Kingdom (about 3 months) during which they provide a reservoir from which some local transmission may occur and hence the risk is not completely avoided. The case which can be applied to the situation in Yibreen (an oasis south of Al-Hassa) during June-August 1994 and April-September 1995 (Kenawy,1994, Unpubl.; Al-Hassa HAD, 1994-1996, Unpubl. Reports) where 75 malaria cases were detected of which 2 were young Saudis who had not been away from the area.

b. Border malaria

Saudi Arabia has common borders with three malarious countries, the United Arab Emirates (UAE) and Oman to the east and Yemen to the southwest. The border areas with

UAE and Oman are malaria-free, mostly uninhabited and occupied by the Empty Quarter (Al Rub'Al-Khali) desert. Along the boarder area with Yemen in Gazan, malaria belongs to the Afrotropical type with a highly efficient vector, *An. arabiensis*. This area whether in the foothills or lowlands is continually showing the highest malaria endemicity in the Southwest. During 1990-1995, the area reported 26-72% of the total malaria cases in Gazan (with the highest percentage was in 1992) although it has only 20% of the total population. The reported API during 1985-1992 has varied considerably between 8 and 54/1000 according to the flow of immigrants, who eventually find their way to other parts of the country (Najera-Morrondo,1996). Malaria transmission in this area is practically uncontrolled which is mainly due to that a number of Saudi and Yemeni villages share the same ecologicl nich, several major streams that originate in Yemen run across the Gazan plain to the Red Sea and no effective control is implemented in the Yemeni side of borders. To overcome such problem, two malaria border meetings were held in 1993 and 1996 (WHO, 1993-b & 1997). Also a meeting between Saudi Arabia and Yemen was held (May, 1996) during which a bilateral programme for malaria control was agreed to be developed with the idea of carrying out the same control measures simultaneously on each side of borders. The programme includes training of Yemeni technicians followed by several field activities mainly: GR, malariometeric survey, mass drug distribution to local inhabitants and house spraying.

c. Occasional epidemics

Epidemics can erupt due to climate changes especially after heavy rainfalls and floods for example, as occurred in the Western Province in 1950, 1957 and 1982 (Sebai,1987). Similarily, a small outbreak of *falciparum* malaria associated with an abundance of *An. arabiensis* occurred (October/November 1996) in the surrounding villages of Makkah.

d. Chloroquine-resistant strains of *P. falciparum*

The danger of introducing such strains through pilgrims and expatriates from far Eastern and African countries is always a threat. About 25% of *P. falciparum* cases reported annually in the Kingdom are imported from countries representing a wide variety of parasite sensitivity to 4-aminoquinolines. Monitoring of parasite resistance in the Kingdom is carried out since 1982 , however only in Gazan. During 1990-1995, *in vivo* resistance was detected in 40.63% (12.50-48.08%) of 96 tests and *in vitro* resistance in 13.01% (3.75-57.14%) of tests. Continuous and rapid increase in resistance level was observed during this period with the highest rates were in 1994. With the continuous flow of foreigners in large numbers into the Kingdom, autochtonous acquisition of chloroquine resistant *P. falciparum* is quite possible (Alrajhi and Fryha,1997). In 1992 (MOH, 1994), parasite RI resistance to chloroquine was documented for some of locally acquired cases mostly in areas bordering Yemen.

e. Vector resistance to insecticides

The development of insecticide resistance in disease vectors can have considerable administrative, financial, operational and socio-cultural implications. For a long time (since 1948), control of the malaria vectors in Saudi Arabia depended largely on the use of chemical insecticides. As a result of the wide and extensive application of DDT and DLD for house spraying, a number of anopheline mosquitoes including malaria vectors and non-vector species developed resistance to these two organochlorine compounds. These species are: *An. arabiensis* and *An. sergentii* (DDT), *An. fluviatilis* and *An. tenebrosus* (DLD) and *An. stephensii, An. multicolor* and *An. pulcherrimus* (DDT and DLD). Although *An.*

arabiensis and *An. sergentii* larvae in the South are susceptible to Temephos (Al-Seghayer,1997, Unpubl.) however, its intensified use all over the Kingdom since 1984 may enhance development of resistance in these two vectors and other mosquito species. Temephos-resistance in some malaria vectors have been reported by WHO (1993-a) in some neighbouring countries; UAE, Oman, Jordan and Egypt.

f. Insufficient management

As for example in Mohayel (Southern Province) the progress made in 1980 was lost in the following years. The parasite rate increased from 4.0% in 1980 to 11.9% in 1983 (Sebai,1987). The same happened in Qunfudah and Lith. This occurred because of managerial problems resulting in the reduction of residual spraying and inadequate coverage by larvicides.

7. FUTURE PLAN

Efforts for malaria control are now being intensified to implement short (yearly) and long term plans of operation that are aiming to:

a. Maintaining the situation in the areas that are free of malaria or those where local transmission has been ceased, interrupting transmission in areas showing low endemicity and lowering infection rates in highly endemic areas to the limit with which malaria can not be considered a public health problem.

b. Limiting and minimizing the use of insecticides as control measures mainly through application of biological control using larvivorous fish (*Aphinus dispar*) and microbial agents, source reduction and impregnated bed-nets.

c. Implementing the joint programme for malaria control in the Saudi Arabia-Yemen border areas.

d. Preventing the spread of *P. falciparum* strains resistant to chloroquine by continuous monitoring of the parasite response to drugs and radical treatment and follow up of all cases proved to be resistant.

e. Encourging and enhancing community participation in the antimalaria programme mainly in antivector activities (through health education).

f. More and continuous in-service training for nationals.

CONCLUSION

The Kingdom of Saudi Arabia with its diverse climatic, topographic and ecological features represents a wide variety of malaria epidemiological patterns. About 1.7 million of the population live in areas where malaria is transmitted. Except for the central part which is free of malaria, the rest of the country includes four malarious areas that differ in their epidemiological characteristics and mosquito vectors but all have *An. sergentii* which is extremely fit for desertic conditions. In the eastern and northern parts where oasis malaria was endemic, local transmission has been terminated since 1972. The ongoing control programme in these two areas is directed to maintain such absence of autochtonous malaria. However, with the abundance of anopheline vectors mainly *An. stephensi* and *An. superpictus,* the continuous flow of parasite carriers from malarious countries or from endemic areas within the Kingdom and the availability of non-immune humans, malaria may be resurged if relaxation occurred in control activities. Moreover, if the situation in the Eastern Province is not well maintained, there is a risk of malaria outbreak in such big cities as Dammam, Al-Khobar and Hofuf due to the known capability of *An. stephensi* as a true vector of urban malaria in other countries. So that, examination of expatriates and malria

surveillance in theses two parts should be kept at a high level of alertness and readiness to respond quickly to any local outbreak of malaria. In the western and southern parts, the geographic distribution of malaria was reduced to some foci inside remote valleys of Hijaz mountain range where rainfall is sufficient to provide abundant areas for breeding of the principal vectors, *An. sergentii* and *An. arabiensis*. Malaria control in such foci is difficult due to the nomadic movement and exophilic (resting outdoors) habit of the mosquito vectors. In the southwestern part especially in the valleys and villages at the foothills of Sarawat mountains (Gazan and Asir regions) where *P. falciparum* is over 90% of cases transmitted by *An. arabiensis* and where rainfall is relatively abundant, malaria occurs at meso- to hyperendemic level. On the basis of epidemiological, ecological and socioeconomic conditions, malaria still represents a significant threat to the people health in this area owing to: (a) continuous movement of population and vector across the Yemeni borders, (b) *An. arabiensis* tendency of biting and resting at outdoors as well as at indoors which allows continued transmission even in the presence of well-executed indoor residual spraying, (c) refusal of local inhabitants for house spraying and (d) the outdoor sleeping habit of rural people.

In addition to the imported and border malaria and the stubborn nature of transmission specially in the South, two major technical problems facing malaria control programme in the Kingdom: (a) the already developed resistance of vectors to organochlorine insecticides and the expected resistance to the insecticides in use, and (b) *P. falciparum* resistance to chloroquine that showed progressive increase in recent years with some of locally acquired cases in areas bordering Yemen. With this situation, monitoring of both vector and parasite resistance must be regularly carried out with vigilance.

The national antimalaria programme is under continuous evaluation and revision. Great emphasis however, must be placed on non-chemical measures for controlling malaria vectors such as environmental management and biological control to: (a) reduce complete reliance on chemical insecticides due to their adverse effects on human health and environment in addition to the problem of vector resistance and (b) to have efficient chemical agent available in emergency situation to assist in check outbreaks of the disease.As malaria is a man- made, community participation in its control is of prime importance especially in antivector activities. Such participation is not yet fully achieved in the Kingdom which represents a major challenge to the MOH control efforts.

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Appendix

LIST OF ABBREVIATIONS

a.i. : Active ingredient.
An. / Ano. : *Anopheles*
API : Annual Parasite Incidence
ARAMCO : Arabian American Oil Company
DLD : Dieldrin
EC : Emulsifiable Concentrate
ECS : Epidemiological Contact Survey
GR : Geographical Reconnaissance
HAD : Health Affairs Directorate.
HQ : Headquarters
IPS : Infant Parasite Survey
MBS : Mass Blood Examination
MOH : Ministry of Health
MS : Malaria Station
MSS : Malaria Substation
P. : *Plasmodium*
PCD : Passive Case Detection
PHC : Primary Health Care

UAE : United Arab Emirates
ULV : Ultra Low Volume
WHO : World Health Organization

الملاريا في المملكة العربية السعودية: الوبائيه والمكافحه

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تتناول هذه الدراسة الوضع الحالي لمرض الملاريا وبرامج مكافحتها بالمملكة مقارنة بما كان عليه الوضع خلال الخمسين عاما الماضية . في عام ١٩٤١ عرف مرض الملاريا كمشكلة صحية أساسية في الواحات بالمنطقة الشرقية وحاليا يعتبر الجنوب الغربي أكثر مناطق المملكة استيطانا للمرض ويشكل تقريبا ٨٣% من جميع الحالات ، ٩٢% من الحالات المحلية وأيضا ٩٦% من حالات الملاريا الخبيثة التي يتم تسجيلها سنويا بالمملكة حيث ينقل المرض ببعوض أنوفيلس أرابينسيس و أن. سرجنتي ، أما في الغرب فيتواجد المرض بدرجة منخفضة ولا يتواجد المرض بالمنطقة الوسطى كما لا يوجد نقل محلي بالمنطقتين الشمالية والشرقية . الأنواع الأربعة لطفيلي الملاريا تتواجد بالمملكة إلا أن بلازموديوم فلسيبارم هو السائد ويمثل حوالي ٨٧% من الحالات. لوحظ خلال العشرين عاما الماضية زيادة في حالات الملاريا كل ٤ أو ٥ سنوات . يعتمد موسم انتقال المرض على معدل هطول الأمطار ولكن عموما خلال الفترة من أكتوبر إلى أبريل وطوال العام في الجزء الجنوبي . من أهم الإنجازات لبرنامج المكافحة (بدأ عام ١٩٤٨م) : (١) إيقاف نقل العدوى منذ السبعينات حتى الآن في المنطقتين الشرقية والشمالية وبعض من أجزاء المنطقة الغربية والوديان بهضبة عسير ، (٢) المحافظة على خلو المنطقة الوسطى والأماكن المقدسة من المرض. بالرغم من هذه النجاحات إلا أنه لم يتم التغلب على المشكلة في الجنوب الغربي وذلك للمشكلات التي تواجه البرنامج و من أهمها الحالات الوافدة ، الملاريا بالمنطقة الحدودية مع اليمن ، مقاومة طفيلي الفلسيبارم لعقار الكلوروكين ومقاومة الناقل للمبيدات ولذا ترمي نشاطات مكافحة الملاريا حاليا للتغلب على هذه المعوقات .