

Ministry of Health and Medical Education

HISTORY OF THE SUCCESSFUL STRUGGLE AGAINST MALARIA IN THE ISLAMIC REPUBLIC OF IRAN

FROM THE EARLIEST RECORDS TO IMMINENT ELIMINATION

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Abbreviations

ABER	Annual Blood Examination Rate
CCM	Country Coordinating Mechanism
CDC	Centre for Disease Control
GEF	Global Environmental Facility
GF	Global Fund to Fight AIDS, Tuberculosis and Malaria
G6PD deficiency	glucose-6-phosphate dehydrogenase deficiency
ICA	International Cooperation Administration
IRS	Indoor Residual Spraying
LLIN	Long-Lasting Insecticidal Net
MOHME	Ministry of Health and Medical Education
PHC	Primary Health Care
RDT	Rapid diagnostic test
UMS	University of Medical Sciences
UN	United Nations
UNDP	United Nations Development Programme
UNICEF	United Nations Children's Fund
WHO	World Health Organization

Foreword I

Scientific development and global advancement of nations promise the elimination of some of the communicable diseases including malaria, which still causes so many deaths in endemic countries of the developing world.

The well managed application of novel tools and solutions in prevention and treatment supported by political commitment and adequate investment has created momentum towards global control and elimination of malaria. Global issues, such as political unrest, armed conflicts and economic crises, impede progress towards the invaluable goal of elimination.

Historical evidence indicates that malaria was highly prevalent in our country in the past. Now, after six decades of battle against the disease, Iran has succeeded to reduce annual malaria cases from approximately 5 million, sixty years ago, when malaria was the main cause of death in the country, to less than 100 cases due to local transmission with zero deaths in 2017. This great achievement is the result of a combination of appropriate interventions against malaria, improvements of the health service network and general social development. Our malaria programme has over the years been led by highly capable national experts, fully supported by government investments, and has also benefited from the cooperation of international organizations, specifically the World Health Organization (WHO).

In spite of the remarkable progress, we must be aware of the potential for re-emergence of malaria throughout the country, because the mosquito vectors are still present. In recent years more than 80 percent of detected malaria cases in Iran have been related to importation of infected cases from endemic neighboring countries resulting in small outbreaks in southeast Iran, which reaffirms the importance of commitment of neighboring countries to work together effectively at regional and global level.

The Islamic Republic of Iran is certainly committed to the global struggle to eradicate malaria from the world. Accordingly, in line with Universal Health Coverage principles, the "Health for All" approach has been adopted for all population groups, including legal and illegal immigrants. Specifically, we provide free diagnosis and treatment of all malaria cases including those among unregistered foreign workers, who are provided with all preventive tools.

I wish to acknowledge the sustained work of the many men and women who have done their best towards the elimination of malaria and I thank all of them as well as the good partners, who have worked with us for decades.

Let us maintain our resolve as we embark on the last and most difficult miles, so that we may soon celebrate the certification of the Islamic Republic of Iran as free from malaria and we continue to support other nations technically towards a world without malaria.



Dr. Seyed Hassan Hashemi, MD
Minister of Health and Medical Education

Foreword II

In May 2015, the World Health Assembly adopted a new Global Technical Strategy for Malaria 2016–2030. The strategy is built on 3 pillars: ensuring universal access to malaria prevention, diagnosis and treatment; accelerating efforts towards elimination and attainment of malaria-free status; and transforming malaria surveillance into a core intervention. It sets ambitious goals for 2030, with milestones along the way to track progress. The elimination of malaria in at least 10 countries is a near-term milestone for 2020.

The Eastern Mediterranean Region has been a pioneer in pushing forward the agenda of malaria elimination. The United Arab Emirates and Morocco were officially certified by WHO as malaria-free in 2007 and 2010, respectively. Two other countries – the Islamic Republic of Iran and Saudi Arabia – have adopted malaria elimination strategies and are part of the “E-2020” initiative, a WHO programme to scale up efforts to achieve elimination within the 2020 timeline.

The malaria team within WHO is excited about the success of Iran’s malaria elimination programme in reducing the country’s malaria burden and moving rapidly toward elimination. In 2017, there were only 68 locally transmitted cases of malaria nationwide, down from 1800 local cases in 2010, and from 12,000 local cases reported in 2000.

This sustained, progressive decline in malaria transmission was achieved through a robust national elimination strategy. Key to this success was country ownership, intersectoral collaboration as part of a national socioeconomic development plan, the allocation of considerable national resources and technical support from WHO. Resources from the Global Fund and support from other international organizations, particularly UNDP, also contributed to an acceleration towards elimination.

Malaria elimination, together with other public health achievements in Iran, will expedite efforts to reach this nation’s goals for sustainable development and a prosperous future. As we celebrate our achievements, we should remind ourselves and our children that this battle is not over: the last mile is as important as the beginning of the journey.

I would like to sincerely express my gratitude on behalf of the World Health Organization for the remarkable support provided by the Government of Islamic Republic of Iran for malaria elimination. I am confident that this support will be sustained, not only for the programme in Iran – but also for other malaria-endemic countries – until we reach our common vision of a world free of malaria.



Dr. Pedro L. Alonso, MD

viii Director of the WHO Global Malaria Programme

Foreword III

Iran has achieved remarkable success in controlling malaria, a communicable disease which has been prevalent in the country for centuries threatening lives and the development efforts of the country. Determined action to combat malaria has been on-going for more than six decades as told in this book which provides a very interesting insight into the country's history during that time, provided through a particular lens.

For the past more than seven years, the action to combat malaria has happened with the support of the Global Fund (GF), with the United Nations Development Programme (UNDP) as Principal Recipient of the grants.

This enabled a strong partnership to be established with the Centre for Disease Control (CDC) of the Ministry of Health and Medical Education (MoHME) of the Islamic Republic of Iran serving as technical lead and coordinating implementation in the field in collaboration with Universities of Medical Sciences (UMSs), local communities and inter-sectoral committees and with the World Health Organization (WHO) as the Sub-Recipient of the project and as the provider of procurement and technical support.

The financial support from the GF and the performance frameworks with baselines and clear targets agreed with Fund as part of the funding envelopes enabled Iran to walk the last miles towards malaria elimination by focusing the efforts where they were most needed and ensuring that the results were monitored. As this book, telling the remarkable story of Iran's fight against malaria is going into print as one of the last expenses to be covered by the grants from the GF before we close the Malaria Project, a Sustainability Plan agreed with the GF to ensure that Iran's efforts will continue is also in place.

Malaria elimination in Iran is within reach, but the battle is not fully over. While the number of indigenous malaria cases in Iran has steadily decreased from 1,847 in 2010 to 84 in 2016, there was in 2017, for the first time, a slight upward trend in number of cases reported due to trans-border population movements, i.e. an increase of about 19.6% in the number of imported cases compared to 2016. This is where the challenges lie ahead due to the high level of population movement among seasonal workers who cross the borders from neighboring countries – where malaria is still endemic – to come into Iran for construction and agricultural work.

This should not distract from the fact that Iran's achievements in fighting malaria have been hard-won, because in high burden areas of this vast country, the malaria transmission season is about nine months a year and has marred the concerned

populations for centuries.

As both Resident Representative a.i. of UNDP and Resident Coordinator a.i. of the United Nations in Iran, I congratulate the Government of the Islamic Republic of Iran with the results achieved. I am extremely proud of the contribution made by UN agencies and the GF to that end and I want to thank all our partners, including the Global Fund, for seven years of very constructive collaboration.

I would also like to take this opportunity to thank others involved in this project as well as publishing this book. Namely: the Country Coordinating Mechanism (CCM), MoHME/CDC, WHO, UMSs and all other programme partners and stakeholders who have partaken in this endeavor.

My sincere hope is that in the near future, we can have “a world free of malaria”. Iran is certainly contributing its part.

A handwritten signature in blue ink, appearing to be 'J. Simonsen', with a stylized flourish at the end.

Jakob Simonsen

UNDP Resident Representative and United Nations Resident Coordinator a.i.
Islamic Republic of Iran

Abstract

This report has been prepared to provide a comprehensive account of the history of malaria and its control in the Islamic Republic of Iran for specialists and lay readers alike. It is based on published and unpublished reports, especially from the Ministry of Health and Medical Education, Tehran, and from the World Health Organization. The main findings are summarized below.

Malaria has been a widespread epidemic disease in Iran for at least 3 000 years. The seriousness of its effect is reflected by historical records; for example, about 20 000 people who had been relocated from Armenia reportedly died from malaria in the Caspian plains in the late 18th century. By the early 20th century, the disease was the most important public health problem in the country. It was particularly severe in the Caspian plains and the southeast, but was prevalent practically everywhere in the country, even in the major cities. Effective large-scale control based on indoor residual spraying was started in the late 1940s and led to major reductions in the Caspian plains and the Central plateau. A national eradication programme was started in 1956, but soon encountered technical and operational problems in the southern plains and the Zagros highlands. However, by combining various interventions and products, the programme succeeded in reducing malaria considerably, even in the southern regions. By 1980, the objectives of the malaria programme changed from eradication to control. Despite limited resources, malaria was greatly reduced in Zagros and the southwestern plains, so that by 1990, the residual problems were concentrated in the three provinces of the southeast. From then on, the strengthening of antimalaria services was integrated in the overall development plans including improved health services. By 2010, the programme was again re-oriented to national elimination. The number of reported malaria cases in I.R. Iran reached a high of 98 160 in 1991, which was related to the extensive case detection activities. Since then, the burden has been steadily declining. The number of reported cases was as low as 92 in 2016. There is concern that importation may impede progress towards elimination, but with sustained investment and further measures targeting international population movement, there is a good chance that Iran can achieve malaria-free status by 2025 or before.

1. Introduction

The purpose of this report is to tell a story. It is about the efforts of a nation over a period of three quarters of a century to rid itself of a public health problem, which at the outset was so overwhelming that it dwarfed any other. It is a story of men and women who took the battle against a deadly disease to the most remote households and pioneered Health for All. The story tracks the reduction in cases and deaths, as more tools became available and were used. The progress has not been linear; at times the resolve weakened, at other times it was possible to accelerate the advance. It was learnt early on that fundamental biogeographic and social differences made it far more challenging to fight malaria in the southern plains and foothills than in the north and the central plateau.

The hope is that a general audience in the Islamic Republic of Iran (I.R. Iran) will find the story interesting, as it recalls how terrible a scourge malaria was, and it pays tribute to the people who worked to combat it. At the same time this report aims to be analytical, to identify which measures and approaches have been cost-effective, and which, in hindsight, have been less successful. Thus, the text should also serve as a reference for those who, for some years to come, will still be dealing with malaria as an actual problem or threat in I.R. Iran or in other countries. The trends and experiences suggest that with continued investments and a spirit of problem-solving, malaria will be eliminated from the I.R. Iran before the official target date of 2025. But that does not mean the end of the struggle. People harbouring malaria parasites will arrive in the country every year. By highlighting the immensity of the threat and presenting the experiences of the past and lessons learned, this report should serve to support the health workers who will be working to protect the country against reestablishment of transmission.

The methodology used in the preparation of this report is given in Annex 1. Annex 2 presents the main malaria data by region of the I.R. Iran and year from 2002 to 2015; it could be used by interested students for further analysis of trends. The number of confirmed malaria cases in regions of I.R. Iran from 1975 to 2009 is summarized in Annex 3. To facilitate the reading of the text by readers without a public health or biological background, an overview of malaria and its control is presented in the next Section.

1.1 What is malaria and how can it be prevented and treated?

Malaria is a mosquito-borne disease caused by unicellular parasites belonging to any one of four species: *Plasmodium falciparum*, *P. malariae*, *P. ovale* and *P. vivax*. *P. falciparum* is the most common and most severe of these; it is the predominant species in tropical Africa, while *P. vivax* is the predominant species in the subtropics. In I.R. Iran, *P. vivax* and *P. falciparum* are now the commonest malaria parasites, the other two being quite rare. The life cycle of malaria is shown in Fig. 1.1.1.

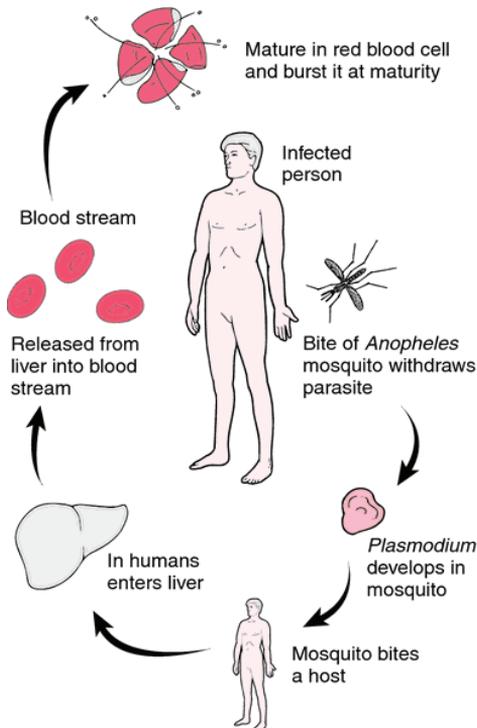


Fig. 1.1.1 Malaria life cycle

the parasites burst, giving rise to thousands of offspring, which are released into the bloodstream. In *P. vivax* and *P. ovale*, some sporozoites become dormant in the liver as hypnozoites for a period lasting months to years (1). The parasites in the blood stream invade red blood cells, where the great majority multiply asexually, undergoing repeated cycles of growth, rupture, release and re-invasion of fresh red cells. All clinical manifestations of malaria are a result of these processes. Eventually, the nuclei of hypnozoites also multiply, leading to relapses of the disease. Some of the blood-stage parasites develop into male or female gametocytes, which only develop further if a mosquito vector ingests them.

About 30–40 species of *Anopheles* in the world are vectors of major importance.

The life cycle of the mosquito has four stages: egg, larva, pupa and adult. Female anopheline mosquitoes lay their eggs on the surface of stagnant or slowly moving water. The eggs develop into larvae, then pupae, which metamorphose into adult, flying mosquitoes. This development is faster at higher temperatures, and so is the development of malaria parasites within the vectors. A blood meal is necessary for maturation of the eggs in the females, and they generally bite at night. Different species have different levels of ability to transmit malaria and different behaviours regarding breeding sites, biting and resting.

The control of malaria relies on measures directed against the parasites and the mosquito vectors. Malaria cases can be diagnosed by microscopical examination of stained blood smears on glass slides, or by detection of parasite antigens in blood samples. Early, effective treatment of malaria cases, according to parasite species, is important to reduce the risk of complications and death; also, it reduces the risk of onward transmission. A variety of antimalarial drugs are available to treat malaria by killing the parasites; some of them can also be used for prevention. A broad range of methods is available to control anophelines including: application of insecticides, especially on the walls of houses or on mosquito nets; environmental measures to eliminate water bodies that serve as breeding sites; fish that eat mosquito larvae (larvivorous); larvicides applied in breeding sites; improved housing, for example with mosquito screens. The malaria parasites can become resistant to antimalarial drugs and anophelines to insecticides. It is therefore important to use these chemicals judiciously and monitor for resistance. Presently, one vaccine against falciparum malaria is available. It has limited efficacy and is being piloted in Africa to mitigate the high burden of childhood malaria.

The elimination of malaria, defined by the World Health Organization (WHO) as the definitive interruption of mosquito transmission of the disease in a given territory, is based on the use of a combination of anti-parasite and anti-vector measures tailored to the local situation. Surveillance to detect all cases early, even those without symptoms, and implementation of appropriate responses are key to elimination. Long-term measures to prevent reestablishment of local transmission of malaria are necessary, as long as malaria has not been eradicated from the world.

1.2 Key events in the history of malaria in the Islamic Republic of Iran

The key events and milestones in the history of malaria and its control in I.R. Iran are presented in Table 1.2.1 and Fig. 1.2.1. The figure covers the period from 1975 and presents the events against the number of cases detected by year. The number of cases detected depends on the intensity of surveillance. Thus, the variations in case numbers before 1990 are more indicative of the activity of the programme than of malaria burden. However, from then onwards, the number of malaria cases does reflect the distribution and trend of the disease in the country.

Table 1.2.1 Malaria in I.R. Iran: major events and milestones before 1975

Gregorian calendar	National population (million)	Event	Iranian calendar
About 1000 BCE		Irrigation expands on the Iranian plateau probably leading to endemic malaria	About 1600 BH
About 600 CE		Ahwaz in Khuzestan known for fevers and making inhabitants "yellow and lean"	About 100 BH
About 900		Ibn Sina classifies fevers including the "hectic" variety	About 300 SH
About 1000		Gorgan on the Caspian plain known as a graveyard of people from Khorasan	About 400
About 1780		About 20 000 re-located Armenians die from malaria on the Caspian plain	About 1160
About 1900		Malaria recognized as the principal public health problem	About 1279
1916–1921	≈ 10	Earliest malaria surveys	1295–1300
1931–1942		Sporadic or focal larviciding and use of quinine	1310–1321
1946		DDT spraying piloted	1325
1949	17.0	Launch of the national malaria control programme	1328
1956	19.8	Reorientation to the national eradication programme	1335
1957	20.3	<i>Anopheles stephensi</i> resistance to DDT emerges in Khuzestan	
1336 ⁶ 1961	22.5	Spraying operations suspended in the southern plains because of insecticide resistance	1340
1963–1967	23.7–26.3	Field trials of new insecticides, chemical and biological larviciding, and mass drug administration	1342–1346
1968	27.0	Attack phase relaunched in the southern plains	1347
1971	29.3	Transmission interrupted north of Zagros, except for small outbreaks from reintroduction	1350

BCE: before the Common Era, BH: before Solar Hejri.

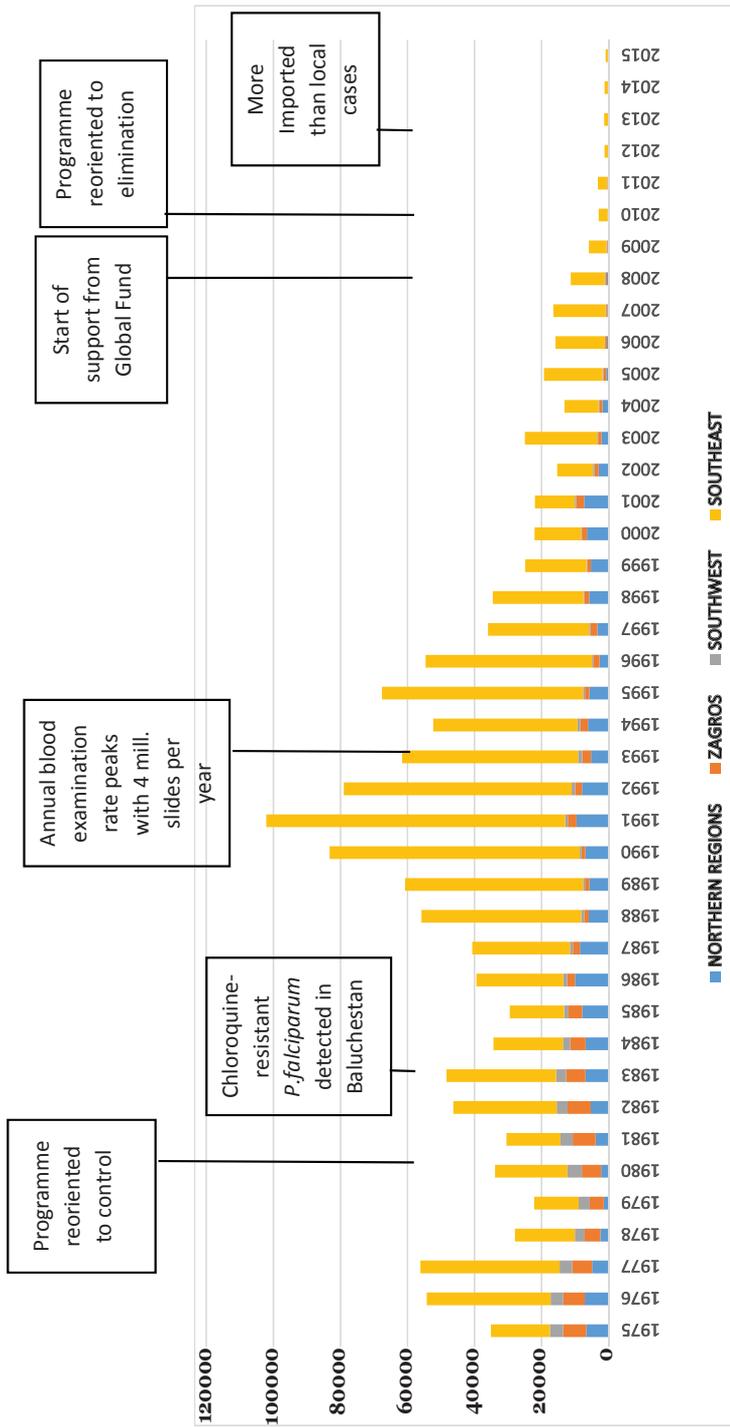


Fig. 1.2.1. Major events and milestones and number of parasitologically confirmed malaria cases in I.R. Iran by year from 1975 to 2015 by Region (see Fig. 3.3.2). Northern Regions include Northwest, Central plateau, Caspian and Northeast.

2. Islamic Republic of Iran – a profile

Geography and climate

The Islamic Republic of Iran is in southwest Asia and covers an area of 1.648 million km². It borders (clockwise from northwest): Armenia, Azerbaijan, the Caspian Sea, Turkmenistan, Afghanistan, Pakistan, the Gulf of Oman, the Persian Gulf, Iraq and Turkey.

I.R. Iran is intersected by two mountain ranges, both starting in Iranian Azerbaijan in the northwest: the Alborz Range, running south of the Caspian Sea and then northeast to the Afghanistan border, and the Zagros range running southwards along the western border, then veering southeast towards the Persian Gulf and ending at the Strait of Hormuz. These ranges divide the country into three major regions: (a) Caspian coastal area between the Caspian Sea and the Alborz, with a broad plain extending into forests on the northern mountain slopes; (b) Central plateau between the two mountain ranges, extending from the northwest to the borders with Afghanistan and Pakistan – despite low precipitation and an absence of major rivers, the plateau is cultivated with the support of irrigation, except in the barren salt marshes and deserts of the east central part; (c) Southern plains, which include the Khuzestan Plain in the southwest extending into the southern plains of Iraq, and the coastal plain (Fig. 2.1).



Fig. 2.1 I.R. Iran's location, neighbouring countries and terrains

The climate is generally arid with extreme differences between summer and winter temperatures. In most of the country, annual precipitation averages 250 mm or less, falling mainly from October to April. The main exceptions are the highlands in the northwest and the Caspian coastal plain, where precipitation averages at least 500 mm per year.

History

Iran has one of the world's oldest civilizations, which culminated with the Achaemenid Empire from 550 BCE to 330 BCE. Over the following centuries, the nation's fortunes fluctuated. Yet, science, medicine, and the arts continued to flourish, especially in the Islamic Golden Age, which reached its peak in the 10th and 11th centuries. Following decline in the 19th century, a constitutional monarchy with a legislative body, the *Majlis*, was established in 1906. After the revolution in 1979, the Islamic Republic of Iran was established. In 1980, Iraq attacked; the ensuing war lasted for eight years. Since 1988 the country has experienced sustained economic development.

Population

The population of I.R. Iran grew rapidly during the second half of the 20th century, increasing from about 17.1 million in 1950 to 32.7 million in 1975 and 79.9 million in 2016. However, the birth rate has declined; from 2006 to 2011, the annual growth rate was 1.22% (2). The urban proportion of the population increased from 27% in 1950 to 69% in 2012. Most citizens are Shia Muslims and have Persian as their first language. The biggest minority group are the Azeris, who live mainly in the northwest. Others include Arabs, Armenians, Kurds, Balochis and those speaking languages closely related to Persian (3).

According to the United Nations, there were 2.6 million immigrants, including 0.8 million refugees, in I.R. Iran in 2013. The great majority of refugees, as well as other migrants, were Afghans (4). Most refugees live in urban areas. Voluntary repatriation has been ongoing for many years, but it is estimated that there are still large numbers of unauthorized refugees, perhaps over one million. Large numbers of Afghans and Pakistanis travel to I.R. Iran in spring and summer to work in agriculture and construction, many of them without a permit.

Administration

I.R. Iran is divided into 31 provinces (as of 2017), each with an appointed governor. The provinces (*ostan*) are divided into counties (*shahrestan*) and subdivided into districts (*bakhsh*) and sub-districts (*dehestan*). In this report, the Iranian terms are used for divisions below province level, to avoid ambiguity. Local councils are elected by public vote for four-year terms in all cities and villages.

Economy

I.R. Iran has 10% of the world's proven oil reserves and 15% of its gas reserves and is the world's fourth largest oil producer. Between 1980 and 2012, gross national income per capita increased by about 48%. In 2014, the gross domestic product was US\$ 404 billion (US\$ 1.33 trillion or US\$ 17 100 per capita at purchase

power parity). I.R. Iran is now ranked as an upper middle-income economy by the World Bank. The government is pursuing market reforms, replacing subsidies with targeted social assistance, and intends to diversify the country's oil-reliant economy. The country has developed advanced biotechnology, nanotechnology and pharmaceutical industries. Economic sanctions have affected the economy and led to a steep fall in the value of the Iranian rial. Unemployment has remained above 10% since 1997.

Education, employment and communication

The adult literacy rate was 93% in 2015, up from 85% in 2008 and 36.5% in 1976. The rate of primary school enrolment is almost 99%, with gender parity in primary and secondary schools. However, there is still geographical variation with the lowest literacy rates (72–76%) in Sistan & Baluchestan Province. By 2012, the ratio of women to men with at least secondary school education was 0.66.

Most villages in I.R. Iran have access to television channels and telecommunications. In 2010, more than 20 million Iranian families had access to television channels, 95% of Iranian families had landlines and 86% mobile phones.

National development plans

Six development plans have been prepared since 1979; among them, the 4th, 5th and 6th are oriented by *Iran Vision 2025*, which is for the country to be a developed nation with the highest economic, scientific and technological status in the region by 2025. The Ministry of Health and Medical Education (MOHME) has prepared an aligned vision statement as follows: “By 2025, Islamic Republic of Iran will be a country with people having the highest level of health and the most equitable and developed health system in the region.” The plan envisages an inclusive strategy of market-based reforms and improved social indices.

3. History and natural history of malaria in the Islamic Republic of Iran

If you want to die, go to Gilan

Iranian proverb (5)

3.1 Before 1916

The historical importance of malaria in I.R. Iran is engraved in the population's DNA. A number of hereditary conditions are prevalent in populations that have been exposed to malaria for many centuries because the disease genes confer some protection against malaria. In Asia, Europe and North Africa the most common of these conditions is beta-thalassaemia. Based on data from a national screening programme (6) the frequency of the beta-thalassaemia gene by region in I.R. Iran is shown in Fig. 3.1.1. The distribution matches the epidemiology of malaria in the first half of the 20th century remarkably well (see below).

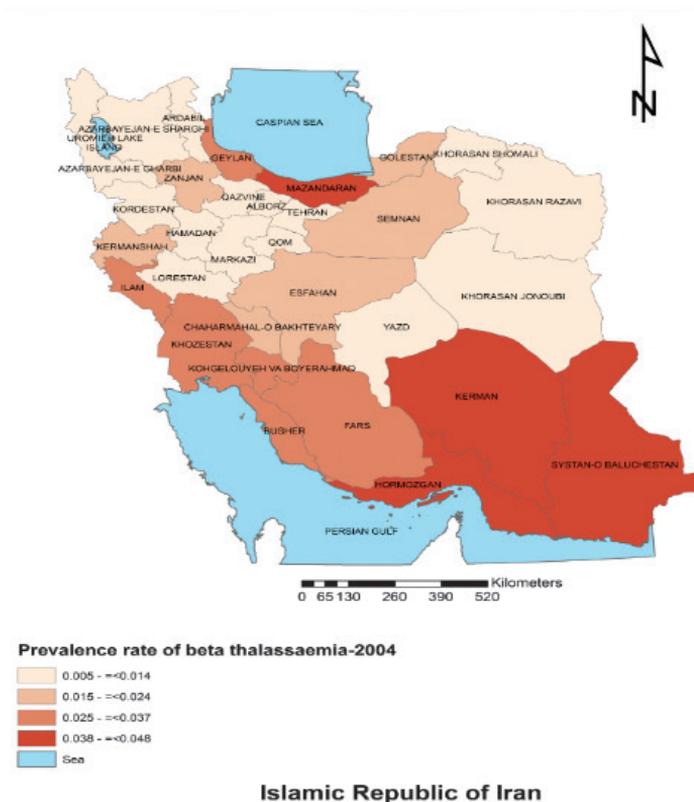


Fig. 3.1.1 Frequency of the beta-thalassaemia gene by province of I.R. Iran. Source:(6)

However, the prevalence of beta-thalassemia does not indicate how long malaria has been a problem. We need to combine with the historical record (7,8) and ecological suitability. A disease resembling malaria was described in *Avesta*, the collection of Zoroastrian religious texts. Deadly intermittent fevers are mentioned in tablets from the library of the Assyrian king, Ashurbanipal, dating back to 2000 BCE (9), suggesting that malaria was prevalent in Mesopotamia and the contiguous plains of Khuzestan.

In contrast, the Iranian plateau, most of which is 1000 m above sea level, may have had little malaria, before humans changed the environment. Since the early part of the first millennium BCE, settlements on the plateau have relied on irrigation, especially large underground channels, *qanats*, a technology, that has since spread to other Asian and Mediterranean lands (Fig. 3.1.2). As most of the rain falls in the winter months and most of the water for agriculture is required over summer, water needed to be stored in reservoirs. Furthermore, excess irrigation water could lie stagnant on the fields over the summer. Later observations indicate that the malaria risk on the Iranian plateau was indeed associated with irrigation. Malaria has therefore probably been endemic on the Iranian plateau at least since Achaemenid times. However, the distribution of malaria varied then, as in the 20th century. Esfahan, at 1600 m above sea level, with ancient river irrigation systems maintained over centuries, was known for its invigorating climate in the middle ages, while Ray, just south of the present Tehran, was well known for frequent lethal epidemics. In the present Fars Province, Bishapur, which was established with extensive irrigation works in *Sassanian* times, suffered a drastic decline in the 10th and 11th centuries, when it was known for its “unhealthy surroundings” and “yellow and sickly inhabitants”. In the Iranian lowlands, the situation was often worse. In Khuzestan, the swampy Ahwaz region was known for fevers making the inhabitants “yellow and lean” since around the 6th century CE. Gorgan, on the Caspian plain, was known as the “graveyard of the people of Khorasan” in the 10th century (10). Such a terrible reputation is compatible only with *falciparum* malaria.



Fig.3.1.2 *Qanat* in the central plateau, and a row of openings of ventilation shafts

However, it is likely that *P. vivax* and *P. malariae* preceded *P. falciparum* by many centuries. In classical Greece (about 500–300 BCE.), *P. falciparum* had probably not gained a foothold for environmental and climatic reasons, and Hippocrates' descriptions of fevers do not suggest *P. falciparum*. Malaria was not a major problem for the Greek army invading Iran in the 4th century BCE – except perhaps for Alexander the Great, who may have died from the disease, but if so, probably from *P. vivax* he contracted in India (11). Thus, the malaria situation in Iran was probably not worse than in Greece at the time.

In the 9th to 11th centuries CE, about 1 400 years after Hippocrates, the clinical picture of malaria was described by several famous Iranian physicians of that era including Ibn Sina (Avicenna), who classified fevers including malaria (*Tab-e Nowbeh*) in his *Canon of Medicine* (12). His classification scheme includes a category of “hectic fevers”, where, “if the heat elevates in intensity so that it could influence the flesh of the body, it would be very difficult to save the patient”, and “the patient gets weak, thin and withered” (13). Although alternative explanations (e.g. typhoid fever) cannot be ruled out, Ibn-Sina's description is a departure from Hippocrates' and suggests that *falciparum* malaria had emerged as a

problem in Iran in his time.

The worst malaria epidemic recorded in Iranian history occurred in the early 18th century, when Shah Abbas relocated 100 000 Armenians from present-day Armenia to Isfahan and the Caspian plain in northern Iran; it was estimated that 20 000 died, probably from malaria. Generally, during the Qajar dynasty (1796– 1925) malaria was known as an endemic and widespread disease (12).

3.2 From 1916 to 1947: the first studies and interventions

“Look at that wall in the corner of the main cross road in the village, this was the place to come together, to sit in the sun during our Tab-e-Nobeh [periodic fever], this was quite normal, everybody expected to have Tab-e-Nobeh several times a year and every year. Do you know what quinine is, of course you don’t, we had to go to the ‘town’ on foot to ask for medicine, if we were lucky enough to reach the city”.

From a conversation around 1970 between an old man and his grandson (later a medical officer in MOHME)

Two reports on public health in Iran dating from 1925 note that that in the late 19th century and early 20th century, the main epidemic diseases –plague, cholera and smallpox – had come under a degree of control, leaving malaria as the most important problem.

One of these, by the British Representative on the Persian Sanitary Council, mentions that malaria was at its worst in the Caspian provinces, where it was associated with irrigated rice fields and marshes; spleen rates (prevalence of splenomegaly among those examined) among children aged under 10 years were 100% in most places. “The people as a whole are anaemic and distressful looking... There are no doctors except in the few towns, and there is very little quinine”. In valleys and on plains, high malaria risk was related to primitive irrigation systems, and in the cities, to the extensive water storage. In Tehran, malaria was attributed partly to importation and partly to local transmission: “Pernicious attacks are frequently seen among poorer labourers and pilgrims...All the patients say they have had malaria... Persians in the towns are constantly taking quinine... Prophylactic measures are not being taken by the Government, even to the extent of making quinine easily and cheaply obtainable...Nets are used by the better-to-do classes.” In a district southeast of Tehran, “the villagers are heavily infected and sallow and lethargic, very different from the sturdy hillsmen a few miles to the north (14).

The other report, from a mission to Iran in 1924 for the League of Nations Health

Organisation (the precursor of WHO), also points to the severity of malaria in the Caspian provinces and the causative role of irrigation and water storage. “Some areas had been abandoned because of malaria. Spleen rates in children in rural areas in western and central Iran were 85–100%, and the spleens are often very large.” This report includes important observations on the health system. The estimated population of Iran was 10 million in 1920, the state expenditures on health were 0.5% of the total government budget, and there were 48 doctors in government service (15).

Table 3.2.1 Compilation of data from malaria surveys in Iran from 1916 to 1943

Region	Area	Year	Season	Age-group	Spleen rate	Parasite rate	Pf%	Pv%	Pm%	Source
Caspian	Rasht	1921	February	Adults?	52	19	44	42	6	Latyshev, 1948
	Bandaranzali	1921	January	Adults?	53	19.5	69	22	4	Latyshev, 1948
	Tonekabon	1934	spring-summer	Children	63.7	20.9	70	8.7	17.4	Amidzadeh, 1941
	Mazendaran East	1934	spring-summer	Children	38.2	12.6	20.8	52.8	17.6	Amidzadeh, 1941
	Gorgan	1934	spring-summer	Children	32.5	5.7	3.9	46.1	50	Amidzadeh, 1941
	Gorgan school	1942		9-16 yrs.	10.3	7.7				Gutsevich, 1948
	Sharafkhaneh school	1942		9-17 yrs.	25.6	15.2				Gutsevich, 1948
	Sharafkhaneh factory	1942		7-15 yrs.	62.6	33.3				Gutsevich, 1948
	Bandar Torkaman	1942		8-17 yrs.	18.3	12				Gutsevich, 1948
	Babolsar school	1942		7-17 yrs.	19	12.8				Gutsevich, 1948
Chalus	1941			89	31	76	24	0	Edrissian, 2006	
Northeast	Mahshad	1935	autumn	6-16 yrs	6.5					Lindberg, 1936
Central	Kermanshah	1919	May	Children	1.3					Christophers&Shortt, 1920
	Kermanshah	1920	January	Children	0.3					Christophers&Shortt, 1920
	Arak	1934	spring-summer	Children	40.4	16.5	44.4	2.8	47.2	Amidzadeh, 1941
	Khorramabad	1934	spring-summer	Children	65.5	30	80.2	8.1	10.4	Amidzadeh, 1941
	Borudjerd	1935	autumn	6-16 yrs	25					Lindberg, 1936
	Qom	1935	autumn	6-16 yrs	22					Lindberg, 1936
	Kashan	1935	autumn	6-16 yrs	13.5					Lindberg, 1936
	Isfahan	1935	autumn	6-16 yrs	9.5					Lindberg, 1936
	Yazd	1935	autumn	6-16 yrs	3					Lindberg, 1936
	Tehran	1935	autumn	6-16 yrs	6					Lindberg, 1936
	Shahrud school	1942		8-17 yrs.	0	0				Gutsevich, 1948
	Semnan school	1942		10-17 yrs.	4	0				Gutsevich, 1948
	Semnan factory	1942		9-16 years	7	2.7				Gutsevich, 1948
	Zagros	Shiraz	1935	autumn	6-16 yrs	15.5				
Southwest	Behbahan	1934			65	30	80	9	11	Edrissian, 2006
	Khoramshahr	1916	August	Children	32					Christophers&Shortt, 1920
	Khoramshahr	1917	June	Children	6.9					Christophers&Shortt, 1920
	Khoramshahr	1936			43	16	54	40	6	Edrissian, 2006
Southeast	Lengeh	1935	autumn	6-16 yrs	77					Lindberg, 1936
	Bandar Abbas	1935	autumn	6-16 yrs	66.5					Lindberg, 1936
	Sirdjan	1935	autumn	6-16 yrs	4					Lindberg, 1936
	Kerman	1935	autumn	6-16 yrs	4					Lindberg, 1936

Spleen rate: prevalence (%) of splenomegaly among those examined; parasite rate: prevalence (%) of malaria parasitaemia among those examined; Pf%/Pv%/Pm%: prevalence (%) of *P. falciparum/vivax/malariae* among those with malaria parasites. Regions: see macro-stratification in section 3.3 and Fig. 3.4.1.

The first malaria surveys in Iran were conducted from 1916 to 1921 (16,17), and were followed by surveys in 1934 (18), 1935 (19) and 1943 (20). A tabulation of

available survey data from 1916 to 1943 based on *Edrissian's* compilation (8) and other sources gives a clear picture (Table 3.2.1). Malaria transmission was high and uniform in the plains along the Caspian and the Persian Gulf coasts. It is interesting to note the high prevalence of *P. malariae* in most areas. Infection from this parasite has become much less frequent over the years, probably because of its high susceptibility to standard treatments. In contrast, in the plateau, there was a high degree of heterogeneity. Except for Tehran, where the spleen rate of 6% in 1935 does not match the descriptions from the 1920s, nothing indicates any improvement in the malaria situation in the country from the 1920s to the 1940s. It is interesting to note the high prevalence of *P. malariae* in most areas. Infection from this parasite has become much less frequent over the years (in Iran and elsewhere), probably because of its high susceptibility to standard treatments.

Malaria control activities before 1949

Before the Second World War, the limited measures against malaria included distribution of quinine, oiling of stagnant waters and the promotion of environmental standards. In the 1920s, *Gambusia* larvivorous fish from Italy were introduced into marshes on the Caspian coastal area; at the same time drainage was started. The activities were interrupted during the Second World War, but the fish remained (21). In 1942, *Gambusia* were introduced again, by a Soviet Union malaria expedition (20).

In 1934 a malaria unit was established at the Pasteur Institute in Tehran (8). From 1943 to 1946, malaria control activities were undertaken in Khorramabad, Sanandaj, Esfahan and Shiraz (12).

In 1945, the United States (US) Army introduced indoor residual spraying (IRS) with dichlorodiphenyltrichloroethane (DDT). Operations were supported by landowners, who provided labourers and funds for mepacrine tablets for free distribution in their villages. From 1946 to 1947, activities were expanded to other areas in the Central plateau and the southwest. An American nongovernmental organization, Near East Foundation, supported operations in Kermanshah, the Caspian region and Baluchestan; the Ministry of Health supplied the DDT, the Ministry of War assigned soldiers as labourers and *Sazeman Shahanshahi*, an Iranian health organization, provided funds (22).

3.3 Natural history of malaria in the Islamic Republic of Iran

Vectors

I.R. Iran straddles two zoogeographical regions, Palearctic and Oriental. In general, Palearctic anophelines are found country-wide and Oriental species only south of the Zagros range and in Baluchestan. A complete bibliography of studies

on anophelines (and other disease vectors) in I.R. Iran was published in 2001 (23). Several updated review articles on malaria vectors have been published since (24,25).

Based on morphology, 19 *Anopheles* species have been recorded in I.R. Iran, of which seven are recognized as malaria vectors based on sporozoite infections in the salivary glands, namely: *An. d'thali*, *An. maculipennis*, *An. sacharovi* (subspecies of *maculipennis*), *An. superpictus* and *An. pulcherrimus* (Palearctic) and *An. culicifacies*, *An. fluviatilis* and *An. stephensi* (Oriental) (26). The characteristics of these species are presented in Table 3.3.1 and their geographic distribution in Fig. 3.3.1.

Studies conducted in 2012 in malaria foci in Sistan & Baluchestan, Hormozgan and Kerman found five vector species: *An. stephensi*, *An. culicifacies*, *An. d'thali*, *An. superpictus* and *An. fluviatilis*, the last three mainly in hilly areas.

3. History and natural history of malaria in the Islamic Republic of Iran

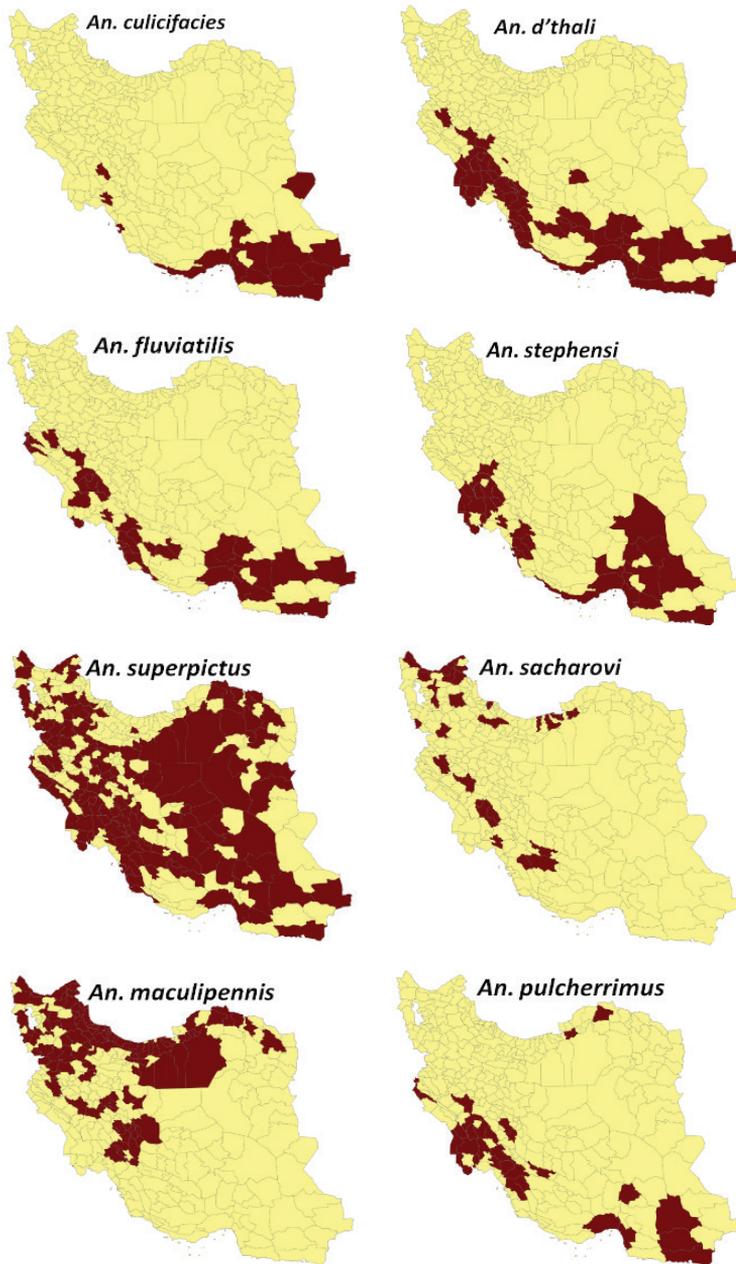


Fig. 3.3.1 Distribution of malaria vectors in I.R. Iran, including *Anopheles pulcherrimus* as a suspected vector (see Table 3.2.1). Courtesy: A.A. Hanafi-Bojd (24) and M. Zaim (27)

Table 3.3.1 Bionomics of *Anopheles* vector species in I.R. Iran

Species	Adult behaviour*	Breeding places (24)
<i>An. fluviatilis</i> (28)	Mainly exophagic and exophilic	Fresh, slow-flowing or stagnant waters, large marshes, river banks, pits in the beds of stony or sandy rivers and rainfall pits
<i>An. maculipennis</i> (29,30)	Endophagic, endo-/exophilic	Swamps, edges of slowing back ends of water supply channels, roadside ditches and rice fields
<i>An. sacharovi</i> (31)	Endo-/exophilic	Swamps with brackish water, stagnant waters, edges of slowing back ends of water supply channels, small water bodies containing vegetation, roadside ditches
<i>An. superpictus</i> (26)	Exophagic tendency, endo-/exophilic	Different water bodies including swamps, edges of rivers and streams, sandy larval habitats of river beds with clear water, rice fields
<i>An. d'thali</i> (32)	Endo-/exophilic	Pebbly margins of rivers, springs, pits around springs with or without vegetation, pools in dried-up river beds, palm irrigation canals, even water with high salinity
<i>An. stephensi</i> (33)	Mainly endophilic and endophagic, but exophagic in the hot season, when people sleep outside	Wells, cisterns, fountains, ornamental ponds, pools, catch basins, seepage canals, stream beds, palm irrigation canals, margins of rivers, seepages and marshy areas with gentle water; dominant vector in urban environments
<i>An. culicifacies</i> (34)	Mainly endophilic	Rice fields, irrigated palms, stream pools and river beds
<i>An. pulcherrimus</i> (35)	Mainly endophilic	Slow-moving streams, ditches, rice fields, pools, marshes and other types of waters with or without vegetation

*Exophilic mosquitoes tend to rest outside after a blood meal; they are therefore less susceptible to being killed by IRS, even if they are susceptible to the insecticide. Exophagic mosquitoes tend to bite outdoors and are often (but not always) also exophilic. Exophagy and exophily are rarely absolute: exophagic and exophilic mosquitoes may sometimes bite and rest indoors.

Macro-stratification and transmission seasons

Over the years, several schemes for stratification of malaria have been applied based on epidemiological and entomological criteria as well as on responsiveness to control measures. Fig. 3.3.2 shows a macro-stratification based on the natural history of malaria (as found in the 1940s), the risk factors which have subsequently emerged, and the accumulated experiences from control and elimination efforts up to 2015. As with all stratifications, this approach is a compromise. The boundaries between the strata follow boundaries between provinces, which is a simplification; this is because for some years, only province-level data were available. It should be noted that Fars Province includes areas that fit the description of not only Zagros, but also of the Central plateau and the southwest. The northern part of Kerman Province belongs to the Central plateau rather than the southeast. Fig. 3.3.3 shows the transmission seasons in those different regions as observed in the 1950s and 1960s.

3.4 Malaria – baseline before the start of control at the national level in 1949

Fig. 3.4.1 shows the presumed distribution of malaria by 1949, before control operations could have had any major effect. At that time, it was estimated that about 11 million people, of the total population of 16 million, were rural residents living in 43 000 villages. Of this rural population, it was assumed that 40% lived in areas of intense endemicity, 20% in areas subject to periodic outbreaks and the remainder in malaria-free areas (37). Malaria transmission has always been impossible in certain areas, either because of desert conditions or because of altitudes 1 500–1 800 m above sea level. In the Caspian area in the north and in the Persian Gulf coastal and plain areas in the south, about 25% of patients referred to dispensaries had malaria symptoms and approximately 30–40% of total mortality was caused by malaria (8).

It was estimated at the start of the national malaria control programme in 1949 that 3–4 million Iranians suffered from malaria every year. The figure seems plausible, but unfortunately no supporting documentary evidence is available (38).

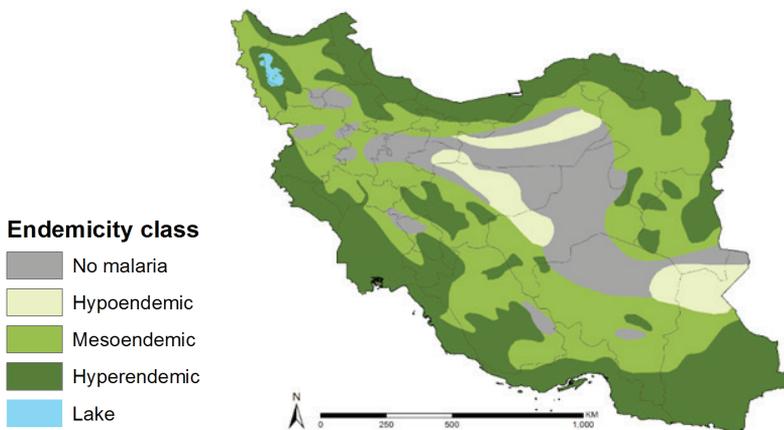


Fig. 3.4.1 Distribution of malaria in Iran in 1949 by endemicity class. Source: Motabar et al. 1975, modified by Snow et al.

CONCLUSIONS

1. *Plasmodium malariae* and *P. vivax* became increasingly important health problems as irrigation was adopted on the plateau some time in the 1st millennium BCE, probably earlier in Khuzestan.
2. *P. falciparum* malaria probably emerged as major problem later: between the 4th century BCE and the 10th century CE.
3. At least since the 10th century CE, malaria was particularly severe in the humid Caspian plains. In the 20th century, rice fields were the main breeding sites in this area.
4. Based on genetic evidence and a few early surveys, the malaria situation on the Persian Gulf coast and in the southeast must historically have been as severe as on the Caspian coastal area.
5. Malaria vectors in I.R. Iran north of the Zagros are largely Palearctic species, which are relatively easy to control. South of Zagros there are also Oriental species, which often cause more intense transmission. In the Zagros foothills and in the southeast some vectors are exophilic (outdoor-resting), increasing the challenges to control transmission.
6. Despite some dramatic epidemics in the past, there is no evidence that malaria ever changed the course of Iranian history. Nevertheless, the malaria burden for rural populations then and until the mid-20th century was almost unimaginable by modern standards. The suffering, the disease burden and deaths in all age groups must have been important factors holding back rural development.
7. The sporadic control efforts undertaken from the 1920s to the 1940s did not change the malaria situation in the country, except possibly in and around Tehran.

4. Development of malaria control and elimination

4.1 The first national malaria control programme (1949–1956)

Organization and resources

In 1949, the Government established an organization called *Edareh-ye Mobarezeh ba Malaria* (the Administration for Malaria Campaign). Three years later, an Institute of Malariology headed by Professor Naser Ansari was established at Tehran University (39), and the resources of the Ministry of Health and the Health Division of the US Mission were combined within a single organization, the Public Health Cooperative. From 1952 to 1956 antimalaria units were established in 10 provinces, and 1 142 individuals were trained in malariology, entomology, microscopy, field surveillance and vector control in annual three-month courses. By 1956, the programme had built an impressive human resource base:

- 28 malariologists
- 16 entomologists
- 16 sanitary engineers
- 30 blood technicians
- 2 pharmacists
- 46 supervisors
- 63 senior foremen
- 368 junior foremen
- 1574 labourers

The budget for the first year for implementation along the Caspian Sea and in Bushehr and Hormozgan corresponded to about a quarter of the total annual health budget (38,40). In Shiraz, a US-based technological resource organization (Pennsalt) supported implementation (41).

Policy and implementation

In the early years, various control methods, including larval control through oiling and *Gambusia* were applied as pilot projects (8,12,37) but by 1953, the programme concentrated almost exclusively on IRS with insecticide such as DDT (38).

In 1949, about 460 000 people were protected by IRS (37). Expansion was rapid and operations were managed with flexibility (Fig. 4.1.1). The control programme reached nearly 5 million of the country's 18 million people in 1953, mainly in the Caspian Region, Hormozgan, Baluchestan and Azerbaijan. From 1954, the number of people covered by IRS started to decline, as transmission was assumed to have been interrupted in some areas. The cost of IRS operations was not very different from what it would be today, when calculated in 2015 US dollars (Table 4.1.1).

Table 4.1.1 Report on IRS and its costs, 1953–1955

	1953	1954	1955
No. villages sprayed	14 542	14 405	16 106
Population protected	4 243 900	3 915 000	3 885 800
DDT technical grade consumed (kg)	1 086 683	1 019 374	No data
Cost (current US\$)	1 485 365	1 174 500	1 327 272
Cost per person protected (current US\$/2015 US\$)	0.35/3.1	0.30/2.6	0.34/3.0

Source (38). The product used was DDT WP 75%, applied once a year with a target dose of 2 g/m².



A field spraying team prepares to move on to the next village. Donkeys are frequently used for transportation when the distance is short or when the destination is inaccessible by motor vehicle.

Fig. 4.1.1 Transport used in spraying operations in the 1950s. Source (42)

Monitoring and impact

From 1952 to 1955 surveys to assess the effect were carried out in 5 720 villages; of 278 400 blood samples taken, only 2 417 (0.87%) were positive, of which 38% were *P. falciparum*, 49% *P. vivax*, 12.5% *P. malariae* and 0.5% were mixed infections. Spleen rate data showed that IRS was highly effective in reducing transmission in the Caspian Region (Fig. 4.1.2). In some villages, IRS was stopped and replaced by surveillance. In 1955, 430 villages with 86 000 inhabitants were recorded as being under protective surveillance (40).

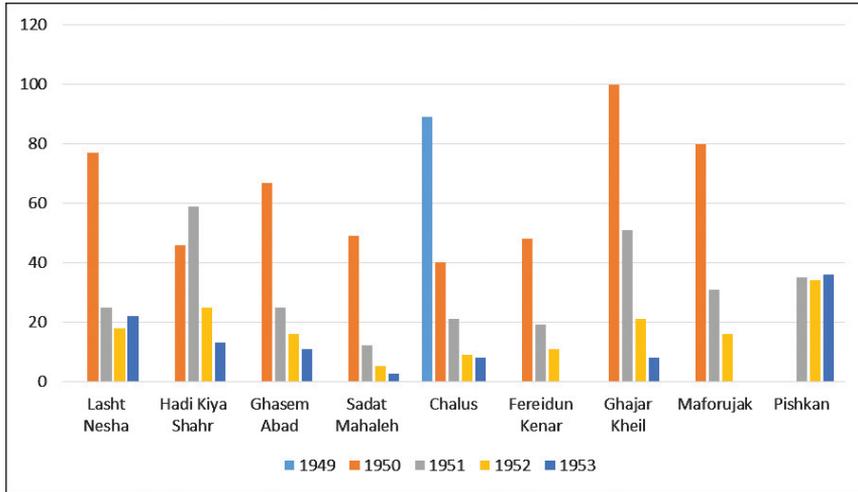


Fig. 4.1.2 Spleen rates in children aged 2–9 years recorded in various locations in the Caspian region, 1949–1953, while annual IRS was being implemented. Sources (38,42)

Spraying in Chalus was a pilot activity in 1949. All locations except Hadi Kiya Shahr and Pishkan were sprayed in the years when the survey was carried out. Hadi Kiya Shahr was not sprayed in 1950, but annually from 1951. Pishkan was an unsprayed control area until it was sprayed in 1953.

The impact in the Caspian Region was felt well beyond the malaria programme:

- Physicians in dispensaries and hospitals reported in late 1952 that they had seen only 10 or 15 malaria patients during the entire malaria season that year, whereas in previous years they had seen 20 to 100 daily.
- A farmer related that after IRS the number of persons needed to harvest one hectare of rice went down from 10 to four (42).

The farmer’s account is a telling example of the societal benefits of early malaria control. Seen against the description of *Tab-e-Nobeh* by the grandfather quoted in the section 3 (Malaria control activities before 1949), the causality is reasonable. Another collateral benefit of IRS was the virtual disappearance of cutaneous leishmaniasis, but unfortunately this disease returned after spraying was stopped (43). The reports from the early 1950s convey a sense of optimism and enthusiasm, which is understandable given the unprecedented reduction in a debilitating disease and a major public health problem.

In the report submitted to WHO in 1956, it was stated that no data on morbidity and mortality from the past 15 years was available. The estimate of 3–4 million cases per year before the start of the control programme (Section 3) was the only “data-point” quoted in official reports. Thus, the formidable progress achieved

through spraying was not matched by a qualitative development of a public health programme supported by a surveillance system. A sad manifestation of this is the observation that “Between 1949 and 1953, around half of the workers who were constructing the roads or industrial factories in Northern Iran died from malaria”(44). Even if the accuracy of this sweeping statement is only relative, it reflects the absence of a modern public health vision in early malaria programmes.

CONCLUSIONS

1. An ambitious malaria control programme, based mainly on IRS with DDT, was started in 1949 with national funding, and organized under the Ministry of Health with international support.
2. A large and varied human resource base was established at central and provincial levels.
3. By 1953, nearly 5 million people of a total national population of 18 million were protected by IRS.
4. The programme prioritized the most malarious areas in the country: the Caspian and the southeast.
5. In the Caspian, the spleen rates plummeted, and in many villages transmission was interrupted after a few years of IRS. The benefits were observed in the general health

4.2 The national malaria “eradication”¹ programme (1956–1980)

Plan of operations

Iran was not the only country experiencing a dramatic effect from IRS. Similar results were seen in the USA, India and southern and eastern Europe. In 1956, against this background, the World Health Assembly endorsed the time-bound Global Malaria Eradication Programme.

WHO and its partners moved quickly. In line with standard procedures, a plan of operations was prepared in 1956 involving the Government of Iran, WHO and the United Nations Children's Fund (UNICEF) (45). The tripartite agreement was signed in December 1957. The US International Cooperation Administration (ICA) was involved through a separate agreement. The goal was eradication of malaria in Iran by 1971. The spirit and techniques of malaria eradication in the 1960s were captured in a series of postage stamps (Box 4.2.1).

Box 4.2.1 Postage stamps from the 1960s commemorating malaria eradication



Recognizing the diversity of conditions, it was decided to divide the country in four zones to be sprayed as follows:

- Zone 1, Caspian region: 1957–1960
- Zone 2, Northwest, southwest, Zagros, southeast regions: 1958–1961
- Zone 3, Central plateau region: 1959–1962
- Zone 4, Northeast region: 1960–1963

The regions corresponding to the macro-stratification are shown in Section 3.3. The progression was generally from higher malaria burden to lower malaria burden. Following the *attack* phase with complete coverage of the at-risk population by IRS for four years, each zone would enter the *consolidation* phase with surveillance and reactive, focused IRS. After verification of the absence of new cases, the zone would move to *maintenance* phase.

1- Until the mid-1990s, the term eradication was applied interchangeably for definitive interruption of transmission in a given territory, typically a country, or in the whole world. Only over the last 30 years has it been generally recognized that there is a fundamental difference between elimination (local) and eradication (worldwide), as elimination requires continued measures to prevent reintroduction.

UNICEF would provide all the insecticide from 1957 to 1961 as well as 7 200 spray cans and 123 jeeps. WHO would provide technical assistance, training of senior staff and, for a limited period, the payment of salaries of some Iranian staff to prevent loss of staff through brain drain. The contribution of the USA was mainly technical assistance. The Institute of Malariology (later Malariology and Parasitology) would organize 40 epidemiological teams to conduct epidemiological and entomological surveys: in 20% of the villages as a baseline 1 year before IRS was started; in 5% of villages under IRS to monitor impact; in 30% of villages scheduled for discontinuation of IRS within one year; and in 10% of villages under surveillance after discontinuation of IRS.

Implementation of the plan

The number of people covered by IRS per year is shown in Fig. 4.2.1. In some areas in the south, there were two spray cycles per year. The number of people covered by IRS peaked in 1957 at 5.8 million and again in 1960 at 8.9 million, corresponding to as much as 40% of the total national population, including cities. In anticipation of the risk of mosquito resistance to DDT, an alternative insecticide, dieldrin (belonging to the same class, organochlorines), was introduced in 1955.

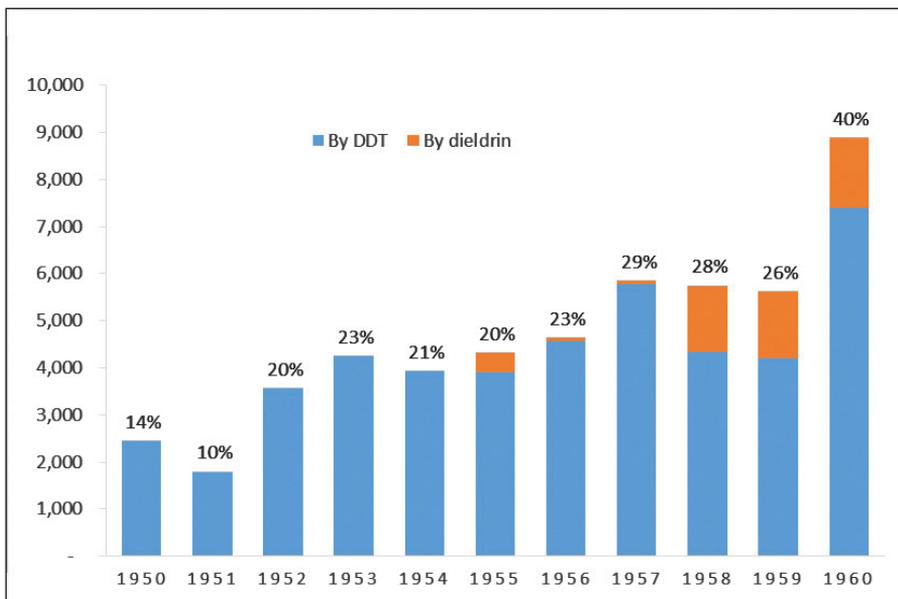


Fig. 4.2.1 Number of people protected by IRS (with DDT or dieldrin) and percentage of the total national population in Iran covered, 1950–1960. Source (46)

Entomological obstacles

Late in 1957, less than a year after the adoption of the eradication strategy and 27

joint plan, a major biological obstacle emerged. Resistance to DDT was detected in *An. stephensi* in Khuzestan and some areas of the Persian Gulf coastal plain. Retrospectively, this problem was linked to epidemics in 1956 in Khuzestan and Kazerun in Fars. It was decided to shift to dieldrin (47). By 1960, resistance to dieldrin was more severe than to DDT, so the programme switched back to DDT (46). Not surprisingly, the vectors soon became fully resistant to DDT. It is not well understood why this problem emerged so early and only in *An. stephensi*. The resistant strains may have been imported from Saudi Arabia, where DDT-resistant *An. stephensi* were detected in 1953 (after five years of IRS) (48) but if so, why did it happen there?

While facing this challenge, the programme, when advancing into physically more difficult terrain in the south in the late 1950s, discovered that malaria in foothill areas, especially on the southern slopes of the Zagros range, was often transmitted by vectors exhibiting a very high degree of exophily: *An. fluviatilis*, *An. d'thali*, *An. superpictus* and *An. culicifacies*. In fact, it has been noted around the world that lush vegetation along streams in hilly areas provides attractive outside resting places for blood-fed anophelines. Unfortunately, this understanding does not help solve the problem. In 1958, the programme was visited by Professor George Macdonald from the United Kingdom (UK) who cautioned that it would take several years to interrupt transmission (“through lysis”) in foothill areas, and this would require strong surveillance coverage in addition to “perfect” IRS (49).

The human factor: nomadic life style

The obstacles were not only entomological. In malaria, human ecology is as important as mosquito biology. Over a few years, it was realized that spraying operations had to contend with people sleeping outside in the hot season, others locking their doors when moving to temporary summer residences for farm work (50) and others who regularly re-plastered their walls. However, none of these problems was as critical and widespread as the nomadic life style.

Less than 15% of the land area of I.R. Iran is cultivable, but at least 25% can support grazing (51). An estimated 2 million Iranians were pastoral nomadic people in the late 1950s. Most of them moved southwards from the Central plateau across the Zagros mountains to warmer plain areas in the autumn and in the opposite direction in spring (Fig. 4.2.2). They lived in goat-hair tents, usually camping near villages of permanent farmers. Typically, they were infected by malaria parasites in their winter quarters, but not in the cooler summer quarters; the parasite rates of the nomadic people correlated with those in nearby permanent villages in the plains. Unfortunately, this human mobility overlapped with the exophilic vectors (Fig. 4.2.3). The programme adapted its tactics: Permanent villages in the winter

quarters were sprayed before the arrival of the nomadic people and after their departure. For spraying of tents, DDT in a kerosene solution gave better results than the aqueous suspension used for house spraying and a dose of 3 g/m² had a long enough effect for the journey to the summer quarters. Literate members of nomadic groups were trained in surveillance (52).



Fig. 4.2.2 Case detection and IRS (dilution of insecticide for spraying) among nomadic people in the Zagros region in the late 1960s. Sources: Digital archives, School of Public Health, Tehran University of Medical Sciences

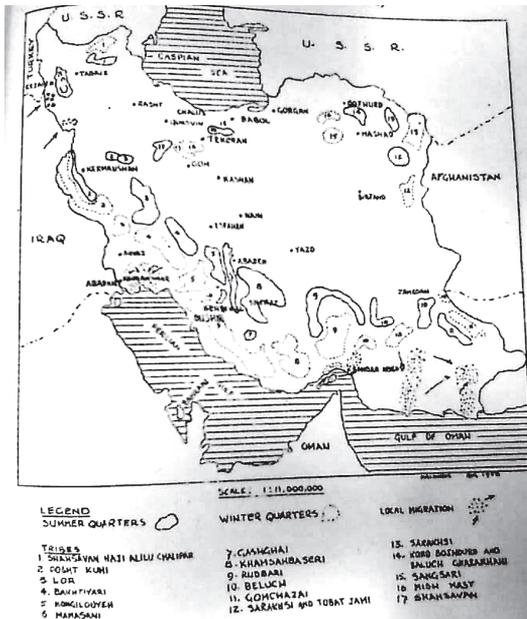


Fig. 4.2.3 Sketch map showing the distribution of summer and winter quarters of nomadic tribes. Source (52)

However, surveillance was still difficult. In such cases, WHO at that time promoted salt with added chloroquine as a supplementary measure—by ensuring that a given population only had access to cooking salt that had added chloroquine at a concentration of 0.3–0.4%, the parasite biomass in humans would be reduced.

In 1959–1960 “medicated” salt (chloroquine alone or chloroquine with pyrimethamine) was used among nomadic people in Fars Province. The parasite rate dropped from 25% to 14% in the chloroquine groups and was unchanged at 20–30% in the control group. Operational use over the years 1962–1965 led to major reductions in levels of blood

parasitaemia, but not interruption of transmission; the intervention was considered

costly and infections returned soon after it was stopped (53).

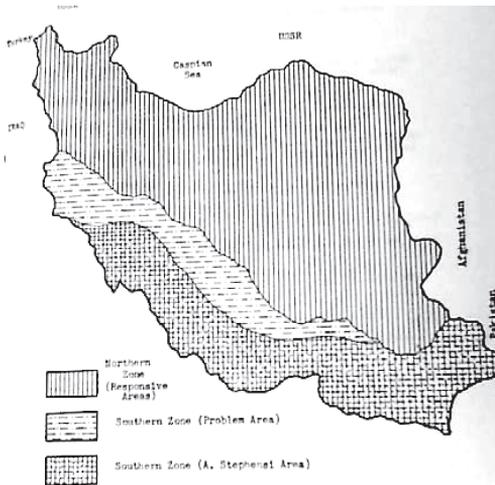
Status 1959–1960

While 9 million people were protected by IRS (Fig. 4.2.1) an equal number were under surveillance during the same period. Out of 488 000 slides from fever cases and children under 2 years of age, 4 576 (0.9%) were positive. Transmission had been interrupted in Khuzestan, but only temporarily, and in the same year, there was an outbreak in Kazerun in Fars, which was attributed to resistant *An. stephensi* and increased density of *An. fluviatilis*. A study of the *An. fluviatilis* vector showed that despite spraying, it was associated with a reproductive number of more than one for *P. falciparum*, meaning that it was still able to maintain transmission on its own (54).

Retreating for a stronger attack (1961–1967)

In 1961, the zoning was revised in light of the entomological and human ecology challenges. The Caspian and the northern part of the Central plateau were now considered malaria-free, while the southwest and southeast including Khuzestan were termed “true non-responsive”, and the Zagros region was classified as “area subject to epidemics” (55). Recognizing the resistance to both DDT and dieldrin, a technically rational but politically bold decision was taken: IRS was suspended in the “true non-responsive” zone (later called the *An. stephensi* area). Unfortunately, the available surveillance data do not allow an assessment of the effect of this strategic change, as the annual parasite incidence was still determined more by the scale-up of surveillance than by actual burden.

By 1963, there were three main strata (Fig. 4.2.4). The main aim now was to achieve malaria-free status in the consolidation phase/responsive areas, i.e. north of Zagros. The strategy was based on surveillance, detection of foci and response, including mass drug treatment and focal IRS in a 6-km radius of any locality where a locally transmitted case had been detected. The programme tried to engage the general health services more in passive case detection, and applied monthly active case detection and activated passive case detection (taking slides from all patients attending selected clinical services).



Northern zone (responsive area) included the Caspian coastal area and the Central plateau. In the 1960s, it was largely in the consolidation phase.

Southern zone (non-responsive area) included:

- Problem area corresponding to the southern foothills of the Zagros, with exophilic vectors and mobile populations
- *An. stephensi* area with organochlorine resistance

Fig. 4.2.4 Stratification malaria zones, 1963. Source(56)

The north had to face the penalty of its success. In the context of agricultural development and the near elimination of malaria there, population resettlement from south to north was encouraged. Because of the migratory flows, the number of cases in the consolidation area rose from 2 895 in 1964 to 4 638 in 1965. Over large areas, IRS had to be re-started, as “protective spraying”.

In the northwest, in West Azerbaijan Province, the risk of importation of malaria from a neighbouring country became important during the 1960s and 1970s. The malaria programme in the neighbouring Soviet Republic of Azerbaijan was dysfunctional during that period; surveillance and response were neglected as the local government refused to recognize that eradication took longer to achieve there than in other republics of the Soviet Union. The result was a serious resurgence of malaria that spilt over into Iran (A. Beljaev, personal communication).

Meanwhile, the situation in the south from 1962 to 1967 was static. In 1965, parasite rates rose in southern Zagros, because the long spring rains encouraged nomadic tribes to stay longer in their winter quarters. However, in Khuzestan, annual IRS with DDT was maintained, as the oil industry had to be protected; the strategy was augmented in oil fields to include: chemical larviciding every 10 days for five months a year; spraying with a knock-down insecticide of all houses of malaria patients and their neighbours, and intense surveillance by teams of nurses. As a result, Abadan had no transmission from 1964 to 1965 (57). The lessons learnt in Khuzestan would soon be applied elsewhere in the south (58).

Funding and organization

As during the early 1950s, most of the budget was provided by the Iranian Plan Organization. UNICEF continued its support with commodities but far less than the government, and the financial contributions from WHO and the USA were minimal (Fig. 4.2.5). A second plan of operations was signed in 1965.

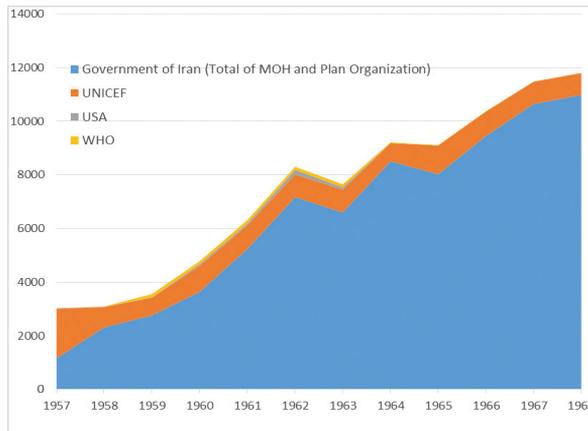


Fig. 4.2.5 Funding in current US\$ of the national malaria elimination programme of Iran by contributor, 1957–1968. Source (36)

The Director of the Malaria Eradication Organization and the Director of the Institute of Parasitology and Malariology (from 1964 called the Public Health Research Institute) were project executors. The Malaria Eradication Organization had a headquarters office, 13 province offices, 75 *shahrestan* (county) offices and a number of *bakhsh* (district) offices. The headquarters had a staff of 244, of whom more than half dealt with administration and logistics. Plans were reviewed and approved by the Scientific and Administrative Council with members from the Ministry of Health, Tehran University, other ministries and international organizations (12). In 1965, the country faced a cholera outbreak. The Malaria Eradication Organization was tasked to rapidly vaccinate several million people against this disease. It acquitted itself very well, boosting its already high prestige.

Assessment of the malaria eradication programme in 1963

A joint WHO–USAID assessment mission in 1963 provided a number of observations and recommendations. Among others, they recommended strengthening the malaria surveillance system in *dehestan* (sub-district level) to improve efficiency, for example shortening the time from slide examination to radical treatment. They pointed out that every time a new focus was detected, decisions had to be made in Tehran, which caused delays in the response. In addition, too much reliance was placed on mass treatment relative to IRS given the threat of resistance (56). After detection of chloroquine resistance in Southeast Asia and South America, WHO’s attitude to mass drug administration was obviously changing.

Overall, the assessment praised the programme, its leadership and scientific

advances. It concluded with the following statement:

The Team having considered this question in all its aspects firmly believes that eradication is feasible and can be achieved in Iran. The team believes that if the recommendations of this report are implemented, malaria eradication can be accomplished in the major parts of Iran in 6 years from 1964.

This was over-confident and political, but it is perhaps understandable that the mission was more concerned with the continuation of a well-run programme than with an evidence-based analysis of trends and options.

Epidemiological, technical and operational developments

If the period from 1963 to 1967 did not see any “shrinking of the map”, there was certainly no stagnation. Field trials and pilot projects that aimed to find solutions to the obstacles and constraints encountered took place as never before. The main developments are listed below.

1. In all areas, passive case detection was promoted more strongly by involving curative services, private practitioners, schools, literacy and health groups and volunteers. Nonetheless, integration of the malaria programme with Primary Health Care (PHC) was a contentious topic. The Director of the Malaria Eradication Organization opposed it, arguing that the rural health services did not have the necessary density for surveillance. His argument was strengthened by reports on disasters in Sri Lanka and India when malaria eradication services were decentralized.
2. On departure from their winter quarters, nomadic people were given mass treatment with chloroquine and primaquine. The parasite rate under this regimen fell from 2.85% in 1968 to 0.12% in 1971. However, compliance of the nomadic people declined (59).
3. A pilot project was established in 1963 in Fassa *Shahrestan* in Fars province with resistant *An. stephensi*, exophilic *An. fluviatilis* and nomadic populations, to determine if transmission could be interrupted by two rounds of DDT under strict supervision. Monitoring by active case detection indicated that 95% of project villages no longer had indigenous cases. It was also attempted to give all nomadic people prophylactic drugs on entering the area, but this failed.
4. Several new compounds for use in IRS were tried out. The best results were with malathion. A pilot project in Bandar Abbas and Minab applied malathion in four rounds per year. In the plains, parasite rates decreased from 36% to 16% after 12 months, but in the foothills the effect was not as good (60).

5. There were complaints from farmers and horticulturists about the oil used for larval control contaminating crops, and field staff noted that it did not spread well. In both respects, there was improvement after switching to a mixture of 80% diesel, 20% furnace oil (crude residue) and 0.5% spreading agent. A controlled trial in Abadan indicated that larviciding reduced parasite incidence and *An. stephensi* densities by a factor of 5–10 (61).
6. The application of the larvivorous *Gambusia affinis* was revitalized. The fish were taken from the Caspian marshes, where they had been introduced in the 1920s, and successfully established in colonies in the south in 1966. Some observations indicate effectiveness. In Gharabagh *Dehestan* in Shiraz, where exophilic vectors were breeding in a large marsh, anopheline larvae disappeared after the introduction of the fish, and the parasite rate decreased. In 1969, *Gambusia* fish were introduced in 3 000 locations in southern Iran. The techniques to maintain the colonies and to distribute the fish are described in detail in a useful report (21).

Relaunching the attack in the south: 1967–1972

Based on the experiences in Khuzestan and the encouraging results of intervention trials and pilot schemes, confidence in the programme was strengthened. From 1967, large-scale IRS resumed in the south: all “non-responsive” areas were covered with DDT and other measures. In 1968, the south was placed in attack phase with malathion spraying up to five rounds per year plus intense surveillance, chemical larviciding around cities and distribution of *Gambusia* (62).

Figs 4.2.6–4.2.8 summarize the main data from the 1960s. The number of people covered in the attack phase was low from 1964 to 1967 but increased sharply in 1968, rising from 5 million to 10 million. Nonetheless, there was a steady increase in the number of people living in areas classified as consolidation phase. The maintenance phase classification (malaria-free) was only applied for a few years in the early 1960s. As shown in Fig. 4.2.7, the number of people protected by IRS continued to increase year by year in the 1960s to reach 12 million in 1967. These populations included those in attack phase, those under preventive IRS in the consolidation phase areas and those under intense malaria control in Khuzestan. In the early 1970s, the insecticide policy was distinct and precise:

- ✓ Malathion alone in 2–3 rounds, where *An. stephensi* was the sole vector;
- ✓ Malathion 2 rounds and DDT 1 round, where *An. stephensi* was the predominant vector;
- ✓ DDT 2 rounds and malathion 1 round, where other vectors were predominant;
- ✓ DDT 2 rounds and malathion 2 rounds, where all vectors were involved in intense transmission;
- ✓ DDT 1 round in high valleys, where there was no *An. stephensi*.

The annual blood examination rate (ABER) reached high levels, with over 20% of the total population examined in the mid-1960s. In the following years, the annual parasite incidence declined even more suggesting that in a large proportion of consolidation phase areas in the late 1960s, the malaria incidence had become so low that active case detection activities could become more targeted. In fact, the expansion of attack phase areas with application of intense vector control led to a reduction in the importation of malaria cases to consolidation phase areas. In the attack phase areas, both IRS and surveillance were intensified from 1968 as reflected in the high ABER, and the rapid decline in annual parasite incidence from 1968 to 1970.

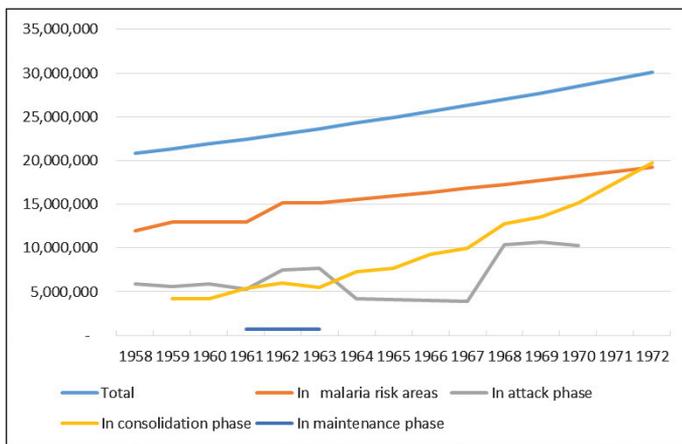


Fig. 4.2.6 Total population and number of people living in areas of original malaria risk and under different phases of the eradication programme (attack, consolidation and maintenance), 1958–1972. Sources: UN Population Division (36); Reports of the WHO Regional Committee for the Eastern Mediterranean, 1958–1963 and 1968–1970; WHO Weekly Epidemiological Report articles on malaria eradication, 1961–1963, 1966–1972

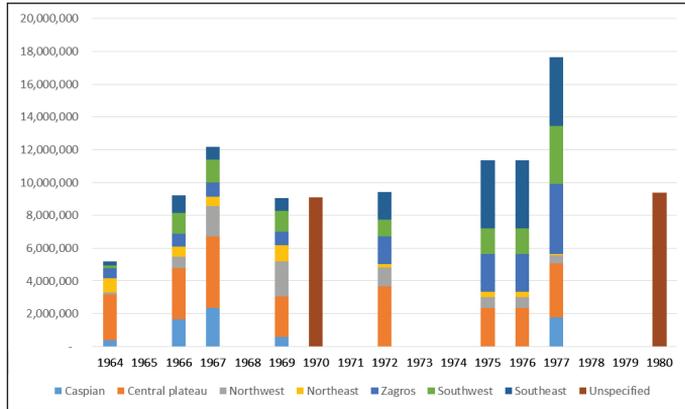


Fig. 4.2.7. People protected by at least one round of IRS in regions of Iran, 1964–1980 for the years for which data are available

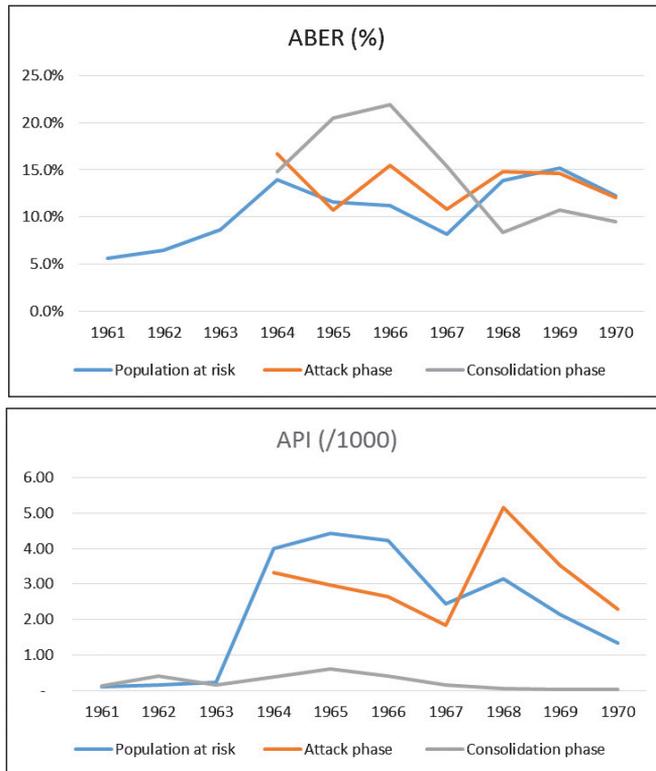


Fig. 4.2.8 ABER and annual parasite incidence (API) in the populations living in areas: of original malaria risk (population at risk), in the attack phase and in the consolidation phase, 1961–1970. Sources as for Fig. 4.2.6 and (63)

The favourable trend continued in the early 1970s, and the reported annual case load reached a low of 12 000 in 1973 (64). Much of the progress was ascribed also to decentralization, with increased power and capacity of the *shahrestan* (counties). The development of the telephone network also supported this development.

From crisis to recovery and re-orientation: 1972–1979

The good results encouraged the Ministry of Health to further integrate the Malaria Eradication Organization in communicable diseases control and to reduce the specific malaria programme activities. Technical problems emerged again: *An. culicifacies* resistance to DDT was detected in Baluchestan in 1973 and *An. stephensi* resistance to malathion in 1975; malaria incidence increased (62). In 1977, the Malaria Eradication Organization regained its autonomy, strengthened its human resources, introduced new insecticides (e.g. replacing malathion with propoxur in 1978 in the southeast), and applied temephos for larviciding in some areas. Coverage of IRS increased again (Fig.4.2.7). Probably, the highest coverage of IRS in absolute and relative numbers was reached in 1977 with 17 million people (50% of the national population) protected, because IRS was applied on a large scale at the same time to prevent resurgence in the northern regions and to reduce transmission south of Zagros (Fig. 4.2.7).

An important development in the 1970s was the consolidation of the national malaria surveillance system. From 1973, cases and slides examined were reported not only as coming from attack or consolidation areas, but in a relatively uniform way from the country's malaria affected provinces. According to records available in 2016, the number of reporting *shahrestan* each year has been relatively stable, above 150.

With the fluctuations in programme effectiveness, a long-term trend emerged in the 1970s: malaria incidence stabilized at low levels in all areas of the country, except the southeast, which emerged as the new problem area (Figs A3.1 and 4.2.9).

It was realized that it was not possible at the time to determine a realistic target date for elimination, and that the development of basic health services in the southeast would be a pre-condition.

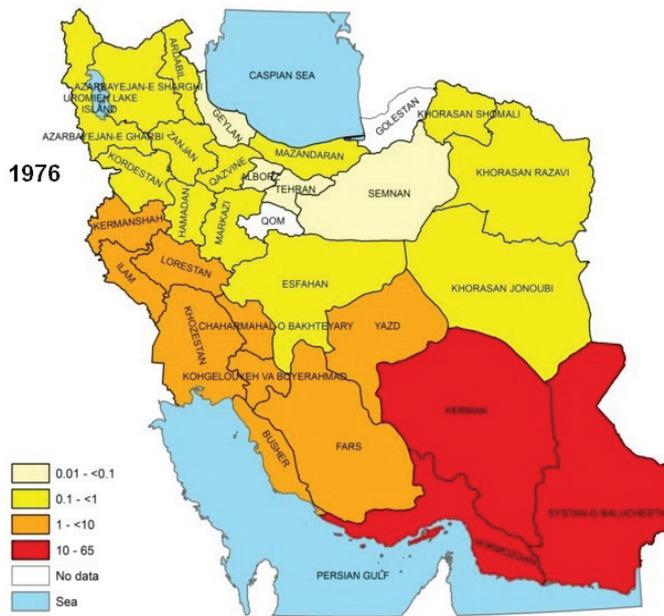


Fig. 4.2.9 Annual parasite incidence (per 1000 population) by province in Iran, 1976

The objectives of the programme were reformulated to reduce transmission in the south and to keep the north as malaria-free as possible. These were malaria control objectives, and in 1980 the Ministry of Health, following recommendations from the National Malaria Scientific Committee and WHO, changed the malaria elimination programme to a malaria control programme (8).

CONCLUSIONS

1. Following the spectacular effect of IRS in the Caspian plains and the Central Plateau, and in line with international recommendations, a national malaria eradication programme was launched in 1956.
2. It was supported by UNICEF, WHO and the US Government, but after the first few years, it was almost entirely financed by the Iranian Government.
3. Already in 1957, the programme encountered a serious technical obstacle: insecticide resistance of the main vectors in the plains in the southwest. Soon after, it became clear that in the Zagros foothills, the combination of exophilic vectors and the human nomadic life style posed a challenge, which was at least as great as the problem of insecticide resistance. The programme therefore suspended attack operations in the south from 1961 to 1967, instead concentrating on trials of new insecticides and alternative interventions, including larval control and mass drug administration.
4. In 1967–1968, attack operations were re-started in the south using a variety of interventions tailored to the entomological and epidemiological characteristics of different areas. There was now rapid progress in the Zagros mountains and the southwest but the southeast emerged as the stubborn problem area.
5. Given the good results, it was attempted to decentralize the programme in the early 1970s, but in many areas, the general health services were not sufficiently developed to take over the responsibility. From 1977, the resources and activities of the malaria programme were expanded with good results.
6. However, elimination was not in sight, and it was decided to reorient the programme to control in 1980.

4.3 The second national malaria control programme (1980–2009)

Advancing despite adversity: 1980–1990

The 1980s was a difficult period. Following the Revolution in 1979, government agencies underwent profound changes. In 1980, Iraq invaded southwestern I.R. Iran; the ensuing war lasted eight years. The economy suffered several blows and budgetary constraints affected the programme (65). However, it was possible to maintain interventions sufficiently, even in combat zones, to avoid any significant upsurge. In Dezful *Shahrestan* in Khuzestan Province, bordering Iraq, an increase in malaria incidence was observed, not during, but after the war (1989–1995), as people returned to their homes (66).

By the mid-1980s, the Ministry of Health Malaria Division included only a medical officer, a sanitary engineer, two technical officers and three statisticians. In the provinces, malaria activities were managed by a technical officer assisted by a chief insect collector. The IRS rounds in the southeast were often delayed and coverage inadequate resulting in little or no effect. Although strategies had been re-set to control malaria, some inefficient “eradication practices” were maintained. Thus, in some areas in consolidation phase, poorly targeted active case detection with positivity rates below 1% led to overburdened laboratories (67).

However, new developments provided support for malaria control: the establishment of the National Health Network in 1983 (68) with emphasis on access in deprived areas and tested approaches to staffing (see Box 4.3.1) allowed the malaria programme to use PHC for case management and surveillance (8).

Box 4.3.1 *Behvarz*, the rural health system and the malaria programme

A national community health worker programme was initiated in 1979 based on experiences from pilot projects in several provinces. The Iranian community health worker, called *behvarz* (meaning “good skill”), is selected from her/his own community and works in the village health house, the most peripheral health facility in rural areas. *Behvarz* are full-time employees of the health system and recognized in national policies and plans.

Behvarz were originally trained to meet the basic health care needs in rural areas with a division of responsibilities between a female and a male *behvarz* in each health house. The pre-service training lasts for two years and takes place in a specialized district *behvarz* training centre. These centres are responsible for *behvarz* recruitment and identifying rural areas with a shortage of *behvarz*. Health houses refer patients to rural health centres with physicians and paramedics. The *behvarz* have come to play a key role in the malaria programme and are responsible for most case management and case detection. In the early years, the technical supervision of health houses was entrusted to malaria staff. By 1984, there was a substantial improvement in health service coverage nationwide, but it was still low in Sistan & Baluchestan, where the population per health house was 2 800–18 600 (median 9 600). In the malaria programme review in 2014, about 70% of *behvarz* answered the questions about malaria case management correctly (69). In areas without *behvarz*, malaria mobile teams were responsible for malaria case detection and management.

4. Development of malaria control and elimination

The situation from 1975 to 1990 has been analysed in a framework of three geographic zones. In the north, i.e. Caspian, Central plateau, northwest and northeast regions, with a total population around 22.4 million, the strategy of strong surveillance and response maintained a low annual parasite incidence of between 0.038 and 0.195 per 1000. An increase after 1979 in the Central plateau and the northeast was attributed to the influx of Afghan refugees. Of 4 076 cases investigated in 1990, 90% were imported from outside the country. In Zagros and the southwest, with a total population of around 14.7 million, IRS, larviciding, case management, expansion of the health infrastructure and socioeconomic improvements together resulted in a marked reduction in malaria cases. The annual parasite incidence declined to 0.09 per 1000 in 1990 with only 1 383 malaria cases reported. In 1990, the annual parasite incidence in Sistan & Baluchestan reached its highest recorded level of 25.5 per 1 000. This was partially explained by the very high ABER(65%) in 1990. However, there were less benign contributing factors: resistance of several anopheline species to propoxur was emerging after 12 years of use; more Afghan refugees were arriving, especially through Pakistan; and chloroquine resistance of *P. falciparum* had arrived. Integration within PHC was still far from complete. Even a pilot project in Bandar Abbas *Shahrestan* in Hormozgan Province suffered as a result of a lack of personnel, especially doctors (7).

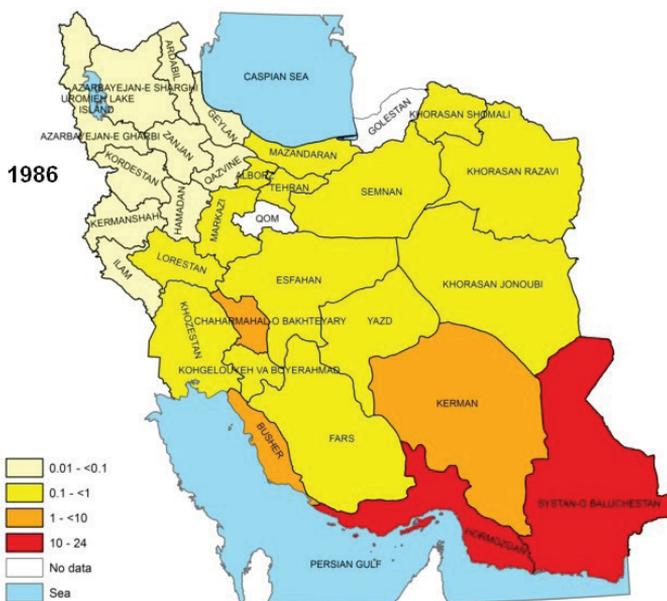


Fig. 4.3.1 Annual parasite incidence (per 1000 population) in the provinces in I.R. Iran, 1986

Fading role of nomadism

During 1970 to 1990, malaria almost disappeared in the Zagros foothills. Very likely, the decline of nomadic life styles in southwest I.R. Iran in the second half of the 20th century played a role. It has been estimated that the total population of nomadic people in the country went from 2–4 million in the 1960s to around 1.3 million in 2000. In fact, the period between 1950 and 1980 saw a partial dissolution of the ethnic, economic and social identity of tribal people caused by factors such as the encroachment of agriculture into grazing pastures, the development of animal husbandry by the farmers, the attractions of an urban life and political repression by the monarchy. While post-revolutionary governments had a far more positive attitude to the tribes, the economic and ecological dynamics continued to work strongly against a nomadic life style (70).

Malaria from blood transfusion and Plasmodium malariae

From 1963 to 1983, 344 cases of malaria transmitted by blood transfusion were reported in Iran: *P. malariae* accounted for 79% and *P. vivax* for 21%. During this time, the sources of human blood for transfusion were paid “professional donors” (71). The lack of any report of transfusion-transmitted malaria since 1983 indicates that donor selection based on interview may be sufficient to prevent transfusion-transmitted malaria (72). By the turn of the 21st century, *P. malariae*, which often persists in the blood stream of humans without causing symptoms, but is also very sensitive to antimalarial medicines, had become very rare in I.R. Iran, and this must also have contributed to the disappearance of transfusion-transmitted malaria.

Consolidating gains and making advances in the southeast: 1991–2009

Overview

As seen in Fig. 4.3.3, the number of reported malaria cases peaked at 98 160 in 1991. From then to 2009, all malaria cases were reduced by 94% – falciparum by 99% and vivax by 90%. Less than five deaths from malaria were reported annually from 1999 to 2008. However, surveillance did not cover all providers fully and deaths may have been missed (Table 4.3.1). The reduction in the number of cases occurred despite the increasing ABER in the early 1990s (Fig. 4.3.2) and can therefore be assumed to reflect a real improvement. By 1997 malaria was concentrated in the southeast more than ever before. Fig. 4.3.3 shows that the annual parasite incidence in 1996 and 2001 was highest in the provinces of the southeast. Yet, local transmission still accounted for 23% of cases north of Zagros (73).

Table 4.3.1 Malaria cases by species and deaths attributed to malaria in I.R. Iran, 2000–2009

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
<i>Falciparum</i> ^a	2 543	2 583	2 382	4 475	1 380	2 219	1 199	1 390	1 123	609
<i>Vivax</i>	17 173	17 145	13176	19 087	12 443	16 747	14 710	14 322	10 337	5 312
Total cases	19 716	19 303	15 558	23 562	13 823	18 966	15 909	15 588	11 275	5 921
Deaths	4	2	2	5	1	1	1	3	3	0

^a*Falciparum* includes mixed infections.

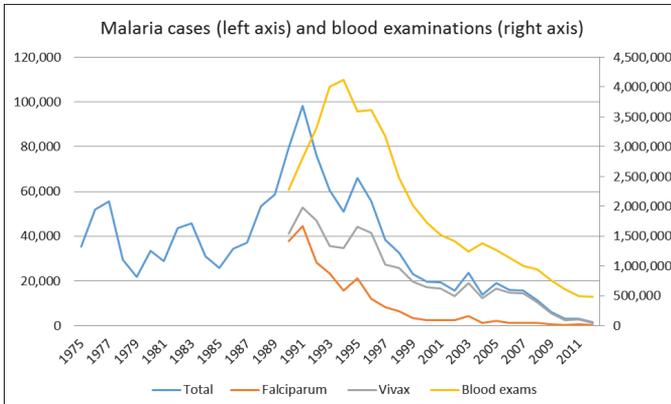


Fig. 4.3.2 Total malaria cases, 1975–2012 and malaria cases by species and blood examinations, 1990–2012, I.R. Iran (*Falciparum* includes mixed infections). Sources: (7) for 1975–1989; malaria surveillance data, CDC, Ministry of Health and Medical Education, I.R. Iran, for 1990–2012

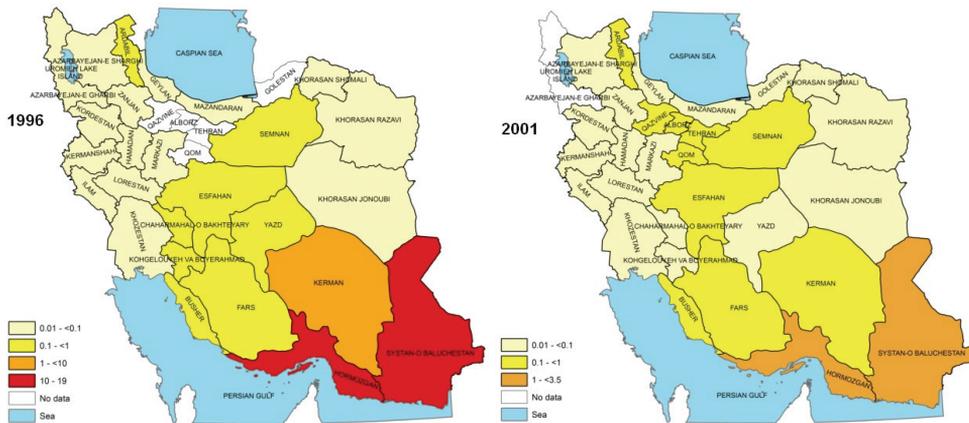


Fig. 4.3.3 Annual parasite incidence (per 1000 population) in provinces in I.R. Iran in 1996 and 2001

The health system

The period 1991–2009 saw sustained development of the national health system. UMSs, of which there is at least one in each province, were now responsible for the provincial health services, including all health centres and hospitals. This arrangement allows for a high degree of decentralization of decision-making. While the health houses have a key role in the provision of curative health services, the rural health centres play an important role in the malaria programme by managing the mobile teams and laboratories (Fig. 4.3.4).

However, in the southeast, the integration of the malaria programme within PHC took time to develop. Thus, a survey in 1994–1995 in endemic areas there found that the knowledge of residents about malaria was still poor. Strikingly, people with access to PHC services had less knowledge about malaria than those served by mobile malaria teams (74). In 2000, Sistan & Baluchestan still lagged significantly behind all other provinces as regards coverage by health houses (75). Over the following years, the health system did improve. Thus, by 2005–2007, there were 644 health staff including 99 in malaria control staff in Minab *shahrestan* with a population of about 300 000 in Hormozgan; the health facilities included 23 health centres and 119 rural health houses (76).

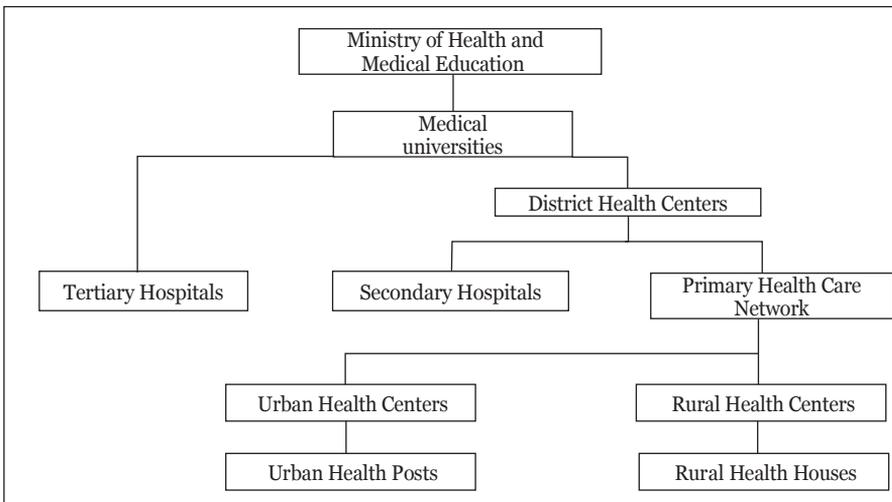


Fig. 4.3.4 Structure of the public sector health care delivery system In I.R. Iran (69)

***Plasmodium falciparum* resistance to chloroquine and antimalarial treatment policy**

Resistance of *P. falciparum* to chloroquine in I.R. Iran was detected for the first time in Iranshahr, Sistan & Baluchestan in 1983; it probably originated from Pakistan and spread rapidly over the southeast (77). From the early 1980s to 1990, the proportion of infections caused by *P. falciparum* in the southeast increased from about 35% to 50% (7). In Bandar Abbas (Hormozgan) and Kahnuj

(Kerman), the rate of chloroquine resistance in *P. falciparum* cases increased from 32.5% in 1986–1987 to 64.8% in 1994–1996 and 68–84% in 1997–2001 (8). In 2004, the national treatment policy for *P. falciparum* changed from chloroquine to chloroquine plus sulfadoxine-pyrimethamine (78). In 2009, the first-line treatment for *P. falciparum* malaria was changed to artesunate plus sulfadoxine-pyrimethamine. The treatment of *P. vivax* (where resistance still has not been detected) was maintained as chloroquine in three daily doses plus primaquine weekly for eight weeks.

Vector control

Mosquito nets are known in I.R. Iran but not widely used traditionally. In 1995



and 2005 in Baluchestan, trials of insecticide-treated versus untreated nets found no significant effect on malaria (79,80). However, in a cluster-randomized village-based trial in Bashagard (Hormozgan Province) in 2009–2010, malaria incidence was reduced by 96.6% in the area with Long-Lasting Insecticidal Nets (LLIN) versus 64.8% in villages with untreated nets.

There was also significant entomological impact (81). In 2004, 20 000 LLINs were introduced as programme staff had noted that in the southeast, during the hot summer months, many people sleep outside and are exposed to the bite of exophilic vectors. At that time, many villages still did not have electricity and/or inhabitants could not afford air-conditioning.

IRS was done with propoxur and pyrethroids until 2003; from 2003 to 2011 only with pyrethroids (deltamethrin and lambda-cyhalothrin). Fig. 4.3.5 shows the estimated number of people covered by IRS and LLINs. A comparison with Fig. 4.2.7 shows that the number of people under vector control had been reduced by an order of size since the 1970s; this testifies to the role of health services and social development in reducing malaria risk (receptivity). Clearly, the challenge for the programme at the central level to ensure quality of operations was much more manageable with limited operations. Larviciding with synthetic larvicides was carried out in the southeast and Fars from 2000 to 2011. From then on, the main product has been a formulation of *Bacillus thuringiensis* produced in I.R. Iran.

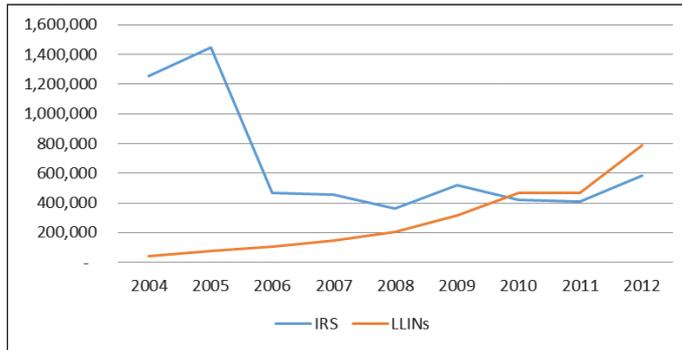


Fig. 4.3.5 Estimated number of people covered by IRS and LLIN based on data on implementation submitted by the MOHME to WHO, 2004–2012. The number of persons covered by LLINs in a year was estimated as the number of LLINs delivered that year and the previous two years multiplied by 2, and adjusted by an annual attrition factor of 0.1. The number of persons covered by IRS was estimated as the lowest of the numbers of houses sprayed in round 1 and round 2, multiplied by 4.7 – estimated persons per house.

Surveillance and impact

According to the national programme surveillance data, the ABER decreased in all regions of the country from 2002 to 2010. The total number of slides examined in the country went from 1.72 million in 2000 to 606 200 in 2009 (Fig. 4.3.2) (82).

Rapid diagnostic tests (RDTs) were introduced in 2009, with support from the GF. Several brands of rapid diagnostic tests were field-tested, and one was selected. Training on these devices was included in workshops on malaria case management and the first kits were distributed in April 2010. The criteria for use of the kits were initially narrow: remote areas (> 50 km from the nearest health facility); among migrants; lack of laboratory services; outbreaks; and strong clinical evidence of malaria with a negative blood smear. Soon after, the programme started training volunteers in remote villages and hamlets in the southeast on the use of RDTs and the referral of cases. This proved a major advance.

As shown in Fig. 4.3.8, the dominance of the southeast in terms of malaria cases was further consolidated from 2002 to 2009. Case numbers in other regions, especially north of Zagros declined steadily to very low levels.

From 1997 to 2012, Mazandaran Province in the Caspian region, with a population of around 3 million, had 13 indigenous and 94 introduced cases. 641 cases imported from abroad and 32 from other provinces in I.R. Iran. More than 46 75% of patients were of Afghan nationality. The last indigenous case was seen in

1997 (83). However, the province is still receptive (84).

In the Central plateau, hundreds of imported cases were recorded annually between 1990 to 2009, for example in Tehran and Isfahan, in Yazd with its employment opportunities in industry and construction (85), and in Qom, with its famous institutions of religious learning (86).

Following the dissolution of the Soviet Union, *P. vivax* malaria re-emerged in the now independent Republic of Azerbaijan, and in 1993 malaria spread to the Iranian side of the border. Some importation was ascribed to truck drivers travelling along the *Aras* valley to the Azerbaijan enclave of Nakhichevan. A small focus was found in Gilan Province; there was concern that malaria could spread southwards in the Caspian region, but the epidemic was contained, mainly by IRS and larviciding (Fig. 4.3.6) (73,87). In the following years, importation of malaria to the northwest declined, reflecting improvement across the border. To reduce long-term risk in Parsabad and Kaleybar counties, vector control is still maintained with anti-larval measures supported by intersectoral cooperation and community participation.

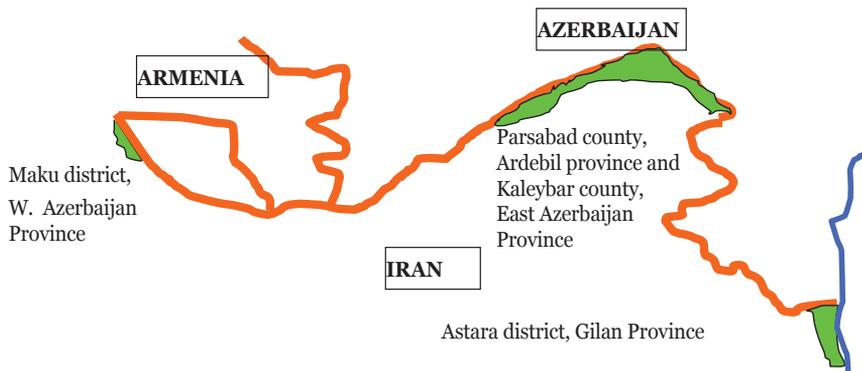


Fig. 4.3.6 Areas with malaria transmission in I.R. Iran during 1993–1998 related to the resurgence of the disease in the Republic of Azerbaijan in the 1990s (Courtesy of A. Beljaev)

In the northeast bordering Turkmenistan and Afghanistan, where malaria was out of control in the 1990s, cases were concentrated in border cities in Razavi Khorasan Province. From 2001 to 2008, 945 cases were detected there, declining from 494 in 2001 to 26 in 2007. Of these, 315 were locally transmitted, 49 were classified as relapses, 418 as imported from abroad, 158 from other provinces, and in five cases the origin was uncertain (88). Malaria control was re-established in Afghanistan during this period, and the number of reported malaria cases there decreased by more than 80% from 2002 to 2010 (89).

Southwest

In the southwest, there was an increase in case numbers in the 1990s (90) ascribed mainly to Afghan refugees and immigrants (66). High case loads were also observed in agricultural areas in Bushehr, where 185 local cases were detected in 2005 (against 43 in 2004 and 27 in 2006). Here, the main problem was importation from within I.R. Iran. There is still a high level of receptivity (risk of onward transmission) in Khuzestan (91).

Southeast

The malaria programme continued to face technical and operational problems: chloroquine resistance, multiple malaria vectors with different bionomics and insecticide resistance, long distances nomadic life style, poverty, low levels of education, understaffed health services, and cross border population movement.

In 2003, there was an upsurge with over 17 000 local cases reported from the southeast against 10 000 the previous year. It was ascribed to heavy rains and inadequate vector control. From 2004, vector control was scaled up. In 2007, following cyclone Gonu, another epidemic was anticipated, but no significant increase was seen (Fig. 4.3.7); this has been ascribed to better control. The change in vector control policy in 2006 with reduced IRS coverage and scale up of coverage of LLINs (Fig. 4.3.5) did not lead to increased incidence (Fig 4.3.7). A study on 60 malaria outbreaks in Sistan & Baluchestan during 2005–2009 found that most outbreaks were small (68% had less than 100 cases) and short (52% lasted less than one month). (92).

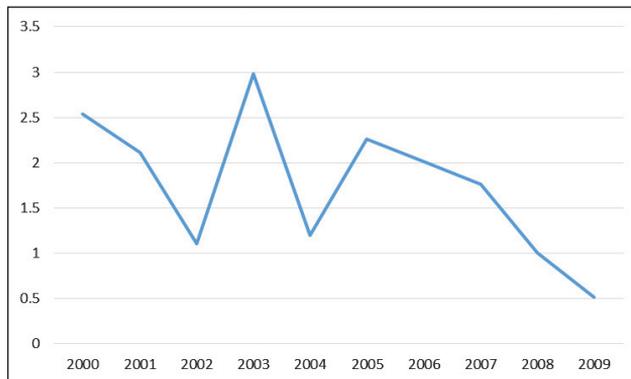


Fig. 4.3.7 Annual parasite incidence based on local cases only per 1 000 population in the three south-east provinces (Hormozgan, Kerman and Sistan & Baluchestan), 2002–2010

Importation and nationality of malaria cases¹

As shown in Fig. 4.3.8, the reduction in the malaria burden after the year 2000

1- In this report, if nothing else is stated, a local case is a case contracted in Iran, even if it may have been imported from one province or *shahrestan* to another. An imported case is a case imported from another country.

was due not only to transmission reduction in I.R. Iran, but also to reduced importation. In 2002, 52% of cases were of Afghan or Pakistani nationality, and by 2007 this had fallen to only 14%. In 2009, the proportion increased to 27% but the proportional increase was due to a reduction of local cases. The decrease in the number of cases of Afghan nationality could have resulted both from repatriation of refugees and reduction in malaria risk in Afghanistan (although many Afghans may have contracted malaria in Pakistan).

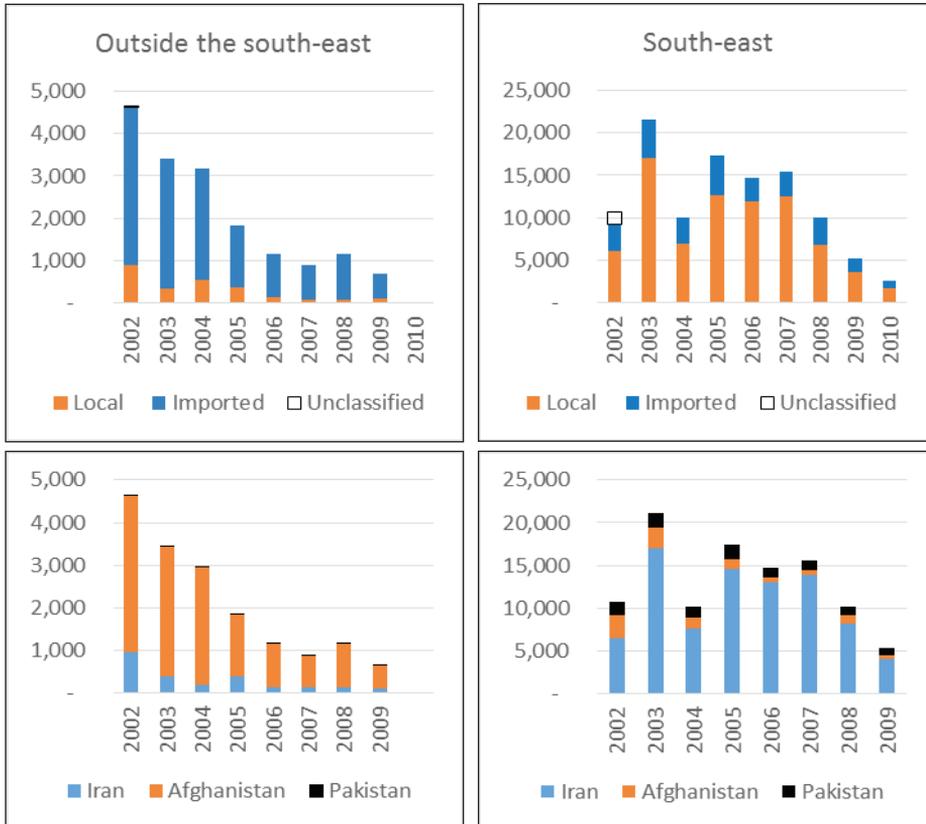


Fig. 4.3.8 Local and imported cases and nationality of malaria cases, I.R. Iran, 2002–2010 in the regions outside the southeast and within the southeast (provinces of Hormozgan, Kerman and Sistan & Baluchestan)

Between 2002 and 2007, there was a decrease in malaria in urban areas, especially in Hormozgan. This has been attributed to the deportation of illegal Afghan immigrants combined with improved water and sanitation and health services in the affected urban areas (93).

Reorientation to elimination

By 2004–2005, with about 12 000 local cases per year nationwide and a downward trend in all areas, it was time to consider elimination again. A WHO consultant assessed the situation and noted favourable epidemiological and technical factors (seasonal malaria transmission, amenability to control of different malaria vectors including susceptibility to pyrethroids, biolarvicides applied with priority to urban areas and effective antimalaria drugs), as well as favourable socioeconomic factors (government support to social and economic development in affected areas, financial support for the malaria programme from central and local governments, limited use of pesticides in agriculture and availability of electricity in most villages). But there were also problems to be addressed, including: shortages of staff such as physicians, technicians, *behvarz* (almost 50% of posts were vacant) and mobile teams; insufficient cooperation between public health and academic entomologists; limited use of mosquito nets; and lack of engagement of private practitioners in malaria treatment (94). The restraint of this analysis contrasts with the over-confident enthusiasm of the assessment by WHO and USAID in 1963, reflecting the accumulated experience in the intervening decades.

The first GF grant, received by I.R. Iran in 2008 targeted 20 *shahrestan*, covering 90% of the population at risk. The support was used to strengthen four thematic areas: (i) early case detection and prompt and effective treatment, including provision of RDTs; (ii) integrated vector control, including LLINs and training the community in their use, IRS and larviciding; (iii) forecasting, prevention, early detection and prompt control of malaria epidemics, including provision of thermal fogging machines; and (iv) health system strengthening to coordinate and implement malaria control interventions by strengthening capacity-building and infrastructure development. Further details on the role of the GF and other stakeholders are provided in Section 4.4.

CONCLUSIONS

1. The second malaria control programme succeeded the eradication programme in 1980 at a time when the international discourse on health was not favourable to any kind of malaria programme.
2. The human resources were drastically cut, mainly because of economic constraints.
3. Yet, the Iranian programme survived and contributed to the strengthening of PHC services in rural areas.
4. Thanks to these approaches, changing social determinants, intense surveillance and gradually improved vector control, the malaria burden was already greatly reduced by the year 2000. Malaria had then ceased to be a major health problem in the country, except in the three southeastern provinces.
5. By 2008–2010, the burden had been further reduced; this, together with sustained economic and social development in the southeast and strong political commitment made it rational – actually imperative – to reorient to malaria elimination.

4.4 The national malaria elimination programme – from 2010

First national elimination plan and its high-level endorsement

A national malaria elimination programme was established in 2010 with the following main objectives (93).

- To eliminate local falciparum transmission in the entire country by 2015.
- To achieve a malaria-free nation by 2025.

The strategy included interventions and norms such as:

- Diagnosis of malaria cases within 24 hours of onset of clinical symptoms and start of malaria treatment within 24 hours of diagnosis;
- National antimalarial drug policy recommendations regularly updated and available to all health personnel, and personnel of health facilities trained in management of uncomplicated and severe malaria;
- Use of LLINs by households living in exposed areas, increased protection of populations at risk by IRS with coverage not less than 80%, and increased protection of populations at risk by larval control;
- Identification of epidemic foci at most one week after the start of any outbreak of malaria and outbreak control within two weeks of detection;
- Non-interrupted supply of antimalarial consumables and equipment;
- Investigation and classification of all detected malaria cases and foci;
- Computerized reporting system covering all reporting sites.

In 2010, the Council of Ministers endorsed the Long-term Strategic Plan for Malaria Elimination (2010–2025) which was developed in line with the National Plan of Development (Iran's 2025 Horizon). Executive decisions on the national malaria elimination programme at the national level have since been made in the Supreme Council of Health and Food Security led by the vice-president of I.R. Iran.

Milestones in the development of the programme, 2010–2015

The strategic plan for malaria elimination included time-bound objectives, targets and strategies, but the programme also developed a culture of innovation and flexibility. Thus, over the following years, several qualitative changes in programme policy were adopted and implemented. Among the most important are:

• 2011

- Establishment of emergency sites with stocks of all major malaria commodities, and rapid response teams (see below under surveillance and case management)
- Initiation of on-site data verification

• **2012**

- Compulsory case notification covering all sectors
- External laboratory accreditation system initiated

• **2013**

- Malaria programme review in collaboration with WHO

• **2015**

- Second National Strategic Plan for Malaria Elimination by 2025 and operational plan 2015–2020
- Establishment of border posts for malaria surveillance

Epidemiological baseline

In 2009, approximately 3.8 million people were at risk of malaria transmission in 29 *shahrestan*. The number of falciparum cases was 609, 13% of which were local. Among 5 312 *vivax* cases (Table 4.3.1.) about 80% were local. Following the assessment in 2004, the national surveillance system had started recording and mapping the malaria distribution in foci according to WHO guidelines.

Transmission of falciparum was recorded in 132 foci in 12 *shahrestan*, and transmission of *vivax* in 3 342 foci in 29 *shahrestan*. However, the number of foci was still too large to serve as a basis for planning at the national level. Targeting was based on classification of *shahrestan*. Fig. 4.4.1 shows maps of this stratification in 2008 with an update in 2012. The two upper maps show stratification by *shahrestan*, with the following criteria:

- Intensified control: annual parasite incidence $\geq 5/1000$
- Pre-elimination: annual parasite incidence $< 5/1000$ to $\geq 1/1000$
- Elimination: annual parasite incidence $< 1/1000$.

By 2012, it had become more important to stratify the areas with malaria risk, but without malaria transmission to determine which ones would need continued vector control and intense surveillance. This is reflected in the bottom map in Fig. 4.4.1, where:

- Zone B: *shahrestan* with malaria transmission
- Zone A: *shahrestan* with imported cases in 2012 and risk of reintroduction. It is divided in:
 - Zone A-HR (high risk of reintroduction due to high receptivity)
 - Zone A-LR (low risk areas)
- Free Zone: no indigenous case of malaria.

In 2012, Zone B (ongoing transmission) included 17 *shahrestan* in the southeast, 53

one in Bushehr with gas-fields attracting foreign workers, and one in Fars, with citrus plantations.

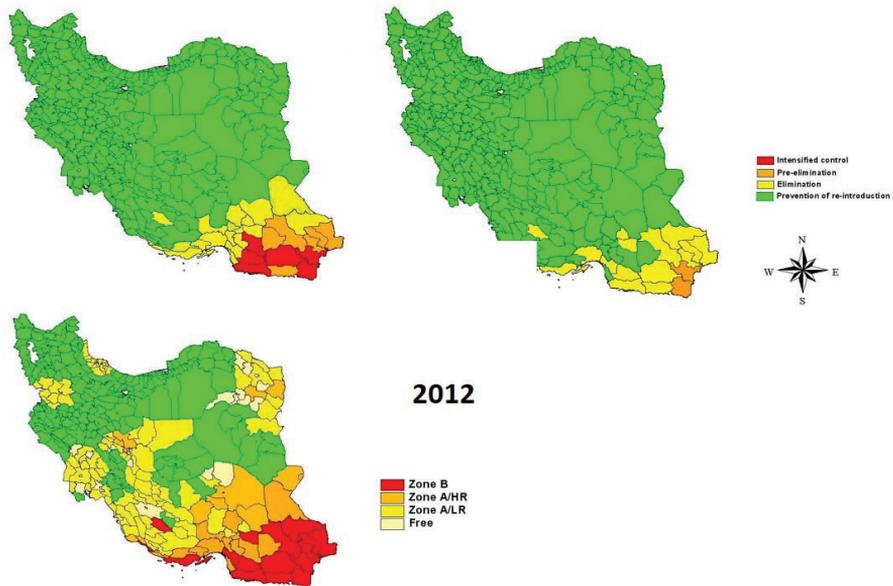


Fig. 4.4.1 Malaria stratification based on 2008 and 2012 data. The zone codes are explained in the text

Surveillance and case management

The ABER continued its steady decline in all regions. Only Sistan & Baluchestan maintained a relatively high ABER of 2% in 2014–2015, reaching 8–10% in some of the most affected *shahrestan* like Chabahar and Konarak (Fig. 4.4.2). While the ABER was low in Hormozgan and Kerman, case finding activities in the north were excessive; for example in 13 provinces over three years, 62 000 slides were examined in active case detection without a single case being found.

4. Development of malaria control and elimination

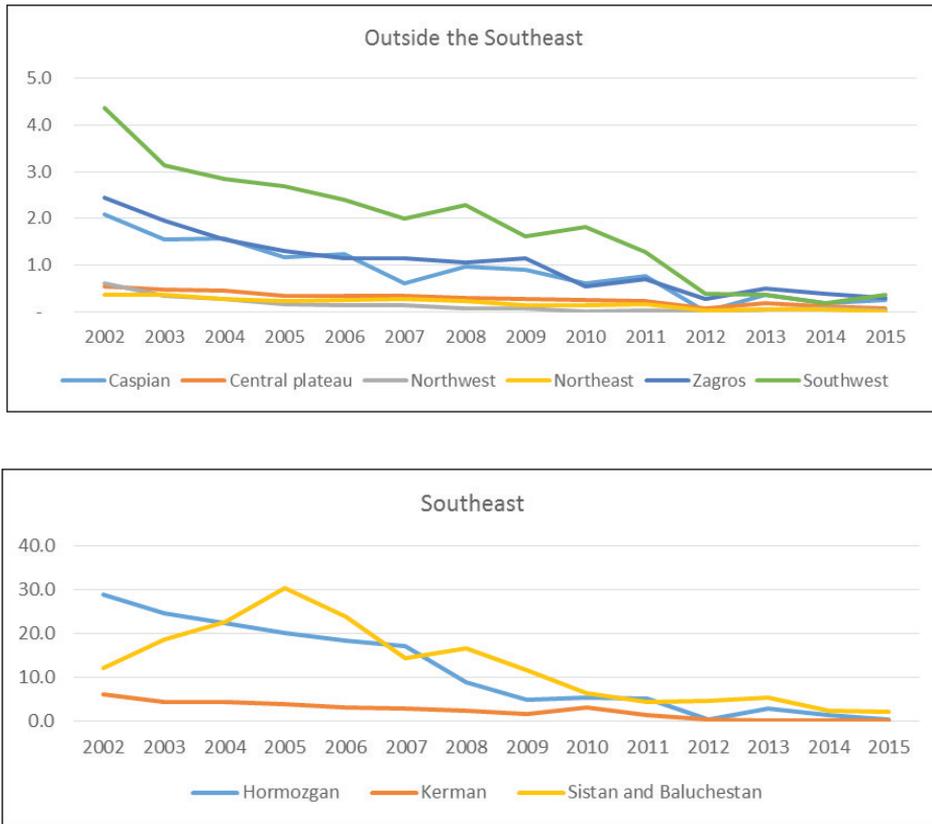


Fig. 4.4.2 ABER (blood slides examined per 100 population) in different regions of I.R. Iran excluding the southeast, and in provinces in the southeast, 2009–2015

The total number of slides examined in the country decreased from 527 209



Fig. 4.4.3 Microscopy training course in Hormozgan, 2014

in 2010 to 155 070 in 2015. The programme review in 2013 based on findings of the external accreditation system indicated some microscopy quality problems. These have been addressed by the establishment of quality assurance system in malaria laboratories and repeated training courses (Fig. 4.4.3).

With elimination approaching, it was important to cross-check the sensitivity of the surveillance system. Several studies in the southeast used molecular and serological methods to investigate the presence or absence of hidden, sub-microscopic infections. The number of cases detected was nil or very low (95–97). Since 2010, all confirmed cases are investigated, and from 2012 all foci are classified based on surveillance and other data. Since 2015, all confirmed cases are reported directly to a central register at the MOHME, where the case investigations are checked and verified. Table 4.4.1 compares active case detection and passive case detection for 2013–2015. In the low transmission regions, the number of slides in passive case detection was higher than in active case detection, while in the southwest, and even more in the southeast, active case detection accounted for more. This is appropriate. In all regions, except the northeast (with small numbers of cases) and the southwest, the positivity rate was higher in passive case detection than in active case detection. This is expected, as those examined in passive case detection are symptomatic whereas some cases covered by active case detection are asymptomatic. In fact, in all regions except the southwest, more than 50% of cases are detected in passive case detection.

Table 4.4.1 Productivity and efficiency of active and passive case detection, data summed over 2013–2015

Region	Active case detection (ACD)			Passive case detection			% slides in ACD	% cases in ACD
	No. slides examined	No. confirmed cases	Positivity rate (%)	No. slides examined	No. confirmed cases	Positivity rate (%)		
Caspian	52 528	2	0.004	27 241	4	0.015	65.9	33.3
Central plateau	59 471	38	0.064	109 441	259	0.237	35.2	12.8
Northwest	5 717	0	0.000	8 414	1	0.012	40.5	0.0
Northeast	4 449	13	0.292	22 574	38	0.168	16.5	25.5
Zagros	51 976	28	0.054	45 191	138	0.305	53.5	16.9
Southwest	116 403	148	0.127	44 463	27	0.061	72.4	84.6
Southeast	558 156	1115	0.200	120 041	1566	1.305	82.3	41.6
Total	848 700	1344	0.158	377 365	2033	0.539	69.2	39.8

By 2011–2012, RDTs had become a routine tool used especially in smaller health facilities and by volunteers (Fig. 4.4.4). These devices have been a lynchpin in the recruitment of community health volunteers, mainly young women. Because of low population density, many people in the southeast, especially in Baluchestan, were not reached by the *behvarz*. Rounds of active case detection were costly and reached communities once a week, at best. In recent years, the increased secondary school attendance by girls in Sistan & Baluchestan has created a potential health work force. As a result, since 2009, young women have been recruited as community health volunteers, especially in small remote villages. By 2015, more

4. Development of malaria control and elimination



Fig. 4.4.4 A community health volunteer using a RDT kit

than 3 700 community health volunteers had been trained in health-related skills focusing on malaria by Zahedan University of Medical Science. Each volunteer is assigned to up to 50 families. By 2016, there were more than 500 peripheral case detection posts staffed by volunteers in the southeast provinces, Bushehr and Fars. Especially since 2013, the number of posts near the Pakistani border was increased.



Fig. 4.4.5 Emergency site with stocks of malaria supplies and educational material

Another important innovation in I.R. Iran has been the introduction of rapid response teams, which are responsible for focus investigation and rapid response including case detection and vector control. Since 2011, over 100 such teams have been set up. Each team includes an entomologist, a communicable disease control expert, a coordinator, and IRS and thermal fogging workers. The teams set up emergency sites with maintenance stocks of antimalarial equipment and supplies (Fig. 4.4.5).

Vector control

The first indications of pyrethroid resistance in *An. stephensi* were observed in 2011 in Chabahar (98). Therefore, from 2012, to prevent and control insecticide resistance, a rotation strategy has been followed using insecticides from different classes (bendiocarb and deltamethrin).

The implementation of vector control has been recorded by focus category according to data collected in *shahrestan* in Zone B by the programme review in 2013. A total of 4.17 million people lived in 12 182 foci (more than 80% cleared, i.e. with no actual transmission or cases). The IRS population coverage was highest (16–17%) – but less than expected – in new active and residual non-active foci. The coverage of LLIN was much higher, reaching 56% in new active foci (69).

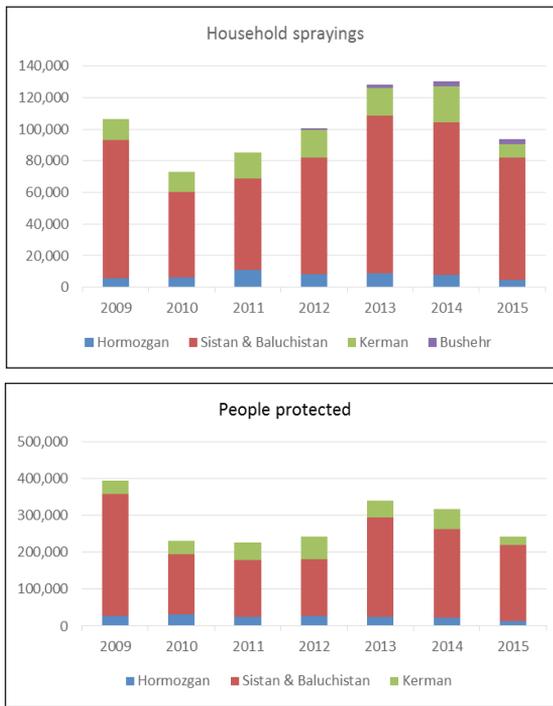


Fig. 4.4.6 Total number of household sprayings (sum of number of houses sprayed in 1–2 rounds each year), and number of people protected by IRS in at least one round each year (the number of people protected in the round that reached most in a year) in regions in I.R. Iran, 2009–2015.

As shown in Fig. 4.4.6, most IRS between 2009 and 2015 was carried out in Sistan & Baluchestan. From 2010 to 2013, the total number of people protected doubled; since then it has decreased slightly.

The distribution of LLIN from 2009 to 2016 is presented in Fig. 4.4.7. It was essential also to educate the target populations on their proper use. In Sarbaz *Shahrestan*, Sistan & Baluchestan in 2009, only 8.8% of participants reported using bed nets regularly. Despite knowing the association between mosquitoes and malaria, 95% of Afghan refugees and 75% of Iranian Baluchi residents did not use self-protection measures in Iranshahr in 2010 (99).

In the first malaria indicator survey in 2010, 20% of households owned at least one mosquito net, but their use was only 5–6% among children under five years and pregnant women (37).

From 2009 to 2013, nearly 120 000 people in high-risk areas were educated on protection against mosquitoes and care-seeking. Health

4. Development of malaria control and elimination

education was provided by community health volunteers, religious leaders, activists and others through a variety of means, including flip charts, posters and the media (Fig. 4.4.8). A second survey after the distribution of thousands of LLINs in 2013 found that 56.5% of the population in the intervention areas (which were now wider) slept under the nets (100). As seen in Fig. 4.4.7, the number LLINs distributed went down after 2012. As explained in Box 4.4.1, this was due to the decreased malaria burden and a shift in strategy.

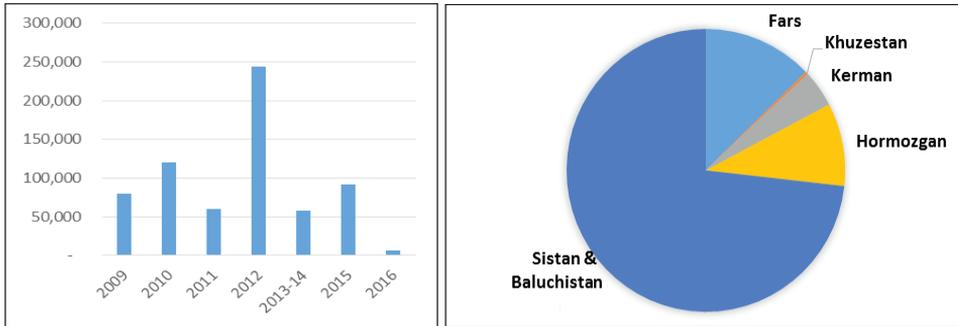


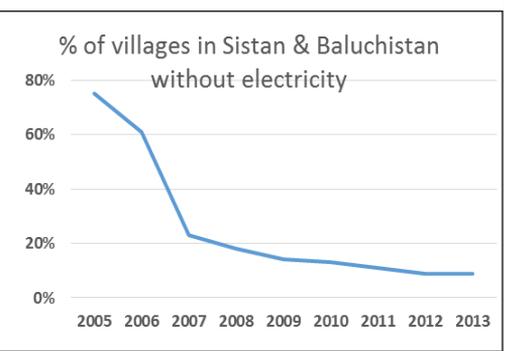
Fig. 4.4.7 LLINs distributed 2009–2016 and distribution by province in 2015–2016



Fig. 4.4.8 Health education on self-protection by a community health volunteer

Box 4.4.1 Electricity and malaria

Inland areas of southeastern I.R. Iran are very hot in summer with average temperatures above 35°C from June to August. People therefore sleep outside and are exposed to mosquito bites. This has justified the introduction of LLINs for outdoor use, in addition to IRS. Over the past 15 years, electricity has been installed in the thinly populated rural areas. This process was accelerated by the advocacy of MOHME and intersectoral collaboration, as can be seen from the graph, which presents the increasing electricity coverage in over 4800 villages in



Sistan & Baluchistan. The Supreme Council of Health and Food Security approved full coverage of electricity in malaria-affected areas and made it a top government priority. The electricity supply allows people to sleep inside with air conditioning and makes LLINs almost unnecessary; this intervention, which was so important only 10 years ago, is now promoted only in specific settings.



Air conditioning in a village in Ghale-Ganj *Shahrestan*, Kerman Province, 2013

Larval source management and intersectoral collaboration

Chabahar is a city in Sistan & Baluchestan, a crossroad close to the Pakistan border. *An. stephensi* there breeds in water storage containers, and larval source management is an option in such settings. In a field research project supported by The Global Environmental Facility (GEF), UNDP and WHO in Chabahar (Fig.4.4.9), it was found that covering container breeding sites with concrete covers with hinged lids was the most effective and cost-effective method; larviciding with Bti was second best, while covering breeding sites with mats was useless and unpopular (101).



Fig. 4.4.9 Water container with concrete cover with hinged lid, Chabahar, 2013

Initially, the fitting of these covers led to increased breeding of anophelines. This was demonstrated to the area inhabitants, and they were educated about the proper use of the lids. After that, they kept the lids closed and mosquito breeding plummeted. A new indicator, “proportion of lids found to be closed on direct observation by health staff”, was introduced to the project.

Thanks to the high-level political support, intersectoral malaria elimination work groups have been set up with official mechanisms in affected provinces and *shahrestan*; however, the level of activity has been variable. Two examples of intersectoral action for vector control are illustrated in Fig. 4.4.10, but the most important result of intersectoral collaboration may be the accelerated installation of electricity in the southeast (Box 4.4.1)



Fig. 4.4.10 Examples of intersectoral action. Left: vector breeding place created by broken water pipe in June 2013 in Minab, Hormozgan; the provincial water and wastewater company repaired the pipes. Right: Bulldozing to fill a breeding site (Photographs: UNDP)

Malaria epidemiology and impact 2009–2015

Table 4.4.2 and Fig. 4.4.11 provide an overview of the epidemiological evolution of malaria from 2009 to 2016. There has been a steady decline in incidence, more for local cases than for all cases. In the southeast, the number of imported cases has been almost constant since 2012. However, some transmission was seen outside the southeast as late as 2015. The number of reported deaths has been 1–2 per year in the period 2009–2015, which is high given the low incidence of falciparum malaria.

Table 4.4.2 Number of malaria cases and deaths in I.R. Iran by importation status and species, 2009–2015

Malaria cases	2009	2010	2011	2012	2013	2014	2015	2016	% reduction 2010 to 2016
<i>All cases</i>									
<i>Falciparum</i> ^a	609	427	562	198	300	119	88	86	80
<i>Vivax</i>	5 312	2 567	2 667	1 040	1 080	1 140	531	618	76
Total	5 921	2 994	3 229	1 238	1 380	1 259	619	705 ^c	76
<i>Local cases</i> ^b									
<i>Falciparum</i> ^a	NA ^d	192	199	75	94	24	22	10	95
<i>Vivax</i>	NA	1 460	1 503	643	425	346	163	82	94
Total	3 606	1 652	1 702	718	519	370	185	92	94
<i>All deaths</i>	1	2	2	1	2	1	1	0	

^a*Falciparum* includes mixed infections.

^bLocal includes all cases transmitted in I.R. Iran.

^cIncludes one case of *Plasmodium malariae*.

^dNA: applicable.

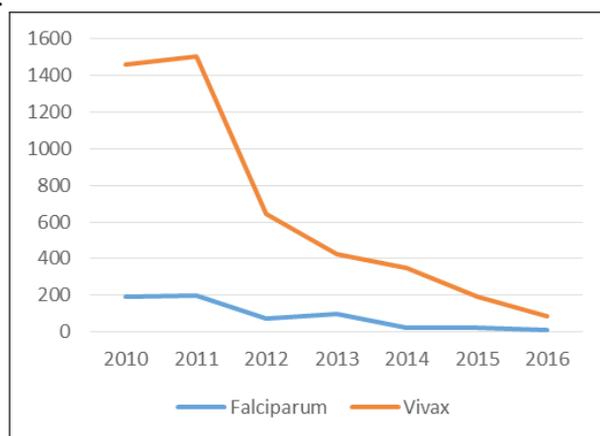


Fig. 4.4.11 Locally transmitted malaria cases in I.R. Iran by species, 2010–2016

concentrated in the border areas of Sistan & Baluchestan with Pakistan. Despite persistent importation, the incidence of local cases steadily fell through the period (Table 4.4.2 and Fig 4.4.13). It has been possible to scale down vector control since 2013 (Figs 4.4.6. and 4.4.7), without losing momentum in reduction of local cases, a good example of effective use of the resources. The improvement in the southeast since 2013 is ascribed by programme staff to a large extent to the establishment of passive case detection posts in border areas. On the other hand, it is of concern that importation to Bushehr and Fars Provinces in 2015 and 2016 could ignite transmission, with more imported and local cases than in 2013 and 2014 (Fig. 4.4.13).

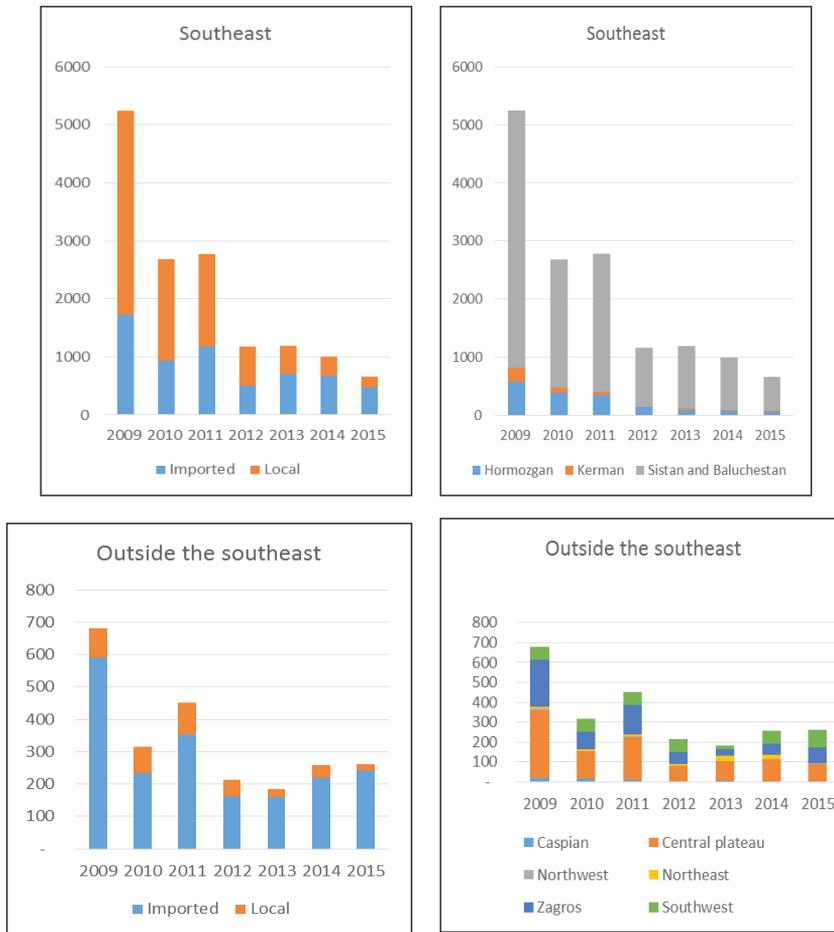


Fig. 4.4.13 Malaria cases in I.R. Iran 2009–2015 in the southeast (by local/imported and province) and all other regions combined (by local/imported and region)

4. Development of malaria control and elimination

At the end of 2013, there were 404 active foci in the country, down from 3 342 in 2009. All were in Hormozgan and Sistan & Baluchestan. In 2015, there were 262 active foci, including four in Bushehr and five in Fars; in 2016, there were 133 active foci, including seven in Bushehr and five in Fars (Figs 4.4.14 and 4.4.15). Thus, the total number of foci has been declining steadily since 2009, but transmission has re-emerged in Fars and Bushehr since 2014. However, no indigenous cases of *P. vivax* or *P. falciparum* have been reported from Bushehr province since 2016. Some of the underlying factors are presented through case stories in Box 4.4.2.

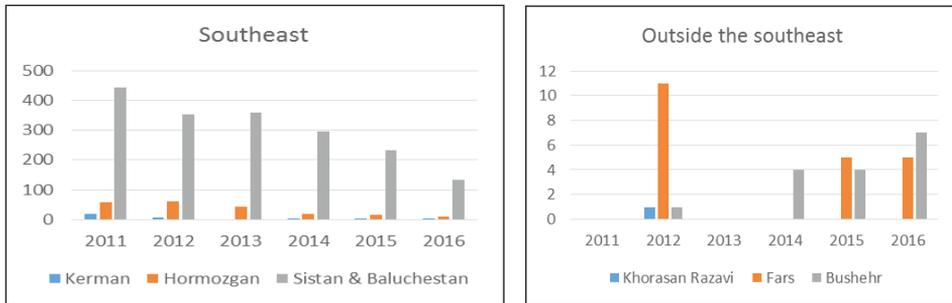


Fig. 4.4.14 Active foci in the southeast and outside the southeast, by province, 2011–2016

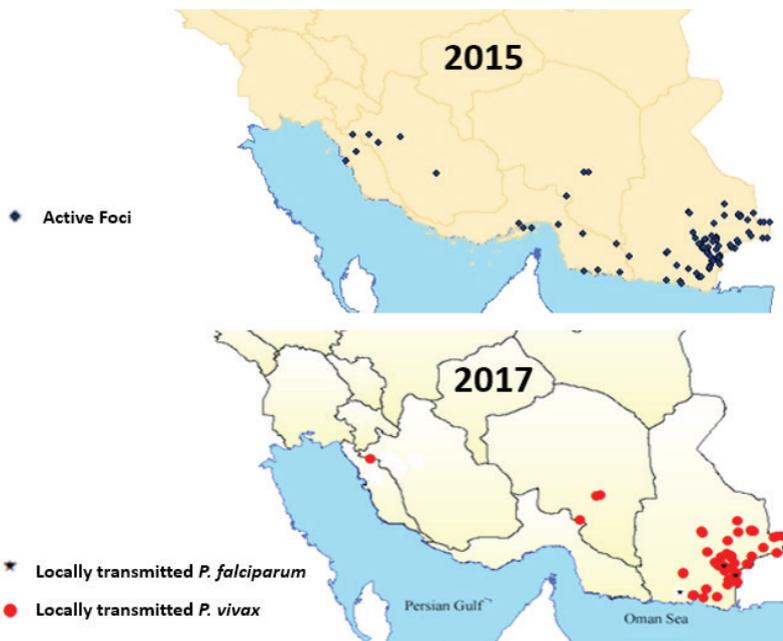


Fig. 4.4.15 Distribution of active foci with locally transmitted cases of *P. falciparum* and/or *P. vivax* in I.R. Iran in 2015 and 2017

Box 4.4.2 Two malaria outbreaks in 2015

***Plasmodium vivax* in Kazerun**

In August–September 2015, an outbreak occurred in Kazerun *Shahrestan* in the northwest of Fars. In the past 40 years, there had been no reports of malaria transmission in the area, but because of the development of citrus orchards in recent years, illegal immigration from Afghanistan had increased. Initially, nine local and one imported *vivax* cases were detected through passive case detection in three foci. Additional imported cases were found by active case detection in the same and neighbouring villages over the following six weeks. The outbreak was recognized one month after the arrival of the presumed index case from Afghanistan. It was controlled through extensive case detection, IRS, LLINs and health education. Colder weather from October helped curb the transmission.



Unregistered Afghan job-seekers, Chabahar, 2013

***P. falciparum* and *P. vivax* in Konarak**

Konarak *Shahrestan* in Baluchestan faces the Gulf of Oman. Transmission has persisted in foci for years, but agricultural development has led to increased immigration. In the outbreak from October 2015 to March 2016, 18 local and 33 imported cases were reported in an area with a radius of 5–7 km. Many were workers at new watermelon or banana plantations, who had slept outside or in open sheds. They were mostly itinerant workers, of Afghan or Pakistani nationality, who had arrived recently from Pakistan (by sea), indicating that importation had started the transmission. The same measures as in Kazerun were applied. Landowners were trained on malaria control. LLINs were distributed among migrant workers and the farms were mapped (Malaria Elimination Department).

Based on these and similar experiences, it was concluded that there is an urgent need to intensify case detection among foreigners seeking work in plantations in the south and southwest and in Fars. This will require stronger collaboration with employers and other sectors.

The GF Support and the Iran Malaria Elimination Partnership

Malaria control support from The GF to I.R. Iran was built gradually from 2008 onwards targeting specific provinces until a consolidated project came into place from 2011 to 2017. UNDP was the Principal Recipient of all the GF grants.

The first grant targeted the reduction of local malaria cases in the three southeastern provinces. In 2011, a second grant aiming at elimination of falciparum malaria in priority areas was agreed and rolled out in eight more provinces (Fars, Isfahan, Gilan, Khuzestan, Bushehr, Qom, Kurdistan and Khorasan Razavi).

Eventually, a consolidated project, the Malaria SSF Project (2011–2017) also known as the “Intensified Malaria Control in High Burden Provinces towards *Falciparum* Elimination” was developed. This approach ensured more efficient and effective supply chain management. To further strengthen control and the move towards elimination, an Iran Malaria Elimination Partnership has been in place since 2008. It includes the CDC-MOHME, UMSs, WHO, and the UNDP. With CDC as the technical lead, coordinating mechanism has provided oversight and served as a platform for continuous dialogue between stakeholders. The financial support from the GF and the performance frameworks, with baselines and clear, agreed targets, have focused efforts where they were most needed and ensured that the results were monitored. The partnership supported the introduction of new tools such as RDTs, LLINs, standard equipment for insecticide application, and strengthened health service infrastructure. More importantly, the capacity of human resources has been strengthened and community involvement facilitated. Some of the initiatives of the project broke new ground for the Iranian programme. These include the malaria programme review, accreditation and systematic quality assurance of malaria laboratories, case notification system, and the creation of the national malaria case and foci database.

Keeping the Iran Malaria Elimination Partnership functional after ending the GF project is on the agenda of decision-makers. Both the UN Development Assistance Framework 2017–2021 and the UNDP country programme 2017–2021 provide for continuation of the UN/UNDP support.

The achievements of the Malaria Elimination Partnership with support of the GF grants (2008–2016) are summarized in Box 4.3.2.

Box 4.3.2 Achievements for which to the support of the GF and the Iran Malaria Elimination Partnership was instrumental

When the support from GF started in 2008, there were over 11 000 malaria cases in I.R. Iran. When it came to an end, in 2016, there were 705 cases, among which only 72 were local.

Provision of goods and development of physical infrastructure

- Procurement and distribution of: about 1 million RDT kits, about 800 000 LLINs, larviciding agents including temephos, and about 2 000 standard spray pumps;
- Equipping 30 dedicated malaria laboratories and provision of standard equipment and supplies to renovate about 500 malaria laboratories in 11 target provinces;
- Establishment of 19 emergency sites and training of 86 rapid response teams to contain malaria epidemics, and establishment of 25 mobile passive posts mostly at border areas to prevent re-introduction of malaria transmission.

Partnership

- Partnership of UNDP, MOHME/CDC and WHO with the Global Fund has ensured that some 1.9 million at-risk people in the target areas of the country, which are mostly remote and underdeveloped, have constant access to prompt malaria diagnosis services, and benefit from preventive measures such as treated nets and IRS.

Development of protocols and plans

- Approved national malaria strategic plans in 2009 and 2014 with UNDP and WHO technical support, performance of a malaria programme review in 2014 involving WHO, and development of a protocol for routine monitoring and evaluation of vector control and one for insecticide resistance management in 2015.

Adoption of new approaches and systems

- Establishment of national/provincial core groups to undertake outreach training and supportive supervision for malaria laboratories and accreditation
- Adoption of results-based management and improving malaria reporting systems with new processes and dedicated staff as well as the introduction of 41 indicators based on roll back malaria and on-site data verification;
- Adoption of foci classification for planning and implementation of interventions allowing better targeting with gains in efficiency;
- Monitoring of cross-border population movements using GIS mapping;
- Establishment of a case notification system with reporting of new malaria cases within 24 hours of detection, and establishment of a malaria information system with its epidemiological database;
- Introduction of intensified malaria case detection among high risk populations arriving from neighbouring countries.

Second National Strategic Plan for Elimination (2015–2020) (102)

Based on the evolution of the malaria situation up to 2014, the following revised objectives were set in the second elimination plan adopted in early 2015.

- Elimination of *P. falciparum* by 2018 or before (zero local cases by 2018);

4. Development of malaria control and elimination

- Reduction in the annual number of new local *P. vivax* cases to less than 10 by 2020 or before;
- Elimination of *P. vivax* by 2022 or before (zero new local cases);
- Zero annual malaria attributable deaths from imported or local cases by 2015.

The following principles define the strategy:

1. The surveillance system detects and treats malaria cases rapidly and effectively, so that the risk of them infecting any vectors is minimized. Two methods are used for detection: RDTs sensitive to *P. falciparum* and *P. vivax*, and microscopy of stained blood slides.
2. Foci of transmission and potential transmission are identified and controlled. Each focus is managed according to its class and other criteria, with an appropriate combination of case detection and vector control measures to interrupt transmission as rapidly as possible, or prevent transmission in case of a potential focus.
3. As the achievement of malaria-free status approaches, the surveillance system is gradually adapted in such a way that most of its functions can be handled by the general health services based on an integrated approach.

The plan is based on precise criteria for application of interventions and standards for timeliness and coverage rates. These norms concern vector control and active and passive case detection according to focus type, and intensified case detection, targeting high-risk groups arriving in the three southeastern provinces from endemic areas in neighbouring countries. The monitoring and evaluation component emphasizes malaria surveillance, where the main indicators are numbers of cases of different types and numbers and distribution of foci of different types. The monitoring of vector control is based on consolidation of data from field operations, and for each intervention, there is an indicator to measure the proportion of foci covered according to the norms for timeliness and coverage.

Budget and financing

The total budget of the plan for five years is US\$ 37 million. Of this, 36% is for supplies and equipment and 30.5% is for health system capacity development. Most of the expenses for malaria elimination are, however, hidden in the general health service expenditures, which includes all costs for personnel in general health services, most of the salaries for malaria staff, and maintenance and running costs of health facilities including malaria laboratories. The second GF grant from 2011 to 2017, at about US\$ 4 million per year¹. If elimination is achieved, funding from national resources for surveillance and preparedness will still be required to prevent reintroduction of malaria for many years into the future.

Human resources

At the central level, the programme has a core staff responsible for planning, policies, management, surveillance, monitoring and evaluation. Many more malaria staff work in the most affected provinces. The MOHME has defined minimum requirements of staff in government health services for malaria elimination. These include a malaria microscopist in each *shahrestan* and in each rural health centre in a transmission area.

Is the programme on track for zero locally transmitted cases by 2025?

WHO has reported that between 2000 and 2015, the 17 countries that attained zero indigenous cases for three years or more reported a median of 184 indigenous cases five years before reaching zero cases. I.R. Iran reported 185 indigenous cases in 2015 and 92 in 2016 (Table 4.4.2). A log transformation of number of indigenous cases indicates a stable downward trend since at least 2009, and the case numbers in 2015 and 2016 are clearly not outliers (Fig. 4.4.16). Thus, it can be expected that zero indigenous cases will be reached in 2020–2021. WHO certification of malaria-free status requires that the country has reported zero indigenous cases for three consecutive years. Thus, it appears that I.R. Iran is on track to achieve that status by 2025 or even a little earlier. Yet, it should be noted that the end stage in I.R. Iran is perhaps more determined by the relatively unpredictable dynamics of importation than has been the case for most of the countries where malaria has been eliminated in recent years.

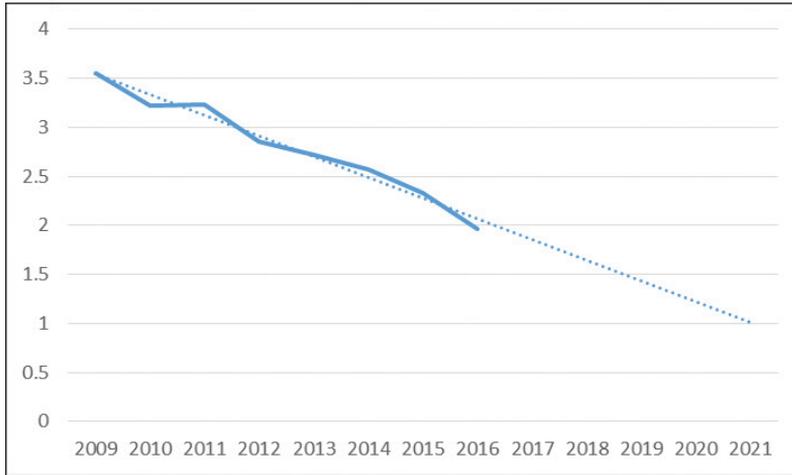


Fig. 4.4.16 Log transformed number of indigenous cases reported from I.R. Iran, 2009–2016 with linear trendline (The trendline suggests about 10 indigenous cases in 2021 [$1 = \log_{10}(10)$], but an elimination programme is expected to apply concentrated efforts in the last few foci to break the log-linear trend)

CONCLUSIONS

1. The advantages of an elimination programme are the well-defined, time-bound objectives and – as a result – high-level political interest, support and commitment. In fact, malaria elimination became part of Iran’s development agenda, resulting in sustained domestic funding and effective intersectoral collaboration.
2. Support from the GF through UNDP facilitated the adoption of a series of new tools and approaches. It also helped focus the efforts and strengthened overall coordination.
3. The focus-based approach with case-finding and vector control adapted to focus classification and the characteristics of each individual focus, supported management, planning, monitoring and, efficiency of operations.
4. External evaluation of malaria laboratories linked to accreditation led to quality improvements, which will remain important also after elimination.
5. The most important advance in the elimination phase Iran may have been the massive extension of malaria services providing immediate diagnosis and treatment through community health volunteers. A dense network of such service points along the border with Pakistan appears to be effective in controlling the risk of importation.
6. Economic opportunities for job-seekers (mainly from Afghanistan and Pakistan) in rural areas are creating new risks in provinces such as Fars and Bushehr, increasing and changing the need for surveillance and intersectoral collaboration.

4.5 Finishing the job

"All endeavour calls for the ability to tramp the last mile, shape the last plan, endure the last hour's toil. The fight to the finish spirit is the one... characteristic we must possess if we are to face the future as finishers."

Henry David Thoreau

The ultimate challenge: controlling the risk of importation of malaria to prevent reintroduction

As clearly shown by Fig.4.5.1, the eastern border of I.R. Iran is an epidemiological fault line. Endemic malaria to the east is the main threat to the country's strategy to eliminate malaria before 2025. The most immediate problem is in Pakistani Balochistan. The few publications on malaria there confirm the impression of Fig. 4.4.14, which is based on government data (103).

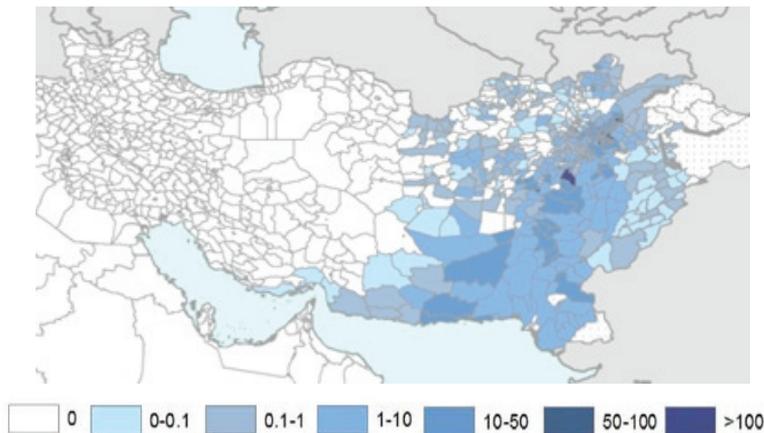


Fig. 4.5.1 Distribution of confirmed malaria cases per 1000 population in Afghanistan, I.R. Iran and Pakistan, 2012. Source (104)

In the southeast, most malaria patients are Iranians, followed by Pakistanis (Fig. 4.5.2). This is explained to some extent by truck drivers engaged in border trade, and it means that in border areas, control efforts must be oriented towards different groups with different characteristics. Meanwhile, the foci described in Box 4.4.2 indicate potential epidemiological developments. Assuming that I.R. Iran's economy continues to grow and attract people seeking jobs, vulnerability will increase and emerge as a major problem, also outside the southeast of the country (Table 4.5.1).

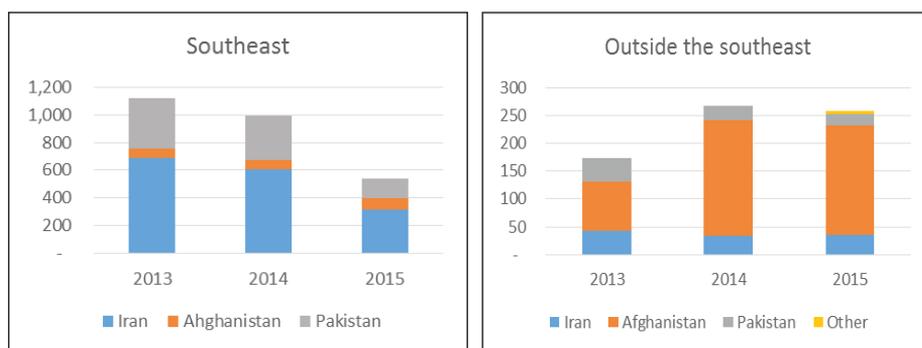


Fig. 4.5.2 Malaria cases (irrespective of importation status) by nationality in the southeast and outside the southeast, 2013–2015

Table 4.5.1 Present and potential migratory flows, which could pose a challenge to malaria elimination and, in the future, maintenance of malaria-free status in I.R. Iran (darker colours indicate a higher present risk). Source: (102)

Area at risk In I.R. Iran	Origin			
	Pakistani Balochistan	Other parts of Pakistan, especially North West Frontier Province	Afghanistan	Africa, India, South-east Asia
Sistan & Baluchestan, to some extent southern Kerman	Overland: Pakistani, Afghan agriculture, construction workers; Iranians in border trade	Overland: Pakistani, Afghan agriculture, construction workers.		
Hormozgan	Overland and by sea and land: Pakistani, Afghan agriculture, construction workers	Overland, by sea or air: Pakistani, Afghan agriculture, construction workers.	Overland: workers and, potentially, refugees	By air: agriculture, construction workers
Fars, Bushehr				
Other areas of rural and suburban development				

Thus, the problem of importation is dynamic and spatially diverse. The response must be equally flexible and dynamic. The main components, as developed in the last few years, are described below.

1. *Identification of risk factors and forecasting (early warning)*

A model assessed determinants of malaria reintroduction in southeastern I.R.Iran.

4. Development of malaria control and elimination

Migrants from endemic neighbouring countries were a pivotal factor, and the risk increased if they were unregistered, and if they slept in the open. Other main determinants were seasonal factors: daily minimum temperature, rainfall and outdoor shelters for vectors. The findings allow forecasting of malaria outbreaks eight weeks in advance (105).

2. *Intersectoral action directed at cross-border population movement and unregistered labour forces*

For risks associated with unregistered labour forces, intense collaboration with landowners (including training them) is a promising approach (Box 4.4.2). Community health volunteers and *beharz* can also identify people crossing the borders at high risk of contracting malaria. Drivers engaged in border trade are being educated on malaria and receive LLINs and insect repellents. Religious figures from Baluchestan (I.R. Iran) regularly attend mass gatherings in Pakistan and sometimes return with malaria. Some of them have been equipped with RDTs and medicines and trained in malaria case management. Border guards and coast guards in Sistan & Baluchestan have also been engaged to help identify symptomatic people at high risk crossing the border to have them screened for malaria voluntarily.

Already the recruitment of community health volunteers involves and mobilizes communities. But there are other approaches, for example the rural Islamic councils, which are the main forum for people's participation in local development. The councils are involved in public health issues in villages. Some of their members have been recruited to identify newcomers and migrant workers. Many *Baluchi* families have members on both sides of the border and are used to crossing back and forth.



Fig. 4.5.3 A young Pakistani girl being examined in a RDT post at the Pishin border crossing, Sistan & Baluchestan (© N. Panahi, 2015)

3. *Further development of the health service network and intensified surveillance*

The density of posts for case detection along the border has steadily increased. These posts provide health education and passive case detection (Fig. 4.5.3). In training, retraining and supervision of health workers, inclusiveness is emphasized: everybody has a right to health care and when people crossing borders are offered screening, this is independent of nationality, free of charge and voluntary. In 2016, more than 45000 individuals received case finding services

and education; as a result, 74 *P. vivax* and 22 *P. falciparum* cases were detected by the posts.

4. Cross-border collaboration

Five cross-border malaria meetings have been held since 2003 with malaria programme staff from Afghanistan and Pakistan, but the collaboration needs to go much further in terms of joint cross-border operations, exchange of information in real time and mutual learning, to mention only the highest priority elements.

5. New interventions

It is planned to try primaquine as the primary chemoprophylaxis for Iranian travellers, e.g. truck drivers visiting Pakistan temporarily, and terminal chemoprophylaxis (after returning from travel) for asymptomatic cases with no history of radical treatment coming from endemic areas in vulnerable and receptive areas (106). This may require screening to exclude glucose-6-phosphate dehydrogenase (G6PD) deficiency (107).

Future of vector control

The capacity to mount a rapid, precise and effective vector control response at any time in any receptive area must be maintained. Insecticide resistance will continue to be a challenge, and recent research demonstrates the potential for unexpected changes in the vector fauna in different places (108).

Against this background, strategic plans for vector control and insecticide resistance management were developed simultaneously with the second malaria elimination (27,109). The main principles of management of insecticide resistance are:

- Minimize insecticide selection pressure through rational use of insecticides and quality vector control applications including rotation, mosaic and combination of insecticides;
- Ensure that vector control is guided by operational research and knowledge of vector biology, epidemiology, and human behaviour, and monitored and evaluated;
- Strengthen collaboration within the health sector and with other sectors (especially agriculture) for prevention and management of insecticide resistance and for management of pesticides;
- Develop new approaches, technologies and tools;

The national vector control plan identifies malaria and leishmaniasis as the two most important endemic vector-borne diseases in I.R. Iran, and dengue and chikungunya as the main threats. In fact, with the emergence of *Aedes albopictus* in *Sistan & Baluchestan* (110), the province must now be considered receptive to

these diseases. To maintain and strengthen capacity, a central cross-cutting vector control unit in MOHME is foreseen to guide, support, oversee and coordinate all vector control activities; it should include a national reference laboratory and be guided by an advisory committee, while a national integrated vector management stakeholder committee should organize intersectoral cooperation in this field.

The role of general health services

Already at present, when malaria in most of the country is an exotic disease, most likely to occur among travellers, who will typically go to a general practitioner in case of fever, it is a priority for the programme to safely hand back the responsibility for malaria case management to the general health services. Outside the southeast, the programme has still not fully engaged private practitioners and other sectors in malaria case management. In some areas where there are many immigrants using private practitioners, for example Qom, Bandar Abbas and Jahrom (Fars), these have been successfully engaged to cooperate on malaria surveillance, using RDTs provided free of charge by the programme. The new family physician programme creates opportunities for the malaria programme by improving access to medical care and upgrading rural health facilities. The number of providers in public and private services is so large and the need for continuity so great that the best solution will be online courses with the passing of examinations linked to renewal of authorizations.

5. Synopsis and lessons learnt

For at least 3000 years, malaria has been part of the history of Iran, continually sapping the life of the people and sometimes erupting as violent epidemics. By the early 20th century, it was the most important public health problem in the country, particularly severe in the Caspian plains and in the southeast, but prevalent practically everywhere, even in the major cities. Effective large-scale control based on IRS was initiated after the Second World War and soon led to major reductions in the Caspian plains and the Central plateau. A national eradication programme was started in 1956, but soon encountered serious problems in the southern plains and the Zagros highlands, where vector biology and human ecology were more challenging than in the north. By combining various interventions and products, the programme succeeded in reducing malaria considerably, also in the southern regions. By 1980, international and national policies had changed, PHC was prioritized and the malaria programme reverted to control. Despite limited resources, malaria was greatly reduced in the Zagros mountains and the southwestern plains, so that by 1990, the residual problems were concentrated in the three provinces of the southeast. These were less developed than the rest of the country and at the same time the environmental situation supported long transmission seasons with 3–5 different vector species in the same place. They also had cross-border population movement with endemic neighbouring countries. Over several decades, the strengthening of antimalaria services was integrated with general development including improved health services. By 2010, the malaria programme was again reoriented to elimination. Good progress has been made since then as a result of targeted and combined interventions, improvements in management, attention to quality and efficiency of services, intersectoral collaboration, and a dense network of community health volunteers. The number of reported malaria cases in I.R. Iran reached a high of 98 160 in 1991, which was related to the extensive case detection activities. Since then, the burden has been steadily declining. The number of reported cases was 92 in 2016; there is concern that importation may impede progress towards elimination, but the mathematical trends, as well as the ability of the programme to respond to emerging threats, indicate that malaria-free status is likely to be reached by 2025 or before.

There are a number of common denominators in successful malaria (and public health) programmes that have been mentioned so many times in advocacy documents (government leadership, adequate funding, community partnership, research, intersectoral collaboration, cross-border collaboration, etc.) that listing them here would be redundant. In the case of I.R. Iran, the long continuity of the programme may allow the identification of some deeper and more specific lessons.

They cannot all be directly generalized to other endemic or elimination countries, but they are instructive and interesting.

1. The early triumphs of the programme in the Caspian and Central plateau regions were achieved despite a weak health system, because the key intervention, IRS, was extremely effective in the prevailing ecological conditions and could be implemented through vertical management. The early success was an asset and strengthened political commitment, but it was also a liability because it was deceptive.

2. Every thing has its time. In the 1960s, the programme was challenged by technical obstacles. Instead of stubbornly pursuing inefficient implementation, it addressed the problems through research and subsequently went on the offensive with better weapons. In the 1980s, the programme was under-resourced. Instead of becoming demoralized, it reoriented to control rather than elimination and joined the national effort to strengthen PHC. Despite serious weaknesses in surveillance and vector control, the disease burden was gradually reduced.

3. The development of an extensive rural health service network adapted to local social and ecological conditions is key to elimination in the last and most difficult areas (Fig. 5.1.1).



Fig. 5.1.1 A former larval habitat in a spring in Sarbaz Shahrestan in Sistan & Baluchestan (© Liaghat Ali Askani). As a result of larviciding, there is no breeding of anophelines anymore. Furthermore, education and health services are now fully developed in this region so that malaria could not erupt on an epidemic scale or regain a foothold.

4. Intersectoral action focusing on the most difficult areas, with the accelerated electrification of the southeast, was a key element. The importance of electrification was determined by the climate and the human ecology in southern I.R. Iran. Similar conditions are found in parts of the Indian subcontinent.

5. A characteristic of the Iranian health system is the leading role of the universities of medical sciences in managing and guiding health programmes at the intermediate level. This means that there is professional leadership with the capacity to assess local situations, use data, disagree constructively with the central level, engage other sectors, promote team work and solve problems rather than merely implementing standard operating procedures. As reflected in the evolving strategy to prevent reintroduction, this has enormous value.

6. International projection of Iran's national malaria programmes and related work

Since 1996, courses in malaria control and elimination have been held regularly in Bandar Abbas. They are organized jointly by WHO, MOHME and the School of Public Health, Tehran University of Medical Sciences. Subjects include biostatistics and epidemiology, microcomputing, malaria parasitology, entomology, vector control, case management, epidemiological approach, field work and planning. The courses apply dynamic, interactive, practical and problem-solving learning methods. Field work takes place in the endemic rural areas of Kahnuj and Minab *Shahrestans* in Hormozgan Province. In 2002, I.R. Iran was designated as a WHO Regional Malaria Training Centre. Some courses were conducted with financial support from the Islamic Development Bank. A total of 300 participants from 26 different countries completed these courses from 1996 to 2012 (111,112).

Other international training activities in recent years include a field visit to I.R. Iran for managers/malaria experts from Tajikistan for sharing best practices in 2014, and in 2016 five participants from Afghanistan attended an advanced course in I.R. Iran on microscopy quality assurance for malaria microscopy.

Iranian expertise has also been seen in the leading role taken by Iranian programme managers and other experts in WHO meetings and international workshops as well as the Iranian parasitologists, entomologists and malariologists who have occupied key posts related to malaria in WHO headquarters and regional offices.

Finally, it should be mentioned that over the past 20 years, Iranian scientists have been increasingly prolific in publishing work related to malaria based on findings in I.R. Iran. Their work can be found in international journals and in several Iranian online English-language journals and is reflected in the list of references below.

References

1. Mandell, G, Bennett J, Dolin R. Mandell, Douglas and Bennett's principles and practice of infectious disease: Malaria (plasmodium species), eighth edition. Philadelphia: Saunders; 2015(4):3070–3075.
2. Statistical Center of Iran. Iran. Main indicators. 2016 [cited 2017 May 16]. Available from: <https://www.amar.org.ir/english/Main-Indicators>
3. Encyclopaedia Iranica: Nomadism. 2011.
4. Iran (Islamic Republic of). Migration profiles. Unicef, 2013. [cited 2016 May 16]. Available from: <https://esa.un.org/migmgprofiles/indicators/files/Iran.pdf>
5. Gregor Greenfield. [Beitrag zur Frage der allgemeinen Hygiene in Persien mit spezieller Berücksichtigung der Malaria]. University of Berlin; 1933.
6. Samavat A, Modell B. Iranian national thalassaemia screening programme. *BMJ*. 2004 Nov 13;329(7475):1134–7.
7. Manouchehri AV, Zaim M, Emadi AM. A review of malaria in Iran, 1975–90. *J Am Mosq Control Assoc*. 1992;8(4):381–5.
8. Edrissian G. Malaria in Iran: past and present situation. *Iran J Parasitol*. 2006;1(1):1–14.
9. Bruce-Chwatt Leonard Jan. History of malaria from prehistory to eradication. In: Wernsdorfer W, McGregor I, editors. *Malaria* v1. Edinburgh: Churchill Livingstone; 1988:1–59.
10. Christensen P. The Decline of Iranshahr. Irrigation and environments in the history of the Middle East 500 B.C. to A.D. 1500. Museum Tusculanum Press, Copenhagen. Copenhagen: Museum Tusculanum Press, University of Copenhagen; 1993:1–351.
11. De Zulueta J. Malaria and Mediterranean history. *Parassitologia*. 1973;15(1):1–15.
12. Azizi MH, Bahadori M. Brief historical perspectives of malaria In Iran. *Arch Iran Med*. 2013;16(2):131–5.
13. Tabei SZ, Masoumpour MB, Asadollahi R, Sobhani N, Sajjadi S. Avicenna's viewpoints on fever and it's comparison to modern medicine. *Med J Islam Repub Iran*. 2004;18(1):79–84.
14. Neligan AR. Public health in Persia. 1914-24. Part II. Epidemic and endemic diseases. *Lancet*. 1926;I:690–4.
15. Gilmour J. Report on an investigation into the sanitary conditions in Persia. Geneva: League of Nations Health Organisation; 1925 (unpublished document C.H.262).
16. Christophers SR, Shortt HE. Malaria in Mesopotamia. *Indian J Med Res*. 1921;8:508–29.

17. Latyshev NI. [About the prevalence of malaria in the Caspian zone of the North-Western Iran]. In: Aristovski VM, editor. [Epidemiological-parasitological expeditions in Iran and parasitological research]. Leningrad: USSR Academy of Science, Moscow; 1948:235–8.
18. Lindberg K. [Le paludisme dans l'Iran]. Riv Malariol. 1936;XV(2):132–45.
19. Amidzadeh. [Recherches sur le paludisme dans l'Iran]. Acta Med Scand. 1941;107(6):579–83.
20. Gutsevitch. [Mosquitoes and malaria in Iran]. In: Aristovski VM, editor. [Epidemiological-parasitological expeditions in Iran and parasitological research]. Moscow, Leningrad: USSR Academy of Science; 1948:209–34.
21. Tabibzadeh I, Behbehani G, Nakhai R. Use of *Gambusia* fish in the Malaria Eradication Programme of Iran. Geneva: World Health Organization; 1970 (unpublished document WHO/MAL/70.716).
22. Ziony M. Malaria control In Iran - Resume of reports made by Dr. Justin M. Andrews and Lawrence B. Hall. Public Health Reports. 1950;65(11):351–67.
23. Abivardi C. Medical entomology. In: Iranian entomology – an Introduction vol 2. Berlin: Springer; 2001:857–90.
24. Hanafi-Bojd AA, Azari-Hamidian S, Vatandoost H, Charrahy Z. Spatio-temporal distribution of malaria vectors (Diptera: Culicidae) across different climatic zones of Iran. Asian Pac J Trop Med. 2011;4(6):498–504.
25. Salahi-Moghadam AV. An overview and mapping of malaria and its vectors in Iran. Hormozgan Med J. 2014;18(5):473–85.
26. Zahar AR. Review of the ecology of malaria vectors in the WHO Eastern Mediterranean Region. Bull World Health Organ. 1974;50(5):427–40.
27. National plan for insecticide resistance prevention and management in malaria vectors of Iran (2015–2019). Tehran: Ministry of Health and Medical Education and World Health Organization; 2014.
28. Manouchehri AV, Djanbakhsh B, Eshghi N. The biting cycle of *Anopheles dthali*. *A. fluviatilis* and *A. stephensi* in southern Iran. Trop Geogr Med [Internet]. 1976;28(3):224–7. Available from: <http://www.ncbi.nlm.nih.gov/pubmed/1006791>
29. Garret Jones C. An experiment in trapping and controlling *Anopheles maculipennis* in North Iran. Bull World Health Organ. 1951;4(4):547–62.
30. Azari-Hamidian S. Checklist of Iranian mosquitoes (Diptera: Culicidae). J Vector Ecol. 2007;32(2):235–42.
31. Yaghoobi-Ershadi MR, Namazi J, Piazak N. Bionomics of *Anopheles sacharovi* in Ardebil province, northwestern Iran during a larval control program. Acta Trop. 2001;78(3):207–15.
32. Manouchehri A, Rohani F. Notes on the ecology of *Anopheles dthali* Patton

in southern Iran. *Ann Trop Med Parasitol*. 1975;69(3):393–7.

33. Vatandoost H. Bionomics of *Anopheles stephensi* Liston in the malarious area of Hormozgan province, southern Iran, 2002. *Acta Trop*. 2006;97(2):196–203.

34. Basseri H, Raeisi A, Ranjbar Khakha M, Pakarai A, Abdolghafar H. Seasonal abundance and host-feeding patterns of *anopheline* vectors in malaria endemic area of Iran. *J Parasitol Res*. 2010;2010.

35. Zaim M. Role of *Anopheles culicifacies* s.l. and *An. pulcherrimus* in malaria transmission in Ghassreghand (Baluchistan), Iran. *J Am Mosq Control Assoc*. 1993;9(1):23–8.

36. Edwards SC. Assignment report. Malaria organization in Iran, 1964-1968. Alexandria: WHO Regional Office for the Eastern Mediterranean; 1969 (unpublished document).

37. Afridi MK. Report on a visit to Iran 30 November 1940 to 9 December 1949. Geneva: World Health Organization; 1949 (unpublished document).

38. Information on the malaria control programme in Iran. Geneva: World Health Organization; 1956.

39. Ansari N. Report on activities of the Institute of Malariology covering period March 15 to September 30th 1953. Tehran: Institute of Malariology; 1953.

40. Malaria eradication programmes in the Eastern Mediterranean Region. Working paper for Regional Committee for the Eastern Mediterranean. Alexandria: WHO Regional Office for the Eastern Mediterranean; 1955 (unpublished document RC5/EM/12).

41. Report on Pennsalt Health and Agriculture Service Activities in Iran. Washington DC: Pennsalt Health and Agriculture Service; 1950.

42. Palmquist EE, Aldridge FF. Malaria control in Iran. *Public Health Rep*. 1954;69(10).

43. Cambournac FJC. Report on a study for the evaluation of the economic impact of malaria eradication in northern part of Iran especially in Caspian Area. Alexandria: WHO Regional Office for the Eastern Mediterranean; 1968 (unpublished document).

44. Saebi E. [Malaria]. In: [Protozoal diseases in Iran] [In Persian]. Tehran: Hayyan Publication; 1998:327–50 [In Persian].

45. Plan of operations for malaria eradication in Iran. Tehran: Ministry of Health; 1957.

46. Charles LJ. Assignment report on malaria eradication in Iran, 1961. Geneva: World Health Organization; 1961 (unpublished document).

47. Houel G. [Première évaluation de l'application du plan d'opérations de l'Eradication du paludisme à l'Iran]. Geneva: World Health Organization; 1958

(unpublished document).

48. Mouchet J. Biodiversité du paludisme dans le monde. Montrouge: John Libby Eurotext; 2004:254.

49. Macdonald G. Report on a visit to Iran. Geneva: World Health Organization; 1958 (unpublished document ME/58/10).

50. Zahar AR. Report on a visit to Iran, 6 September–6 October 1968. Alexandria: WHO Regional Office for the Eastern Mediterranean; 1969 (unpublished document EM/MAL/73).

51. Agriculture in Iran. In: Encyclopaedia Iranica [Internet]. Available from: <http://www.iranicaonline.org/articles/agriculture-in-iran>

52. Mofidi C. Present aspect of malaria problem and its control among nomadic tribes in Iran. Working paper no. 34. Expert Committee on Malaria, Lisbon, 15–23 September 1958. Geneva: World Health Organization; 1958.

53. Saebi A, Motabar M. A medicated salt project in the Kazeroun area, Iran, Second report 1962-1965. Geneva: World Health Organization; 1968 (unpublished document WHO/Mal/68.669).

54. Report on malaria eradication program, Iran. Washington DC: USA International Cooperation Administration; 1961.

55. New zoning for malaria eradication based on status of malaria epidemiology in Iran 1961. Tehran: Ministry of Health; 1961.

56. Ramakrishnan S. Report of the Iran Malaria Eradication Assessment Team. WHO-USAID November 17–December 17, 1963. World Health Organization, USAID; 1963 (unpublished document).

57. Edwards SC. Assignment Report. Malaria Organization In Iran 1964-1968. Alexandria: WHO Regional Office for the Eastern Mediterranean; 1969.

58. Mulhern TD. Report relating to the control of malaria vector mosquitoes In Iran by methods directed against the mosquito sources 18 September–21 December 1965. Alexandria: WHO Regional Office for the Eastern Mediterranean; 1966 (unpublished document EM/MAL/54/IRAN 1).

59. Motabar M, Behbahani GR. Nomadism and the problem of eradication in southern Iran. Geneva: World Health Organization; 1973 (unpublished document WHO/MAL/73.813).

60. Report on the sixth inter-country border meeting on malaria eradication, 4–5 December 1965. Ministry of Health, Iraq; 1965.

61. Javadian E, Acheson MA. An evaluation of the effect of larviciding operations in rural areas near Abadan, Iran. *Iran J Public Health*. 1974;28(3):54–61.

62. Manouchehri A V, Janbakhsh B. [The present status of malaria eradication in Iran and its operational and technical problems]. *Iran J Public Health*. 1977;2:56–9. [In Persian].

63. Acheson MA. Assignment Report. Malaria Eradication Organization in Iran 1967–1970. Alexandria: WHO Regional Office for the Eastern Mediterranean; 1970 (unpublished document EM/MAL/92/IRAN 0001).
64. Edwards SC. Report on a visit to Iran 10–28 November 1972. Alexandria: WHO Regional Office for the Eastern Mediterranean; 1972 (unpublished document EM/MAL/114).
65. Zaim M. Malaria control In Iran--present and future. *J Am Mosq Control Assoc.* 1987;3(3):392–6.
66. Molaee Zadeh M, Shahandeh K, Bigdeli S, Basseri HR. Conflict in neighboring countries: a great risk for malaria elimination in southwestern Iran: Narrative review article. *Iran J Public Health.* 2014;43(12):1627–34.
67. Smolinschi M. Report on a visit to Iran concerning the Malaria Eradication Programme 13 January – 17 April 1984. Alexandria: WHO Regional Office for the Eastern Mediterranean; 1984.
68. Heshmati B, Joulaei H. Iran's health-care system in transition. *Lancet.* 2016;387(10013):29–30.
69. Majdzadeh R, Schapira A, Raeisi A, Ranjbar M, Taghizadeh R, Zamani G, et al. Review of the National Malaria Elimination Program, Islamic Republic of Iran, 2013. Cairo: WHO Regional Office for the Eastern Mediterranean; 2014.
70. Ehlers E. Nomadism. In: *Encyclopaedia Iranica* [Internet]. 2011. Available from: <http://www.iranicaonline.org/articles/nomadism#>
71. Edrissian GH. Blood transfusion induced malaria In Iran. *Trans R Soc Trop Med Hyg.* 1974;68(6):491–3.
72. Mardani A, Keshavarz H, Pourfathollah AA, Maghsudlu M. Transfusion-transmitted malaria in iran: a narrative review article. *Iran J Parasitol* [Internet]. 2016;11(2):136–43. Available from: <http://www.ncbi.nlm.nih.gov/pubmed/28096847>
73. Sadrizadeh B. Malaria in the world, in the Eastern Mediterranean Region and in Iran. *Arch Iran Med* [Internet]. 1997; Available from: <http://www.ams.ac.ir/AIM/9924/sadrizadeh9924.html>
74. Zaim M, Naseeri-Nejad D, Azoordegan F, Emadi AM. Knowledge and practice of residents about malaria in southeast Iran (1994). *Acta Trop.* 1997;64(3–4):123–30.
75. Hosseinpoor AR, Mohammad K, Majdzadeh R, Naghavi M, Abolhassani F, Sousa A, et al. Socioeconomic inequality in infant mortality in Iran and across its provinces. *Bull World Health Organ.* 2005;83(11):837–44.
76. Vatandoost H, Arash R, Mehdi J, Ahmad R, Ali HBA, Wali YA, et al. Demonstration of malaria situation analysis, stratification and planning in Minab District, southern Iran. *Asian Pac J Trop Med.* 2011;4(1):67–71.

77. Edrissian GH, Afshar A, Sayedzadeh A, Mohsseni G, Satvat MT. Assessment of the response in vivo and in vitro of *Plasmodium falciparum* to sulphadoxine-pyrimethamine in the malarious areas of Iran. *J Trop Med Hyg.* 1993;96(4):237–40.
78. Saebi E. National malaria treatment guideline in I.R. Iran. Tehran: Diseases Management Center, Ministry of Health and Medical Education; 2004.
79. Zaim M, Ghavami MB, Nazari M, Edrissian GH, Nateghpour M. Cyfluthrin (EW 050)-Impregnated bednets in a malaria control program in Ghassreghand (Baluchistan, Iran). *J Am Mosq Control Assoc.* 1998;14(4):421–30.
80. Moosa-Kazemi SH, Vatandoost H, Raeisi A, Akbarzadeh K. Deltamethrin impregnated bed nets in a malaria control program in Chabahar, southeast Baluchistan, IR Iran. *Iran J Arthropod Borne Dis.* 2007;1:43–51.
81. Soleimani-Ahmadi M, Vatandoost H, Shaeghi M, Raeisi A, Abedi F, Eshraghian MR, et al. Field evaluation of permethrin long-lasting insecticide treated nets (Olyset®) for malaria control in an endemic area, southeast of Iran. *Acta Trop.* 2012;123(3):146–53.
82. Raeisi A, Gouya MM, Nadim A, Ranjbar M, Hasanzehi A, Fallahnezhad M, et al. Determination of malaria epidemiological status In I.R.Iran's malarious areas as baseline information for implementation of malaria elimination program In I.R. Iran. *Iran J Public Health.* 2013;42(3):326–33.
83. Ghaffari S, Mahdavi SA, Moulana Z, Mouodi S, Karimi-Nia H, Bayani M, et al. Malaria in Mazandaran, northern Iran: Passive case finding during 1997–2012. *Iran J Parasitol.* 2012;7(3):82–8.
84. Nikookar SH, Azari-Hamidian S, Fazeli-Dinan M, Nasab SNM, Aarabi M, Ziapour SP, et al. Species composition, co-occurrence, association and affinity indices of mosquito larvae (Diptera: Culicidae) in Mazandaran Province, northern Iran. *Acta Trop.* 2016;157:20–9.
85. Khalili MB, Anvari-Tafti MH, Sadeh M. Epidemiological pattern of malarial disease in the province of Yazd, Iran (Since 1986-2006). *World J Med Sci.* 2009;4(1):41–5.
86. Farzinnia B, Saghafipour A, Abai M. Malaria situation and *anopheline* mosquitoes in Qom province, central Iran. *Iran J Arthropod Borne Dis.* 2010;4(2):61–7.
87. Vatandoost H, Ashraf H, Lak SHS, Mahdi RE, Abai MR, Nazari M. Factors involved in the re-emergence of malaria in borderline of Iran, Armenia, Azerbaijan and Turkey. *Southeast Asian J Trop Med Public Health.* 2003;34 Suppl 2:6–14.
88. Shafiei R, Mahmoodzadeh A, Hajia M, Sanati A, Shafiei F. Epidemiology of malaria in Khorasan Razavi Province, northeast of Iran, within 7 years (April

2001–March 2008). *Ann Trop Med Public Health*. 2011;4 (1):12–7. Available from: <http://www.atmph.org/article.asp?issn=1755-6783;year=2011;volume=4;issue=1;spage=12;epage=17;aulast=Shafiei>

89. World Malaria Report 2015. Geneva: World Health Organization; 2015.

90. Malaria control. Report on a border meeting between the Islamic Republic of Iran, Iraq, Jordan, Lebanon, Syrian Arab Republic and Turkey. Beirut, Lebanon, 22–24 May 1995. Alexandria: WHO Regional Office for the Eastern Mediterranean; 1995 (unpublished document WHO/EM/MAL/240/E).

91. Maghsoodi N, Ladonni H, Basseri HR. Species composition and seasonal activities of malaria vectors in an area at reintroduction prevention stage, Khuzestan, south-western Iran. *J Arthropod Borne Dis*. 2014;9(1):60–70.

92. Ostovar A, Raeisi A, Haghdoost AA, Ranjbar M, Rahimi A, Sheikhzadeh K, et al. Lessons learnt from malaria epidemics in the Islamic Republic of Iran. *East Mediterr Health J*. 2012;18(8):864–9.

93. The Long-term Strategic Plan for Malaria Elimination (2010-2025). Tehran: Ministry of Health and Medical Education; 2010.

94. Kondrachine A. Evaluation of progress in malaria elimination in the Islamic Republic of Iran. Cairo: WHO Regional Office for the Eastern Mediterranean; 2005 (unpublished document EM/MAL/512/E/R/02.05/20).

95. Zoghi S, Mehrizi AA, Raeisi A, Haghdoost AA, Turki H, Safari R, et al. Survey for asymptomatic malaria cases in low transmission settings of Iran under elimination programme. *Malar J* [Internet]. 2012;11(1):126. Available from: <http://www.malariajournal.com/content/11/1/126%5Cnhttp://www.malariajournal.com/content/pdf/1475-2875-11-126.pdf>

96. Turki H, Raeisi A, Malekzadeh K, Ghan-Barnejad A, Zoghi S, Yeryan M, et al. Efficiency of nested-PCR in detecting asymptomatic cases toward malaria elimination program in an endemic area of Iran. *Iran J Parasitol*. 2015;10(1):39–45.

97. Zakeri S, van den Hoogen LL, Mehrizi AA, Karimi F, Raeisi A, Drakeley C. Anti-malarial seroprevalence assessment during an elimination programme in Chabahar District, south-eastern Iran. *Malar J* [Internet]. 2016;15:382. Available from: <http://dx.doi.org/10.1186/s12936-016-1432-1%5Cnhttp://malariajournal.biomedcentral.com/articles/10.1186/s12936-016-1432-1>

98. Vatandoost H, Hanafi-Bojd AA. Indication of pyrethroid resistance in the main malaria vector, *Anopheles stephensi* from Iran. *Asian Pac J Trop Med* [Internet]. 2012;5(9):722–6. Available from: [http://dx.doi.org/10.1016/S1995-7645\(12\)60114-X](http://dx.doi.org/10.1016/S1995-7645(12)60114-X)

99. Basseri HR, Raeisi A, Holakouie K, Shanadeh K. Malaria prevention among Afghan refugees in a malarious area, southeastern Iran. *Bull la Soc Pathol Exot*.

2010;103(5):340–5.

100. CDC, Ministry of Health and Medical Education. Household survey on ownership and utilization of LLIN and KAP study on malaria in high risk malaria areas in I.R. Iran. Community Based Participatory Research Center, Tehran University of Medical Sciences, Iran; 2013.

101. Kiani M, Mohamamdi M, Nikpour F, Raeisi A, Ranjbar M, Sargolzaei N, et al. To demonstrate cost-effective and sustainable larval source management solutions in urban setting in Chabahar, Sistan & Baluchistan, Iran. Tehran: Ministry of Health and Medical Education; 2015.

102. Malaria Elimination Plan Drafting Team. Second Malaria Elimination Plan covering the period 2015–20 (1394–98) “Towards a malaria-free Iran by 2025.” Tehran: Ministry of Health and Medical Education; 2014.

103. Yasinzai MI, Kakarsulemankhel JK. Prevalence of human malaria infection in Pakistani areas bordering with Iran. *J Pak Med Assoc.* 2013;63(3):313–6.

104. Malaria in the Eastern Mediterranean Region 2012 [Internet]. World Health Organization. 2012. Available from: http://www.emro.who.int/images/stories/rbm/Regional_profile_2012.pdf?ua=1

105. Ranjbar M, Shoghli A, Kolifarhood G, Tabatabaei SM, Amlashi M, Mohammadi M. Predicting factors for malaria re-introduction: an applied model in an elimination setting to prevent malaria outbreaks. *Malar J* [Internet]. 2016;15:138. Available from: <http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=4776358&tool=pmcentrez&rendertype=abstract>

106. Kolifarhood G, Raeisi A, Ranjbar M, Haghdoost AA, Schapira A, Hashemi S, et al. Prophylactic efficacy of primaquine for preventing *Plasmodium falciparum* and *Plasmodium vivax* parasitaemia in travelers: A meta-analysis and systematic review. *Travel Med Infect Dis.* 2017 May-Jun;17:5–18.

107. Tabatabaei SM, Khorashad AS, Sakeni M, Raeisi A, Metanat Z. Prevalence of glucose-6-phosphate dehydrogenase (G6Pd) deficiency in southeast Iran: Implications for malaria elimination. *J Infect Dev Ctries.* 2015;9(3):289–97.

108. Salahi-Moghaddam A, Khoshdel A, Dalaei H, Pakdad K, Nutifafa GG, Sedaghat MM. Spatial changes in the distribution of malaria vectors during the past 5 decades in Iran. *Acta Trop.* 2017;166:45–53.

109. National Vector Control Plan. Tehran: Centre for Disease Control & Prevention, MOHME and World Health Organization; 2016.

110. Doosti S, Yaghoobi-Ershadi MR, Schaffner F, Moosa-Kazemi SH, Akbarzadeh K, Gooya MM, et al. Mosquito surveillance and the first record of the invasive mosquito species *Aedes (Stegomyia) albopictus* (Skuse) (Diptera: Culicidae) in southern Iran. *Iran J Public Health.* 2016;45(8):1064–73.

111. Vatandoost H, Mesdaghinia AR, Zamani G, Madjzadeh R, Holakouie

K, Sadrizadeh B, et al. Development of the regional malaria training centre in Bandar-e Abbas, Islamic Republic of Iran. *East Mediterr Heal J.* 2004;10(1-2):215-24.

112. Mesdaghinia AR, Vatandoost H, Hanafi-Bojd AA, Majdzadeh R, Raeisi A. Conducting international diploma course on malaria program planning and management (1996-2012). *J Arthropod Borne Dis.* 2013;7(2):100-12.

Annex 1 Methods in preparing the report

PubMed was searched for “malaria AND Iran” and “health system AND Iran” until March 2017. Based on titles, abstracts were selected, and then the full articles were obtained for review.

WHO archives in Geneva and Cairo were searched through catalogues and by hand for reports on malaria in Iran, especially reports by WHO consultants and reports on border meetings. WHO’s Weekly Epidemiological Records and the WHO/MAL repository were searched for titles relevant to Iran and malaria.

Programme documents in English held by the Ministry of Health and Medical Education were explored. Reports related to the support provided by The Global Fund through UNDP for the programme were reviewed.

Where data are presented without mention of a source, they have been retrieved from the archives and databases of the national malaria elimination programme, Center for Communicable Disease Control (CDC), Ministry of Health and Medical Education, Tehran. Likewise, photographs and illustrations for which a source is not mentioned were sourced from the national malaria elimination programme.

Annex 2 Main malaria surveillance data, by region and year, 2002–2015

API: annual parasite incidence; Pf: *Plasmodium falciparum*.

Year	Region	Population	No. slides examined	Total no. confirmed cases	API/1000	No. local cases	No. Pf + mixed cases
2002	Caspian	6 748 720	140 075	159	0.024	36	6
	Central plateau	26 125 865	142 669	2 272	0.087	17	180
	North-west	7 523 323	45 761	370	0.049	345	–
	Northeast	6 509 205	23 783	224	0.034	121	7
	Zagros	7 218 857	175 544	1 187	0.164	303	77
	Southwest	5 358 268	234 025	453	0.085	82	120
	Southeast	5 514 646	674 728	10 713	1.943	6 101	2 089
	TOTAL	64 998 884	1 436 585	15 378	0.237	7 005	2 479
2003	Caspian	6 729 704	104 317	155	0.023	12	4
	Central plateau	27 087 947	124 964	1 748	0.065	86	110
	North-west	7 543 352	25 114	96	0.013	82	2
	Northeast	6 386 119	22 938	125	0.020	1	13
	Zagros	7 457 246	145 972	1 050	0.141	128	28
	Southwest	5 542 018	173 727	285	0.051	17	34
	Southeast	5 733 980	729 815	21 568	13	17 105	4 870
	TOTAL	66 480 366	1 326 847	25 027	0.376	17 431	5 061
2004	Caspian	6 810 460	107 138	201	0.030	9	3
	Central plateau	27 412 998	123 057	1 535	0.056	383	72
	North-west	7 633 872	21 355	31	0.004	21	1
	Northeast	6 462 753	18 018	51	0.008	–	4
	Zagros	7 546 732	116 104	900	0.119	81	14
	Southwest	5 608 522	159 599	257	0.046	57	14
	Southeast	5 802 786	780 837	10 191	6	6 952	1 051
	TOTAL	67 278 123	1 326 108	13 166	0.196	7 503	1 159

Year	Region	Population	No. slides examined	Total no. confirmed cases	API/1000	No. local cases	No. Pf + mixed cases
2005	Caspian	6 915 377	80 400	51	0.007	15	2
	Central plateau	28 743 437	94 583	634	0.022	51	32
	North-west	7 764 044	12 842	13	0.002	3	2
	Northeast	6 279 694	13 785	37	0.006	2	5
	Zagros	7 499 021	97 898	848	0.113	106	12
	Southwest	5 641 181	151 990	284	0.050	190	6
	Southeast	5 587 191	833 187	17 418	12	12 643	2 181
	TOTAL	68 429 945	1 284 685	19 285	0.282	13 010	2 240
2006	Caspian	6 871 043	84 007	19	0.003	–	2
	Central plateau	28 828 267	97 891	485	0.017	44	55
	North-west	7 792 322	9 843	4	0.001	–	–
	Northeast	7 123 506	17 787	18	0.003	–	4
	Zagros	7 512 050	86 195	550	0.073	63	36
	Southwest	5 518 520	132 274	104	0.019	29	9
	Southeast	5 935 638	708 305	14 689	10	11 938	1 068
	TOTAL	69 581 346	1 136 302	15 869	0.228	12 074	1 174
2007	Caspian	6 871 043	41 365	6	0.001	2	1
	Central plateau	28 883 704	100 070	387	0.013	29	50
	North-west	7 792 322	9 744	4	0.001	–	–
	Northeast	7 123 506	18 732	27	0.004	1	3
	Zagros	7 512 050	85 117	322	0.043	19	37
	Southwest	5 654 834	112 771	144	0.025	25	12
	Southeast	7 086 000	688 987	15 599	8	12 462	1 421
	TOTAL	70 923 459	1 056 786	16 489	0.232	12 538	1 524
2008	Caspian	7 057 765	67 963	20	0.003	–	–
	Central plateau	29 655 271	86 456	495	0.017	33	50
	North-west	7 824 035	6 132	5	0.001	–	–
	Northeast	7 245 604	16 253	17	0.002	–	3
	Zagros	7 693 581	81 426	409	0.053	18	25
	Southwest	5 841 570	133 182	218	0.037	32	30
	Southeast	6 848 482	543 144	10 169	5	6 873	787
	TOTAL	72 166 308	934 556	11 333	0.157	6 956	895

Year	Region	Population	No. slides examined	Total no. confirmed cases	API/1000	No. local cases	No. Pf + mixed cases
2009	Caspian	7 057 765	63 802	18	0.003	–	4
	Central plateau	29 655 271	79 500	340	0.011	59	37
	North-west	7 824 035	5 984	10	0	2	1
	Northeast	7 245 604	10 074	11	0.002	–	–
	Zagros	7 693 581	87 884	236	0.031	24	11
	Southwest	5 841 570	93 899	66	0.011	5	6
	Southeast	6 848 482	360 416	5 240	3	3 516	550
	TOTAL	72 166 308	701 559	5 921	0.082	3 606	609
2010	Caspian	7 177 891	43 725	14	0.002	8	1
	Central plateau	31 078 896	76 309	140	0.005	31	22
	North-west	7 950 527	255	2	0.000	2	–
	Northeast	7 456 341	10 875	7	0.001	1	3
	Zagros	7 435 542	39 658	88	0.012	30	4
	Southwest	5 981 355	108 599	64	0.011	9	6
	Southeast	6 978 259	330 398	2 679	0.384	1 571	391
	TOTAL	74 058 811	609 819	2 994	0.040	1 652	427
2011	Caspian	7 331 831	56 207	9	0.001	2	–
	Central plateau	31 126 740	69 944	216	0.007	48	26
	North-west	8 053 684	1 787	2	0.000	–	1
	Northeast	7 524 663	12 546	13	0.002	10	1
	Zagros	7 904 793	54 840	148	0.019	19	8
	Southwest	6 122 268	78 836	64	0.010	20	16
	Southeast	7 655 037	253 049	2 777	–	1 603	510
	TOTAL	75 719 016	527 209	3 229	0.043	1 702	562
2012	Caspian	7 299 697	763	–	–	–	–
	Central plateau	32 132 797	24 937	78	0.002	20	18
	North-west	8 056 639	–	–	–	–	–
	Northeast	7 740 494	2 681	10	0.001	7	3
	Zagros	7 524 505	19 882	62	0.008	8	1
	Southwest	6 125 041	23 691	67	0.011	18	5
	Southeast	5 904 680	135 946	1 021	–	665	171
	TOTAL	76 319 689	207 900	1 238	0.016	718	198

Year	Region	Population	No. slides examined	Total no. confirmed cases	API/1000	No. local cases	No. Pf + mixed cases
2013	Caspian	7 360 600	3 217	4	0.001	1	–
	Central plateau	32 659 747	11 847	101	0.003	5	18
	North-west	8 109 695	–	–	–	–	–
	Northeast	7 882 571	4 173	26	0.003	15	7
	Zagros	7 568 986	15 177	32	0.004	5	2
	Southwest	6 196 884	19 924	21	0.003	–	4
	Southeast	10 100 097	184 951	1 196	–	493	269
	TOTAL	77 450 128	239 289	1 380	0.018	519	300
2014	Caspian	7 421 503	2 818	1	0.000	–	–
	Central plateau	33 186 698	28 746	113	0.003	7	5
	North-west	8 162 752	–	–	–	–	–
	Northeast	8 024 648	3 966	21	0.003	14	1
	Zagros	7 613 467	9 429	56	0.007	2	1
	Southwest	6 268 727	8 494	67	0.011	15	–
	Southeast	7 388 159	84 805	1 001	5	332	112
	TOTAL	78 580 567	138 258	1 259	0.016	370	119
2015	Caspian	7 482 406	–	–	–	–	–
	Central plateau	33 713 648	5 975	91	0.003	2	12
	North-west	8 215 808	279	1	0.000	–	–
	Northeast	8 166 725	120	3	0.000	2	2
	Zagros	7 657 949	4 510	77	0.010	12	2
	Southwest	06 340 570	21 348	88	0.014	2	4
	Southeast	7 701 278	67 866	664	–	197	108
	TOTAL	79 711 006	100 098	924	0.012	215	128

Annex 3 Number of confirmed malaria cases by region in I.R. Iran, 1975 to 2009

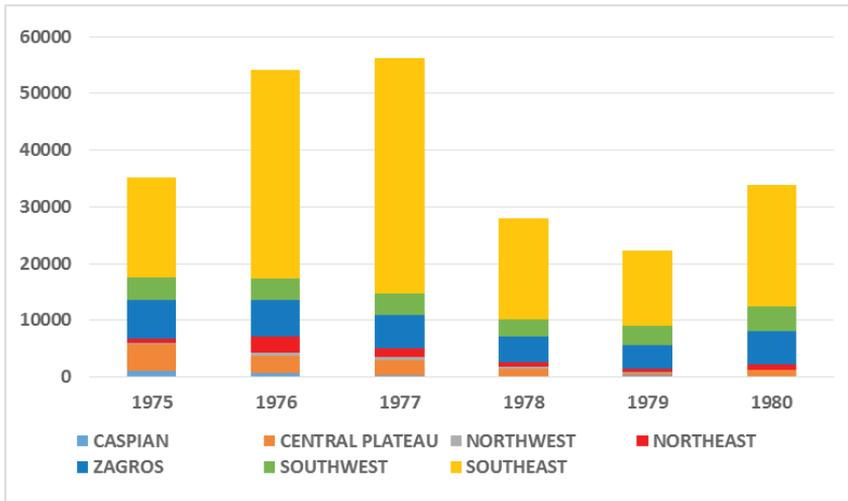


Fig. A3.1. Confirmed malaria cases by region in I.R. Iran, 1975–1980

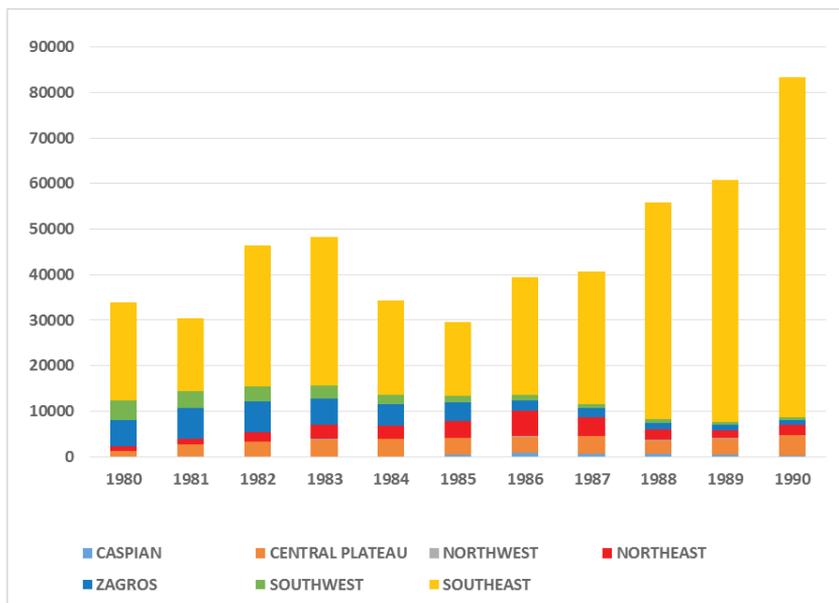


Fig. A3.2. Confirmed malaria cases by region in I.R. Iran, 1980–1990

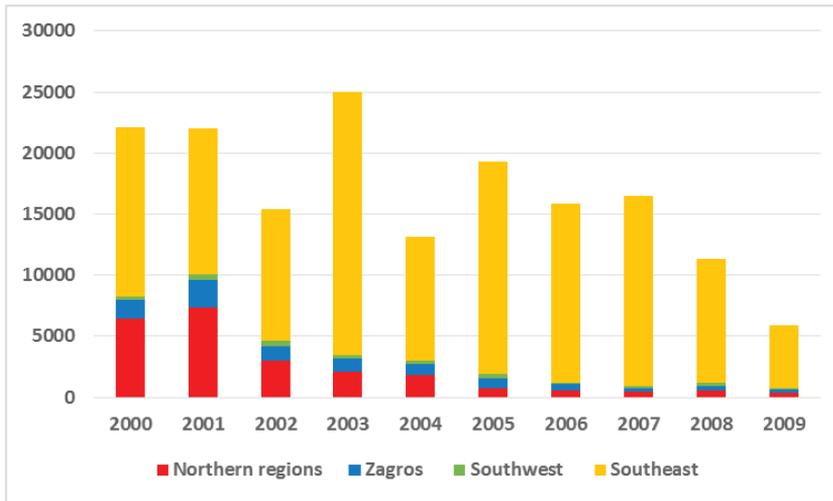


Fig. A3.3. Confirmed malaria cases by region in I.R. Iran, 2002–2009

Northern regions include Caspian, Central plateau, northwest and northeast.

