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Original Article

Incidence, Mortality, and Burden of Malaria and Its Geographical Distribution in Iran during 2002-2015

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Abstract

Background: This study aimed at estimating the incidence, mortality, burden, and geographical distribution of malaria between 2002 and 2015 in Iran.

Methods: DALYs index was used to estimate the burden of malaria. DALYs-related malaria was calculated using a method developed by (WHO) for investigating the Global Burden of Disease (GBD); it was calculated through adding Years of Life Lost (YLLs) due to premature death to Years Lived with Disability (YLDs).The data on the incidence and mortality were collected from the malaria surveillance system in the Center for Communicable Diseases Control (CCDC), Ministry of Health and Medical Education (MOHME).

Results: The incidence of malaria had a decreasing trend over the studied period and it reduced from 15378 cases in 2002 to 777 cases in 2015. Overall, 28 cases of mortality were observed between 2002 and 2015. In addition, disease burden decreased from 90.78 DALYs in 2002 to 22.38 DALYs in 2015.Overall, there were 949.2 DALYs due to malaria from 2002 to 2015. The incidence and burden of malaria were not equally distributed among all the provinces in Iran and some areas were suffering from the highest burden of the disease.

Conclusion: The incidence and burden of malaria have had a decreasing trend over the years of the study and Iran has little to do in order to eradicate malaria. Since the disease is not equally distributed among various provinces of Iran, health policymakers must direct health resources towards specific areas of the country (Sistan and Baluchistan, Kerman, and Hormozgan) with high concentration of cases of malaria.

Keywords: Incidence; Mortality; Disability adjusted life years; Malaria; Iran

Introduction

Malaria is one of the most common parasitic diseases worldwide and half of the world's population lives in areas where they ar e at the risk of this disease (1-3). As reported by the WHO in 2016, 212 million new cases of malaria (144 to 304 million people) were observed in the world; of all new cases, 90%, 7%, and 2% occurred in Africa, south-east Asia, and east Mediterranean region, respectively(4). In the same year, 429 thousand people (235 to 639 thousand people)

died of malaria. The highest and the lowest mortality rates were observed in Africa (92%), and Southeast Asia (6%) and east Mediterranean region (2%). Because of the implementation of some preventive measures, malaria incidence and mortality reduced from 21% in 2010 to 29% in 2015, respectively (2, 4). As stated by Margaret Chan, the former Director-General of the WHO, "*we owe this great achievement to better equipment, political commitment, prosperous regional actions, and significant increase in national and international budgets*"(5).

The WHO adopted "Global Technical Strategy for Malaria 2016-2030" to deal with challenges related to malaria. The strategy sets out ambitious but feasible targets, including a 40% reduction in malaria incidence and mortality in the world by 2020, disease eradication in at least 10 countries by 2020, and prevention reemergence of new cases in countries where the disease has been eradicated (6). In Iran, malaria is reported endemic in some areas. A significant portion of Iran's geography has the potential climate for malaria transmission. Moreover, Iran's neighboring countries like Afghanistan (7, 8), Pakistan (9, 10) and Iraq (11) are the sources of the transmission of malaria into the country through immigrants (12, 13).

Disability-Adjusted Life Years (DALYs) is an index developed by the WHO, World Bank, and Health School of Harvard University for calculating the burden of diseases (14-16). Estimating the burden of diseases helps health sector authorities to better allocate health resources, set goals and focus on high-risk areas, and evaluate health care interventions (17-19). Based on a global report on the disease burden, the global rate of DALYs caused by malaria was 69138000 in 1990, 90438100 in 2005, 82685000 in 2010, and 55769600 in 2015.According to this report, malaria was the 7th leading cause of global burden of diseases in 1990, 2005, and 2010 and 14th leading cause in 2015 (15, 20).

In order to evaluate the effectiveness of interventions implemented to fight malaria, it is necessary to estimate the incidence, mortality, and burden of the disease at national and provincial levels. To our knowledge, no study has ever been conducted in Iran to estimate the burden of malaria. Thus, this study is the first national study that aimed at estimating the incidence and burden of malaria at national and provincial levels. In addition, our study investigated the incidence and burden of malaria over a 14-year period. Therefore, it can be a comprehensive and authentic document for representing the status of malaria in the country.

Methods

Disability-Adjusted Life Years (DALYs) index and the Global Burden of Disease method developed by the WHO were used for calculating the burden of malaria (21). DALYs is calculated through adding Years of Life Lost due to premature death (YLLs) to Years of Life Lost due to disability (YLDs) (18).

$$DALY = YLL + YLD$$

YLL is the number of deaths (N) multiplied by Iranian life expectancy at the age of death in years

$$YLL = N \times L$$

The data on the incidence and mortality from 2002 to 2015 were obtained from the malaria surveillance system in the Centre for Communicable Diseases Control (CCDC), Ministry of Health and Medical Education (MOHME). The age weights were not included in the calculations; however, a discount rate of 0.03 was applied for discounting health values in future years (19). For each age group, the mean age of that group was considered as the mortality age for patients died of malaria. However, the mean mortality ages for the two age groups of 0-1 and 1-5 were set at 0.1 and 2.6, respectively. Life expectancy remaining for each age group was calculated using life tables of Iranians reported by the WHO.

YLD was calculated through multiplying the number of incident cases (I) by the average duration of the disease until remission or death (D) multiplied by Disability Weight (DW).

$$YLD = I \times DW \times D$$

After holding an expert panel, the average period of the disease was set to be 12 d (0.0329 years).

We also used the special disability weight for each age group (Table 1) (22). Disability weight varies from 0 (complete health) to 1 (death).
The data on the population of the country and its provinces during the period of the study was obtained from the Statistical Center of Iran23). For the years without a census, the size of population was estimated based on the population growth rate. The data were analyzed using Excel software (ver. 2010).

Table 1: Disability weight of malaria for various age groups

Age group (yr)	*0-4*	*5-14*	*15+*
Disability Weight	0.211	0.195	0.172

Results

Table 2 presents the incidence, mortality, and burden of malaria by sex from 2002 to 2015. The incidence of malaria had a decreasing trend for both sexes. Overall, 11437 males and 3941 females were suffering from malaria in 2002. In 2015, it reduced to 651 males and 126 females.During the years under study, six deaths from malaria were reported in the country: three of them occurred in people with non-Iranian nationalities (2 Afghans and 1 Pakistani) infected with the disease out of Iran. The disease burden among males was always higher than that among females.The burden of malaria among females reduced from 23.26 DALYs in 2002 to 0.96 DALYs in 2015. The same trend was also observed among males; it reduced from 67.52 DALYs in 2002 to 21.42 DALYs in 2015. Overall, DALYs-related malaria per 1000000 population reduced from 1.370 to 0.284 over a 14-year period.

Table 2: Incidence, mortality, and burden of malaria (DALYs) by sex during 2002-2015

Year	*Sex*	*Total cases of Malaria*	*Cases Leading To Death*	*Total YLL*	*Total YLD*	*Total DALYs*	*DALYs/1000000 Population*
2002	Male	11437	0	0.00	67.52	67.52	1.370
	Female	3941	0	0.00	23.26	23.26	
2003	Male	17154	0	0.00	101.76	101.76	2.201
	Female	7844	0	0.00	46.46	46.46	
2004	Male	9417	0	0.00	55.88	55.88	1.140
	Female	3749	0	0.00	22.19	22.19	
2005	Male	12627	0	0.00	75.25	75.25	1.651
	Female	6658	0	0.00	39.65	39.65	
2006	Male	9924	0	0.00	59.59	59.59	1.351
	Female	5945	0	0.00	35.68	35.68	
2007	Male	10272	0	0.00	61.65	61.65	1.386
	Female	6217	0	0.00	37.31	37.31	
2008	Male	7786	0	0.00	46.38	46.38	0.932
	Female	3536	0	0.00	21.02	21.02	
2009	Male	4062	0	0.00	24.06	24.06	0.479
	Female	1858	0	0.00	11.01	11.01	
2010	Male	2361	0	0.00	13.99	13.99	0.237
	Female	602	0	0.00	3.57	3.57	
2011	Male	2564	0	0.00	14.96	14.96	0.254
	Female	707	0	0.00	4.12	4.12	
2012	Male	1479	2	55.10	10.33	65.43	0.891
	Female	323	0	0.00	2.35	2.35	
2013	Male	1130	2	55.15	1.74	56.89	0.763
	Female	262	0	0.00	1.85	1.85	
2014	Male	1050	1	26.21	7.35	33.56	0.450
	Female	204	0	0.00	1.45	1.45	
2015	Male	651	1	16.91	4.51	21.42	0.284
	Female	126	0	0.00	0.96	0.96	

Fig. 1 presents the trend of the incidence of malaria by sex from 2002 to 2015. Fig. 2 presents the burden of malaria in both sexes over the studied period. Fig. 3 presents the share of YLL and YLD from the total DALYs caused by malaria over the studied period. Due to the lack of reports on death between 2002 and 2011, the share of YLL from the total DALYs was zero. However, the share of YLL form the total DALYs varied from about 5% to 75%-94% between 2012 and 2015.

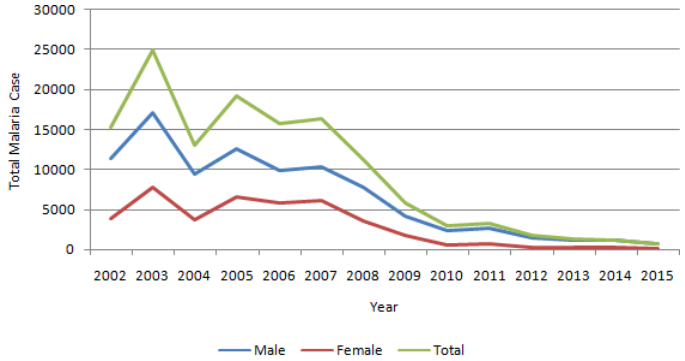

Fig. 1: Time trend of changes in the incidence of malaria by sex during 2002-2015

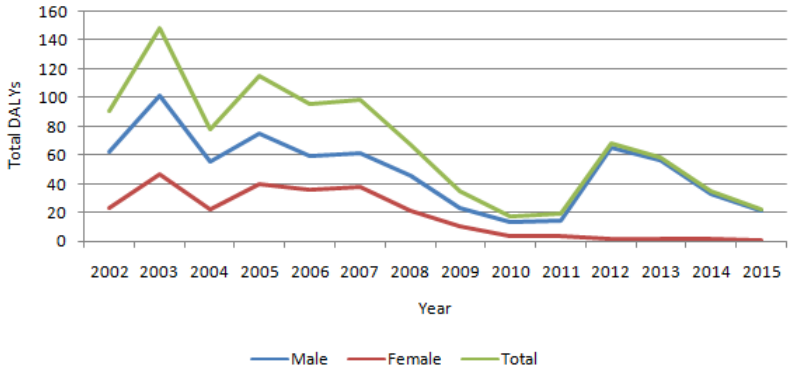

Fig. 2: Time trend of changes in the burden of malaria (DALYs) by sex during 2002-2015

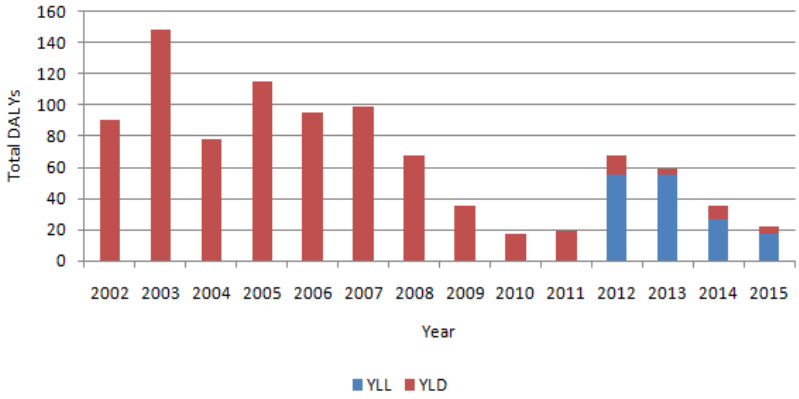

Fig. 3: Share of YLL and YLD in the burden of malaria (DALYs) during 2002-2015

In 2006, Hormozgan (2.54 DALYs/100000 population), Sistan and Baluchistan (2.45 DALYs/100000 population), and Kerman (0.37 DALYs/100000 population) had the highest burden of malaria. In the same year, there was no case of malaria in Ilam, Kermanshah, Kurdistan, Hamedan, Zanjan, West Azerbaijan, and North Khorasan of the 15869 cases with malaria in 2006, the provinces of Sistan and Baluchistan (8317 cases), Hormozgan (5009 cases), Kerman (1363 cases), and Fars (514 cases) had the highest proportion of the patients. More than 17% of the reported patients in the country (2769) were non-Iranians (1617 Afghans, 1142 Pakistanis, and 10 from other countries) and acquired malaria outside Iran. (Fig. 4).

In 2011, the highest burden of malaria was observed in Sistan and Baluchistan (0.65 DALYs/100000 population) and Hormozgan (0.15 DALYs/100000 population). In the same year, there was no case of malaria in Ilam, Zanjan, West Azerbaijan, Tehran, and Alborz (Fig. 5). Of the 3271 cases with malaria in 2011, Sistan and Baluchestan Province (2383 cases), Hormozgan (351 cases), Fars (144 cases), Bushehr (53 cases), and Kerman (51 cases) had the highest proportion of patients.

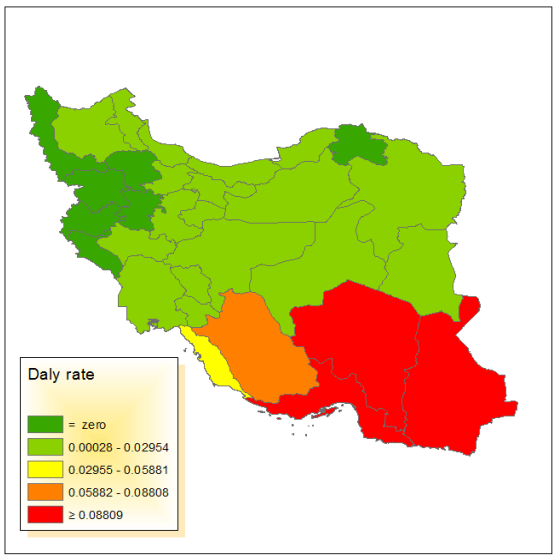

Fig. 4: Geographical distribution of the burden of malaria by DALYs/100000 population in all provinces of Iran, in 2006

About 48% of the reported cases in the country (1568 cases) were non-Iranians (577 Afghans, 966 Pakistanis, and 10 from other countries) and acquired malaria outside Iran.

In 2015, the highest burden of malaria was observed in Tehran (0.13 DALYs/100000 population) and Sistan and Baluchistan (0.11 DALYs/100000population). In the same year, there was no case of malaria in South Khorasan, North Khorasan, Semnan, Chaharmahal Bakhtiari, Kohgiluyeh and Boyer Ahmad, Hamedan, Kurdistan, Ilam, Kermanshah, Lorestan, Markazi, Zanjan, East Azerbaijan, Ardebil, Mazandaran, and Guilan (Fig. 6). Of the 777 cases with malaria in 2015, the provinces of Sistan and Baluchistan (448 cases), Bushehr (81 cases), Fars (76 cases) and Hormozgan (54 cases) had the highest proportion of the disease. In 2015, only one death occurred due to malaria in the country (Tehran Province) and the patient had been infected abroad. More than 50% of the patients reported in the country (359 cases) were non-Iranians (270 cases of Afghans, 151 cases of Pakistanis, and 8 from other countries) and malaria-infected outside Iran.

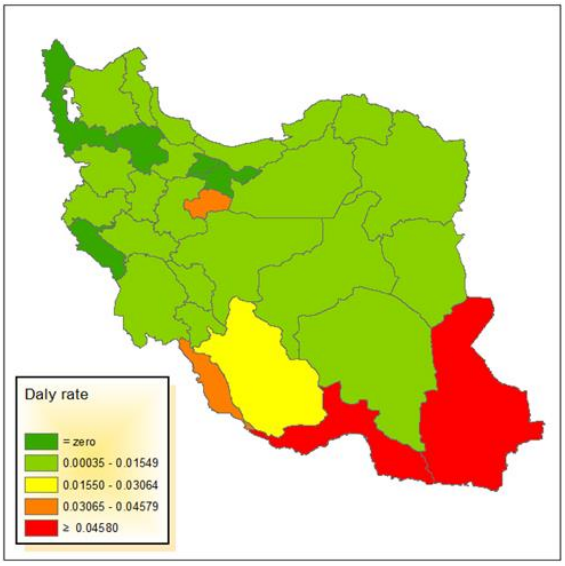

Fig. 5: Geographical distribution of the burden of malaria by DALYs/100000 population in all provinces of Iran, in 2011

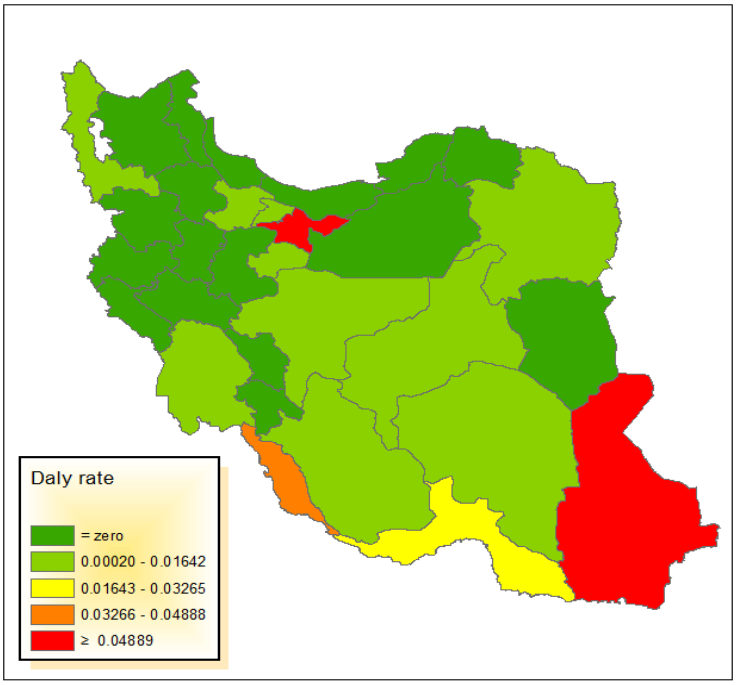

Fig. 6: Geographical distribution of the burden of malaria by DALYs/100000 population in all provinces of Iran, in 2015

Discussion

The results of our study showed a dramatic decrease in the incidence and burden of malaria in Iran between 2002 and 2015. In 2002, the incidence and burden of malaria were 15378 cases (2.32 per 10000 population) and 90.78 DALYs (0.28 per 1000000 population), respectively. However, in 2015, they reduced to 777 cases and 22.38 DALYs, respectively. This downward trend demonstrates the success of interventions and programs to combat malaria. It is also partially due to climate change, such as warming the climate and reducing rainfall (24). In order to achieve the goal of malaria eradication, it is necessary to adopt measures such as controlling border areas to prevent the transfer of patients from outside into the country, strengthening inter-institutional and inter-sectoral cooperation, and strengthening health systems for the rapid identification of possible epidemics and adopting appropriate interventions. A similar decreasing trend was observed in the world, too. In addition, number of DALYs caused by malaria had a 38.3% reduction between 2005 and 2010 (15, 20). Of course, this reduction in the malaria incidence and number of DALYs in Iran is larger than that observed in the world; it indicated the success and effectiveness of interventions carried out in Iran to prevent or control malaria. In Sudan, the estimated incidence and burden of malaria were 9 million cases (282 cases per 1000 population) and 2.877 million DALYs (191.33 per 1000 population), respectively (25). In Quanda city of Zimbabwe, the incidence of malaria was 2.12, 0.63, 0.99, 1.43, and 0.49 per 1000 population from 2011 to 2015, respectively. In addition, number of DALYs caused by malaria was 153.47, 0.22, 0.35, 27,25, and 0.18 per 1000000 population in the same years of the study, respectively. Number of DALYs was reduced in Quanda over the studied period (22).

Results of our study indicated that, on average, each case of malaria led to 0.007 loss of DALYs. This loss was 0.320 DALYs in Sudan in 2002(17) and 0.349 DALYs in Zimbabwe from 2011 to

2015 (22). The observed difference can be attributed to the high mortality rate of malaria in Sudan (0.00488 in 2002) and Quanda (0.00834 over five years of study) as compared withIran (0.00004 over a 14-year study period). Because of the lack of reports on the number of deaths caused by malaria in Iran between 2002 and 2011, the share of YLD from DALYs was 100%. However, between 2012 and 2015, since six deaths were reported, this percentage varied from 13% to 21%. The share of YLD from the total DALYs was 3% in Sudan in 2002 (25). In Quanda, the share of YLD from the total DALYs was 0.05%, 100%, 100%, 2%, 100%, from 2011 to 2015, respectively (22).

According to the results of our study, the incidence, mortality, and number of DALYs lost due to malaria were higher in males, as compared with females. These findings are in line with results of a study (22). Moreover, in Sudan, the incidence and mortality of malaria in males were more than that in females; however, the number of DALYs lost due to malaria was higher among females than males (25). Based on the findings of our study, the incidence and burden of malaria varied between different provinces of Iran, and the high share of the incidence and burden of this disease was observed in several provinces of the country, including Sistan and Baluchistan, Hormozgan, Bushehr, Fars, and Kerman. To prevent, control, and eliminate malaria, policymakers and health managers should pay special attention to these provinces. During the studied years, the incidence of malaria in specific provinces (with the highest incidence) decreased significantly. For instance, the incidence of malaria between 2002 and 2015 varied from 6,394 to 448 in Sistan and Baluchistan, from 2695 to 54 in Hormozgan, from 1609 to 23 in Kerman, decreased 321 to 81 in Bushehr, and from 1073 to 76, in Fars, decreased. A significant percentage of reported cases of malaria in Iran occurred among non-Iranians or they had been infected outside Iran; accordingly, it has been 17% (2769 out of 15869 cases) in 2006, 48% (1568 out of 3271 cases) in 2011, and 51% (359 out of 777 cases), respectively. In addition, more than 98% of the new cases were transmitted from Pakistan and Afghanistan. Therefore, it is necessary to consider the border areas, quarantine, and visit travelers and individuals entering the country from Afghanistan, Pakistan, and Iraq, and provide antimalarial drugs to travelers to these countries and other malaria-endemic countries to prevent and eliminate this disease.

Conclusion

The incidence of malaria and the number of DALYs lost due to it did not have an equal distribution in Iran. The main burden of malaria is observed in some specific provinces. Iran has little to do in order to eradicate malaria, therefore, health authorities and policy-makers should direct the resources towards provinces where are the foci of malaria. Although the number of cases with malaria has reduced in the country and the disease is close to being eradicated, we still must pay enough attention to this disease and keep it as an agenda for health policymakers. Neighboring with countries such as Afghanistan and Pakistan, as the countries at high risk of malaria and the risk of treatment-resistant malaria threaten the success of steps taken in Iran and in the world to reduce the incidence of the disease. If we do not pay enough attention to these issues, the incidence and mortality rate of malaria will rise again. In addition, with a reduction in the number of cases with malaria, per capita cost spent for reducing every case of malaria will increase.

Ethical considerations

Ethical issues (Including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, redundancy, etc.) have been completely observed by the authors.

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Conflict of interest

The authors declare that there is no conflict of interests.

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