Am. J. Trop. Med. Hyg., 93(6), 2015, pp. 1240–1248
doi:10.4269/ajtmh.14-0486

A Cost-Effectiveness Analysis of *Plasmodium falciparum* Malaria Elimination in Hainan Province, 2002–2012

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Abstract. In Hainan Province, China, great achievements in elimination of falciparum malaria have been made since 2010. There have been no locally acquired falciparum malaria cases since that time. The cost-effectiveness of elimination of falciparum malaria has been analyzed in Hainan Province. There were 4,422 falciparum malaria cases reported from 2002 to 2012, more cases occurred in males than in females. From 2002 to 2012, a total of 98.5 disability-adjusted life years (DALYs) were reported because of falciparum malaria. Populations in the age ranges of 15–25 and 30–44 years had higher incidences and DALYs than other age groups. From 2002 to 2012, malaria-related costs for salaries of staff, funds from the provincial government, national government, and the GFATM were US$3.02, US$2.24, US$1.44, and US$5.08 million, respectively. An estimated 9,504 falciparum malaria cases were averted during the period 2003–2012. The estimated cost per falciparum malaria case averted was US$116.5. The falciparum malaria elimination program in Hainan was highly effective and successful. However, funding for maintenance is still needed because of imported cases.

INTRODUCTION

Hainan Island, located in the tropics, is a province that had the highest incidence of malaria in China before 2002.[1] Most of the malaria cases were caused by *Plasmodium falciparum* or *Plasmodium vivax* or by a combination of both species. Historically, the malaria endemic area was located in the forested areas in the central and southern parts of the island, where *Anopheles minimus* and *Anopheles dirus* were the main vectors. In the 1950s, *P. falciparum* infection and the mixed infections of both *P. falciparum* and *P. vivax* accounted for 74.1% of all malaria cases. However, after decades of implementing large-scale antimalarial programs in Hainan, the malaria incidence declined by 98% from 1955 to 1995. The percentage of infections of *P. falciparum* alone or mixed infections of both species decreased to 35.1 in the 1980s and 29.2 in the 1990s.[2] Malaria cases accounted for 28.7% (4,678/16,136) of all infectious diseases in Hainan Province, China, in 2001, which was a serious health challenge at that time.

In accordance with national and provincial policy, and with support from the World Health Organization (WHO) and the Global Fund for AIDS, Tuberculosis and Malaria (GFATM), a program aimed to eliminate falciparum malaria had been implemented in Hainan Province since 2003. The key interventions of the program include treatment of infected patients through passive and active surveillance, vector control (indoor residual spraying [IRS], insecticide-treated nets [ITNs], long-lasting insecticide-treated bed nets [LLINs] [starting in 2007]), and high-risk population management (mainly mountain populations and migrants). These interventions reduced both falciparum and vivax malaria, especially the former,[2] and there have been no locally acquired falciparum malaria cases through passive or active surveillance since 2010. This indicates that falciparum malaria has been eliminated from Hainan Province.[3]

Cost-effectiveness analysis, which provides information that is crucial for policy recommendations for malaria control at both the national and international levels, can help guide the optimal allocation of health-sector resources.[4] Reported here are the results of the cost-effectiveness analysis of elimination of falciparum malaria in Hainan Province from 2002 to 2012.

MATERIALS AND METHODS

Falciparum malaria cases. Falciparum malaria cases were identified by laboratory (including microscopic detection, rapid diagnostic test, and polymerase chain reaction) or clinical diagnosis.

Data collection. Data were collected from published literatures[1,5,6] and the Infectious Disease Management System of the National Center for Disease Control and Prevention. The collected data included the number of falciparum malaria cases, number of falciparum malaria-associated deaths, gender and age of patients, and dates of onset of symptoms and visits to a health facility. The imported cases were first included in statistical analysis in 2009.

Early diagnosis and treatment. The aim of this strategy was to diagnose and treat malaria cases promptly so as to prevent them becoming severe or lethal. To ensure that all fever cases were identified and treated, a training program was launched to aim at every hospital, Centers for Disease Control and Prevention (CDC), and every health centers possessing one or two microscope inspectors. Every fever case was subjected to a peripheral blood smear, and appropriate presumptive treatment for malaria was initiated.

Seasonal antimalaria. Most malaria cases occurred in Hainan Province from May to October each year. The antimalaria program was set up in hyperendemic area in April and August every year. Interventions, including mass drug administration (MDA), target drug administration (TDA), IRS, ITNs, and LLINs, were delivered to habitants. In this program, MDA means each individual in a defined population or geographical

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area was required to take antimalarial treatment on a given day in a coordinated manner, including the people who are not sick and not infected with malaria parasites at the time. Depending on the contraindications of the medicines used, pregnant women, young infants, and other population groups are excluded from the program.[7] TDA means every individuals who had been infected by falciparum malaria within 1 year or vivax malaria within 2 years or blood test with parasite positive were required to take antimalarial treatment. Drugs are generally a less satisfactory way of preventing infections, as they have to be taken regularly over the period for which protection is required. The number of the population that should take drugs (NPTD) and take drugs at reasonable doses were calculated. The NPTD was more than 90% at reasonable doses. Either deltamethrin or lambda-cyhalothrin was used for vector control, including IRS and ITN. The MDA and vector control programs were deliberately chosen in remote villages where major vectors, malaria outbreak spots, and construction sites with high incidences were present.

Costs for falciparum malaria elimination. Costs data (in U.S. dollars) including salaries of staff and funds from the national, provincial governments and the GFATM were collected. Expenditure was disaggregated by capital and recurrent expenditure showing the difference between investment costs that are one-off and recurrent costs that are ongoing and represent the running costs of any program implementation (see Table 1). Capital costs included training and purchase of computers and some equipment (including vehicles, microscopes, anatomical lens, sprayers, refrigerators, nets, LLINs, and so on). Recurrent costs included staff-related costs, consumables, and fees. All costs of items were valued according to their market values in the year where they were purchased, in either China RMB (renminbi in yuan) or U.S. dollars. All costs in Chinese yuan were exchanged to the U.S. dollars based on the exchange rate (China ¥ − US$) for the year in which they were incurred.

Reported local malaria cases were classified as falciparum, vivax, and unclassified malaria cases. The annual investments for falciparum malaria elimination in Hainan was measured by calculating the total expenditure for malaria elimination and determining the ratio of falciparum malaria cases based on the total number of malaria cases.

$$\text{Costs on falciparum malaira elimination} = \text{Total costs} \times \frac{\text{Falciparum malaria cases}}{\text{All malaria cases}}$$

Disability-adjusted life years. Disability-adjusted life years (DALYs) are the sum of years of life lost (YLLs) and years of life lived with disability (YLDs); it can be calculated by formulas described by Fox-Rushby and Hanson.[8]

$$\text{DALYs} = \text{YLLs} + \text{YLDs}$$

$$\text{YLLs} = \frac{Ce^{(ra)}}{(\beta + r)^2}\left\{e^{-(\beta+r)(L+a)}[-(\beta + r)(L + a) - 1] - e^{-(\beta+r)a}[-(\beta + r)a - 1]\right\}$$

where C = constant (0.1658), r = discount rate (0.03), a = age of death, β = parameter from the age weighting function (0.04), L = standard expectation of life at an age, and e = 2.72 (approximately).

Table 1
Financial costs, 2002–2012

	US$	%
Capital		
Training	564,087.44	4.79
Computers and other electronic products	179,064.76	1.52
Vehicles	220,028.15	1.87
Microscopes	193,234.80	1.64
Sprayers	425,015.17	3.61
Anatomical lens	19,754.82	0.17
Refrigerators	26,289.10	0.22
Warehouse rental	810.45	0.01
Planning costs	182,895.23	1.55
Set up electronic malaria statement system	15,406.73	0.13
Establishing microscopy laboratory	3,039.20	0.03
Establishing G6PD testing laboratory	30,392.03	0.26
Meeting	190,950.58	1.62
Improve the packaging of antimalaria drugs	10,130.68	0.09
Nets	137,155.25	1.16
LLINs	279,759.53	2.38
Printing	114,628.34	0.97
Subtotal	2,592,642.27	22.01
Recurrent costs		
Case treatment materials and activities	726,409.49	6.17
Insecticides	353,804.53	3.00
Rapid diagnostic test	124,512.71	1.06
Consumable items for vector monitor	506.53	0.00
Distribution	72,169.67	0.61
Monitor	102,705.81	0.87
Promotion materials and activities	503,725.60	4.28
Supervision and evaluation	476,718.42	4.05
Blood test	1,337,135.62	11.35
Management of malaria outbreak	301,871.41	2.56
Personnel	3,832,855.66	32.54
Management cost	261,043.21	2.22
Vector control	971,849.24	8.25
Baseline survey	120,093.09	1.02
Subtotal	9,185,400.97	77.99
Total financial costs	11,778,043.24	100

G6PD = glucose-6-phosphate dehydrogenase.

According to the Fifth National Population Census report, the life expectancies of men and women were 74.2 and 79.0 during 2002–2004, respectively. The formula for YLDs differs from the YLLs only in the addition of D and the definition of L, which is shown below:

$$\text{YLDs} = \frac{DCe^{(ra)}}{(\beta + r)^2}\left\{e^{-(\beta+r)(L+a)}[-(\beta + r)(L + a) - 1] - e^{-(\beta+r)a}[-(\beta + r)a - 1]\right\}$$

where C = constant (0.1658), r = discount rate (0.03), a = age of onset of disability, β = parameter from the age weighting function (0.04), and e = 2.72 (approximately).

Because there was no data available on neurological sequelae and anemia, the values of L (duration of disability) and D (disability weight) were 0.01 years and 0.211, respectively, according to Tediosi and others,[9] Goodman and

others,[10] and Murray and Lopez.[11] The age data of patients have been used to calculate the DALYs of a patient except for 2002–2004 because of lack of data.

Consequence of the interventions. Consequence of interventions was measured by the number of falciparum malaria cases averted. Falciparum malaria cases averted were estimated by the reduction of the annual malaria incidence rate multiplied by the total person's life years at risk.[12] In 2002, the project "Pilot Study of Falciparum Malaria Control and Elimination in Hainan Province, China," funded by the WHO, was launched in lower falciparum malaria–epidemic area, and followed up with falciparum malaria elimination program in 2003 in the whole province sponsored by the GFATM. The data for 2002 was used as the base line to calculate falciparum malaria cases averted from 2003 to 2012, which is shown below:

$$\mathrm{CA} = \sum_{2003}^{2012}\left(\left(P_i \times I\right) - C_i\right)$$

where CA = cases averted, P = total populations in Hainan Province, I = incidence of falciparum malaria in 2002, C = falciparum malaria cases, and i = year.

Cost-effectiveness analysis. The cost per falciparum malaria case averted was estimated by using the cumulative costs of the interventions implemented from 2003 to 2012 and the estimated number of falciparum malaria cases averted as a result of elimination interventions.

RESULTS

Disease burden. A total of 4,422 falciparum malaria cases, with five deaths, were reported in Hainan Province from 2002 to 2012. Although the incidence of falciparum malaria was higher in 2004 than that in 2003, the prevalence of falciparum malaria showed an overall declining trend across the decade (Table 2). In 2005, the incidence of falciparum malaria decreased to a level lower than 100/1,000,000 with no deaths. From 2010 to 2012, no locally acquired falciparum malaria cases were reported. However, imported falciparum malaria cases showed an increasing trend from 2009 to 2012. From 2005 to 2012, more falciparum malaria cases occurred in males than in females, with more than 1.7 annual sex ratio (male/female) (Figure 1). The highest incidence of falciparum malaria in the period 2005–2007 was in the age group 30–44 years, regardless of gender (Figure 2).

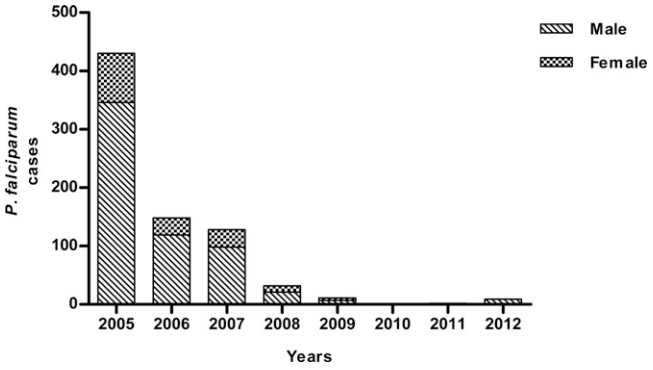

FIGURE 1. Gender distribution of falciparum malaria cases from 2005 to 2012 in Hainan Province, China. Gender data for falciparum malaria from 2002 to 2004 were not available.

Costs. Historically, the endemic area of falciparum malaria was located in the central and southern part of Hainan Province. About 56.0% (142/254) of towns and 17.1% (1,358,112/8,105,200) of the population were at risk.

From 2002 to 2012, the numbers of individuals receiving blood tests and antimalarial medications were 2,022,375 and 601,234, respectively. The covered area of IRS was 4,790,409 m^2 and the number of ITN was 1,003,076 (Table 3). From 2007 to 2011, 309,608 LLINs were used in Hainan Province. As shown in Table 3, interventions to falciparum elimination were significantly decreased in 2012.

During the period 2002–2012, malaria-related costs for staff salaries, funds from provincial, national governments, and the GFATM were US$3.02, US$2.24, US$1.44, and US $5.08 million, respectively (Figure 3). Besides salaries of staff, the GFATM was the major financial support for the prevention of malaria in Hainan Province, and it accounted for equal or more than 50% except for the years 2002, 2003, and 2005 (Figure 3).

The total financial costs of malaria control was US $11,778,043, with capital and recurrent costs accounting for

TABLE 2
Malaria incidence in Hainan Province, China, from 2002 to 2012

Year*	No. of population	Total no. of malaria cases†	Falciparum malaria cases‡				
			Local cases	Imported cases	Subtotal	No. of death§	Incidence‖
2002	7,955,500	5,354	1,210	–	1,210	1	152.10
2003	8,047,983	6,357	982	–	982	1	122.02
2004	8,142,155	9,382	1,469	–	1,469	3	180.42
2005	8,277,196	4,480	430	–	430	0	51.95
2006	8,287,308	3,853	148	–	148	0	17.86
2007	8,355,040	3,387	128	–	128	0	15.32
2008	8,400,616	1,844	32	–	32	0	3.81
2009	8,445,994	685	9	2	11	0	1.30
2010	8,496,938	78	0	1	1	0	0.12
2011	8,501,390	9	0	2	2	0	0.24
2012	8,560,292	13	0	9	9	0	1.05

*Data from 2002 to 2004 were reported by Sheng and others[1] and Zhou and others.[5,6]
†No. of malaria cases including falciparum, vivax, and unclassified malaria cases.
‡Source of falciparum malaria cases were not classified from 2002 to 2008.
§No. of death because of falciparum malaria.
‖Incidence = $\frac{\text{No. of falciparum malaria cases}}{\text{No. of population}} \times 1{,}000{,}000$.

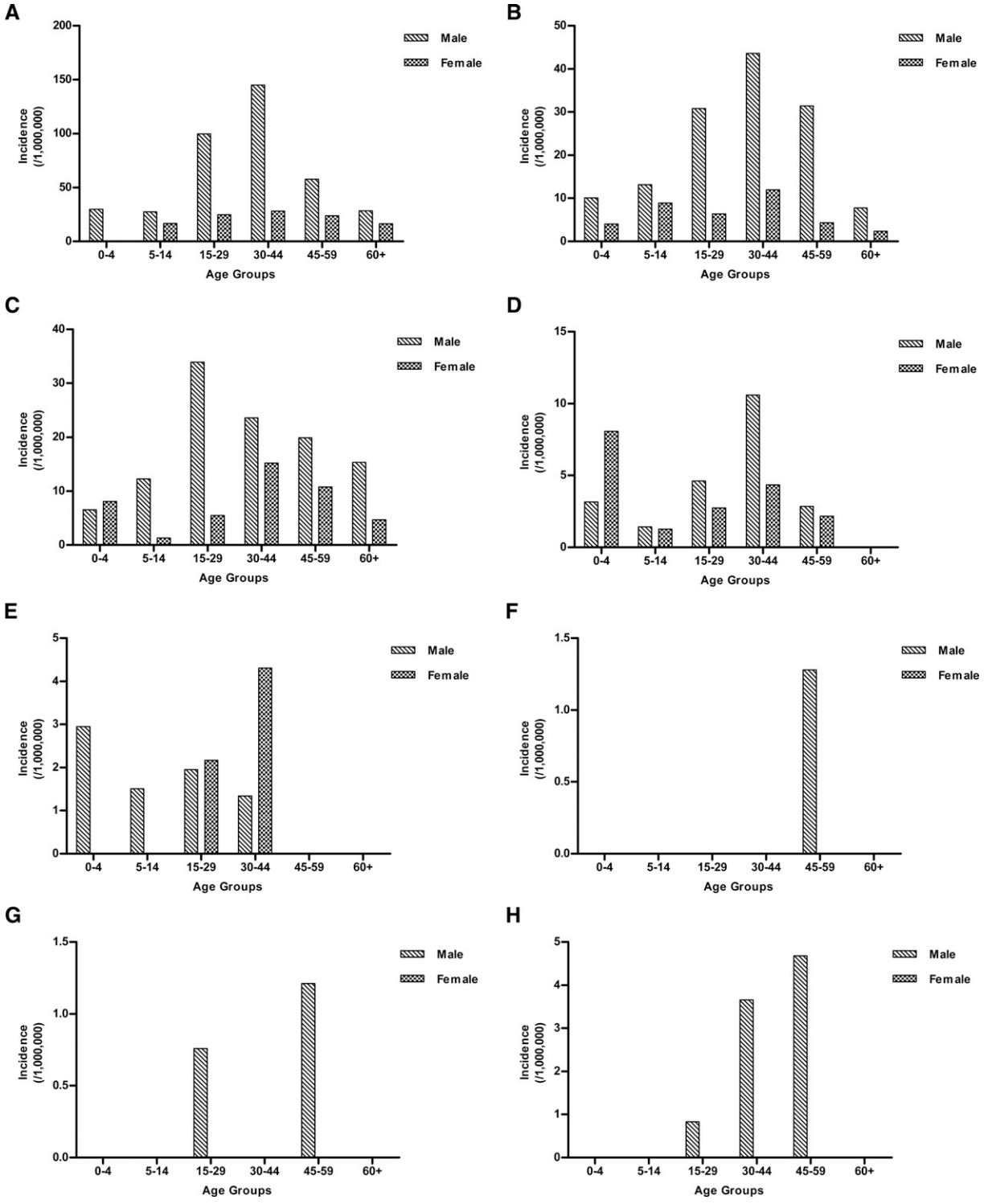

FIGURE 2. Age and gender distribution of falciparum malaria incidence (/1,000,000) from 2005 to 2012 in Hainan Province, China. Gender and age data for falciparum malaria from 2002 to 2004 were not accessible. (**A**–**H**) Data for 2005–2012, successively.

22% and 78%, respectively. The largest individual cost item was that of personnel, which amounted to 32% of the total cost, and at 11%, blood testing was the second largest item. Staff time spent on vector control, health promotion, distribution, and management is presented in Table 1.

DALYs. From 2002 to 2012, a total of 98.5 DALYs (96.4 YLLs and 2.1 YLDs) were observed. DALYs of falciparum malaria decreased yearly from 2005 to 2010 (from 1.2 to 0.003), but increased a bit from 2010 to 2012. Males had 1.8–4.3 times more DALYs than females from 2005 to 2009 (Figure 4). Regardless of age stratifications, males showed a greater loss of DALYs compared with their female counterparts, except populations in the age ranges of 0–4 years in 2008 and 30–44 and 45–59 years in 2009. From 2005 to 2009,

TABLE 3
Major measures in malaria elimination from 2002 to 2012 in Hainan Province, China

		MDA			TDA				Insecticides for vector control	
Years	No. of blood tests	NPTD	NPRD	%	NPTD	NPRD	%	No. of LLINs	Area of IRS	No. of ITN
2002	169,903	28,731	26,629	96.05	31,580	26,882	93.01	0	0	26,669
2003	170,609	21,115	19,687	97.98	27,623	25,854	97.42	0	988,165	31,098
2004	196,655	6,760	6,419	98.69	10,180	9,994	99.68	0	869,996	57,551
2005	196,643	30,241	28,800	98.5	25,635	24,769	98.65	0	506,935	58,624
2006	210,197	131,154	104,080	85.29	45,995	43,707	98.88	0	1,049,305	55,188
2007	282,107	31,374	27,089	94.56	30,710	29,974	99.05	48,293	248,425	177,742
2008	174,170	32,728	30,719	99.68	56,628	54,426	98.79	159,366	1,257	162,064
2009	185,618	37,224	35,592	99.39	58,256	56,332	98.74	53,122	282,908	158,541
2010	182,066	13,649	12,478	97.11	18,196	17,201	97.89	28,722	470,701	138,548
2011	118,319	10,634	9,535	98.82	7,743	7,552	99.11	20,105	326,097	89,695
2012	136,088	614	592	96.42	3,053	2,923	95.74	0	46,620	47,356
Total	2,022,375	344,224	301,620	87.62	315,599	299,614	94.94	309,608	4,790,409	1,003,076

IRS = indoor residual spraying; ITN = insecticide-treated nets; LLINs = long-lasting insecticide-treated nets; MDA = mass drug administration; NPRD = no. of population that take drugs at reasonable doses; NPTD = no. of population that should take drugs; TDA = target drug administration; % = rate of taking drugs at reasonable doses (NPRD/NPTD × 100%).

the DALYs were more frequent in the populations in the age ranges of 15–29 and 30–44 years (Figures 4 and 5).

Cost-effectiveness of elimination of falciparum malaria. The additional costs for the elimination of falciparum malaria, compared with the alternative "continued control" strategy were US$1,750,030.6. An estimated 9,504 cases averted were observed. The estimated cost per case averted from 2003 to 2012 was US$116.5. There were 7,603 and 1,901 cases averted among males and females, respectively. More averted cases occurred in the populations in the age ranges of 15–29 and 30–44 years (Figure 6).

DISCUSSION

Data analysis of falciparum malaria elimination during the period 2003–2012 in Hainan Province showed that the locally acquired falciparum cases were reduced to zero with no death since the beginning of 2005.

Effective interventions for falciparum malaria elimination included blood testing for fever cases, management of migrated populations, IRS, ITNs, and artemisinin-based combination therapy treatment.[13,14] The estimated cost of US$117 per falciparum malaria case averted during the period 2003–2012 was higher than that of the ITN in Gambia and environmental management in Zambia, which were US$15.8 and US$22.2, respectively.[12,15] However, the costs for the treatment and prevention will be reduced in Hainan Province, because the treatment and intervention measures for the imported malaria cases will be limited to restricted geographic areas such as entry ports. The preventive interventions carried out in Hainan Province gained remarkable achievement in terms of eliminating locally acquired falciparum malaria. No locally acquired falciparum malaria cases have been reported and no malaria parasites have been found from a total of 436,473 individual blood samples in the past 3 years. This indicates that falciparum malaria elimination has achieved its goal in Hainan Province.

Adequate funding is the most important requirement for malaria prevention. Many countries and regions throughout the world have experienced increases in the incidence of malaria due to shortages in funding or failures in implementation of preventive interventions. For example, the number of falciparum malaria cases in India soared from 100,000 in 1965 to 6,000,000 in 1976 because the government did not provide sufficient funding to procure adequate amounts of dichlorodiphenyltrichloroethane.[16] The WHO-funded dieldrin spraying has greatly reduced the incidence of malaria in the western Kenya highlands; however, after the local government took over control and prevention interventions in 1957, the incidence of malaria in this area increased significantly in 1959

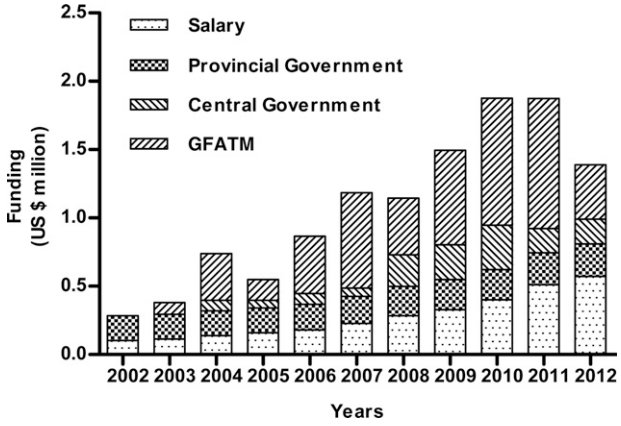

FIGURE 3. Histogram of funding for salaries of staff and funds from provincial, central governments, and the GFATM from 2002 to 2012 in Hainan Province.

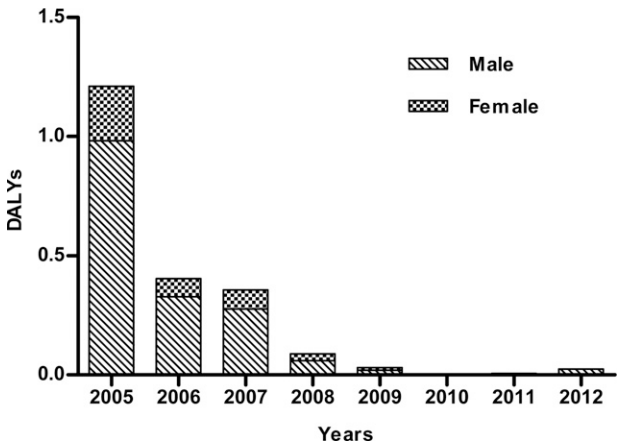

FIGURE 4. Gender distribution of disability-adjusted life years (DALYs) from 2005 to 2012.

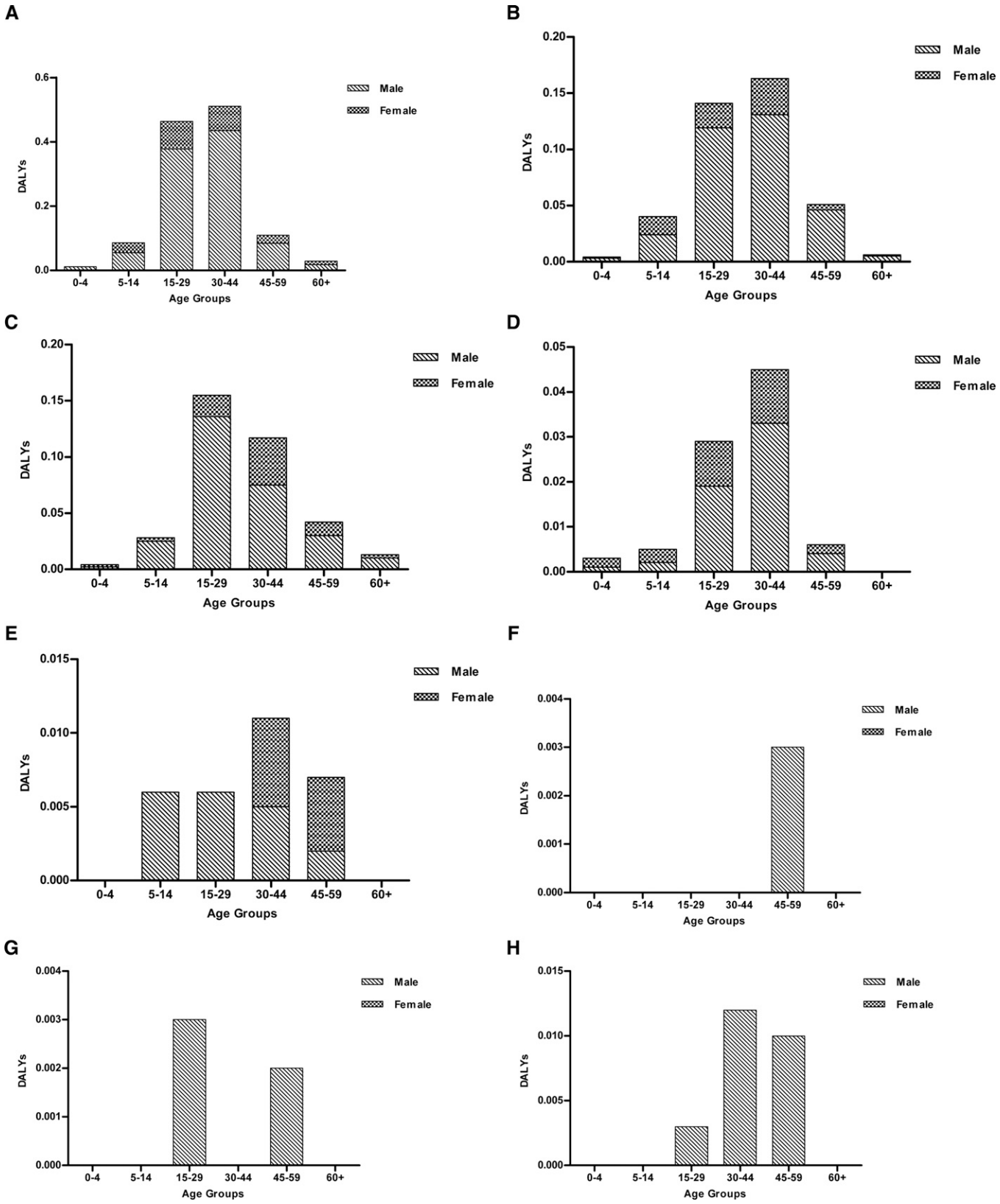

FIGURE 5. Age and gender distribution of disability-adjusted life years (DALYs) during 2005–2012. (**A**–**H**) Data for 2005–2012, successively.

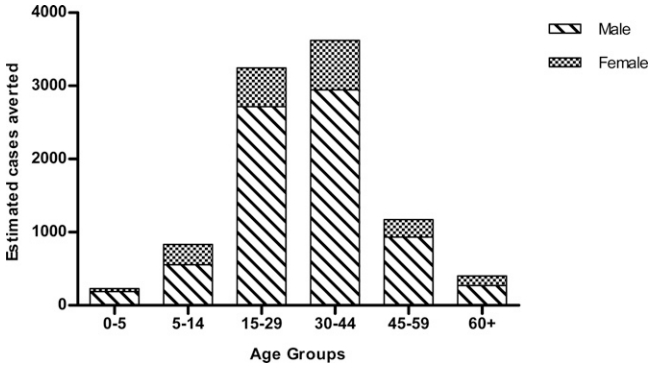

FIGURE 6. Gender and age distribution of estimated cases averted from 2003 to 2012.

due to lack of enough funds.[17] Because of financial difficulties in 1998, the total number of cases in 10 malaria eradication pilots in Hainan Province increased by 17.9% over the previous year.[18] For a decade, the GFATM has been the major funding source for falciparum malaria elimination in Hainan Province. Because of the investments from both international organizations and domestic financial institutions, Hainan Province has achieved falciparum malaria elimination with no locally acquired falciparum malaria from 2010 to 2012. Elimination programs will require additional resources to develop and sustain the strong health systems to prevent the reintroduction of malaria.[19] Unfortunately, the GFATM for malaria elimination in Hainan has been terminated since 2012. The sustainable achievement for malaria elimination in Hainan requires the local government to search for new investments and funding from other organizations or institutions.

In 2012, expenditure for the elimination of malaria was significantly decreased compared with those in 2011 and 2010, and some conventional antimalarial interventions were also conducted at a dramatically reduced frequency (Table 3, Figure 3). Since there were no locally acquired falciparum malaria cases reported, further work in the field of malaria elimination has focused on blood testing, which would help to identify imported cases and prevent subsequent local transmission. Compared with the elimination phase, the malaria control phase requires increased workload and financial support because additional blood testing, IRS, and ITN should be carried out at the same time. The continued support of malaria elimination programs is essential in Hainan Province because maintaining elimination is less costly than sustaining high levels of control.[20]

Over the 10 years, the program had averted an estimated 9,504 falciparum malaria cases. The estimated cost per case averted was US$116.5, and no endemic falciparum malaria cases were reported since 2010. According to the WHO criterion for malaria elimination, falciparum malaria has been eliminated from Hainan Province. During the context of malaria elimination campaigns, few cases were reported, but large costs were needed because of intensive monitors. Cost per case averted was used in our cost-effectiveness analysis. Compared with other areas, our interventions seem "unattractive" because large costs were needed to eliminate falciparum malaria with few falciparum malaria cases.[4,12,15] Although prevention and treatment costs, in highly endemic areas, are generally very cost-effective, elimination presents different economic issues. Elimination is contemplated only in situations with relatively few malaria cases. Thus, new strategies are likely to yield relatively few malaria cases or deaths averted when compared with the same strategies in high-burden settings.[20] Malaria elimination is a valuable investment.[21] It is noteworthy that this study assessed only measurable benefits and did not analyze other potential benefits that may have been brought about by malaria elimination, such as improving the investment environment and stimulating tourism development.[20] Considering the potential benefits of malaria elimination, the profound significance of falciparum malaria eradication can hardly be measured in terms of monetary value.

Because of the increase in international migrants to Hainan Province,[22] the number of imported falciparum malaria cases exhibited an increasing trend in recent years (Table 2). Thus, recognizing and understanding the influence of immigration populations will help to improve interventions against malaria.[23] In case a locally acquired falciparum malaria case is identified, health education and hygiene promotion should be carried out among nonimmunized migrant workers to prevent them from infecting in endemic areas with malaria. On the other hand, imported falciparum malaria cases should be reported immediately to avoid outbreaks of falciparum malaria resulting from the import of the parasite.[24,25] In current situation, future work attempting to eliminate malaria in Hainan Province should be focused on preventing the entry of individuals carrying malaria into areas with potential malaria vectors and on educating individuals returning from travel abroad, especially those returning from Africa. Approximately 125 million international travelers visited malaria-endemic countries yearly, and over 10, 000 cases are reported after returning home worldwide.[26] It makes malaria a threat not only to nonimmune travelers, but also among local populations where those travelers live. For countries and areas that are near to or have already achieved elimination, imported malaria is a risk for resurgence or reintroduction of malaria.[27] In Mauritius, local vivax malaria transmission was reestablished in 1975 after large cyclones created new breading sites, and parasitemic workers from endemic countries arrived to rebuild the damaged infrastructure.[28] Also, in Hainan Province, resurgence of malaria was reported because of imported malaria.[29–31] In the past few years, local malaria cases were decreased annually in China, and locally acquired falciparum malaria cases were only reported in the China–Myanmar border.[32–34] From 2009 to 2012, all imported falciparum malaria cases in Hainan Province were from Africa and the southeast Asia and showed an increasing trend year by year (Table 2). It is obvious that risk from overseas is higher than neighboring provinces and internal migrants in Hainan Province.

After the 1990s, mountain climbing became the dominant pathway of falciparum malaria transmission in Hainan Province.[35] Since individuals participating in mountain climbing are mainly young men, the male population and individuals in the age range of 15–59 years showed higher incidences of falciparum malaria infection (Figure 2). In contrast, in Sudan, in-village transmission is the major pathway of falciparum malaria infection. Thus, in Sudan, infants and the elderly are most susceptible to *P. falciparum*, and there was no difference in the prevalence between genders.[36]

The goal of falciparum malaria elimination was achieved in Hainan Province because there were no locally acquired

falciparum malaria cases reported from 2010 to 2012. However, lots of measures are needed to be taken to maintain the situation in the future. First, it is obvious that the maintenance of the adopted strategies to achieve malaria elimination (and sustain thereafter) would require substantial funding, and such monetary allocations in the midst of conflicting priorities for the government certainly is a challenge and will be more so in the future.[37] Second, although cases imported from other countries have not led to secondary cases in the past years, careful surveillance and further research to prevent the reintroduction of malaria by imported cases from other countries are necessary and required.[27] Third, health education and health promotion intervention contributed to the early diagnosis of malaria, especially to the population that visited falciparum malaria-endemic countries recently. Early diagnosis and prompting treatment of malaria patients and asymptomatic parasite carriers block transmission effectively.

Received August 4, 2014. Accepted for publication August 6, 2015.

Published online October 5, 2015.

Acknowledgments: We thank the patients who participated in this report and the staff from County's Center for Disease Control and Prevention and Charolette Hall, and Lisa Drake who edited the manuscript.

Financial support: This study received financial support from Natural Science Foundation of China (grant no. 81460520) and the Hainan Provincial Scientific Research grant (no. 813251).

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