Malaria in China, 2011-2015: an observational study

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# ABSTRACT

**Objective** To ascertain the trends and burden of malaria in China and the costs of intervention for 2011-2015 while experiencing transitions between funders during a national plan launched to interrupt malaria transmission in most counties by 2015 and ultimately eliminate malaria by 2020.

**Methods** We analysed the spatiotemporal and demographic features of autochthonous and imported malaria using disaggregated surveillance data on malaria from 2011 to 2015, covering the range of dominant malaria vectors in China. The total and mean costs for malaria elimination were calculated by funding sources, interventions, and population at risk.

**Findings** A total of 17,745 malaria cases, including 123 deaths (0.7%), were reported in mainland China from 2011-2015, with 89% being imported cases, mainly from Africa and Southeast Asia. Most counties (99.9%) have achieved their elimination goals by 2015, and autochthonous cases dropped from 1,469 cases in 2011 to 43 cases in 2015, mainly occurring in the regions bordering Myanmar where *Anopheles**minimus* and *An. dirus* are the dominant vector species. A total of US$134.6 million was spent in efforts to eliminate malaria during 2011-2015, with US$57.2 million (42.5%) from the Global Fund and US$77.3 million (57.5%) from the Chinese Central Government. The average annual investment per person at risk was $0.05 (SD 0.03) with the highest ($0.09) in 2012 and subsequent reductions between 2013 and 2015 after the Global Fund ceased providing investments.

**Conclusion** The autochthonous malaria burden in China has decreased significantly, and malaria elimination is an achievable prospect in China. The key challenge is to address the remaining autochthonous transmission, as well as simultaneously reducing importation from Africa and Southeast Asia. Continued efforts and appropriate levels of investment are needed in the 2016-2020 period to achieve elimination.

**Keywords:** Malaria; epidemiology; elimination; cost; importation; China.

# INTRODUCTION

Malaria remains one of the most serious public health issues globally, with an estimated 214 million cases and 438,000 deaths in 2015.[1-3](#_ENREF_1) Historically, malaria has been widespread in China with 24 malaria-endemic provinces, and over 24 million cases being reported in the early 1970s, with *Plasmodium vivax* and *P. falciparum* the main parasite species responsible.[4](#_ENREF_4),[5](#_ENREF_5) After control efforts were intensified, incidence has been substantially reduced with 95% of the counties in China having an incidence rate under 1/10,000 in 2009.[6](#_ENREF_6) The Chinese government launched a National Malaria Elimination Programme (NMEP) in May 2010, aimed at reducing the number of autochthonous malaria cases across the majority of China to zero by 2015 (except some border areas of Yunnan province where the goal is elimination by 2017), and achieve certification of malaria elimination for China by 2020.[4](#_ENREF_4),[7](#_ENREF_7) Comprehensive intervention policies and strategies have been adopted,[8](#_ENREF_8),[9](#_ENREF_9) and indigenous malaria infections were only found in Yunnan and Tibet Provinces in 2014.[10](#_ENREF_10) As one of the 35 malaria-eliminating countries in the process of moving from controlled low-endemic malaria to elimination,[11](#_ENREF_11) China is a major contributor towards the goal of elimination of malaria in all of the Greater Mekong Subregion countries by 2030.[12](#_ENREF_12" \o "World Health Organization., 2015 #708)

Both international and domestic funds have been used to implement the NMEP to achieve the goal of malaria elimination. The Global Fund to Fight AIDS, Tuberculosis and Malaria (the Global Fund) has supported China to progress from control to elimination between 2003 and 2012.[10](#_ENREF_10),[13](#_ENREF_13) The Global Fund disbursed approximately US$113 million to China for malaria-related support during 2003-2012, and the coverage of Global Fund-supported projects expanded from 47 high malaria-burden counties (within 10 provinces) in 2003 to 762 high and lower malaria-burden counties (within 20 provinces) in 2010.[10](#_ENREF_10) The Global Fund accounted for all documented operational malaria funding in China between 2005 and 2010,[14](#_ENREF_14) and the National Strategy Application (NSA) project from the Global Fund was specific for malaria elimination in China since 2010. However, changes to eligibility criteria in November 2011 meant that China was no longer eligible for renewals of grants, due to categorisation as an upper middle income country and the malaria burden being sufficiently low.[10](#_ENREF_10),[13](#_ENREF_13) The NSA was closed ahead of schedule on June 30, 2012, and the financial commitment of the Chinese central government has since been utilised to cover the investment gaps.[10](#_ENREF_10)

There are few comprehensive analyses of the changing epidemiology of malaria in China, or of the achievement of the NMEP by 2015 and challenges for the halfway point goals of the NMEP, and the evidence in favour of these actions has been more descriptive than quantitative.[10](#_ENREF_10),[15-18](#_ENREF_15) Both donors and policy makers should ideally have information about the costs and benefits of interventions.[19-21](#_ENREF_19) A robust epidemiological and cost analysis is crucial to support the design and update of national strategies and future needs for malaria elimination.[20-22](#_ENREF_20) Here we have conducted an observational analysis to determine (1) the epidemiological trends and burden of malaria, (2) areas and populations with residual transmission, and (3) the costs of interventions from different donors for malaria elimination from 2011 to 2015 in China. This work identifies the achievements and challenges and thereby helps to plan resource allocation for the second-half (2016-2020) of the elimination plan and the ultimate goals of NMEP in China.

# METHODS

## Data sources

Data on individual malaria cases, including clinically diagnosed and laboratory-confirmed cases reported in all 31 provinces of mainland China during 2011–2015, were obtained from the Malaria Enhanced Surveillance Information System (MESIS). The MESIS was developed as a part of the NMEP to actively collect demographic and epidemiological information, using the unified form for case investigation required by the Technical Scheme of China Malaria Elimination.[8](#_ENREF_8),[23](#_ENREF_23) Laboratory-confirmed malaria cases refer to patients with a positive result from one of the laboratory tests including rapid diagnostic tests (RDTs), microscopy, or polymerase chain reaction (PCR). [24](#_ENREF_24) RDTs were the primary diagnostic tools in the remote villages, townships and counties; microscopy was used in county, prefectural and provincial levels as the gold standard method for case verification; and PCR was mainly used for case verification at provincial levels because of its higher sensitivity than microscopy and RDTs. Clinically diagnosed cases were defined as patients with malaria-like symptoms but no parasites detected in blood examination. A malaria patient was classified as an imported case if the individual travelled to malaria-endemic areas outside China within the month prior to illness onset, and the last country visited was taken as the potential origin of infection.[8](#_ENREF_8)

We extracted data on costs of malaria control and the estimated yearly population at risk in 2011-2015 from the annual World Malaria Report (WMR) in 2012-2016 of the World Health Organization,[1](#_ENREF_1),[25](#_ENREF_25) the China Annual Report of Malaria Elimination, the National Programme Office for malaria of the Global Fund in China, and information publicly available through the Global Fund website.[13](#_ENREF_13) This study included the costs from the Global Fund (2011-2012) and Chinese Central Government (2011-2015). Other sources of international malaria funding (e.g. the President’s Malaria Initiative, the United Nations International Children’s Emergency Fund, and the World Bank) were checked but excluded here because no funding for malaria was allocated to China from these sources in 2011-2015. The costs incurred by the governments at sub-national levels are also not included here because the Chinese Central Government plays a major role in domestic funding to the NMEP. From the WMR and the China Annual Report of Malaria Elimination, we also collected the number of long-lasting insecticidal nets (LLINs) and insecticide-treated nets (ITNs) distributed, the number of people protected by indoor residual spraying (IRS), and the number of blood samples collected and tested for malaria using these funds. All the funds documented in Chinese Yuan were converted into US dollars using the average exchange rate from the year of the award/funding, and the values were adjusted for the annual average inflation rate (2.65% in 2012, 2.62% in 2013, 1.99% in 2014 and 1.44% in 2015) in China through comparison to 2011, in order to measure funding/spending trends in real terms.

The geographic distributions of dominant *Anopheles* vectors of human malaria in China were obtained from the Malaria Atlas Project[26](#_ENREF_26) to define high risk areas for malaria residual transmission. The population data at national and sub-national level for each year were obtained from the National Statistical Bureau of China,[27](#_ENREF_27) to estimate the incidence rate and population living in counties with malaria transmission by different dominant *Anopheles* mosquitoes.

## Data analyses

We included all cases reported in all 2858 counties of 333 prefectures in 31 provinces of mainland China, with illness onset from January 1, 2011, to December 31, 2015, in this analysis. The epidemiologic characteristics of malaria cases were summarized. We estimated the incidence rate for each year at national and county levels, and calculated the case-fatality rate of malaria (number of deaths divided by number of probable and confirmed cases), overall, and stratified by autochthonous and imported cases. All counties in mainland China have been classified into four categories with different goals for malaria elimination in the NMEP (Table 1). We defined the achievement of the NMEP for 2011-2015 by comparing the incidence of malaria with the mid-way goals of the four categories of counties by 2015. The population living in the counties with autochthonous *P. falciparum* and *P. vivax* each year were stratified by the different dominant *Anopheles* vectors.

We calculated the values of disbursed funds for malaria elimination by the Global Fund and Chinese Central Government in 2011-2015. The costs of different interventions and management (e.g. insecticidal nets, diagnostic testing, insecticide and spraying materials, antimalarial medicines, monitoring and evaluation, human resources and technical assistance, management and “other” costs) were summarized for each year, and stratified by sources of funding. The coverage of nets (LLINs and ITNs) and IRS were estimated using the corresponding at-risk population in China. Test positivity proportion was calculated by dividing the total number of laboratory-confirmed malaria cases by the number of blood samples tested, multiplied by 100 (and expressed as a percentage). Version 3.3.1 of the *R* statistical software (R Foundation for Statistical Computing, Vienna, Austria) was used to conduct statistical analyses.

# RESULTS

From 2011 to 2015, a total of 17,745 malaria cases, including 123 deaths (0.7%) were reported in mainland China, of which 15,840 (89%) were imported and 1,905 (11%) were autochthonous (Figure 1). The number of autochthonous malaria cases dropped from 1,469 cases (1.1 cases per one million persons) in 2011 to 43 (0.03 cases per one million persons) cases in 2015, with most (94%) autochthonous cases being infected with *P. vivax*. Compared with the goals set for different counties in the NMEP by 2015, most counties (99.9%) had achieved their goals by 2015, and all counties in the border areas of Yunnan had an annual incidence rate less than the target of one case per 10,000 persons since 2013. However, three areas failed to achieve their goal (reducing autochthonous case to zero) by 2015, including Motuo county in Tibet, Sanya City in Hainan Island and Donggang City in Liaoning Province (Table 1).

The residual transmission by 2015 might reflect the spatial variability and complexity of *Anopheles*vectors in China. Among the counties with only *An. sinensis* and/or *An. lesteri* as dominant vectors, the number of *P. vivax* and *P. falciparum* cases have been reduced substantially, with only one county reporting the occurrence of autochthonous *P. vivax* (Table 2). However, among the counties with other dominant vectors (e.g. *An. minimus s.l.*, *An. dirus s.l.*, *An. stephensis*, and *An. Maculatus*),there were still more than 10 counties (with a combined population of 3.7 million) reporting autochthonous *P. vivax* annually in 2013-2015, and two countries (with a combined population of 569,000) reporting autochthonous *P. falciparum* in 2015.

Imported cases have been reported in all 31 provinces of mainland China, with a median of 3,091 cases (interquartile range [IQR] 3,049-3,221 cases) from 2011 to 2015. The imported cases originated from 69 countries, in Africa (44 countries), Southeast Asia (18) and other regions (7). Most imported cases were male (95%) and Chinese (94%) migrant workers with a longer stay in Africa than in Southeast Asia (median 320 days; IQR 171-515 vs 120 days; IQR 59-229). Most cases (80%) imported from Africa were infected with *P. falciparum*, whereas a high proportion (78%) of cases from Southeast Asia were cause by *P. vivax*. Yunnan province imported the most cases (68%) from Southeast Asia, while Guangxi (17%), Jiangsu (15%) and Sichuan (8%) provinces imported the most cases from Africa. For *P. vivax*, 1536 counties (54% of all counties) only reported imported cases, six counties (0.2%) only reported autochthonous cases, and 18 counties (0.6%) had both. For *P. falciparum*, 857 counties (30%) only reported imported cases, 90 counties (3%) only reported autochthonous cases, and 103 counties (4%) had both.

China spent US$134.6 million on malaria elimination efforts during 2011-2015, including $57.2 million (42.5%) from the Global Fund in 2011-2012 and $77.3 million (57.5%) from the Central Government of P. R. China in 2011-2015 (Table 3). The value of funding varied each year, with the highest ($51.5 million) provided in 2012, and subsequent reductions between 2013 and 2015 after the Global Fund ceased providing investments. The level of funding from the Chinese central government increased to fill the gap during the transition of funders, but the annual values were still lower than that previously provided by the Global Fund. The annual investment per person at risk varied during the study period with an average of $0.05 (SD 0.03) and the highest ($0.09) in 2012.

The expenditure by intervention varied between international and domestic funding. The expenditure on management and “other” (e.g. vehicle, small refrigerators and computers) costs accounted for 57% of the $24.4 million from the Global Fund in 2011, followed by the costs of human resources and technical assistance (26%, $6.3 million) for providing township hospitals and village clinics with incentives to improve case management and reporting. However, the financing for interventions from the Chinese Central Government from 2013 to 2015 was predominantly allocated for diagnostic testing (57.4%, $29.6 million), and management and “other” costs (28.7%, $14.8 million). The costs of ITNs and LLINs, insecticide and spraying materials, and antimalarial medicines accounted for small proportions of both international (4%) and domestic (12.7%) funders. A total of 30,119,108 blood samples were collected for testing with a positive proportion of 0.06% (16,579). A total of 1,274,548 nets were purchased with 509,333 LLINs (40%) and 765,215 ITNs (60%), with the annual numbers of nets purchased each year decreased from 2011 to 2014, and the high-risk populations (>1 case per 1000 persons) were covered by IRS during 2011-2015 (Table 3).

# DISCUSSION

The incidence of autochthonous malaria has decreased in mainland China following the first 5 years of elimination efforts, which began in May 2010. The geographic range of endemic areas with *P. falciparum* and *P. vivax* transmission has shrunk dramatically, with most counties having achieved their NMEP goals by 2015. Malaria is on the verge of elimination in central China. This reduction corresponded with the implementation of the NMEP and continuous investments from international and domestic funders to support diagnosis and treatment, indoor residual spraying, and the distribution of insecticidal nets.[14](#_ENREF_14),[28](#_ENREF_28) This success also could be attributed, at least in part, to robust surveillance systems that rapidly detected and responded to individual cases.[9](#_ENREF_9) This study also suggests that the greatest threats to successful elimination efforts in China are the residual malaria transmission in the regions with dominant vectors of *An. minimus s.l.*, and *An. dirus s.l*.

In areas where malaria transmission has been interrupted, the challenge is to maintain malaria-free status and prevent reintroduction. In contrast, in areas with ongoing local transmission (i.e. Yunnan and Tibet), the main challenges are the higher malaria burdens and lack of healthcare and malaria control services in malaria endemic areas of Myanmar and India which border China, and the importation of cases from mobile and migrant populations.[29](#_ENREF_29) High incidence of clinical malaria has been reported from the villages in Yunnan along the border, and the risk increases with decreasing distance from the international border.[26](#_ENREF_26),[30-32](#_ENREF_30) There is also a risk of malaria parasites being carried across the borders by infected mosquitoes, due to the very close proximity of villages along the border on both sides.[30](#_ENREF_30),[31](#_ENREF_31) Additionally, malaria importation from beyond neighbouring countries in Africa and southeast Asia also remains a serious challenge, because only a few countries in Africa and southeast Asia are expected to eliminate malaria by 2020. Therefore, addressing cross-border malaria carried by travellers, especially Chinese migrant workers, to/from Africa and nearby countries in Southeast Asia is crucial to eliminate malaria and maintain the gains that have been achieved by China so far.[17](#_ENREF_17),[33-38](#_ENREF_33)

The cost per person at risk in China was low compared with other countries.[20](#_ENREF_20),[39](#_ENREF_39) Among 87 malaria-endemic countries that received financial support from international donors to control malaria from 2008 to 2012, China (>56 million people living in endemic districts) ranked 2nd in terms of the size of population at risk of malaria, but it ranked 82nd in terms of the amount of international funding invested per person.[20](#_ENREF_20),[39](#_ENREF_39) Furthermore, as international support wanes due to the decreasing burden of malaria, it is the central and local governments of China who will continue to fund malaria elimination activities, and ensure that the universal coverage of interventions is maintained for the second-half of the elimination program and post-elimination era. Resurgence of malaria may occur if control and surveillance measures are scaled back too early following elimination, and consistent financing is necessary to avoid this.[6](#_ENREF_6),[40](#_ENREF_40),[41](#_ENREF_41) Malaria elimination in China may be currently underfunded relative to the frequency of parasite importation and the size of the population living in areas at risk of malaria, and increased funding could be crucial for elimination efforts.

This study had some limitations. It is possible that not all improvements in the malaria situation were attributable to the elimination activities. For example, it is known that socioeconomic development can be associated with reduced malaria in urban areas,[42](#_ENREF_42) and China has undergone substantial socioeconomic growth and unprecedented urbanization.[43](#_ENREF_43) These changes could have contributed to a decrease in malaria prevalence, irrespective of malaria control and elimination activities. The number of malaria cases identified in the present study might be an underestimate if some cases did not seek treatment, or imported malaria was misdiagnosed in malaria-free areas or hard-to-reach areas, even though the individual case-based malaria surveillance system in China operated well during the malaria elimination stage.[23](#_ENREF_23) Furthermore, the cost calculations did not include funding from governments at national and sub-national levels to support the salaries of department of health staff at county level or above who were responsible for most of the malaria elimination activities (e.g. surveillance, data collection, vector control and diagnosis), and the direct costs of eliminating malaria incurred by the governments at sub-national levels were also not included. Additionally, the costs of treatment of malaria provided by physicians and the costs of patients for malaria related expenditure were not included in the study because of difficulties in obtaining adequate data.

The results of this study show that the malaria burden in China fell substantially during the study period, with substantial financial support from international and domestic funds. Elimination is a realistic aim, and the benefits are not only local, but also international if elimination in China acts to reduce or delay the spread of artemisinin resistance from the Mekong region. However, the foreseeable challenges presented here need national attention to achieve the goal of malaria elimination in China by 2020. Investment needs to be maintained and ideally increased to target resources towards the remaining high-burden and high importation regions, and strong surveillance and response systems need to be maintained to monitor residual transmission in endemic areas. Monitoring the risk of importation and predicting the onward transmission potential in importation risk areas using a substantial early warning tool with robust spatiotemporal models linking to disease data and different environmental factors will ensure that elimination is sustained and will form a cornerstone of post-2015 elimination strategies in China.[7](#_ENREF_7)

**Authors' contributions**

HY and AJT conceived, designed, and supervised the study. SL designed the study, collected data, finalised the analysis, wrote the manuscript, and interpreted the findings. ZL designed the study and interpreted the findings. NAW, ZH, XNZ, AJT, and HY interpreted the findings and commented on and revised drafts of the manuscript. JS, SZ, JY, ZZ, SSZ, ZX, RW, BZ, YR, and LZ collected and analysed data, and interpreted the findings. All authors read and approved the final manuscript.

**Competing interests**The authors declare that they have no competing interests.

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The sponsors of the study had no role in the study design, data collection, data analysis, data interpretation, writing of the report, or the decision to publish. The corresponding author had full access to all the data in the study and had final responsibility for the decision to submit for publication. The views expressed here are those of the authors and do not necessarily represent the policy of the China CDC or the institutions with which the authors are affiliated.

## Ethical approval

It was determined by the National Health and Family Planning Commission, China, that the collection of malaria case reports was part of continuing public health surveillance of a notifiable infectious disease and was exempt from institutional review board assessment. The Chinese Center for Disease Control and Prevention (China CDC) has strict regulations on how to protect patients’ privacy. The National Center for Public Health Surveillance and Information Services at the China CDC is responsible for the management of all disease surveillance data, and it anonymized the individual malaria data by deleting the personal identifiers (such as patient name, home address, and telephone number) before the China CDC co-authors of this article, in the Division of Infectious Disease, were given access to the surveillance data for the purposes of research. The co-authors of this article did not participate in de-identifying the data and do not have the personal identifiers of the cases. The ethical clearance of collecting and using second-hand data was also granted by the institutional review board of the University of Southampton, UK (No. 18152). All data were supplied and analysed in an anonymous format, without access to personal identifying information.

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## Figure

**Figure 1. Epidemic curves of *Plasmodium* malaria in mainland China, 2011-2015.** (A) Autochthonous cases (n=1,905) including 1708 *P. vivax* cases, 92 *P. falciparum*, 4 *P. malariae*, 1 *P. ovale*, 5 mixed infections and 95 untyped. (B) Imported cases (n=15,840) including 9754 *P. falciparum* cases, 4,882 *P. vivax*, 524 *P. ovale*, 188 *P. malariae*, 202 mixed infections and 290 untyped.

## Tables

**Table 1. Four categories of counties and their goals and achievements for malaria elimination in mainland China.**

| **Type** | **Definition** | **Number of counties (%)** | **Goals by 2015** | **Goals in 2016-2020** | **Achievements for the goals by 2015** |
| --- | --- | --- | --- | --- | --- |
| **1** | Local infections detected in three consecutive years and the annual incidence ≥ 1 per 10,000 persons for each year. | 75 (2.6%) | The counties in border areas of Yunnan: annual incidence < 1 per 10,000 persons. | The counties in border areas of Yunnan: no local infections detected by 2017; malaria elimination by 2020. | Yes. The annual incidence rate < 1 cases per 10,000 persons. |
| Other counties: no local infections detected by 2015. | Other counties: malaria elimination by 2018. | Partly. Motuo county in Tibet bordering with India, Sanya City in Hainan in tropic reported autochthonous cases in 2015, and Motuo county had ≥ 1 cases per 10,000 persons for each year in 2011-2015. |
| **2** | Local infections detected in the last three years and at least the annual incidence < 1 per 10,000 persons in one of the three years. | 687 (24.0%) | No local infections detected by 2015. | Malaria elimination by 2018. | Partly. Donggang City in Liaoning Province bordering with North Korea reported autochthonous cases in 2015. |
| **3** | No local infections reported in the last three years. | 1432 (50.1%) | Malaria elimination by 2015. | Maintaining malaria-free status. | Yes. Pass the sub-national malaria elimination assessment. |
| **4** | Non-malaria-endemic area. | 664 (23.3%) | Maintaining malaria-free status. | Maintaining malaria-free status. | Yes. Maintaining malaria-free status. |

The counties are categorized by the malaria incidence data reported in China from 2006 to 2008. Only the counties (n=2858) of 31 provinces in mainland China are included in the NMEP.

**Table 2. Trends in autochthonousmalaria infections and indicators in mainland China, 2011-2015.**

|  | **2011** | **2012** | **2013** | **2014** | **2015** | **2011-2015** |
| --- | --- | --- | --- | --- | --- | --- |
| **Overall** |   |   |   |   |   |
|  Number of cases | 1396  | 231 | 78 | 59 | 36 | 1800 |
|  Incidence per one million persons  | 1.0  | 0.2 | 0.1 | 0.04 | 0.03 | 1.3 |
|  Counties affected | 183  | 50 | 21 | 10 | 11 | 196 |
|  Population in counties (in thousands) | 104,499 | 25,940 | 9,202 | 1,872 | 3,945 | 112,059 |
| **Autochthonous *P. vivax*** |   |   |   |   |   |   |
|  Number of cases | 1344 | 212 | 65 | 53 | 34 | 1708 |
|  Incidence per one million persons | 1.0 | 0.2 | 0.05 | 0.04 | 0.03 | 1.3 |
|  Counties affected | 182 | 50 | 18 | 10 | 10 | 193 |
|  With only *An. sinensis* and/or *An. Lesteri* | 119 (65%) | 24 (48%) | 5 (28%) | 0 (0%) | 1 (10%) | 127 (66%) |
|  With other *Anopheles* mosquitoes | 63 (35%) | 26 (52%) | 13 (72%) | 10 (100%) | 9 (90%) | 66 (34%) |
|  Population in counties (in thousands) | 104,242 | 25,940 | 7,622 | 1,872 | 3,766 | 110,618 |
|  With only *An. sinensis* and/or *An. Lesteri* | 84,376 (81%) | 18,199 (70%) | 3,937 (52%) | 0 (0%) | 627 (17%) | 89,313 (81%) |
|  With other *Anopheles* mosquitoes | 19,866 (19%) | 7,741 (30%) | 3,685 (48%) | 1,872 (100%) | 3,139 (83%) | 21,305 (19%) |
| **Autochthonous *P. falciparum*** |   |   |   |   |   |   |
|  Number of cases | 52 | 19 | 13 | 6 | 2 | 92 |
|  Incidence per one million persons | 0.04 | 0.01 | 0.01 | 0.004 | 0.001 | 0.07 |
|  Counties affected | 17 | 9 | 6 | 2 | 2 | 24 |
|  With only *An. sinensis* and/or *An. Lesteri* | 2 (12%) | 0 (0%) | 3 (50%) | 0 (0%) | 0 (0%) | 5 (21%) |
|  With other *Anopheles* mosquitoes | 15 (88%) | 9 (100%) | 3 (50%) | 2 (100%) | 2 (100%) | 19 (79%) |
|  Population in counties (in thousands) | 4,391 | 2,941 | 2,246 | 484 | 569 | 7,208 |
|  With only *An. sinensis* and/or *An. Lesteri* | 362 (8%) | 0 (0%) | 1,581 (70%) | 0 (0%) | 0 (0%) | 1,943 (27%) |
|  With other *Anopheles* mosquitoes | 4,029 (92%) | 2,941 (100%) | 665 (30%) | 484 (100%) | 569 (100%) | 5,265 (73%) |

Data are numbers or percentages, unless otherwise indicated. 11 counties within five provinces reported autochthonous cases in 2015, including Yunnan, Tibet, Hainan, Guangxi, Liaoning provinces. The geographic distribution of dominant *Anopheles* vectors of human malaria in China was obtained from the Malaria Atlas Project.[26](#_ENREF_26) Other *Anopheles* mosquitoes includes *An. minimus s.l.*, *An. dirus s.l.*, *An. stephensis*, and *An. maculatus*.

**Table 3. Interventions and costs for malaria elimination in mainland China, 2011-2015.**

|   | **2011** | **2012** | **2013** | **2014** | **2015** |
| --- | --- | --- | --- | --- | --- |
| Population at risk (in thousands) |   |   |   |   |  |
| Overall (% of total population) | 563,574 (42%) | 575,911 (42%) | 579,467 (42%) | 575,985 (42%) | 575,985 (42%) a |
|  At high risk (> 1 case per 1000 persons) | 192 (0.01%) | 196 (0.01%) | 197 (0.01%) | 196 (0.01%) | 196 (0.01%) |
| Funds (US$) |   |   |   |   |   |
| Overall (in millions) | 31.5 | 51.5 | 16.0 | 19.4 | 16.2 |
|  The Global Fund | 24.4 (77%) | 32.8 (64%) | 0  | 0 | 0 |
|  Central Government of P. R. China | 7.1 (23%) | 18.6 (36%) | 16.0 (100%) | 19.4 (100%) | 16.2 (100%) |
| Spend per risk person | 0.06 | 0.09 | 0.03 | 0.04 | 0.03 |
| Expenditure by interventions b |   |   |   |   |   |
| Insecticide and spraying materials | 0.5 (2%) | - | 1.1 (7%) | 0.8 (4%) | 0.7 (4%) |
| ITNs and LLINs | 0.4 (2%) | - | 1.4 (9%) | 1.1 (6%) | 0.9 (6%) |
| Diagnostic testing | 0.7 (3%) | - | 13.3 (83%) | 8.9 (46%) | 7.5 (46%) |
| Antimalarial medicines | 0 | - | 0.2 (1%) | 0.2 (1%) | 0.2 (1%) |
| Monitoring and evaluation | 2.8 (12%) | - | 0  | 0 | 0 |
| Human resources and technical assistance | 6.3 (26%) | - | 0 | 0.3 (2%) | 0.3 (2%) |
| Management and other costs | 13.9 (57%) | - | 0 | 8.1 (42%) | 6.7 (41%) |
| Nets coverage |   |   |   |   |   |
| Overall | 656,674 | 509,490 | 58,874 | 19,899 | 29,611 |
|  LLINs | 149,394 | 251,555 | 58,874 | 19,899 | 29,611 |
|  ITNs | 507,280 | 257,935 | 0 | 0 | 0 |
|  |  |  |  |  |  |
| IRS coverage |   |   |   |   |   |
| Persons protected by IRS |  1,043,963  |  1,092,158  |  447,639  |  504,936  | 1,697,188 |
|  |  |  |  |  |  |
| Laboratory-confirmed malaria |   |   |   |   |   |
| Blood sample collection | 9,189,270 | 6,918,657 | 5,554,960 | 4,403,633 | 4,052,588 |
| Positive (% of blood samples) | 3629 (0.04%) | 2633 (0.04%) | 4029 (0.07%) | 3065 (0.07%) | 3223 (0.08%) |
|  *P. falciparum* | 1467 (40%) | 1460 (55%) | 2892 (72%) | 1879 (61%) | 1977 (61%) |
|  *P. vivax* | 2087 (58%) | 1068 (41%) | 915 (23%) | 919 (30%) | 910 (28%) |
|  Other | 75 (2%) | 105 (4%) | 222 (6%) | 267 (9%) | 336 (11%) |

a Using the estimates of population at risk in 2014 from the World Malaria Report 2015. b Expenditure by interventions in 2011 only included the cost of the Global Fund. “-” data unavailable. Data are n or n (%), unless otherwise indicated. The Global Fund = The Global Fund to Fight AIDS, Tuberculosis and Malaria. LLINs = Long-lasting insecticidal nets. ITNs = Insecticide-treated mosquito nets. IRS = Indoor residual spraying. Malaria cases confirmed by diagnostic tests of microscopy, rapid diagnostic tests, or polymerase chain reaction. *P. falciparum* = *Plasmodium falciparum*. *P. vivax* = *Plasmodium vivax.*

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