Malaria is an insect-borne disease transmitted by *Anopheles* mosquitoes or the importation of *Plasmodium*-infected blood, posing a serious threat to human health and life safety. This study aims to analyze the incidence of malaria in Qingdao at various stages from 1949 to 2021, to collate the control measures taken at different epidemic stages to assess the effectiveness of malaria control, and to identify a set of malaria control strategies suitable for Qingdao, while providing Chinese experience for other countries or cities in their malaria elimination efforts. A retrospective survey was used to collect information on malaria cases, control measures and prevention and control effects in Qingdao from 1949 to 2021, and to evaluate malaria control strategies and measures in Qingdao. 704 155 cases have been reported from 1949 to 2021, with three epidemic peaks: the incidence rate was 1715.9/100 000 in 1961, 1409.7/100 000 in 1965, and the most severe case occurred in 1972, with an incidence rate of 1635.6/100 000 and a case count exceeding 90 000. Throughout the various stages of malaria epidemics, Qingdao has effectively eliminated indigenous malaria by implementing diverse preventive and control measures. Since the last indigenous case of *Plasmodium vivax* was reported in 2002, all locally reported cases have been imported, mainly by returning migrant workers from Africa. This study examines a range of malaria prevention and control strategies and interventions that are appropriate for Qingdao. These measures have enabled Qingdao to successfully eliminate malaria and maintain malaria-free status for more than 20 years. These measures can also serve as a reference for similarly situated cities in Africa and Southeast Asia.

**Keywords:** Malaria epidemic; retrospective survey; eliminate malaria; control strategy; Qingdao.
cases. Imported cases include two types of infected persons who returned to the local area after being infected outside the city by residents of the city and those who returned to the local area after being infected outside the city by outsiders, and the rest are indigenous cases.

In China, confirmed cases were diagnosed based on the malaria diagnostic criteria issued by the country at different stages. The clinical diagnosed case was defined as patients with malaria-like symptoms but no parasite detected upon blood testing, while laboratory-confirmed case was defined as case confirmed by using any of the following methods including microscopy, rapid diagnostic tests (RDTs) or polymerase chain reaction (PCR) (Kong et al., 2017). In the outbreak epidemic stage, diagnosis was made based on clinical symptoms only because of the large number of malaria cases.

Blood testing of patients with the “four fever” refers to the microscopic examination of blood samples from patients with four types of fevers: primary malaria, suspected malaria, colds and fevers of unknown origin. After the eradication of indigenous malaria, patients with fever caused by colds are no longer undergo microscopic examination of blood smears, and the remaining three types of patients are called “three fever” patients.

Statistical analysis
Annual incidence rates were calculated as the number of new cases per 100 000 population per year (January 1 to December 31 defined as the year). A retrospective analysis of historical information on malaria prevention and control in Qingdao from 1949-2021 was conducted by reviewing archives and collecting information on cases. The database was created using Microsoft office Excel 2021 (Microsoft Corporation, Redmond, WA, USA), and the chi-square test of malaria incidence changes was performed using GraphPad Prism 8.0 (GraphPad Software Inc., San Diego, CA, USA, https://www.graphpad.com/), with P < 0.05 set as a statistical difference. The spatial trend map of malaria incidence in Qingdao city was drawn with Arcgis 10.8 (Environmental Systems Research Institute Inc., RedLands, CA, USA, https://www.esri.com/en-us/home).

RESULTS

Epidemiological dynamics of malaria
During the malaria epidemic period, from 1949 to 2021, a total of 704 155 malaria cases were reported in Qingdao, including 703 893 indigenous and 262 imported cases. Within the period of 1950 to 1984, malaria was in a high-level epidemic stage in Qingdao, with three peak incidence rates: 1 715.9 per 100 000 (1961), 1 409.7 per 100 000 (1965), and the highest incidence rate in 1972 of 1 635.6 per 100 000, resulting in more than 90 000 cases (Figure 1). After 1972, the incidence of malaria in Qingdao decreased year by year, with it dropping to less than one thousandth in 1976 and one of

Figure 1. 1949-2021 malaria incidence and cases distribution in Qingdao.
The prevention and control of malaria in Qingdao have undergone five stages: from the early years of founding of China (1949-1959), to the period of national malaria control (1959-1979), and then to the phase of provincial elimination of malaria (1979-1999), the establishment of a malaria-free county (1999-2002), and the transition to an area of residual malaria (2002-present). Each stage marked significant milestones and strategies in malaria prevention and control.

1. **Preventive measures and effects**
   - **Early years of founding of China (1949-1959)**: The government established control structures for malaria, disseminated information on prevention, and verified the occurrence of malaria epidemics. The annual incidence of malaria was reduced from 247.6 per 100,000 in 1953 to 620 per 100,000 in 1954.
   - **Period of national malaria control (1959-1979)**: Malaria control measures were implemented to eliminate breeding grounds of mosquito vectors and to prevent the spread of malaria. The incidence dropped to 1,635.6 per 100,000 in 1972, and 42.9 per 100,000 in 1979. The annual number of blood tests was 101,124.
   - **Phase of provincial elimination of malaria (1979-1999)**: The incidence reached its lowest level, with less than 900 cases per 100,000 individuals.
   - **Establishment of a malaria-free county (1999-2002)**: All malaria cases were imported, with no indigenous cases reported.
   - **Transition to an area of residual malaria (2002-present)**: The remaining foci are few and scattered, universal prophylactic drug administration at key infected sites in districts with general morbidity has been implemented, and the rate of regular drug use has increased.

2. **Strategies and methods**
   - **Preventive measures** included the management of anti-malarial drugs, strengthening verifiable reporting of malaria outbreaks, and spreading awareness of malaria prevention and treatment widely to the public.
   - **Control measures** focused on eliminating indigenous malaria based on the malaria epidemiology, prevention, and control characteristics in different periods.
   - **District-wide drug administration** was carried out to control outbreaks and epidemics, with the incidence dropping to 0.18 per 100,000 in 1981.

3. **Public health education**
   - The public's knowledge of malaria prevention and treatment has increased over the years, with the rate of regular drug use increasing from 135,819 patients in 1975 to 101,124 in 2002.

4. **Recent developments**
   - Since 2002, all malaria cases have been imported cases. There are no indigenous cases reported. The last indigenous case was reported in 2002. Since then, all malaria cases in Qingdao have been imported cases. There are no indigenous reports have been made to date.

5. **Future challenges**
   - With the increase in drug-resistant malaria, there is a need for continued surveillance, improved treatment, and enhanced public health education.
been stopped and the focus of malaria control has been placed on households living on the outskirts of villages, key populations and populations around the foci. Villages where malaria is common and recurrence is frequent are used as “malaria foci”, and the sources of malaria transmission are eliminated through repeated removal of the “foci”. In 1982, a total of 564 people were randomly tested inside and outside the “foci”, and the blood tests for Plasmodium were all negative, proving the success of “zoning the stoves and eliminating the sources of malaria”, and in 1982 it began to be promoted in Qingdao, and the incidence of malaria declined rapidly, and in 1986 there were only 9 people suffering from malaria. At this stage, preventive medicine and anti-mosquito measures were also taken simultaneously, and blood tests for Plasmodium were actively carried out on patients with “four fevers”. In 1980, Qingdao carried out blood tests for Plasmodium in patients with “four fevers”, and all districts, counties and towns in the city set up microscopy stations or microscopy clinics. From 1980 to 1985, a total of 523,966 people were blood tested, of which 1,639 were positive, with a positivity rate of 0.31%. From 1988 to 1996, there were occasional new cases in Qingdao, and most malaria cases were imported from other provinces. There were imported cases from outside the country that started to appear in 1997, with a trend of increasing year by year.

Reinforcement of the management of mobile populations and consolidation of the results phase (2000-2009)

All malaria prevention management systems were further improved during this phase. Qingdao has established malaria case management methods, requirements for microscopic examination of febrile patients, and requirements for the treatment of lesions. Qingdao has further consolidated the results of malaria prevention and treatment by strengthening technical training and establishing a system of mobile community managers, so that the quality of malaria prevention and treatment work has been continuously improved and enhanced. The last indigenous case was reported in Qingdao in 2002, and since 2005, Qingdao has implemented a direct reporting network for malaria cases, which enables timely and accurate detection of malaria and other infectious diseases, and prevents the resurgence of indigenous epidemics by closely monitoring malaria outbreaks.

The final phase is malaria elimination and sustained compliance (2010-2021)

In this time, Qingdao followed the principles of adapting to local conditions, classifying and guiding, and scientifically preventing and controlling; taking control of the source of infection as the core and surveillance work as the leading role; strengthening capacity building; increasing the training of professional and technical personnel; and intensifying the work of blood testing for malaria. From 2010 to 2021, a total of 172,668 patients with “three fevers” were tested for Plasmodium in Qingdao, and 190 positive cases were found, all of which were imported cases, with a positive rate of 0.11% (Table 1). Since 2012, we have been managing each case found in accordance with the “1-3-7” surveillance and response strategy (Lu et al., 2016). Case reporting is required within 1 day of case discovery, case investigation and case review within 3 days, and targeted outbreak site investigation and disposal within 7 days to ensure that malaria cases are detected, reported, diagnosed and treated early.

From 2010 to 2021, the laboratory testing rate of imported malaria cases, the proportion of confirmed diagnoses and the standardised treatment rate in Qingdao City will all reach 100%. At this stage, large-scale training is conducted annually for malaria control specialists and technicians, with repeated and intensive training in all aspects of malaria blood film production and in identifying the morphology of various microscopic forms of Plasmodium to improve their malaria blood testing capacity, and skills competitions are held to further improve the detection and control capacity of specialists and technicians in the form of competitions as a substitute for training. In terms of malaria blood testing, Qingdao has set up municipal, district, county and township microscopy stations as sentinel sites for malaria case surveillance, so that malaria patients can be detected at the earliest opportunity through blood testing for Plasmodium parasites in patients with the “three fevers”, and then designated fixed-point hospitals for those patients detected to receive a full course of standardised treatment with a full dose of free anti-malarial drugs.

During this period, Qingdao established a comprehensive malaria surveillance system and treatment network throughout the city, including three levels of sentinel microscopy stations to monitor patients with “three fevers” and designated hospitals for malaria treatment at the city, district and county levels. After 2017, Qingdao City continued to consolidate the results of malaria elimination, taking “timely detection and standardised and effective treatment of imported cases” as the core, consolidating joint prevention and control, improving monitoring and early warning, and strictly implementing the requirements of “1-3-7” imported malaria prevention and control work, timely blocking transmission and effectively controlling re-transmission of imported malaria.

Effectiveness of malaria control

We conducted a comparative analysis of malaria incidence in five phases from 1949 to 2021. 1949-1959 was the initial period of the country’s establishment, when malaria was in the epidemic phase, with a cumulative total of 9814 cases reported, accounting for 1.30%

Table 1. Blood testing for malaria in febrile patients in Qingdao, 2010-2021

<table>
<thead>
<tr>
<th>Year</th>
<th>Number of blood testing</th>
<th>Blood testing rate</th>
<th>Number of positive cases</th>
<th>Positive rate</th>
<th>Plasmodium species</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>P. v P. f others</td>
</tr>
<tr>
<td>2010</td>
<td>24,548</td>
<td>0.28%</td>
<td>16</td>
<td>6.52%</td>
<td>3 2 11</td>
</tr>
<tr>
<td>2011</td>
<td>28,242</td>
<td>0.32%</td>
<td>10</td>
<td>3.54%</td>
<td>2 4 4</td>
</tr>
<tr>
<td>2012</td>
<td>24,548</td>
<td>0.27%</td>
<td>17</td>
<td>6.52%</td>
<td>4 13 0</td>
</tr>
<tr>
<td>2013</td>
<td>16,716</td>
<td>0.18%</td>
<td>11</td>
<td>7.18%</td>
<td>1 10 0</td>
</tr>
<tr>
<td>2014</td>
<td>14,056</td>
<td>0.15%</td>
<td>11</td>
<td>7.83%</td>
<td>2 9 0</td>
</tr>
<tr>
<td>2015</td>
<td>13,014</td>
<td>0.14%</td>
<td>18</td>
<td>13.83%</td>
<td>2 16 0</td>
</tr>
<tr>
<td>2016</td>
<td>11,867</td>
<td>0.12%</td>
<td>26</td>
<td>21.91%</td>
<td>1 23 2</td>
</tr>
<tr>
<td>2017</td>
<td>7,190</td>
<td>0.07%</td>
<td>21</td>
<td>27.82%</td>
<td>1 17 3</td>
</tr>
<tr>
<td>2018</td>
<td>7,766</td>
<td>0.08%</td>
<td>23</td>
<td>30.90%</td>
<td>1 20 2</td>
</tr>
<tr>
<td>2019</td>
<td>8,229</td>
<td>0.08%</td>
<td>19</td>
<td>23.09%</td>
<td>2 16 1</td>
</tr>
<tr>
<td>2020</td>
<td>8,084</td>
<td>0.08%</td>
<td>13</td>
<td>16.08%</td>
<td>4 7 2</td>
</tr>
<tr>
<td>2021</td>
<td>8,408</td>
<td>0.08%</td>
<td>5</td>
<td>5.95%</td>
<td>2 2 1</td>
</tr>
<tr>
<td>Total</td>
<td>172,688</td>
<td>0.15%</td>
<td>190</td>
<td>0.11%</td>
<td>25 139 26</td>
</tr>
</tbody>
</table>
of the total number of reported cases. 1960-1979 was in the malaria outbreak epidemic phase, with a cumulative total of 691,600 cases reported, accounting for 98.33%. From 1980 to 1999, the incidence of malaria decreased significantly, new indigenous cases occasionally appeared, and imported cases from other provinces accounted for most of the cases. A total of 2,499 cases were reported in this period, accounting for 0.33% of the total number of reported cases. During 2000-2009, named the period of consolidating the results of malaria control, 52 malaria cases were reported in this period, accounting for 0.007% of the total number of reported cases. From 2010 to 2021, the period of complete elimination of indigenous malaria, the number of reported cases is 190, all of which are imported cases, accounting for 0.25% of the total number of reported cases. The incidence rates of the five phases showed a trend of increasing and then decreasing sharply ($\chi^2=21,817,634$, $P<0.0001$) (Table 2), which proved that the preventive and control measures we took were precise and effective.

Epidemiological characteristics of cases

Before 1985, most of the malaria patients in Qingdao were located in the rural areas, and all of them were clinically diagnosed cases of *P. vivax*, and the vector of malaria transmission was *Anopheles sinensis*. Cases occurred throughout the year, but there were obvious seasonal peaks, and the seasonal peaks are consistent at different stages, all rising in June, peaking in July-September, and starting to decline in October. With the continuous expansion of opening to the outside world and the increase of mobile people year by year, the proportion of imported malaria has increased. After 1985, indigenous malaria was basically eliminated, and imported malaria cases gradually increased, and the malaria epidemic no longer has obvious seasonality (Figure 2). Imported cases began to appear in 1986, and the last indigenous case was reported in 2002, after which imported cases have been reported every year (Figure 3). The type of infection with *Plasmodium* changed from a single *P. vivax* infection to a multi-species *Plasmodium* infection. The results of the analysis of *Plasmodium* species infected in 230 malaria cases in the last 20 years showed that *P. falciparum* infection was the majority, accounting for 63%, *P. vivax* infection accounted for 14%, and other types of *Plasmodium* infection accounted for 23% (Table 3).

Between 2010 and 2021, a total of 190 cases of imported malaria were reported (Table 2), out of which 176 were male and 14 were female. The maximum age reported was 64 years, including one year, with an average age of 39 years. Out of the 190 cases of malaria, 3 were imported from other provinces and 187 were imported from other countries. Out of these, 178 (95.19%) were from Africa and 9 (4.81%) from Asia. Among the 190 reported cases, 161 individuals resided in Qingdao. According to the spatial distribution analysis, patients were mainly concentrated in the coastal region of Qingdao. Additionally, the distribution of patients was closely associated with the level of local openness to the outside world (Figure 4).

**Table 2. Incidence of malaria at different stages of the epidemic**

<table>
<thead>
<tr>
<th>Stage</th>
<th>Total population</th>
<th>Cases</th>
<th>Morbidity (1/100,000)</th>
<th>$\chi^2$</th>
<th>$P$ value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1949-1959</td>
<td>12,566,693</td>
<td>9,814</td>
<td>78.10</td>
<td>21,817,634</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>1960-1979</td>
<td>103,314,697</td>
<td>691,600</td>
<td>669.41</td>
<td>1.92</td>
<td>0.07</td>
</tr>
<tr>
<td>1980-1999</td>
<td>130,183,271</td>
<td>2,499</td>
<td>1.92</td>
<td>0.07</td>
<td>0.07</td>
</tr>
<tr>
<td>2000-2009</td>
<td>77,573,110</td>
<td>52</td>
<td>0.07</td>
<td>0.07</td>
<td>0.07</td>
</tr>
<tr>
<td>2010-2021</td>
<td>114,038,500</td>
<td>190</td>
<td>0.17</td>
<td>0.17</td>
<td>0.17</td>
</tr>
</tbody>
</table>

**Figure 2. Seasonal distribution of malaria incidence in different epidemic stages.**

**Figure 3. Composition of indigenous and imported cases in Qingdao from 1985-2021.**

(*Indigenous cases of malaria in 2005, 2009 were recurrent cases.*)

**Table 3. Malaria case typings in Qingdao from 2002-2021**

<table>
<thead>
<tr>
<th><em>Plasmodium</em> species</th>
<th>Cases</th>
<th>Proportion (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$P. f$</td>
<td>145</td>
<td>63</td>
</tr>
<tr>
<td>$P. v$</td>
<td>32</td>
<td>14</td>
</tr>
<tr>
<td>Others</td>
<td>53</td>
<td>23</td>
</tr>
<tr>
<td>Total</td>
<td>230</td>
<td>100</td>
</tr>
</tbody>
</table>
Based on the observations by Boccolini et al. (2013) and Hua-Yun et al. (2017, 2022a), Huangdao District was chosen as the site for vector monitoring due to the presence of Anopheles mosquitoes. These findings were confirmed by the manual trapping method, which indicated a significant decline in the density of Anopheles sinensis after 1995, and by 2021, no more Anopheles sinensis were caught at the monitoring site (Figure 5).

**DISCUSSION**

The purpose of this study was to analyze the incidence and epidemiological characteristics of malaria in Qingdao over the past 70 years, evaluate a series of malaria control strategies adopted in different malaria epidemic stages in Qingdao, and identify a set of malaria control strategies and measures that are currently suitable for Qingdao to maintain the state of indigenous malaria elimination.

According to the WHO report, the European Region achieved the goal of eliminating endemic malaria in the 1970s (Danis et al., 2013). After the elimination of indigenous malaria, some European countries have only a few cases of imported malaria each year. Local government health budgets have been cut, and malaria surveillance and laboratory diagnostic capacity has declined over the years (Danis et al., 2013; Boccolini et al., 2020; Mironova et al., 2020). The presence of local malaria vectors and susceptible populations, together with increased economic and trade exchanges and an increase in mobile populations, led to the emergence of secondary cases of imported malaria and even outbreaks of malaria epidemics in areas such as Greece, Russia and Italy after the 1990s (Danis et al., 2013; Boccolini et al., 2020; Mironova et al., 2020). Similar to the situation in Greece and other countries, Qingdao has had imported malaria cases every year since the elimination of malaria in the area, and malaria vectors and susceptible populations have persisted, but Qingdao has succeeded in eliminating endemic malaria and has had no reports of endemic malaria for more than 20 consecutive years. What lessons can be learnt from the success of Qingdao in the elimination of endemic malaria and the sustainability of malaria elimination?

The statistical analysis of the epidemic data from 1949-2021 showed that the changing characteristics of the malaria epidemic in Qingdao over the past 72 years were basically similar to the historical process of malaria control in most cities in China (Qian & Tand, 2000; Yong-Liang et al., 2015; Hua-Yun et al., 2018). The findings of our research are specific technical approaches that have been used at different times and its contexts. We need to better understand the ways in which policies and approaches are developed on the ground, and the systems and capacities that make this possible.

There are some key factors here, the first of which is the importance the government attaches to malaria control. From the founding of the country in 1949 to the present day, the importance attached by the government has provided a strong organizational guarantee for the smooth running of the work. Malaria is an important parasitic disease that poses a serious threat to human health and life and affects socio-economic development, and the participation of the whole society is necessary to achieve the goal of eliminating indigenous malaria. The Qingdao Municipal Government attaches great importance to the elimination of malaria and has formulated appropriate policies at each historical stage of the elimination process. For example, every year the government organizes the city’s Spring Patriotic Hygiene Month, during which active measures are taken to eliminate a large number of dead-end sewers, improve environmental hygiene and household sanitation, reduce the number of mosquito breeding sites, cut off transmission routes and prevent the occurrence of malaria cases. Following the elimination of indigenous malaria, the government quickly adapted its strategies, shifting the focus of its malaria control efforts from controlling local malaria outbreaks to preventing local transmission caused by imported malaria, and ensuring the smooth implementation of its efforts by strengthening the public
health system and improving the malaria prevention and control network. Currently, the “1-3-7” surveillance and response strategy is being followed, and secondary cases of imported malaria have been effectively prevented by strengthening case finding and source management, and by timely treatment of potential transmission outbreaks.

In the 1950s, due to the lack of knowledge about malaria prevention and control among the public, who did not seek medical treatment or accept scientific treatment after falling ill, the phenomenon of under-reporting of cases occurred from time to time, and Qingdao experienced a number of malaria outbreaks and epidemics. Therefore, the second key factor is to strengthen public health education and raise awareness of malaria prevention and control among the entire population. Based on the World Malaria Day, China has established a National Malaria Day according to the actual situation in China. Qingdao takes advantage of the National Malaria Day each year by carrying out a variety of publicity activities in different forms and through different channels, so that the general public can have a better understanding of malaria prevention and treatment, raise their awareness of self-protection, and actively take preventative measures to stop the spread of malaria.

With the rise of tourism and the development of the foreign economy in Qingdao, a large number of transient people gather in the city every year. According to the Qingdao Statistical Yearbook 2020, the annual air passenger throughput reached 25,556,300 in 2019, and the city received a total of 11,303,000 tourists in 2019, of which 111,325,800 were domestic tourists and 1,702,600 were entrance tourists (Qingdao Municipal Bureau of Statistics, 2020). It is worth noting that among the entrance tourists, those from malaria-endemic areas such as South Korea and Southeast Asia account for 48.67% (Qingdao Municipal Bureau of Statistics Team, 2020). The WHO annual world malaria report indicates that P. vivax is mainly found in Southeast Asia (Feng et al., 2015; WHO, 2022). Of the 190 imported cases in Qingdao from 2010 to 2021, 25 were P. vivax. This greatly increases the risk of malaria importation and the potential threat of outbreak epidemics.

The third key factor is therefore the strengthening of the management of the floating population by the government and health care institutions. The CDC collaborated with customs, economic, tourism and other departments to target the migrant population from malaria-endemic areas, particularly those returning from overseas work. To keep these departments informed about malaria infection, morbidity and treatment, timely blood tests for Plasmodium parasites are carried out on febrile patients. If a person is found to be positive for Plasmodium, in addition to standard treatment, he or she is promptly followed up to investigate secondary infections.

The fourth key factor is continuous training of doctors to improve the diagnosis and treatment of malaria and to ensure that malaria cases are detected in time. Clinicians, public health workers, malaria microscopists and community health workers upgrading their skills through annual training, examinations and competitions to ensure that the three links of prevention, detection and treatment are closely integrated to further eliminate the incidence and prevalence of malaria.

The fifth factor is that the establishment of a powerful malaria defense system has played an important role in the elimination phase. Between 2010 and 2017, the establishment of a three-tier surveillance network and a secondary treatment system in Qingdao enabled timely monitoring of patients with triple fever, timely identification of malaria patients, and timely and standardised treatment. It was also able to quickly close points and eliminate sources, preventing the re-transmission of imported malaria.

During the period of the indigenous malaria pandemic, seasonal peaks in malaria incidence were characteristic of the transmission of the vector insect Anopheles sinensis. After the elimination of indigenous malaria, the vectors of malaria still exist because the ecological environment of the Qingdao area has not fundamentally changed. Therefore, the sixth key point is to continue to monitor vector mosquitoes, treat possible infection sites in a timely manner, eliminate mosquito breeding sites, reduce the chances of mosquito bites and cut off transmission channels. In 1981, Qingdao began to establish a vector monitoring system, and the results of more than 40 years of monitoring show that the number and population of Anopheles sinensis in Qingdao have changed, and the catch of Anopheles sinensis has decreased year by year, with the density of Anopheles sinensis in 1985 was 39.07 per person-hour, and the density of Anopheles sinensis will decrease to 2.08 per person-hour by 2020. However, the recent monitoring results of vector population show that there is still a small amount of Anopheles sinensis in Qingdao. Anopheles sinensis is a semi-domestic mosquito species, which can feed on human and cattle blood. The significant decrease in the number of Anopheles sinensis may be related to the ecological habit of Anopheles sinensis. On the one hand, with economic development and accelerated urbanization, the number of farmers’ cultivated land has been reduced and the mode of farming has been changed from cattle farming to mechanized farming, and the number of cattle kept in residents’ homes has been greatly reduced. On the other hand, the increase in the use of insecticides and the scope of use also made the population of Anopheles sinensis change. Conducting mosquito vector surveillance is helpful to understand the geographical distribution of Anopheles sinensis and predict the risk of malaria retransmission, and at the same time, targeted epidemic site treatment can be carried out according to the incidence of imported malaria in different seasons and regions.

This study examined a group of strategies and measures for preventing and controlling malaria that are appropriate for Qingdao. These measures enabled the city to eliminate malaria and maintain that status for over 20 years without any indigenous cases. These measures include: 1. Government attention and support; 2. Census to verify malaria epidemics, cut off transmission routes and rapidly control epidemics; 3. Joint prevention and control to prevent outbreaks and epidemics; 4. Consolidation of malaria prevention and control achievements through elimination of foci and sources of the disease; 5. Elimination of malaria by adapting to local conditions and using prevention as the mainstay of prevention; 6. Establishment of a strong network system for malaria control, following the strategy of “1-3-7”, strengthening monitoring and community health education and prevent the importation and re-transmission of malaria.

FUNDING
This work was supported by Projects of the Qingdao 2021 Medical and Health Research Program (2021-WJZD153).

Competing Interests
The author declares that they have no conflict of interests.

Author Contributions

ACKNOWLEDGEMENTS
The authors extend their gratitude to Professor Ning Xiao of the Institute of Parasitic Disease Prevention and Control of the Chinese Center for Disease Control and Prevention for his invaluable guidance in this study. They also acknowledge the support of the Qingdao Districts (Municipal) CDCs in malaria prevention and control efforts in Qingdao.


Accessed 19 January 2024


