

Characteristics and Temporal-Spatial Analysis of Overseas Imported Dengue Fever Cases in Outbreak Provinces of China, 2005-2019

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Research Article

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Abstract

(1) Background: Overseas imported dengue fever is an important factor in the local epidemic of dengue fever in mainland China. Therefore, in order to effectively prevent and control the local epidemic of dengue fever in mainland China, the epidemiological characteristics and temporal-spatial distribution of overseas imported dengue fever cases in provinces where dengue fever is endemic in mainland China are explored.

(2) Methods: Through the infectious disease report information management system of the Chinese Disease Prevention and Control Information System, we sorted out overseas imported dengue fever cases in local outbreaks of dengue fever in mainland China from 2005 to 2019. Using Excel 2016 to sort out the data and draw the epidemic curve and population characteristic distribution of overseas imported cases in each province. Using ArcGIS 10.7 and SaTScan 9.5, we analyzed the temporal-spatial distribution of dengue fever in provinces where dengue fever is outbreak in mainland China.

(3) Results: A total of 11407 imported cases, mainly from Southeast Asia, were recorded from 2005 to 2019 in 13 provinces, of which 62.08% were imported into Yunnan and Guangdong provinces. Among the imported cases, there were more males than females, mainly from 21-50 age group. 59.18% of the cases were farmers, businessmen, housework or unemployed. The hot spots were concentrated in parts of Yunnan and Guangdong provinces. Meanwhile, we found the clustered areas were expanding northward.

(4) Conclusions: Focus on the publicity and education of dengue fever prevention knowledge among men, 21-50 years old, farmers, business services, housework or unemployed professionals. Further improve the awareness of the prevention and control of imported cases in border areas and economically developed cities. At the same time, the northern region cannot relax its vigilance.

1. Background

Dengue fever is a mosquito-borne disease that is caused by the dengue virus and vectored by *Aedes albopictus* and *Aedes aegypti*[1–3]. The virus belongs to the flavivirus genus of the Flaviviridae family and can be divided into 4 serotypes (DENV-1, DENV-2, DENV-3 and DENV-4)[4, 5]. As early as 1780, Benjamin Rush described the dengue fever epidemic in Philadelphia[6]. Before 1970, only 9 countries had recorded dengue epidemics[7]. However, the prevalence of dengue fever had expanded dramatically to 128 countries by 2012 [8]. It was estimated that there were 390 million dengue infections worldwide in 2010 and Asia accounted for 70% of them [9]. The clinical manifestations of dengue fever are diverse, including fever, nausea, vomiting, skin rash and other symptoms. In some severe cases, shock and death can occur[10, 11]. Dengue fever brings a major economic and social burden to the affected country and poses a great threat to public health[12].

The first outbreak of dengue fever in mainland China since 1949 took place in Guangdong province in 1978, and the province was the most frequent outbreak of dengue fever in mainland China[13–15]. In 2014, it reached a peak, with more than 45,000 cases reported[16]. Meanwhile, the geographic range of the indigenous dengue fever in mainland China is gradually expanding northward[17]. As of 2019, there had been local outbreaks of dengue fever in 13 provinces, and the northernmost line of the dengue fever outbreak had arrived at Jining City, Shandong Province in 2017[18].

The imported cases is an important factor affecting the local outbreak of dengue fever in mainland China[19, 20]. As of 2019, the overseas imported cases had been reported in all provinces in mainland China except Tibet Autonomous Region[21]. More importantly, the number of imported cases kept increasing year by year from 2005 to 2016. Most of the cases were imported from neighboring Asian countries[22]. These imported cases often lead to the local outbreak of dengue fever[23, 24]. However, few studies are focusing on the epidemiological characteristics and temporal-spatial distribution of the imported dengue fever cases in China.

This study summarized the overseas imported dengue fever cases in 13 provinces where dengue fever was locally outbreak from 2005 to 2019, analyzed the epidemiological characteristics and the temporal-spatial distribution of the cases in these provinces, and proposed different prevention measures for geographical areas with different dengue outbreak characteristics. This study provides a basis for the reasonable allocation of medical resources and the effective prevention and control of dengue fever.

2. Materials And Methods

2.1. Study area

As of 2019, there had been local outbreaks of dengue fever in 13 provinces in mainland China, namely Hainan Province, Yunnan Province, Guangxi Province, Guangdong Province, Fujian Province, Hunan Province, Jiangxi Province, Sichuan Province, Chongqing City, Zhejiang Province, Hubei Province, Henan Province and Shandong Province.

2.2. Data sources

2.2.1. Cases data

The dengue cases data we used in this study were retrieved from the infectious disease report information management system of the Chinese Disease Prevention and Control Information System. We selected the clinically diagnosed and confirmed cases of dengue fever from 1 January 2005 to 13 December 2019 based on the date of onset. The addresses of the cases should be confined to 13 provinces. The source of dengue fever cases was distinguished as indigenous dengue cases, overseas imported dengue cases, domestic imported dengue cases and cases of unknown origin. The indigenous dengue cases refer to the cases that had not left the local city where they lived in 14 days before the onset of onset; the overseas imported dengue cases are defined as those who had been to a dengue-endemic country or region within 14 days before the onset; the domestic imported dengue cases refer to cases that had left their current city of residence and went to another city in the country within 14 days before the onset of the disease; cases of unknown origin refer to cases whose origin cannot be identified. In this study, we used overseas imported dengue cases as the research content.

2.22 Geographical coordinate data

We imported the vector maps of 13 provinces into ArcGIS 10.7, and obtained their latitude and longitude coordinates by transforming the plane coordinates x and y of each city.

2.23 Demographic data

From the statistical yearbooks or yearbooks of 13 provinces, we obtained the annual permanent population data or household registration population data of each city from 2005 to 2019. This data is used for temporal-spatial scanning analysis.

2.3 Statistical analysis

The Excel 2016 software was used to sort out the epidemiological characteristics of overseas imported dengue cases in 13 provinces from 2005 to 2019, including import source country or region, import region distribution, time characteristics and demographic distribution characteristics such as gender distribution, age distribution, occupation distribution, etc.

The ArcGIS 10.7 software was used to perform spatial autocorrelation analysis of the overseas imported dengue cases. Spatial autocorrelation analysis[25] can be used to analyze the spatial correlation of a variable, which included global autocorrelation and local autocorrelation. In this study, we used global Moran's I[26, 27] and Getis-Ord General G analysis[28, 29] to estimate the global autocorrelation. The value range of Moran's I index is between -1 and 1. When Moran's I index is closer to 1, the positive spatial correlation is stronger, that is, there is a spatial aggregation relationship between regions; when Moran's I index is closer to -1, the stronger the negative spatial correlation, which means that the attributes between the regions are opposite; when the Moran's I index is more equal to 0, it means that the distribution of the research variables in the research area is a random distribution pattern; but the index cannot determine the specific aggregation mode. The Getis-Ord General G index can indicate the degree and quantity of high and low values, and is used to analyze the correlation of a variable between adjacent areas. The null hypothesis indicates that there is no space for the research variable in the adjacent study area. When the calculated P value is statistically significant, we can judge it by observing the Getis-Ord general G value and Z score; when the Getis-Ord general G value is higher than the expected value and the Z score is positive, it indicates that the high value is clustered, that is, hot spot; when the Getis-Ord general G value is lower than the expected value and the Z score is negative, it indicates that the low values have a tendency to gather, that is, cold spot.

The local autocorrelation was analyzed using Anselin Local Moran's I[30, 31] and Getis-Ord G_i^* [32]. Anselin Local Moran's I index, as a local index of spatial correlation, represents the spatial correlation between a research area and its neighboring areas for the research variables, including low-low, low-high, high-low, and high-high, and not significant. The low-low and high-high types indicate spatial aggregation, that is, cold spots and hot spots, respectively. It suggests that an area with a small number of imported cases of dengue fever is surrounded by a neighboring area with a small number of imported cases, and an area with a large number of imported cases of dengue fever is surrounded by a neighboring area with a large number of imported cases. The low-high and high-low types indicate spatial outliers, which respectively indicate that the area with a small number of imported cases of dengue fever are surrounded by adjacent areas with a large number of imported cases, and the area with a large number of imported cases of dengue fever is surrounded by an adjacent area with a small number of imported cases. Through Getis-Ord G_i^* analysis, the specific spatial clustering positions of high and low values can be observed, and the specific distribution of cold spots and hot spots can be identified.

We used SaTScan 9.5 software to perform the temporal-spatial scanning analysis of overseas imported cases. SaTScan 9.5 software detects the accumulation of a certain disease in time and space by scanning the studied areas using a cylindrical scan window. The log-likelihood ratio (LLR) can be used to identify the location of the

most likely clusters and secondary clusters and other clustering regions. Under Poisson's assumption, the log-likelihood ratio of the scanning window is:

$$LLR = \left(\frac{c}{E[c]}\right)^c \left(\frac{C-c}{C-E[c]}\right)^{(C-c)} I()$$

C represents the total number of cases, c represents the number of observed cases in the window, E(c) represents the expected number of cases adjusted by covariates in the window under the condition of the null hypothesis. Here, the null hypothesis is that for window scanning, the aggregation trend inside the window is the same as that outside of the window. C-E[c] represents the expected number of cases outside the window, and I() represents the indicator function. LLR is related to the scan rate of the cluster. When the cluster is scanned only at a high rate, and the number of cases in the window is higher than the expected number of cases under the null hypothesis, I() = 1; otherwise, I() = 0.

The Poisson model was used to analyze the spatial aggregation area. The circular window is selected as the scanning window, and the largest scanning area is 50% of the total population. The P-value was determined by the combination of standard Monte Carlo method, sequential Monte Carlo method and Gumbel approximation. The test level $\alpha=0.05$, and the number of Monte Carlo iterations was set to 999. The temporal-spatial scanning analysis was visualized using ArcGIS 10.7 software.

3. Results

3.1. Overview of overseas imported dengue fever cases in 13 provinces

3.1.1. Sources of the imported cases

From 2005 to 2019, a total of 11407 imported cases of dengue fever were reported in the 13 provinces in China. Among these cases, 11045 were imported from the Asian region, accounting for 96.83%, particularly from Southeast Asia which accounted for 94.50%. In addition, Africa, Oceania, South America and North America are also the sources of imported cases, accounting for 1.60%, 0.51%, 0.25% and 0.10%, respectively. The source of the remaining 0.72% of imported cases wasn't identified.

3.1.2. Distribution areas and epidemic trend of imported cases

All the municipalities had imported dengue fever cases in the studied 13 provinces from 2005 to 2019 with a few exceptions for the northwestern part of Yunnan province, the northwestern part of Sichuan province, Shennongjia forest region of Hubei province and Rizhao city of Shandong province and a few areas in Chongqing (Fig. 1). The areas in western Yunnan Province bordering Myanmar had the largest number of overseas imported cases, reaching 2,485 cases, accounting for 21.78% of the total overseas imported cases in all the 13 provinces. In general, the overseas imported cases are more likely to be observed in the border areas of Yunnan Province, the southeast coastal areas and the capital areas with developed economies and convenient transportation (Fig. 2).

It can be seen from Table 1 that overseas imported dengue fever cases in most of the provinces began to increase since 2013 and accounted for 94.91% of the total cases, so here we mainly described the prevalence of the imported dengue fever cases from 2013 to 2019. During this period, Yunnan province and Guangdong province reported a large proportion of imported cases, accounting for 62.08% in total. The prevalence curve of these cases

from 2013 to 2019, in provinces with more imported cases, showed a clear seasonal trend with most import cases happened from July to November (Fig. 3).

Table 1. The proportion of overseas imported dengue fever cases in provinces where dengue fever is locally outbreak in mainland China, 2005-2019.

Area	2005-2012		2013-2019		2005-2019	
	overseas imported dengue fever cases	Percentage[%]	overseas imported dengue fever cases	Percentage[%]	overseas imported dengue fever cases	Percentage[%]
Yunnan	177	30.46	4483	41.41	4660	40.85
Guangdong	173	29.78	2249	20.77	2422	21.23
Fujian	95	16.35	1009	9.32	1104	9.68
Zhejiang	40	6.88	952	8.79	992	8.70
Sichuan	15	2.58	433	4.00	448	3.93
Hunan	28	4.82	412	3.81	440	3.86
Henan	4	0.69	257	2.37	261	2.29
Hubei	13	2.24	240	2.22	253	2.22
Chongqing	4	0.69	236	2.18	240	2.10
Jiangxi	9	1.55	192	1.77	201	1.76
Shandong	7	1.20	149	1.38	156	1.37
Guangxi	10	1.72	138	1.27	148	1.30
Hainan	6	1.04	76	0.71	82	0.71
Total	581	100.00	10826	100.00	11407	100.00
		5.09%		94.91%		100.00%

3.2. Population distribution characteristics of overseas imported dengue fever cases in 13 provinces

3.2.1. Gender characteristics

As shown in Fig. 4, the number of males was higher than females for the imported cases from 2005 to 2019, with a male-to-female ratio = 1.97:1. The ratio in Yunnan province and Hainan province was relatively low, which was below the overall male-to-female ratio in 13 provinces, 1.28:1 and 1.83:1 respectively. The highest ratio was observed in Shandong Province, about 6:1.

3.2.2. Age characteristics

As shown in Fig. 5, the age distribution of the imported dengue fever cases in 13 provinces exhibited similar patterns. The young and middle-aged people aged 21–50 accounted for a large proportion (76.61%) of the

imported cases. Specifically, imported cases in Yunnan province and Guangxi province were concentrated in the 21–30 age group. In Fujian Province, Henan Province, Chongqing City and Hainan Province the number of imported cases also was the largest in the 21–30 age group, and there were the second-largest imported cases in the 31–40 age group. The imported cases in other provinces were more concentrated in the 31–40 year-old age group, followed by the 21–30 year-old age group.

3.2.3. Occupational characteristics

Among the 13 provinces, the top ten occupations for the imported cases were farmers, businessman, housework or unemployed, workers, students, cadre, migrant laborer, scattered children, retiree, and catering industries, accounting for 85.59% of the total number of imported cases. Those above occupations showed different proportions slightly in different provinces. Farmers accounted for the highest proportion of imported cases in Yunnan, Hunan, Henan, Jiangxi and Shandong provinces. In contrast, the proportion of commercial services were highest in Guangdong, Zhejiang and Hainan provinces. Most imported cases in Fujian Province and Chongqing City were domestic and unemployed people. In Sichuan Province, Hubei Province, and Guangxi Province, in addition to farmers, the proportion of housework and unemployed among imported cases was also very high. (Fig. 6).

3.3. Temporal-spatial distribution characteristics of overseas imported dengue fever cases in 13 provinces

3.3.1. Global autocorrelation statistics

Using ArcGIS, we estimated the global Moran's I index as 0.110708 and the z-score as 3.595916 ($P < 0.05$) for all the imported cases from 2005 to 2012. The results suggested that the spatial autocorrelation of these cases during this period was significantly positive. Getis-Ord General G value was estimated as 0.000001 and z score as 2.526695 ($P < 0.05$), suggesting a tendency for clustering of the overseas imported dengue fever cases from 2005 to 2012.

From 2013 to 2019, the global Moran's I index was 0.083838 and the z-score was 3.642993 ($P < 0.05$). The results showed that the spatial autocorrelation was significantly positive for the imported cases during this period. Getis-Ord General G value was 0.000001 and z score was 1.756175 ($P < 0.1$), suggesting a tendency for clustering of dengue fever cases imported from 2013 to 2019.

3.3.2. Local autocorrelation analysis

Anselin Local Moran's I analysis of the imported cases from 2005 to 2012 revealed high-high clusters at the border area of of Yunnan province, southeast of Guangdong province, and two coastal areas in Fujian province. In contrast, the low-low clusters were detected at most areas of Henan province and Shandong province, as well as one area or two areas in Guangxi province, Jiangxi province, Sichuan province, and Hubei province respectively. Sichuan province and Shandong province had one region exhibited high-low clusters respectively. Two border areas in Yunnan province, and the other 6 cities in the northern part of Guangdong Province were identified as low-high clusters (Fig. 7. a).

From 2013 to 2019, the number of provinces with local spatial autocorrelation areas decreased. four border areas in Yunnan province, and a region in the southeast of Guangdong province were high-high clusters. The central part of Guangxi Province, the central part of Hubei Province, Henan Province and Shandong Province were mostly

low-low clusters. The capital of Hubei province was a high-low cluster. Two border areas in Yunnan Province and a city in eastern Guangdong province were low-high clusters(Fig. 7.b).

Getis-Ord G_i^* analysis showed that imported cases from 2005 to 2012 had formed hot spots in some areas in Yunnan, Guangdong, and Fujian provinces including the border areas of Yunnan province, most parts of Guangdong province and the coastal areas of Fujian province(Fig. 7.c). However, the hot spots of the imported cases during 2013–2019 were only identified in Yunnan province(Fig. 7.d).

3.3.3. Temporal-spatial distribution characteristics of overseas dengue fever cases

We used the maximum spatial cluster size of 50% of the at-risk population to scan the clustering areas in the two time periods of 2005–2012 and 2013–2019. The results showed that the Dehong Dai and Jingpo Autonomous Prefecture in Yunnan Province was the most likely cluster for both of the two time periods($P < 0.01$). The regional scope of the secondary cluster was significantly larger from 2013 to 2019. During 2005–2012, the secondary clusters were identified in Hainan Province, eastern Yunnan Province, Guangxi Province, Guangdong Province, central and southern Hunan Province, southern Jiangxi Province, and southern Fujian Province ($P < 0.01$). During 2013–2019, the secondary cluster expanded westward and northward, reaching the areas around Chongqing ($P < 0.01$) (Fig. 8, Table 2).

Table 2. Temporal-spatial scan results of overseas imported dengue fever, 2005-2019.

period	Clusters	Aggregation time	Observed cases	Expected cases	Relative risk	LLR	P-value
2005-2012	I	2008/8/1-2008/11/30	46	0.038	1321.43	282.688853	<0.01
	II	2010/7/1-2012/12/31	223	66.37	4.83	140.393001	<0.01
2013-2019	I	2014/8/1-2017/12/31	1986	8.62	282.05	9019.769506	<0.01
	II	2019/5/1-2019/11/30	3266	463.81	9.65	3991.103028	<0.01

Discussion

Dengue fever in mainland China is an imported vector-borne disease and has not yet formed epidemics[33]. A better understanding of the epidemiological characteristics and temporal-spatial distribution of the imported cases will provide a theoretical basis for the rational allocation of medical resources and thus benefit the prevention and control of dengue fever. In this study, we analyzed over eleven thousand overseas imported dengue fever cases in 13 provinces in China from 2005 to 2019, including the locations of these cases, the onset date, the gender and age distributions and the occupations. We also investigated the geographic autocorrelation of these cases and identified the hot spots and spatial clusters.

Most overseas imported cases were located in the border areas of Yunnan province, coastal areas of Zhejiang province, Fujian province, and Guangdong province, provincial capitals of Chongqing City and some other provinces. The reasons for these locations being mostly affected by the import cases may vary considerably.

Yunnan province lying in the southwest of China is one of the provinces with the longest border. It shares a borderline with Myanmar, Laos, and Vietnam over 4,060 km. It is also a key region connecting Southeast Asia and South Asia. Given the prevalence of dengue fever in Southeast Asia and South Asia[34, 35] and the frequent cross-border migrants, this region has been a high-risk area for imported dengue fever. In contrast, the coastal areas of Zhejiang province, Fujian province, and Guangdong province, provincial capitals of Chongqing City and some other provinces, despite the absence of borderlines with neighbouring countries, have relatively developed economies and high trade activities with large population flows. These factors elevated the transmission of dengue fever, making these areas susceptible to imported cases. Some studies [36, 37] have shown that a series of infectious diseases such as dengue fever have been imported into China amid the rapid development of globalization, the increase of global migrants caused by tourism, the exchange of a large number of laborers and products. Another study found that the number of imported dengue fever cases in China was closely related to the number of tourists from Southeast Asia and the number of overseas workers[37].

In the 13 provinces studied above, the number of overseas imported dengue fever cases reached a peak in 2019, which may be closely related to the intensity of the dengue fever epidemic in neighbouring countries. A large number of cases were imported from Cambodia[38]. This may be related to the fact that after the Chinese businessmen set up new factories in Cambodia, they summoned a large number of multinational migrant workers to work in Cambodia[39]. For provinces with a large number of imported cases, such as Yunnan province and Guangdong province, most of the imported cases were reported between July and November, which overlapped with the local outbreak of dengue fever in mainland China[21, 40–42]. Studies have shown that rainfall, temperature and humidity are important climatic factors affecting the density of mosquitoes[43, 44], and the climatic conditions in this period are just conducive to the breeding of mosquitoes of the vector. Therefore, the measures to prevent and control overseas imported dengue fever should be intensified between July and November.

In terms of gender, the number of imported cases of men from 2005 to 2019 was greater than that of women. This may be related to the difference in the social division of labor between men and women. Men are more frequently moving across borders whether for business purposes or as migrant workers, which greatly expose them to dengue fever. As opposed to men, most women often live at home or work indoors, so they have less chance of exposure to mosquito bites than men. In terms of age, most of the imported cases were between 21 and 50 years old. Given that people in this age group are more likely to be laborers, they have more chances of contracting dengue fever.

In terms of occupation, the difference in the distribution in the 13 provinces reflects a distinct economic status and overall occupational difference of residents in each province. For example, the imported cases in the developed provinces, such as Guangdong province and Zhejiang province, were more likely to be businessmen instead of farmers and workers as that in less developed provinces. Independent of the provinces, we identified several high-risk occupations for imported cases including farmers, commercial services, border trade, housework and unemployed people. The surveillance of these occupations should be strengthened to minimize the chances of being imported cases. In addition, whatever the occupations are, the community should strengthen publicity and education for residents to protect them from mosquitoes. It is also important to familiarize the residents in risk areas with the common symptoms of dengue fever and the way to seek medical treatment timely.

This study combined the spatial autocorrelation analysis and that temporal-spatial scanning to explore the spatial clustering of overseas imported dengue fever cases in 13 provinces. The results exhibited a trend of more cases in

the south and less in the north, more in border and coastal areas, and less inland. Global autocorrelation revealed a spatially positive correlation, suggesting the uneven distribution of these imported cases and the presence of case clusters. This phenomenon may be related to the population flow, international business and employment, studying abroad, and some environmental factors such as temperature or humidity. The local autocorrelation identified the areas with outliers in southern Yunnan, northern Guangdong and some provincial capitals. The number of outliers in 2013–2019 had decreased compared with that in 2005–2012. The clustering areas were mostly distributed in the border areas of Yunnan province, Hubei province, Henan province and Shandong province. The border areas of Yunnan province are high-value clusters, while the other areas are low-value clusters. The number of cluster areas in 2013–2019 had increased compared with that in 2005–2012.

The hot spots were identified in the southern and southwestern regions of Yunnan province from 2005 to 2019. These regions are likely to be high-risk areas of imported dengue fever in the future. Stringent measures should be implemented to prevent and control the imported cases and public health education regarding dengue fever should also be strengthened in these regions. From 2005 to 2012, most of the northern part of Guangdong Province and some coastal areas of Fujian Province were also identified as hotspots, but by 2013–2019, most of the northern part of Guangdong Province and some coastal areas of Fujian Province were no longer a hotspot. The temporal-spatial scan results obtained by SaTScan are different from Getis-Ord G_i^* analysis, which may be due to the different principles of them[45]. The temporal-spatial scan also showed that the cluster areas of imported cases in 2013–2019 have expanded northward compared with that in 2005–2012. Although we are not sure whether the trend will continue in the future, attention should also be paid to the northern regions amid global warming and climate change.

The imported dengue fever cases are the most important driver of dengue outbreaks in China. For better prevention and control of dengue fever, the knowledge of dengue fever should be publicized for the entry and exit personnel, increasing their awareness of dengue fever. Meanwhile, health monitoring and surveillance should be implemented, particularly for people from dengue fever epidemic areas or countries. It also necessitates regular training for medical personnel in private clinics, township health centers, community hospitals, and large central hospitals to improve their knowledge on dengue fever and their abilities to identify dengue fever. This will help achieve early detection, early diagnosis and early treatment of suspected dengue fever. At last, the pandemic of COVID19 gives us a lesson that the control of infectious diseases entails joint efforts and global cooperation. It is pivotal to collaborate with other countries, particularly with those experiencing dengue fever epidemics, by providing technical assistance, training relevant professional personnel, exchanging knowledge and sharing experience in dengue fever control. These efforts will eventually prevent the further spread of dengue fever and minimize the disease burdens resulted from dengue fever.

Conclusions

With the acceleration of globalization and the advancement of international cooperation under the “Belt and Road” initiative, economic and trade activities, cultural exchanges, transnational labor and tourism have significantly increased in recent years. Consequently, the pressure on the prevention and control of overseas imports of dengue fever in China has increased as well. In this study, we characterized the imported dengue fever cases from 2005 to 2019 in 13 provinces in China and identified the hot spots of these imported cases which includes the border areas of Yunnan Province, coastal areas of Zhejiang province, Fujian province, and

Guangdong province, provincial capitals of Chongqing City and some other provinces. These findings will provide valuable information in making strategies and policies to prevent and control dengue fever.

Declarations

Ethics approval and consent to participate: Not applicable.

Consent for publication: Not applicable.

Availability of data and materials: The datasets used and analysed during the current study are available from the corresponding author on reasonable request.

Competing interests: The authors declare no conflict of interest.

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Figures

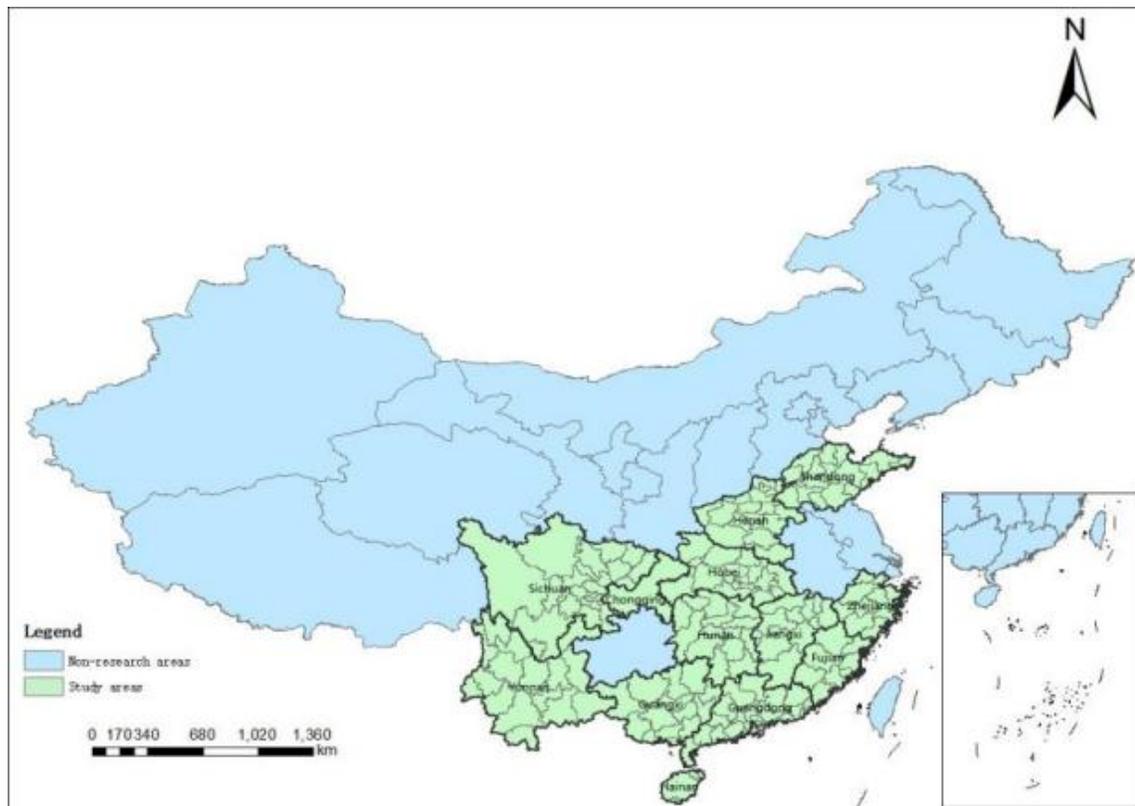


Figure 1

Schematic diagram of the study area.

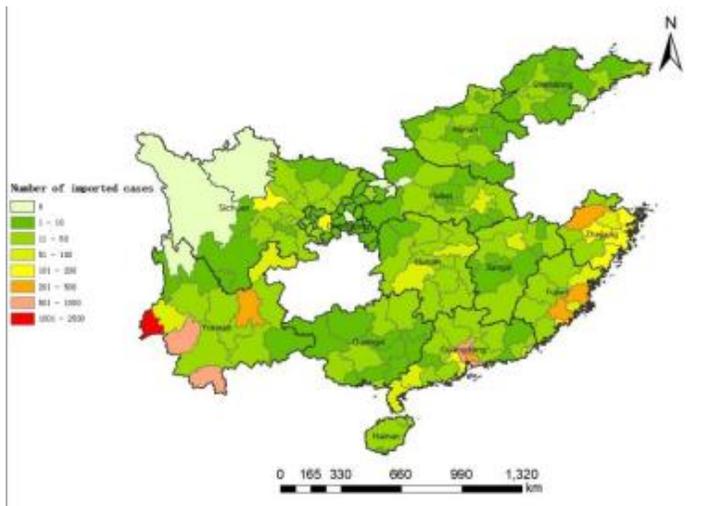
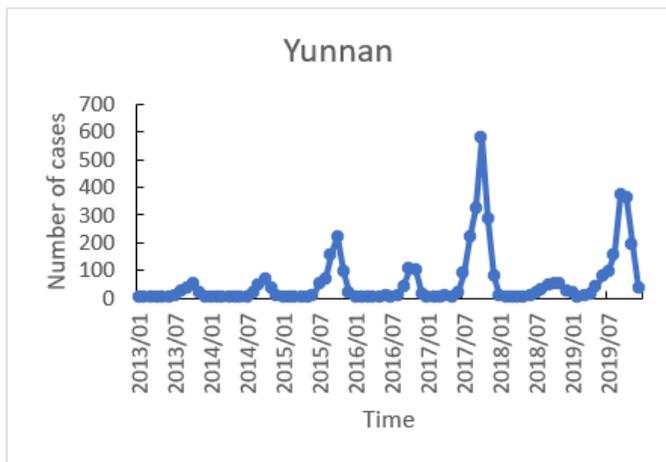
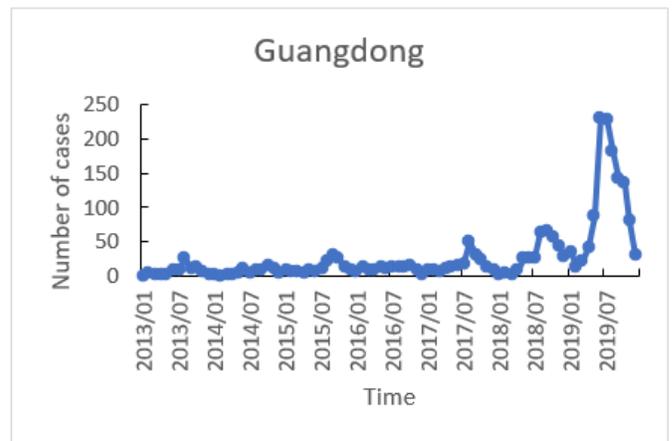


Figure 2

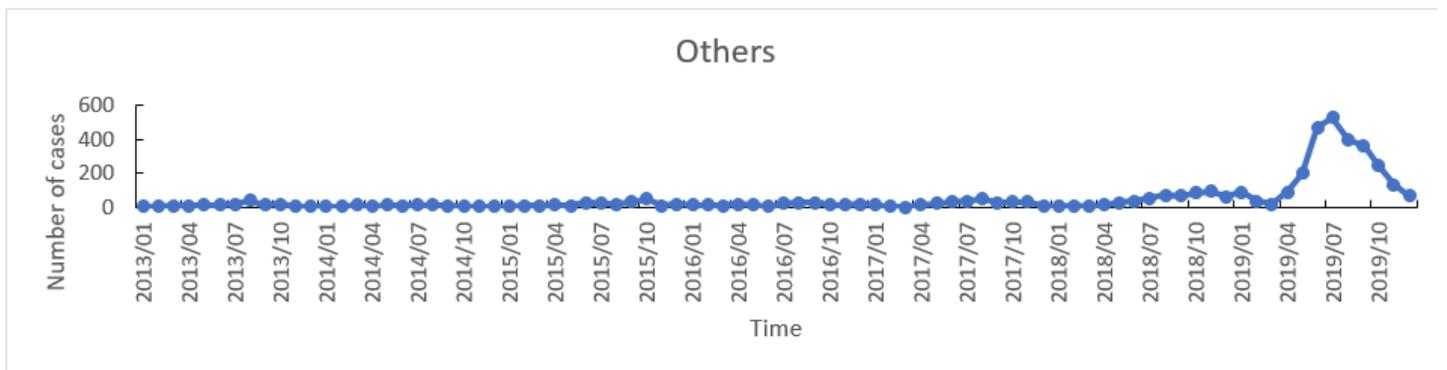
Distribution of overseas imported dengue fever cases in the provinces where dengue fever is locally outbreak in mainland China, 2005-2019.



(a)



(b)



(c)

Figure 3

The prevalence trend of overseas imported dengue fever cases in provinces where dengue fever is locally outbreak in mainland China, 2013-2019.

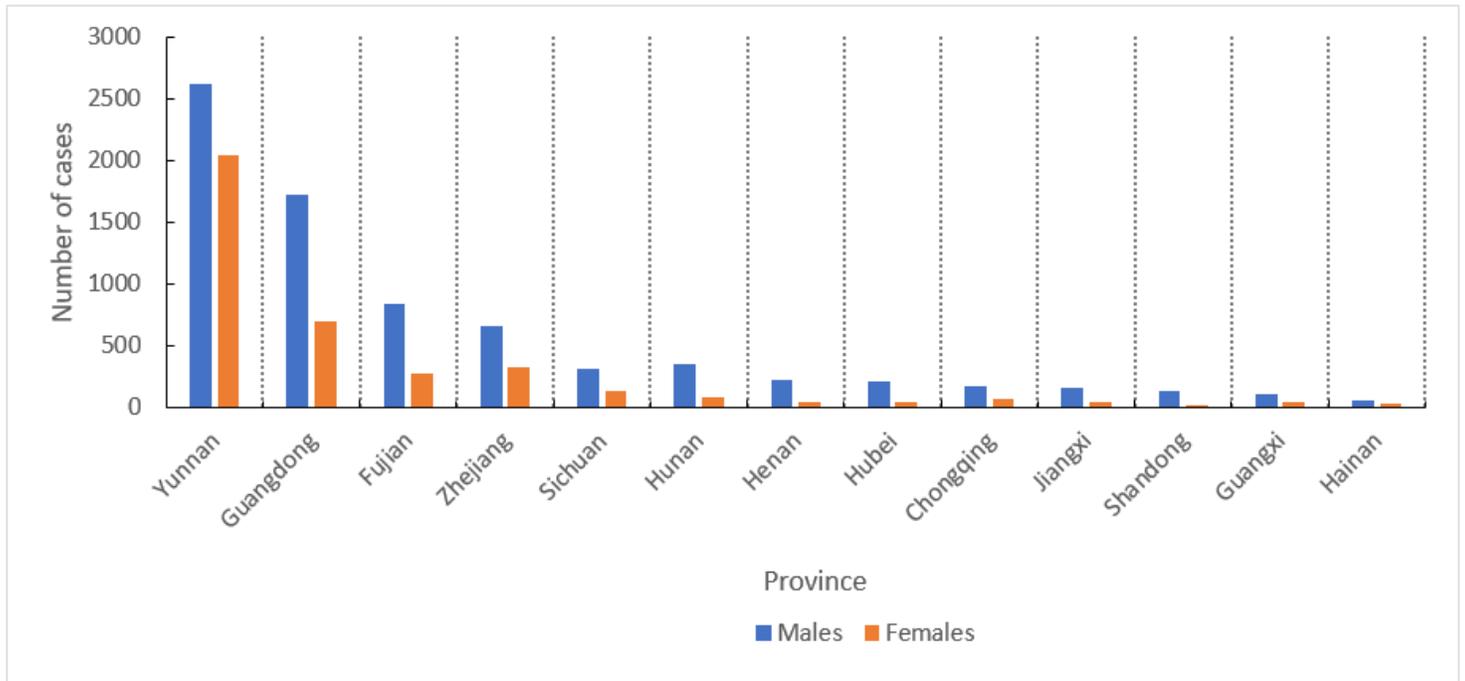
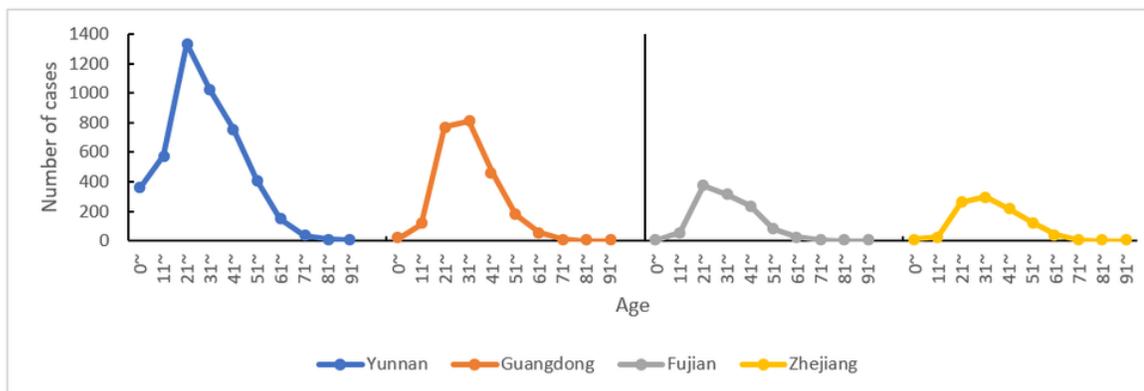
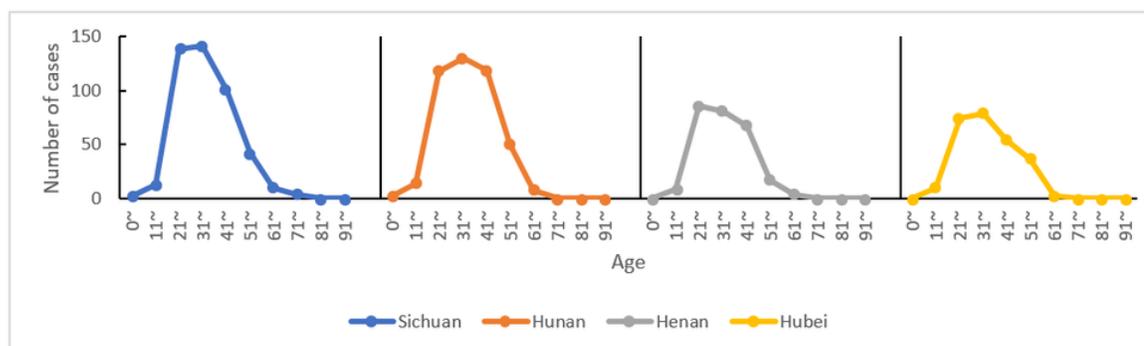


Figure 4

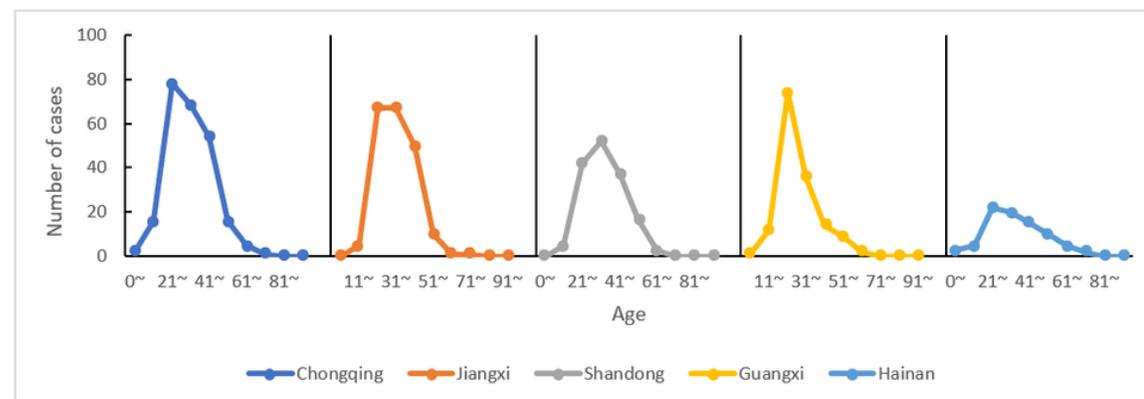
Gender distribution of overseas imported dengue fever cases in provinces where dengue fever is locally outbreak in mainland China, 2005-2019.



(a)



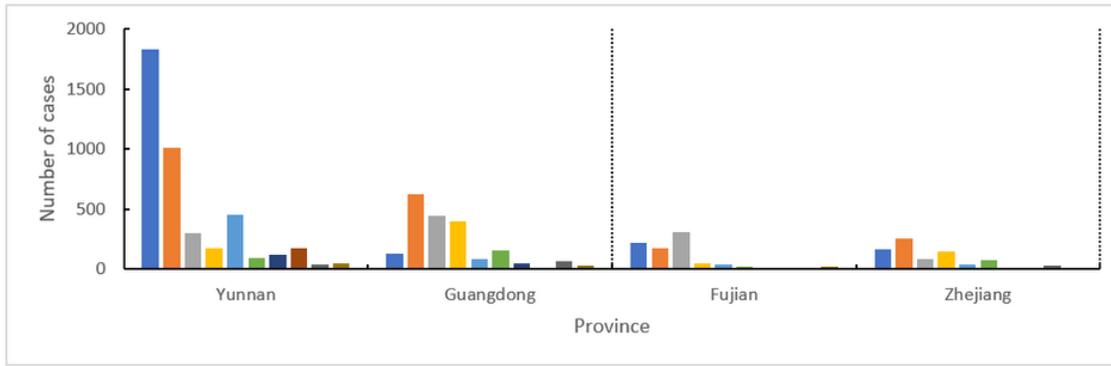
(b)



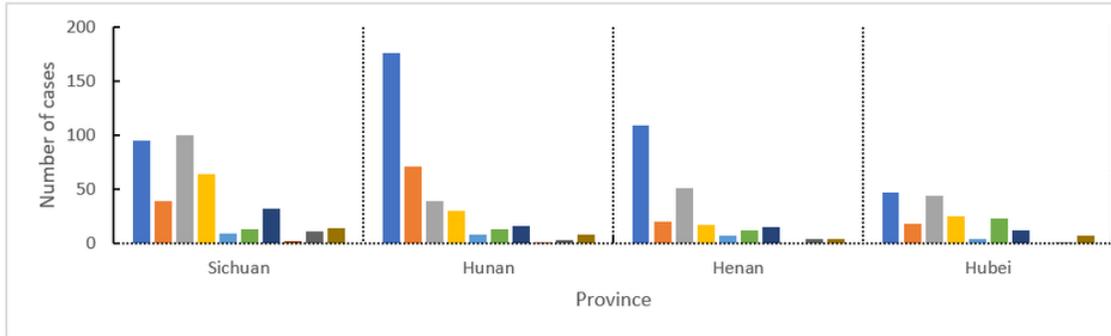
(c)

Figure 5

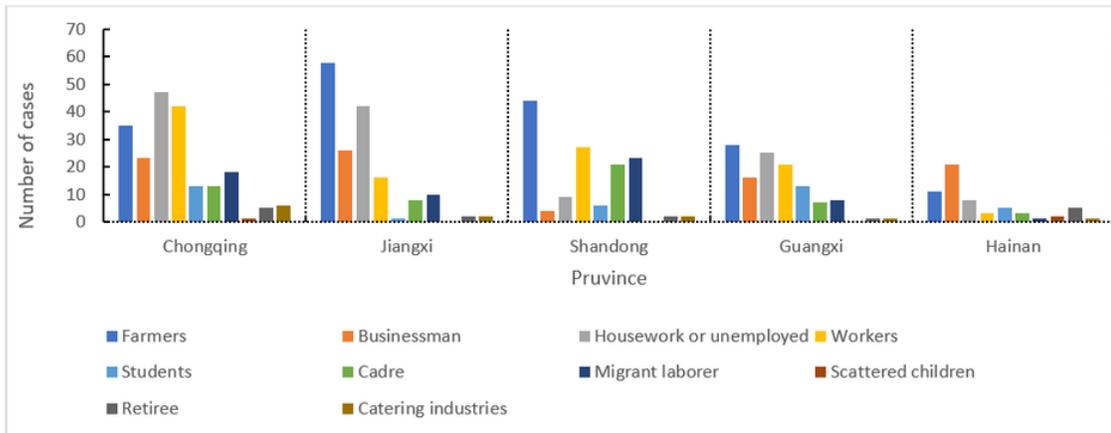
Age characteristics of overseas imported dengue fever cases in provinces where dengue fever is locally outbreak in mainland China, 2005-2019.



(a)



(b)



(c)

Figure 6

Occupational characteristics of overseas imported dengue fever cases in provinces where dengue fever is locally outbreak in mainland China, 2005-2019.

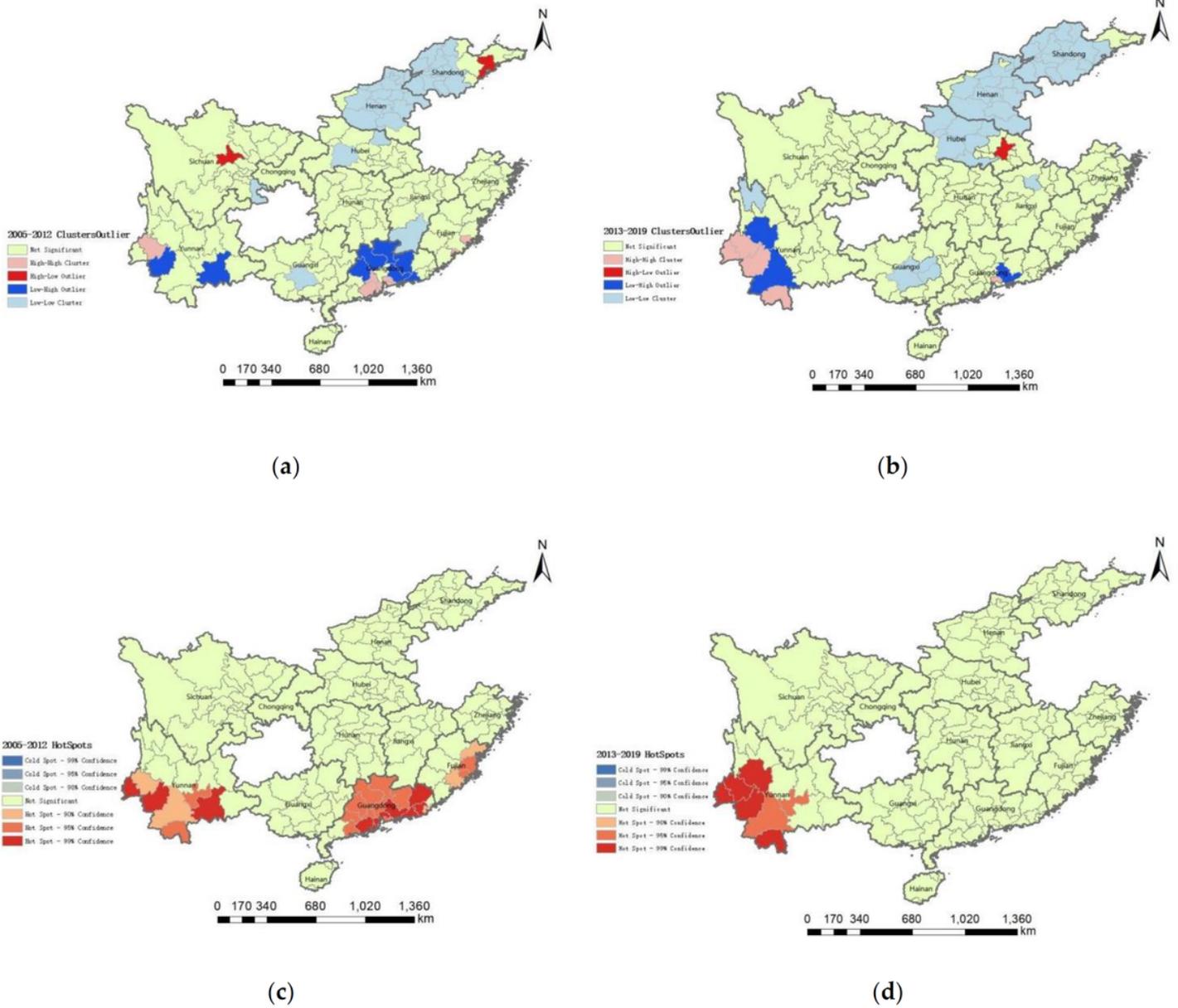
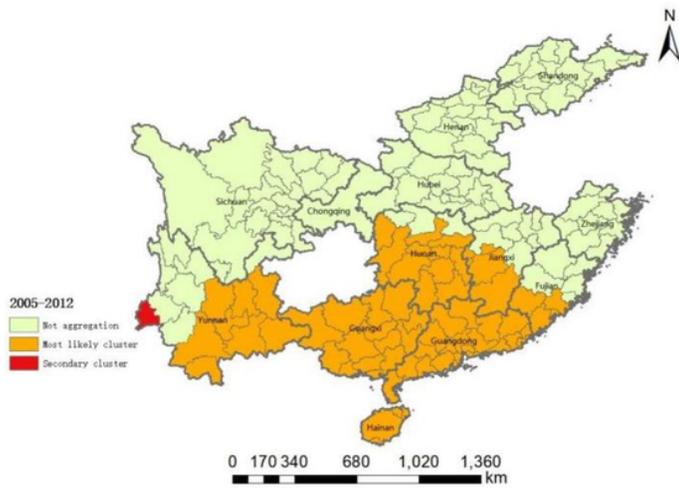
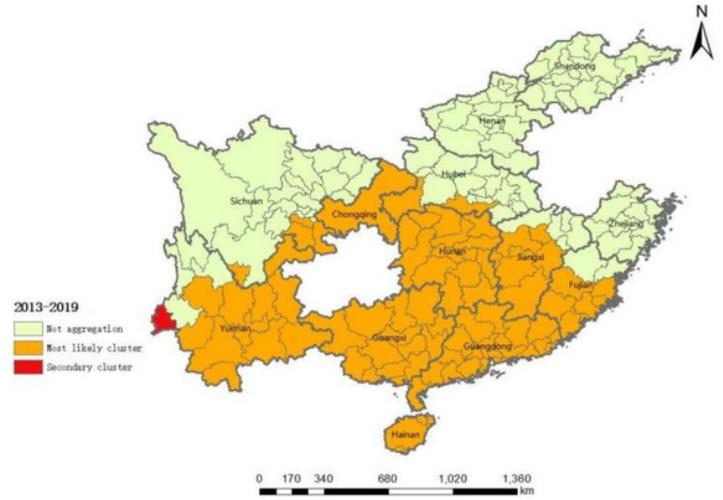


Figure 7

Local spatial autocorrelation of overseas imported dengue fever cases in provinces where dengue fever is locally outbreak in mainland China, 2005-2019.(a is the result of Anselin Local Moran's I analysis in 2005-2012; b is the result of Anselin Local Moran's I analysis in 2013-2019; c is the result of Getis-Ord G_i^* analysis in 2005-2012; d is the result of 2013-2019 The result of the Getis-Ord G_i^* analysis.)



(a)



(b)

Figure 8

Distribution of spatial clusters of overseas imported dengue fever cases in provinces where dengue fever is locally outbreak in mainland China, 2005-2019.(a is the result of the temporal-spatial scan analysis from 2005 to 2012; b is the result of the tem-poral-spatial scan analysis from 2013 to 2019.)