Comparative analyses on epidemiological characteristics of dengue fever in Guangdong and Yunnan, China, 2004-2018

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Research article

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Abstract

Background Guangdong and Yunnan were the two provinces with the toughest dengue epidemic in China. It was to compare epidemiological characteristics of dengue fever there, 2004-2018.

Methods Epidemiological method and spatial-temporal analysis were used to explore time-series, spatial and demographic features of dengue fever.

Results 93.7% of indigenous cases and 65.9 % of imported cases in mainland China, 2004-2018 occurred in Guangdong and Yunnan. 55,970 and 5,938 indigenous cases occurred in 108 counties of Guangdong and 8 counties of Yunnan, respectively. 1,146 and 3,050 imported cases occurred in 84 counties of Guangdong and 72 counties of Yunnan, respectively. Guangdong and Yunnan had similar seasonal characteristics for dengue fever, and Guangdong had a longer peak period. 85.1% of indigenous cases in Yunnan were located in Ruili City and Jinghong City along the southwestern border. Most dengue cases in Guangdong occurred in the Pearl River Delta region, and especially more than 70.0% of dengue cases in Guangdong occurred in Guangzhou City. 93.9% of imported cases in Guangdong and Yunnan were imported from 9 countries of Southeast Asia. Thailand, Cambodia and Malaysia were the main imported origins in Guangdong. Myanmar and Laos were the main imported origins in Yunnan. There was a strong male predominance among imported cases and an almost equal gender distribution among indigenous cases. Most dengue cases were from individuals in 21-50 years old, accounting for 57.3% and 62.8% of indigenous cases and 83.2% and 62.6% of imported cases in Guangdong and Yunnan, respectively. There were similar major occupations as housework or unemployment, retiree and businessman for indigenous cases, and businessman for imported cases. However, farmers accounted for a larger proportion of dengue cases in Yunnan.

Conclusions The findings of epidemiological characteristics and differences of dengue fever in Guangdong and Yunnan are helpful to formulate targeted, strategic plans and implement effective public health prevention measures in China.

Background

Dengue fever, one of the most prevalent mosquito-borne diseases in humans, is mainly transmitted by *Aedes aegyptiand* and *Aedes albopictus*[1]. There are four distinct serotypes for dengue virus, namely DENV 1-4 [2].It is endemic in more than 100 countries in Southeast Asia, the Americas, Western Pacific, Africa, and Eastern Mediterranean regions [3]. It has evolved from a sporadic disease to a major public health problem as geographical extension, numbers of cases, and disease severity increases[3]. It is estimated that 390 million people had dengue virus infections with 96 million cases annually worldwide [1].

A total of 655,324 cases and 610 deaths were reported in mainland China from 1978 to 2008. A total of 52,749 cases and six deaths were reported from 2009 to 2014 [4]. A dengue fever outbreak occurred in China, 2014, with 47,127 dengue cases according to Chinese National Notifiable Infectious

Disease Reporting Information System (CNNDS) [5]. Dengue fever outbreaks have spread from the southern coastal areas as Guangdong (GD) and Hainan to the relatively northern and western areas including Fujian, Zhejiang, and Yunnan (YN), with shorter outbreak intervals as compared to those before the 1990s [6]. The affected regions expanded gradually over the 10-year period, from the coastal provinces (Hainan, GD, Fujian, and Zhejiang) of southern China and provinces (Guangxi and YN) adjacent to Southeast Asian countries to the central provinces of China (Henan) [7].

Most dengue cases, accounting for more than 80% of the total dengue cases, were reported in GD, YN, Fujian, and Zhejiang, 2005-2015. The overall number of dengue cases reported from GD was largest, and the number of dengue cases in YN increased in recent years and had the largest number of cases in 2015 [8]. During 2005-2014, 94.3% and 3.0% of the total indigenous cases and 18.3% and 28.8% of the total imported dengue cases in mainland China were from GD and YN, respectively[7]. Therefore, dengue epidemic was grimmest in GD and YN, China. It is of great significance for the prevention of dengue fever in mainland China to explore dengue fever in GD and YN. However, Comparative analyses on epidemiological characteristics of dengue fever in GD and YN were rare. Therefore, this study was to compare epidemiological characteristics from indigenous dengue cases and imported dengue cases in GD and YN, including time-series, spatial and demographic features.

Methods

Data collection

Dengue cases were defined based on clinical diagnosis and laboratory confirmation according to diagnostic criteria and principles of management for dengue (WS 216-2001, before 2008) or diagnostic criteria for dengue (WS 216-2008, after 2008) [9-10].

Dengue fever is a vector-borne notifiable disease in China, and are reported to Chinese Center for Disease Control and Prevention (China CDC) through CNNDS. Dengue case report includes sex, age, occupation, national code of current address, date of illness onset, remarks, etc. There are several kinds of occupations, such as farmer, businessman, student, etc. Daily dengue case reports in GD and YN, China from January 1st 2004 to December 13th 2018 were from CNNDS (http://www.chinacdc.cn/). The vector data of Chinese administrative divisions, which were used for geographical mapping, were from CNNDS. Monthly average of daily temperature observation data from 2004-2018 were from Library for Climate Studies of Chinese Meteorological Administration (http://data.cma.cn/). China's sixth population census and gross domestic production (GDP) in 2010 was from National Bureau of Statistics of China (http://www.stats.gov.cn/). China's population census surveys and registers the existing national population according to the unified time node and method formulated by the nation, in order to understand population development and gender ratio in different regions. So far, China has conducted six national population censuses in 1953, 1964, 1982, 1990, 2000 and 2010, respectively.

Data processing

According to the remarks of dengue case reports, dengue cases were divided into indigenous dengue cases, imported dengue cases and others. Indigenous dengue cases refer to the cases who did not leave the local counties (the current addresses) within 14 days before illness onset. Imported dengue cases refer to the cases who went to foreign countries or regions within 14 days before illness onset where dengue fever was prevalent. Other cases included what we were not sure how to classify. Indigenous dengue cases occurred from June to December finally. In order to perform spatial analysis, dengue cases were aggregated at the county level according to national codes of current addresses, and then were geocoded and matched to the county-level administrative boundaries using ArcGIS version 10.5 [11].

Data analysis

Time-series analyses and demographic analyses were conducted using IBM SPSS Statistics version 24.0. The Chi-square test was used to compare the overall discrepancies of dengue cases in sex distributions, age group distributions and career distributions in GD and YN, 2004-2018. Spatial distribution analyses for dengue cases were conducted using ArcGIS version 10.5 [11].

Results

Common information comparison between GD and YN, China was showed in Table 1. The population ratio between GD and YN was 2.3, but the area ratio was only 0.5. Compared with Yunnan, Guangdong had a slightly smaller number of districts and counties. The ratio of indigenous dengue cases between GD and YN during 2004-2018 reached 9.4, but the ratio of imported dengue cases was only 0.4. There were 73,761 dengue cases in mainland China during 2004-2018, among which there were 93.7% of indigenous dengue cases, 65.9 % of imported dengue cases occurred in GD and YN.

Comparative analyses of indigenous dengue fever in GD and YN

Time-series comparative analyses of indigenous dengue cases

There were 55,970 and 5,938 indigenous dengue cases in GD and YN during 2004-2018, respectively. Indigenous dengue fever had been both more and more serious in these years (Figure 1(A)). There both existed seasonal characteristics from July to November for indigenous cases and counties (Figure 1(B)). No indigenous cases occurred in GD, 2005. Indigenous cases occurred in YN only in 2008 and 2013-2018. Indigenous cases in YN in 2017, 1,954 cases, exceeded those in GD, and indigenous dengue counties in YN, 2008 exceeded those in GD. A dengue fever outbreak occurred in GD, 2014, and indigenous cases reached 44,795, accounting for 80.0% of indigenous cases in GD during 2004-2018.

Indigenous cases and counties in GD, October, 2014 reached the largest monthly numbers as 22,505 and 97.

Spatial comparative analyses of indigenous dengue cases

YN is located in southwestern China, and GD is located in southern China (Figure 2 (A)). Compared with 108 indigenous dengue counties in GD (87.8% of its total counties), there were 8 indigenous dengue counties in YN (6.2% of its total counties). Most indigenous cases in YN were clustered in the southwestern border, and most indigenous cases in GD were clustered in the southern coastal areas. There were 1,239 indigenous cases in Ruili city, Dehong Dai Jingpo Autonomous Prefecture and 3,803 indigenous cases in Jinghong City, Xishuangbanna Dai Autonomous Prefecture, respectively, which accounted for 85.1% of indigenous cases in YN. There were 12 counties with indigenous cases within 1 000-12,359 cases in GD, which included 7 counties in Guangzhou City (with 70.9% of indigenous cases in GD), 3 counties in Foshan City (6.9% of indigenous cases in GD) and 1 county in Chaozhou City and 1 county in Zhongshan City (Figure 2 (B)). The largest indigenous cases, 12,359 cases, occurred in Baiyun County, Guangzhou City. Spatial distribution of indigenous dengue morbidity was similar with that of indigenous dengue cases (Figure 2 (C)).

Demographic comparative analyses of indigenous dengue cases

Gender composition of the total indigenous cases in GD differed significantly with that in YN during these years (Table 2). There were both slightly more female indigenous cases than male indigenous cases.

Age group composition of the total indigenous dengue cases in GD differed significantly with that in YN during these years (Table 3). Most indigenous cases were from individuals in 21-50 years old, accounting for 57.3% and 62.8% of indigenous cases in GD and YN, respectively. The largest proportions were both located in individuals in 21-30 years old.

Career composition of the total indigenous dengue cases in GD differed significantly with that in YN during these years (Table 4). In GD the top four careers for indigenous cases were housework or unemployment, retiree, businessman and worker, with the case proportions as 23.3%, 12.6%,11.3% and 9.9%, respectively. However, in YN the top four careers for indigenous cases were businessman, farmer, housework or unemployment and retiree, with the case proportions as 24.0%, 13.6%, 12.8% and 9.2%, respectively.

Comparative analyses of imported dengue fever in GD and YN

Time-series comparative analyses of imported dengue cases

There were 1,146 and 3,050 imported dengue cases in GD and YN during 2004-2018, respectively. Imported dengue fever had been both tougher and tougher in theses years (Figure 3(A)). No imported cases occurred in YN in 2004. There were imported cases in GD all the years around 2014-2018. The imported cases reached a peak of 1,468 cases in YN, 2017, accounting for 48.1% of its imported cases. The peak periods of imported cases and counties in YN were both from July to December, however, those in GD were both from May to December (Figure 3(B)).

Spatial comparative analyses of imported dengue cases

Compared with 84 imported dengue counties in GD (68.3% of its total counties), there were 72 imported dengue counties in YN (55.8% of its total counties). Most imported cases in YN were clustered in the southwestern border, and most imported cases in GD were clustered in the Pearl River Delta region. The largest imported cases at the county level in YN, 1,745 cases, were located in Ruili City, Dehong Dai Jingpo Autonomous Prefecture. 50-300 imported cases at the county level, where imported cases accounted for 91.5% of the total in YN, were located in the border areas as Xishuangbanna City, Lincang City and Dehong City. However, imported cases at the county level in GD were all below 100 cases. 50-100 cases at the county level, where imported cases accounted for 58.2% of the total in GD, were located in the coastal areas as Guangzhou City, Dongguan City, Shenzhen City and Zhongshan City (Figure 4).

Imported cases in GD were from 42 countries, 19 of which imported cases in YN were from. There were 9 imported countries from Southeast Asia, namely Vietnam, Laos, Cambodia, Thailand, Myanmar, Malaysia, Singapore, Indonesia and Philippines, from which there were 3,939 imported cases, accounting for 93.9% of the total imported cases in GD and YN. And there were 2,854 imported cases from Myanmar, which accounted for 68.0% of the total imported cases. 100-300 imported cases in each country were from Laos, Thailand, Malaysia, Indonesia and Cambodia (Figure 5). Thailand, Cambodia and Malaysia were the top three sources of imported cases in GD, with 220 cases, 171 cases and 152 cases, respectively. Myanmar, Laos and Thailand were the top three sources of imported cases in YN, with 2,793 cases, 122 cases and 49 cases, respectively.

Demographic comparative analyses of imported dengue cases

Gender composition of the total imported dengue cases in GD differed significantly with that in YN during these years (Table 2). There were both more male imported cases than female imported cases.

Age group composition of the total imported dengue cases in GD differed significantly with that in YN during these years (Table 3). Most imported cases were from individuals in 21-50 years old, accounting for 83.2% in GD and 62.6% in YN. The largest proportions were both located in individuals in 21-30 years old.

Career composition of the total imported dengue cases in GD differed significantly with that in YN during these years (Table 4). In GD the top three careers for imported cases were businessman, worker and housework or unemployment, with the case proportions as 26.3%, 16.8% and 15.2%, respectively. However, in YN the top three careers for imported cases were farmer, businessman and student, with the case proportions as 36.8%, 23.3% and 12.6%, respectively.

Discussion

Dengue fever occurred most seriously in GD and YN, accounting for 93.7% of indigenous cases and 65.9 % of imported cases in mainland China. Compared with YN, GD had much more indigenous dengue cases but much less imported dengue cases during 2004-2018. Furthermore, dengue fever occurred more widely in space in GD. Dengue fever is closely related with population density and mobility, economic development, traffic development, etc [12-15]. GD has a much smaller area but a great larger population (Table 1). GD also has a much more developed economy (Table 5). YN is on the border next to Myanmar, where dengue fever was very tough. 68.0% of imported cases in this study were also from Myanmar. Above all, because of different spatial locations and social conditions, etc., much more indigenous cases were widely distributed in GD, while more imported cases were distributed in YN.

GD and YN had similar seasonal characteristics for dengue fever, and GD had a longer peak period. They had similar seasonal characteristics for temperature and rainfall too (Figure 6). Dengue fever is closely related with climate factors such as temperature and rainfall [8,14-15]. Yunnan border belongs to the torrid zone, with annual rainfall of 800-1,600 mm. The Southern region of Guangdong belongs to the subtorrid zone, with annual rainfall of more than 1,600 mm. Similar climates led to similar seasonal characteristics of indigenous dengue fever there [16]. However, imported dengue fever is more related with economy, population migration, business, travel, etc., and GD had a much broader imported origins of dengue fever.

Most dengue cases in GD were located in the Pearl River Delta region, and especially 70.9% of indigenous cases occurred in 7 counties in Guangzhou City, which is the capital city in GD. 85.1% of indigenous cases were located in Ruili City and Jinghong City along the southwestern border adjacent to Myanmar, Laos and Vietnam. 93.9% of the total imported cases in GD and YN were from 9 countries of Southeast Asia, where dengue fever was very grim [17-20]. Thailand, Cambodia and Malaysia were the top three sources of imported cases in GD. Myanmar and Laos were the main sources of imported cases in YN. Dengue outbreaks were triggered by imported cases [21]. Thus both imported cases and indigenous cases were clustered in the similar regions in GD and YN. Therefore, we should focus on the prevention and monitoring of the southwestern border of YN and the Pearl River Delta region of southern GD, especially Ruili City and Jinghong City in YN, as well as Guangzhou City and Foshan City in GD.

By gender, there was a strong male predominance among imported cases and an almost equal gender distribution for indigenous cases. By age group, most of dengue cases were from individuals in 21-50 years old, especially 83.2% of imported cases in GD. This might reflect a population of younger working male adults who tend to travel more domestically and regionally and thereby have more exposure risk to dengue [7]. In addition, both indigenous and imported cases across all age groups in GD and YN, which is different from other countries in Southeastern Asia where dengue fever is endemic and most dengue cases occur in children or younger adults [22]. The pattern is most likely due to the fact that dengue was not endemic in China and the population in China has very low seroprevalence of dengue antibodies, whereas the population in endemic countries has higher rates of immunity, especially in adults and the elderly [23-25]. By occupation, there were similar major occupations as housework or unemployment, retiree and businessman for indigenous cases, and similar major occupation as businessman for imported cases. Farmers accounted for a larger proportion of dengue cases in YN, which was decided by their industrial structures (Table 5). In order to cope with dengue fever in China, it is necessary to strengthen knowledge propaganda of dengue prevention among these occupations.

There also existed some limitations for this research. Data quality of dengue case reports from CNNDS should be improved. Remarks, as a field of case report, describe imported origins as foreign countries or Hong Kong, Macao and Taiwan in China, or simple case definition of imported case or indigenous case, or the process of disease onset and medical treatment, etc. So the descriptions of remarks were not standardized. And a few remarks were missing. However, dengue cases were divided as indigenous or imported cases mainly according to remarks. Therefore there existed a few inevitable errors in case division. There was a large number for unavailable career type, which would make us miss some focus groups of dengue fever. Above all, these factors might influence the results more or less in this study.

Conclusion

Dengue fever occurred most severely in GD and YN. This research provided valuable information on epidemiological characteristics of dengue fever in GD and YN, 2004–2018 by using statistical method and spatial analysis technology. Much more indigenous cases were widely distributed in Guangdong, while imported cases were more common in Yunnan. Dengue fever showed similar seasonal patterns in YN and GD. There existed clustering characteristics for dengue fever. Most dengue cases in Yunnan were clustered in the southwestern border. Most dengue cases in Guangdong occurred in the Pearl River Delta region. Thailand, Cambodia and Malaysia were the top three origins of imported cases in GD. Myanmar and Laos were the main origins of imported cases in YN. There was a strong male predominance among imported cases and an almost equal gender distribution for indigenous cases. Most indigenous and imported cases were both distributed in 21–50 years old. There were similar major occupation origins of dengue cases as Housework or unemployment, Retiree and Businessman. Farmers accounted for a larger proportion of dengue cases in YN. Grasping epidemiological characteristics and differences of dengue fever in GD and YN is helpful to formulate targeted, strategic plans and implement effective public health prevention and control measures.

Abbreviations

GD
Guangdong;
YN
Yunnan;
CNNDS
Chinese National Notifiable Infectious Disease Reporting Information System.

Declarations

Ethics approval and consent to participate

Not applicable. No human or animal samples were included in the research presented in this article, therefore ethical approval was not necessary for this research according to Measures for ethical review of biomedical research involving human beings (No. 11 of National health commission of the People's Republic of China. http://www.xinyu.gov.cn/fg3tg/201610/f57487a5ef8f4bf3a6df2210956f1963.shtml).

Consent for publication

Not applicable.

Availability of data and materials

Daily dengue case reports were obtained from CNNDS (http://www.chinacdc.cn/). The sixth population census in 2010 and gross domestic production (GDP) was obtained from National Bureau of Statistics of China (http://www.stats.gov.cn/).

Competing interest

The authors declare that they have no competing interests.

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Author Contributions

QL initiated the study. YY collected the data, cleaned the data, performed the analysis and drafted the manuscript. XL and HW revised the manuscript.

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Tables

Table 1 Common information comparison between GD and YN, China

	Population in 2010	Area (km^2)	Administrative divisions	Indigenous dengue cases in 2014-2018	Imported dengue cases in 2014-2018
GD	104 320 459	177 548	123 counties in 21 cities	55 970	1 146
YN	45 966 766	383 966	129 counties in 16 cities	5 938	3 050

Table 2 Information comparison of dengue cases from gender in GD and YN, 2004-2018.

	Indigenous cases		Imported cases	
Gender	GD	YN	GD	YN
Male	27760	2843	765	1638
Female	28210	3095	381	1412
In all	**55970**	**5938**	**1146**	**3050**
Chi-square	**6.353,P=0.012(<0.05)**		**57.962, P<0.001(<0.05)**	

Table 3 Information comparison of dengue cases from age group in GD and YN, 2004-2018.

	Indigenous cases		Imported cases	
Age group	GD	YN	GD	YN
0-10	2661	287	8	294
11-20	4675	635	60	444
21-30	12003	1350	379	842
31-40	10267	1196	369	600
41-50	9782	1182	206	467
51-60	7539	710	83	258
61-70	5019	348	34	107
71-	4024	230	7	38
In all	**55970**	**5938**	**1146**	**3050**
Chi-square	**2.202E2, P=0.000(<0.05)**		**2.270E2, P<0.001(<0.05)**	

Table 4 Information comparison of dengue cases from career in GD and YN, 2004-2018.

Career	Indigenous cases		Imported cases	
	GD	YN	GD	YN
Cadre	1740	278	102	49
Worker	5566	322	193	97
Housework or unemployed	13030	760	174	199
Retiree	7065	546	39	18
Rural laborer	1046	149	16	75
Farmer	2957	807	31	1122
Businessman	6336	1427	301	712
Student	4287	480	58	384
Children	1463	140	6	155
Else	1652	367	54	76
Unavailable	10828	662	172	163
In all	**55970**	**5938**	**1146**	**3050**
Chi-square	**2.153E3,P=0.000(<0.05)**		**1.027E3,P<0.001(<0.05)**	

Table 5 GDP comparison in GD and YN, 2018

	GD	YN
GDP (0.1Billion RMB)	97 277.77	17 881.12
The primary industry (0.1Billion RMB)	3 831.44	2 498.86
The secondary industry (0.1Billion RMB)	40 695.15	6 975.44
The third industry (0.1Billion RMB)	52 751.18	8 424.82
Per capita GDP (RMB/Person)	86 412	37 136

Figures

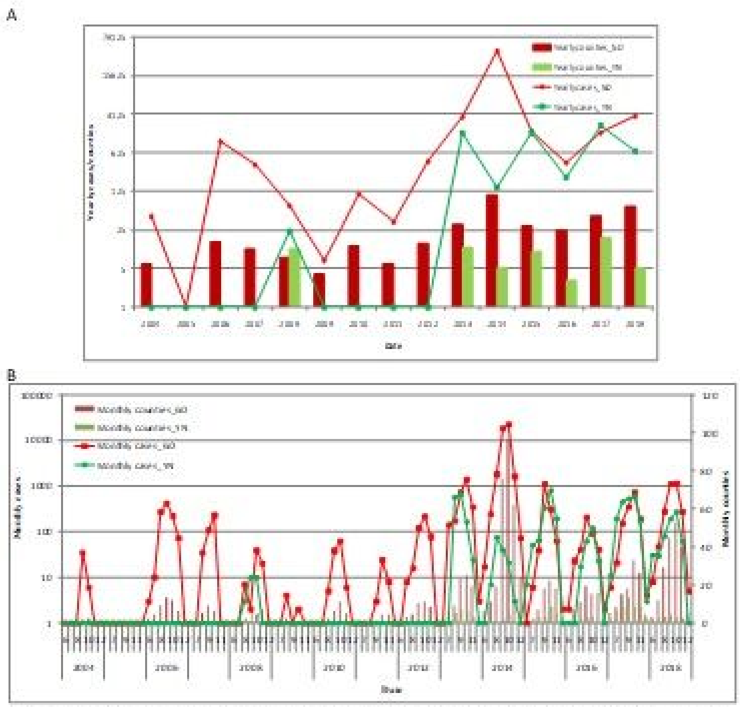


Figure 1 Time-series mapping of indigenous dengue fever in GD and YN, 2004-2018. A. Yearly indigenous fever. B. Monthly indigenous fever.

Figure 1

Time-series mapping of indigenous dengue fever in GD and YN, 2004-2018. A. Yearly indigenous fever. B. Monthly indigenous fever.

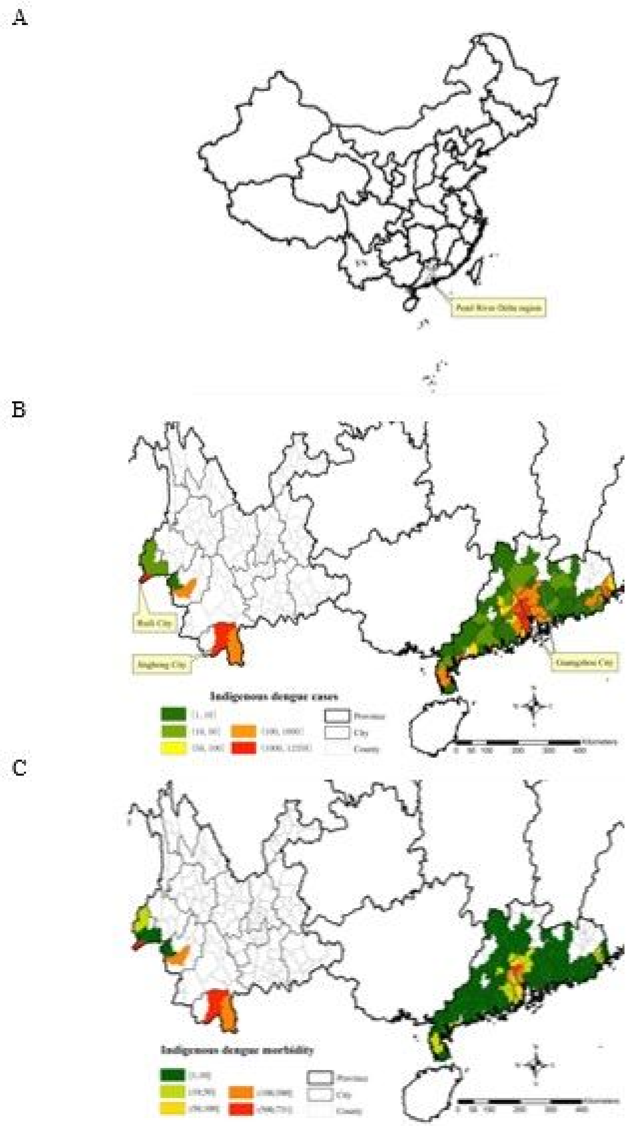
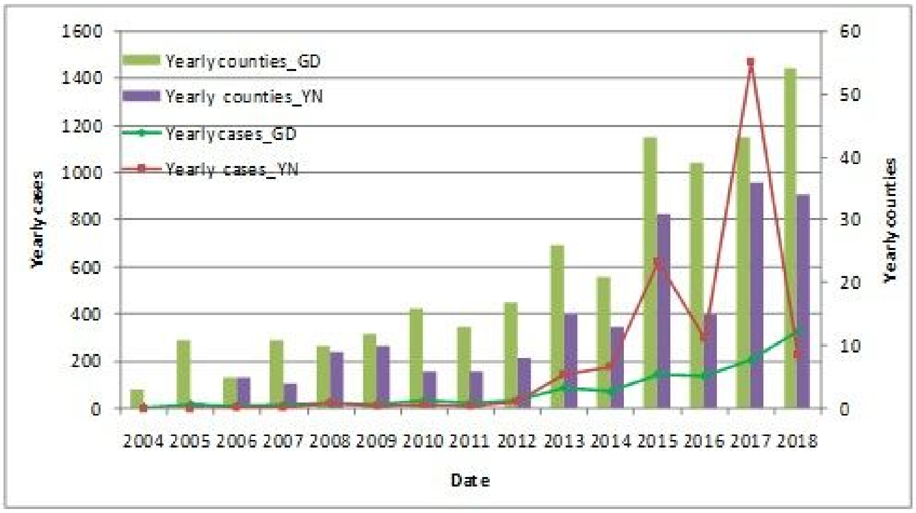


Figure 2 Spatial distribution of indigenous dengue fever in GD and YN, 2004-2018.A. the study area. B. Indigenous dengue cases. C. Imported dengue cases.

Figure 2

Spatial distribution of indigenous dengue cases in GD and YN, 2004-2018.

A



B

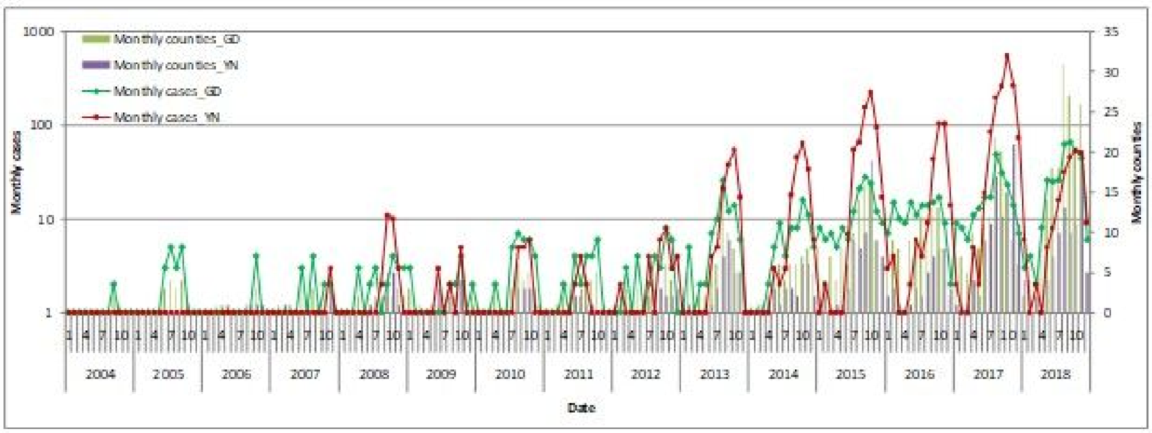


Figure 3

Time-series mapping of imported dengue cases in GD and YN, 2004-2018. A. Yearly imported fever. B. Monthly imported fever.

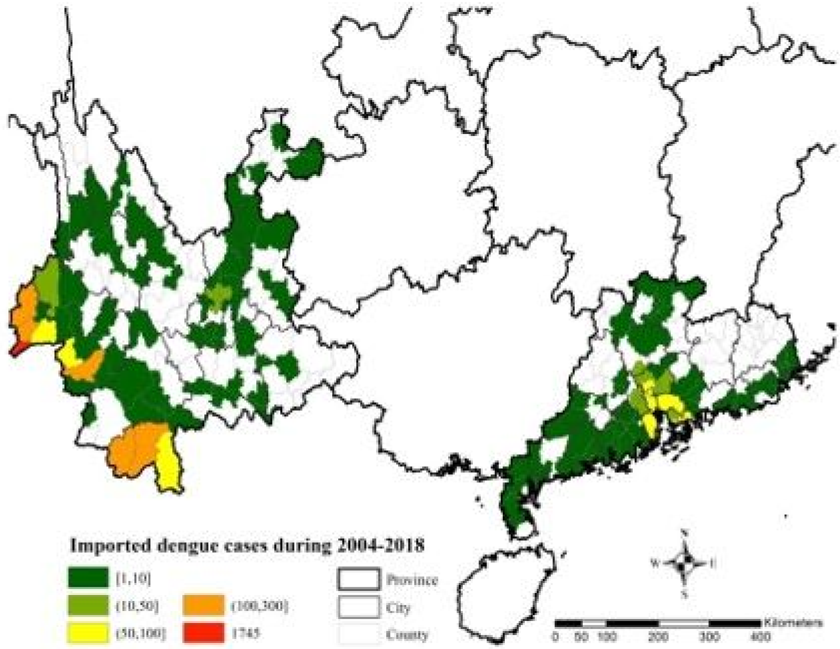


Figure 4 Spatial distribution of imported dengue cases in GD and YN, 2004-2018.

Figure 4

Spatial distribution of imported dengue cases in GD and YN, 2004-2018.

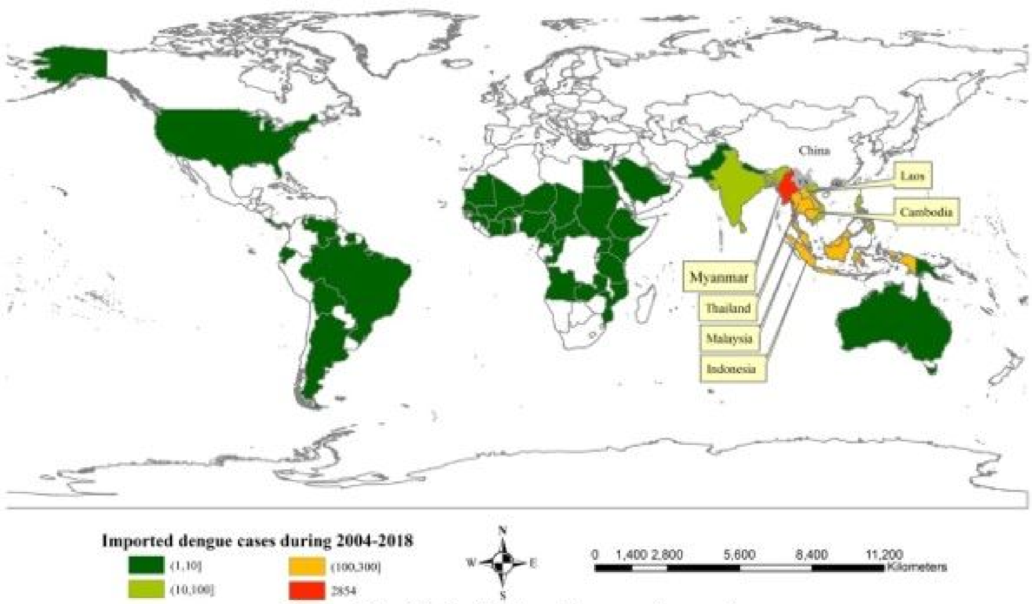


Figure 5 Spatial distribution of imported countries.

Figure 5

Spatial distribution of imported countries.

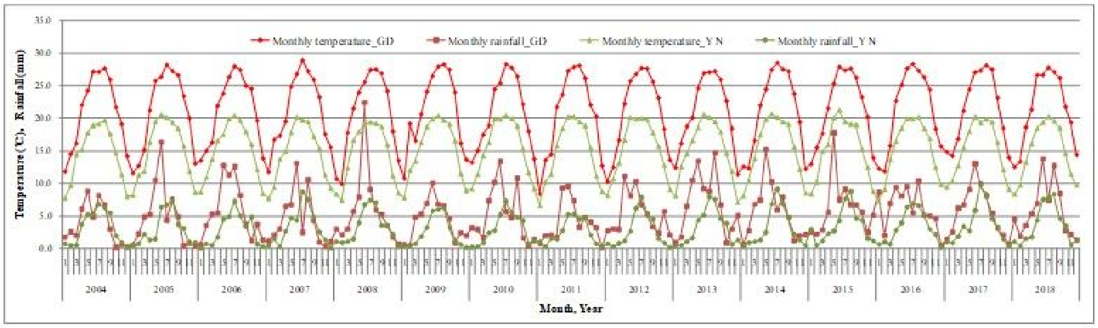


Figure 6 Monthly temperature and monthly rainfall in GD and YN during 2004-2018

Figure 6

Monthly temperature and monthly rainfall in GD and YN during 2004-2018