Trend Analysis of Major Sexually Transmitted Infections in China , 1999-2018

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Research article

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Abstract

Background：The aim of our study was to analyze the trend changes and region distribution changes of three sexually transmitted infections (STIs) in China and provided a scientific basis for the government to make prevention and control measures.

Methods：This study used Joinpoint regression model to fit the morbidity data of three STIs in China from 1999 to 2018. Annual percentage change (APC) and Average annual percentage Change (AAPC) were calculated to evaluate the trend changes of three STIs. We also used hierarchical clustering analysis to analyze the region distribution of three STIs in China from 2003-2018.

Results：We analyzed the morbidity data of three STIs in 1999-2018 derived from China Health Statistics Yearbook. The final model of AIDS was the 3 Joinpoint model ($P = 0.01$) with an annual average percent change (AAPC) of 33.7 (95% CI: 26.1-41.8, $P < 0.001$). The final model of gonorrhea was the 1 Joinpoint model ($P= 0.0025$) with an annual average percent change (AAPC) of -4.9 (95% CI: -6.2- -3.6, $P < 0.001$). The final model of gonorrhea was the 1 Joinpoint model ($P < 0.05$) with an annual average percent change (AAPC) of 9.1 (95% CI:6.9-11.4, $P < 0.001$). The region distribution of the morbidity of three STIs mainly concentrated in the southeast coastal areas and Xinjiang, other areas showed low epidemic levels.

Conclusions: In a word, the morbidity of three STIs in China is still increasing slowly, the form of prevention and control for STIs is still very severe, especially in coastal provinces and Xinjiang. Therefore, it is necessary to actively popularize knowledge related to STIDs, and carry out large-scale peer education, further reduce epidemic of sexually transmitted infections in China.

Background

Sexually transmitted infections are among the most common communicable conditions and affect the health and lives of people worldwide[1]. These mainly transmitted by sexual contact or similar sexual contact and can cause diseases of genitourinary organs, accessory lymphatic system and major organs of the whole body. The World Health Organization (WHO) reports that More than 1 million STIs are acquired every day worldwide[2]. In China, our government has taken corresponding prevention and control measures for AIDS, gonorrhea, syphilis and other sexually transmitted diseases, and achieved good effect. But the China Health Statistics Yearbook (2019) showed that the reported morbidity of three kinds of sexually transmitted infections were still in the forefront of the notifiable infectious diseases[3] .

The JoinPoint regression model, also known as fragment regression, was proposed by Kim in 2000[4].The basic idea is to divide a long-term liner trend into several segments, each of which is described by a continuous linear pattern. It mainly includes two models: linear data model and logarithmic linear data model.

The Autoregressive moving average (ARIMA) model is the most widely used time series analysis method for infectious diseases[5, 6], but it has high requirements on the data sample size. The Joinpoint model does not have strict requirements on distribution of data, and can describe the long-term trend in linear model, which has been gradually paid attention to in recent years[7-9]. There is no model that assesses the trend changes and region distribution changes of three STIs among the whole population in China over 20 years.

The purpose of this study is to analyze the trend changes and region distribution changes of three STIs in China from 1999-2018, and provided a scientific basis for the government to make prevention and control measures.

Methods

Source of data

The morbidity data came from China Health Statistics Yearbook 2003-2019, and it is derived from the annual statistical report of infectious diseases[3]. Since exact morbidity was difficult to obtain, we replaced the morbidity of the three STIs with reported incidence indicator. Population data came from the website of the statistical yearbook of the National Bureau of Statistics (http://www.stats.gov.cn/tjsj/ndsj/).

Statistical analysis

The Joinpoint regression model is used to fit the morbidity of the three STIs, and annual percent Change (APC) and average annual Percent Change (AAPC) are calculated to evaluate the trend changes of the three STIs in China from 1999 to 2018. If APC<0, indicating that the morbidity rate is decreasing per year; If APC>0, meaning that the morbidity rate is increasing per year; If APC=AAPC, indicating no Joinpoint and data increases monotonously or decreases monotonously with the change of the years.

We use hierarchical clustering analysis to describe the regional distribution differences of the three major STDs. This method clusters provinces with similar incidence into one group by taking 31 provinces as independent samples and the incidence of three major in 2018 as cluster indicators.

The Joinpoint regression model and hierarchical clustering analysis are performed by the Joinpoint Regression Software (4.8.1.0 version developed by the American cancer research center) and R software version 4.0.2, respectively. A bilateral probability value of $P < 0.05$ was considered indicative of statistical significance.

Results

The morbidity of AIDS, syphilis and gonorrhea in China

Our study analyzed the data about AIDS, syphilis and gonorrhea reported publicly by the Chinese government. The results showed that morbidity of AIDS and syphilis (1/100000) ranged from 0.02 to 4.62 and from 6.50 to 35.63, which indicated the morbidity of both showed a trend of increasing per year. On the contrary, the morbidity of gonorrhea (1/100000) ranged from 27.54 to 9.59 with continually decreased per year. The differences among the three major STIs were statistically significant (P <0.001). All results can be seen in Table1.

Time trends of AIDS, syphilis and gonorrhea

Time trends of AIDS The Joinpoint model showed that the morbidity of AIDS increased at an average annual rate of 33.7%, with a statistically significant change trend (P <0.001). There were three turning points:2002, 2005, 2011, respectively (Table2 and Fig1). From 1999 to 2002, the morbidity of AIDS had a clear upward trend (1999-2002: APC=42.62; 2002-2005: APC=102.52; 2005-2011: APC=38.25; P<0.001). The upward trend from 2011 to 2018 began to slow down (APC=5.74, P<0.001).

Time trends of gonorrhea The results showed that the final model of gonorrhea was the 1 Joinpoint model (P <0.05) (Fig2). The annual average percent change (AAPC) was -4.9 (95CI%: -6.2 to -3.6, P <0.001), indicating a downward trend in the gonorrhea morbidity (Table3). The gonorrhea morbidity decreased at an average rate of 9.57% per year from 1999 to 2012, and reached the lowest in 2012.From 2012-2018, the upward trend of gonorrhea morbidity began to appear (APC=5.96, 95%CI: 1.8-10.3)

Time trends of syphilis The Joinpoint model showed that the morbidity of syphilis increased at an average annual rate of 9.1%, with a statistically significant change trend (P <0.001) (Fig3). The final model of syphilis was the 3 Joinpoints model (Table4). The syphilis morbidity decreased at an average rate of 3.65% per year from 1999-2003, and reached the lowest in 2003. From 2003 to 2010, it had an outstanding upward trend, with APC of 36.62 and 20.33 (P <0.001). The upward trend began to slow down in 2010-2018 (APC=1.68, 95%CI:0.4-3.0, P <0.001)

Regional distribution of AIDS, syphilis and gonorrhea

The results of hierarchical clustering analysis indicated that the provinces with the highest morbidity of the three STDs were mainly Shanghai and Zhejiang province in 2003-2010, Xinjiang and more southern provinces also began to be classified as high-prevalence regions after 2010 (Fig4). The 2018 cluster plot showed that the current three STIs high morbidity areas are mainly in Guangdong, Zhejiang and Hainan provinces, followed by Chongqing and Xinjiang.

Discussion

Our study showed that the morbidity of AIDS in Chinese population increased from 1999 to 2018, which were consistent with the results of Yong-Chao and Zun-you Wu's study[10, 11]. The rising tendency was the most pronounced during 2002-2005. The possible reasons are the abuse of intravenous drug, the increase in the number of homosexual men and infection occurred after irregular blood collection[12].

Since the implementation of the blood donation law in 1998, the transmission of HIV through blood collection and supply has been controlled in China. At present, the transmission of HIV is mainly through sexual transmission[13-15]. The introduction of "four exemptions and one care" policy in 2006 and the implementation of the "six expansion and five strengthening" prevention and control measures in 2011 have also effectively slowed down the rising tendency of AIDS morbidity, which is consistent with our study results[16-18]. In addition, a research report on the global AIDS epidemic showed that compared with other countries, the current AIDS epidemic in China is at a low epidemic level[19].

Previous study indicated that the epidemic of gonorrhea in China rose rapidly in the 1970s, reached its peak in 1999, and then declined, which was consistent with our study results[20]. But our study showed that the morbidity of gonorrhea began to rising in 2012-2018, which was similar to that of the United States and the United Kingdom in the same years[21]. This phenomenon may be due to the expanded coverage of gonorrhea screening, the increased sensitivity of diagnostic methods and the increase in the number of MSM patients[22, 23]. Although our study indicated that the morbidity of gonorrhea in China from 1999 to 2018 had an overall trend of decline, it is still in the forefront of the notifiable infectious diseases, especially in 2018 its morbidity reached 9.58%, ranking fourth. Additionally, many studies found neisseria gonorrhoeae was resistant to many antibiotics, making the treatment of gonorrhea become a major challenge for clinicians in recent years[14, 24-26].

The results of our study showed that the morbidity of syphilis in China was on the rise during 1999 to 2018, which was contrary to the overall trend of gonorrhea incidence[20]. The trend changes in the both SIDs were similar to developed countries. On the one hand, this phenomenon may be due to the increased number of syphilis infection population in MSM; On the other hand, it mainly because the government launched a national plan on expanding syphilis screening in 2010, which led to an increase in the number of cases diagnosed as latent syphilis[27, 28]. And the related literature also suggested that syphilis morbidity rate was higher than AIDS in Chinese MSM population[10]. Our study indicated that the morbidity of syphilis had been increasing per year since it reached lowest level in 2003, and its morbidity was higher than that of AIDS and gonorrhea. Moreover, previous studies also showed that the majority of Chinese people's knowledge of syphilis is far lower than the standard of 10-year plan set by our country[27, 29, 30].

We also used hierarchical clustering analysis to describe the region distribution of three STIs. Compared with previous years, the current high incidence of the three STIs is mainly concentrated in the southeast coastal areas and Xinjiang. The reason for the high morbidity of STIs in southern cities is mainly due to the sexual disorder caused by the rapid increase of floating population in recent years. However, the cause of the high morbidity of STIs in Xinjiang still needs further study. The above results suggest that the government should strengthen the prevention and treatment of southeast coastal areas and Xinjiang.

Some limitations also need to be noted. First, the sample size of our study is very small. Second, the study data comes from passive monitoring, exact morbidity rates are hard to obtain, and reported morbidity rates may underestimate the true status of STIs. In final, the morbidity of infectious diseases is

related to the natural environment, social economy and personal hygiene habits, which may lead to unstable prediction results.

Conclusion

In summary, the morbidity of three major STIs in China is still increasing slowly, the form of prevention and control for STIs is still very severe, especially in coastal provinces and Xinjiang. Therefore, it is necessary to actively popularize knowledge related to STIDs, and carry out large-scale peer education, so as to further reduce epidemic of sexually transmitted infections in China.

Abbreviations

STIS: Sexually transmitted infections

HIV: Human immunodeficiency virus

AIDS: Acquired immune deficiency syndrome

APC: Annual percentage change

AAPC: Average annual percentage change

Declarations

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Contributions

All authors contributed to the manuscript proof. All authors read and approved the final manuscript.

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Ethics declarations

No Applicable.

Consent for publication

No Applicable.

Competing interests

The authors declare that they have no competing interests.

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Tables

Table1 Morbidity of AIDS, syphilis, gonorrhea in China in 1999-2018

year	Number(million)	Morbidity of AIDS (1/100,000)	Morbidity of gonorrhea (1/100,000)	Morbidity of syphilis (1/100,000)
1999	125786	0.02	27.54	6.50
2000	126743	0.02	22.92	6.43
2001	127627	0.04	18.57	6.11
2002	128453	0.06	16.14	5.80
2003	129227	0.08	16.54	5.63
2004	129988	0.23	17.71	7.70
2005	130756	0.43	14.27	10.96
2006	131448	0.60	12.46	14.24
2007	132129	0.82	11.33	17.16
2008	132802	1.10	10.16	21.06
2009	133450	1.51	9.19	24.66
2010	134091	2.56	8.07	28.90
2011	134735	2.92	7.61	32.04
2012	135404	3.11	7.07	33.30
2013	136072	3.12	7.61	32.86
2014	136782	3.33	7.05	30.93
2015	137462	3.69	7.36	31.85
2016	138271	3.97	8.39	31.97
2017	139008	4.15	10.06	34.49
2018	139538	4.62	9.59	35.63

Table 2 APC and AAPC of AIDS morbidity in China ,1999-2018

Joinpoint (95%CI)	year	APC（95%CI）	AAPC（95%CI）
_	1999-2002	42.62* (20.0-69.4)	33.7*(26.1-41.8)
2002 (2001-2004)	2002-2005	102.52* (43.5-185.8)	
2005 (2004-2008)	2005-2011	38.25* (28-49.3)	
2011 (2008-2013)	2011-2018	5.74* (1.0-10.7)	

*P<0.05

Table 3 APC and AAPC of gonorrhea morbidity in China ,1999-2018

Joinpoint (95%CI)	year	APC (95%CI)	AAPC (95%CI)
_	1999-2012	-9.57* (-10.7--8.4)	-4.9*(-6.2--3.6)
2012 (2011-2014)	2012-2018	5.96* (1.8-10.3)	

*P<0.05

Table 4 APC and AAPC of syphilis morbidity in China ,1999-2018

Joinpoint (95%CI)	year	APC (95%CI)	AAPC (95%CI)
-	1999-2003	-3.65* (-7.1--0.1)	9.1* (6.9-11.4)
2003 (2002-2004)	2003-2006	36.62* (21.9-53.2)	
2006 (2005-2008)	2006-2010	20.33* (13.6-27.4)	
2010 (2009-2018)	2010-2018	1.68* (0.4-3.0)	

*P<0.05

Figures

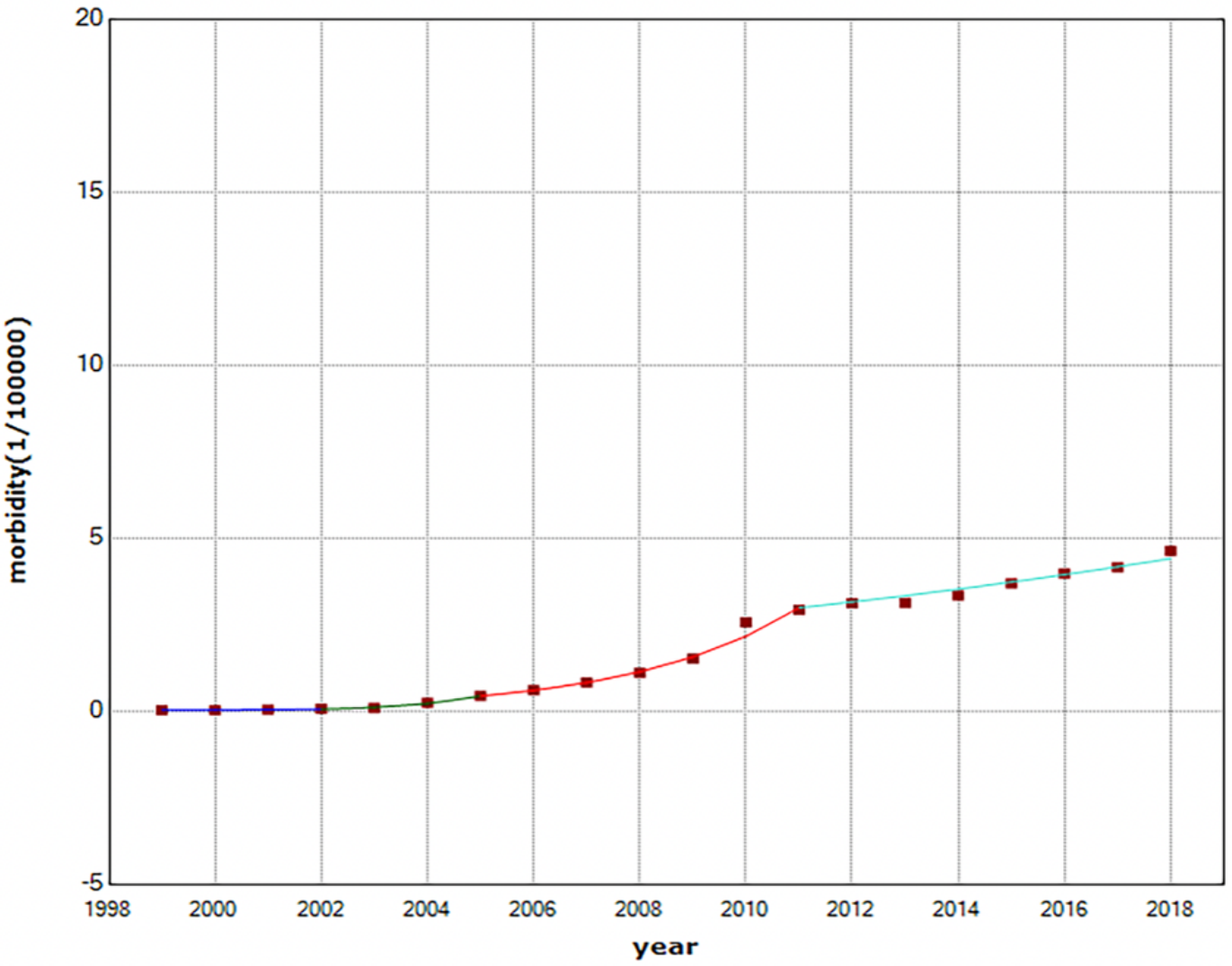

Figure 1

Time trend of AIDS morbidity in China ,1999-2018

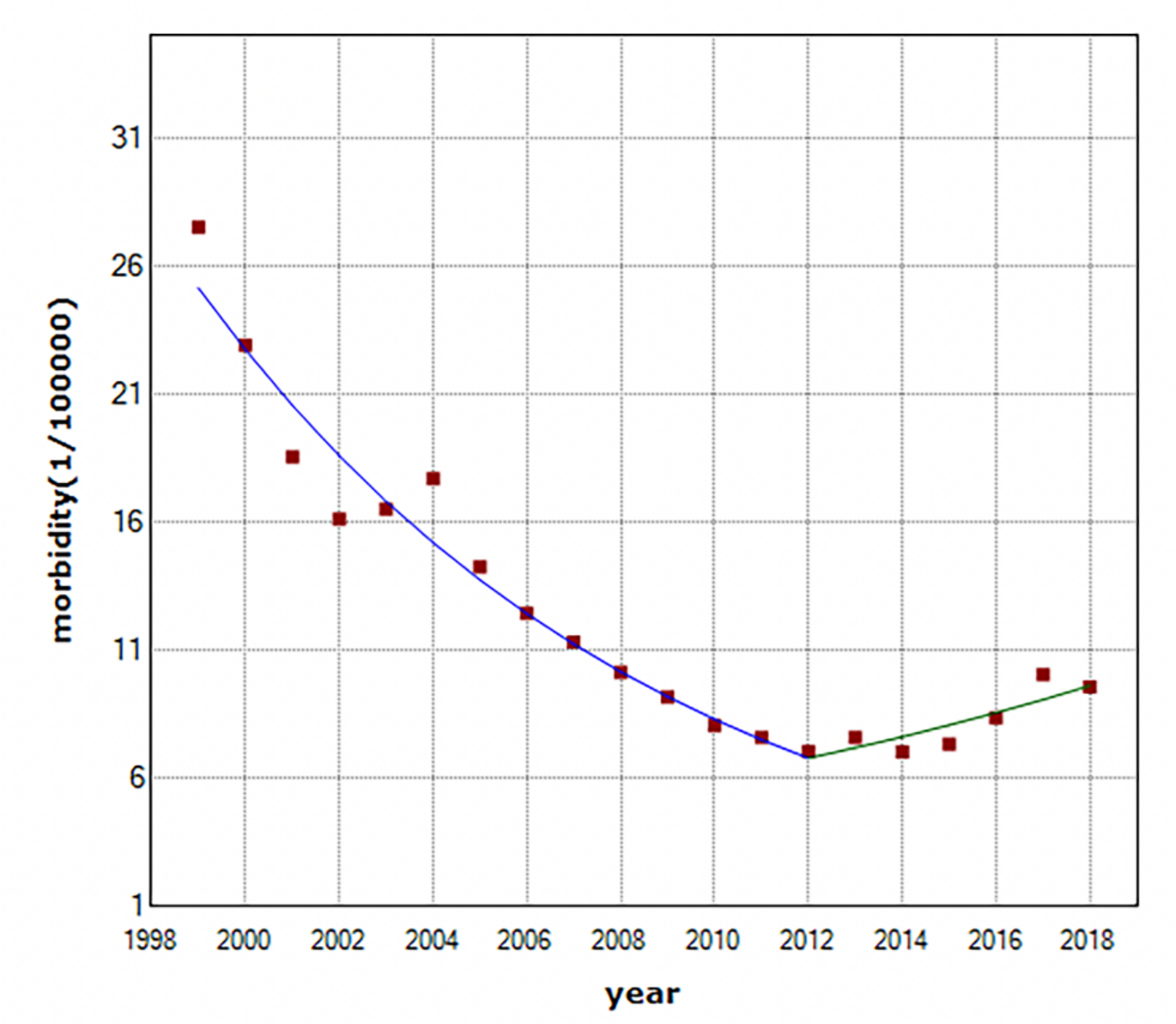

Figure 2

Time trend of gonorrhea morbidity in China ,1999-2018

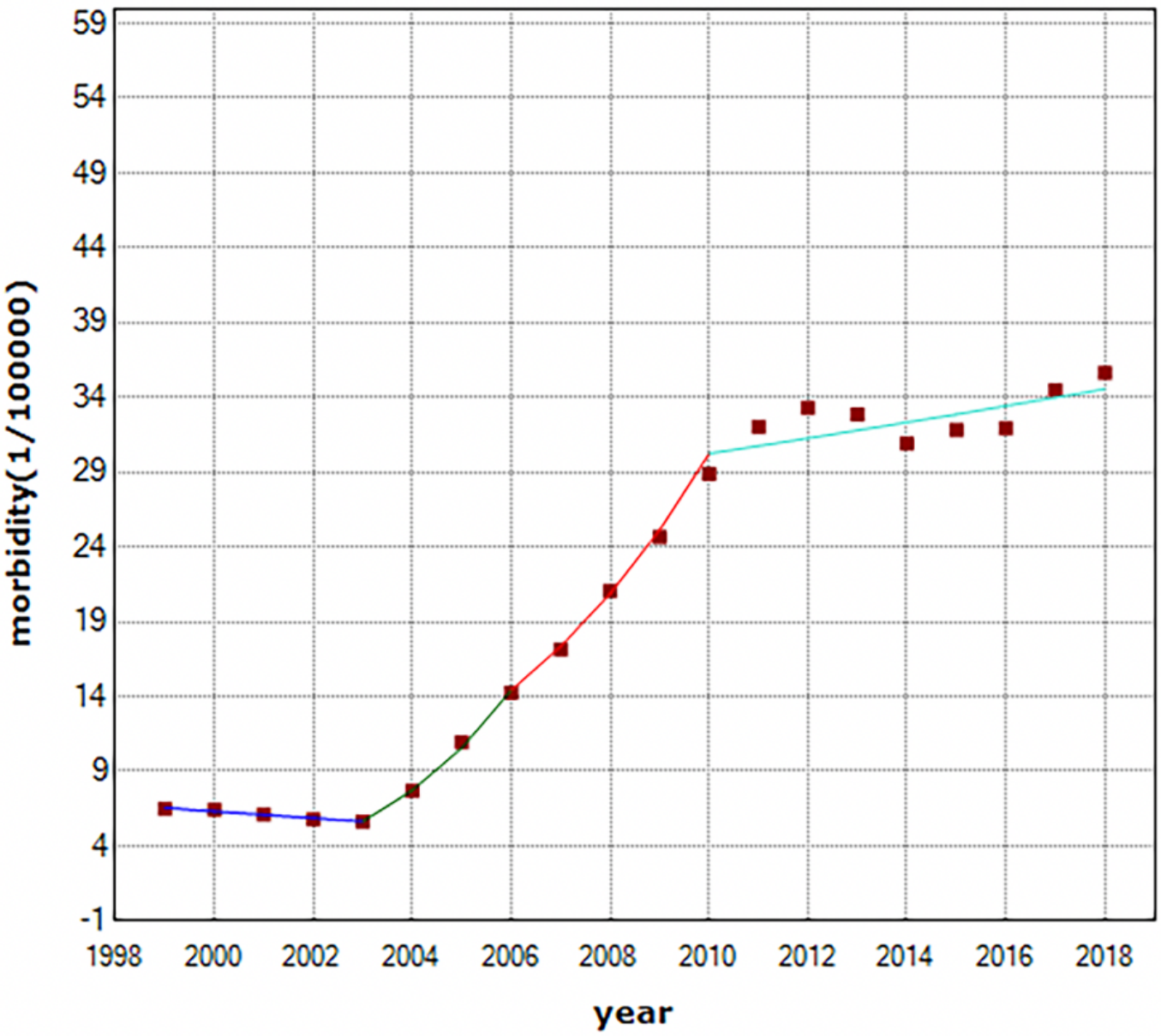

Figure 3

Time trend of syphilis morbidity in China ,1999-2018

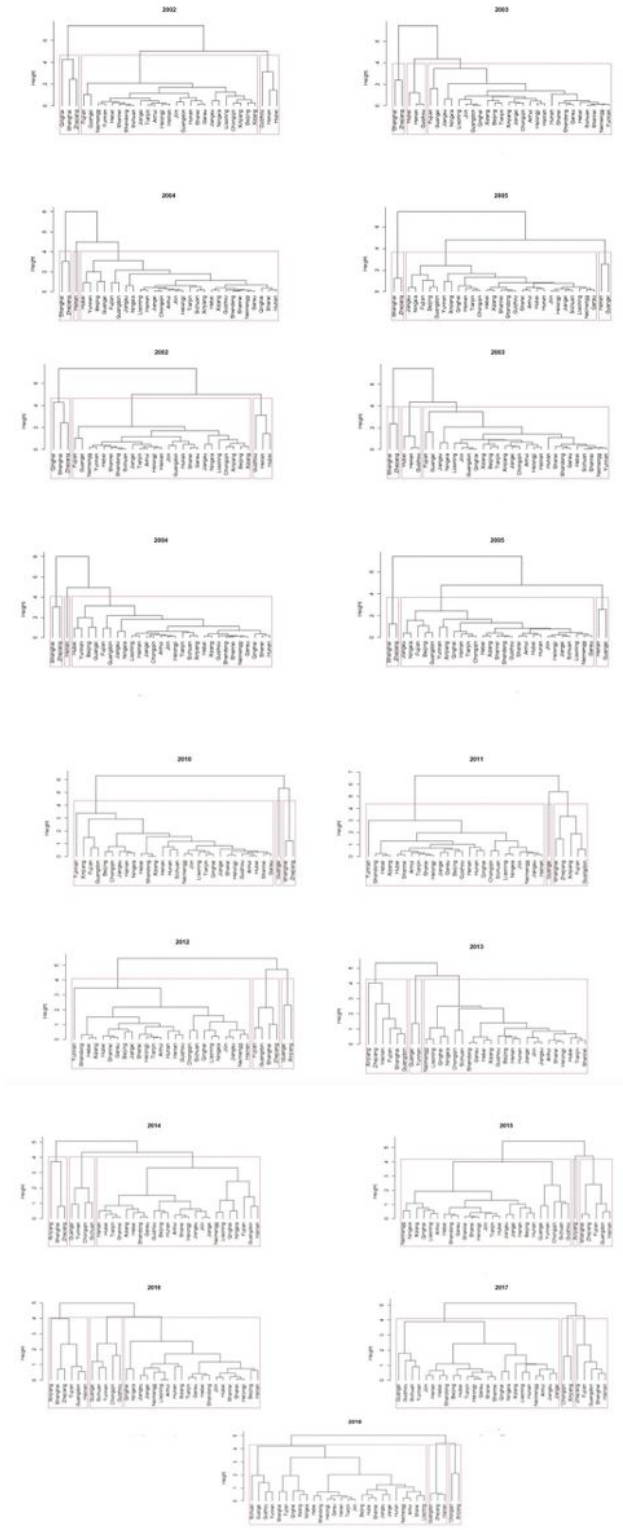

Figure 4

systematic cluster chart of the reported incidence rates of three major STIs in each province in 2002-2018