

Vital Surveillances

Trends and Spatial Pattern Analysis of Typhoid and Paratyphoid Fever Incidence — Yunnan Province, China, 1989–2022

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ABSTRACT

Introduction: This study explored the incidence trends and spatial clustering of typhoid and paratyphoid fever (TPF) in Yunnan Province to provide scientific evidence for developing and improving prevention and control strategies.

Methods: Temporal trends were investigated by calculating the annual percent change (APC) and average annual percent change (AAPC), along with their 95% confidence intervals (CIs). The spatial clustering of TPF across Yunnan Province was examined using global Moran's I and local indicators of spatial association (LISA) statistics.

Results: A total of 206,066 TPF cases were reported in Yunnan Province from 1989 to 2022, with an average annual incidence of 13.98 per 100,000 population and a case fatality rate of 2.5 per 1,000. The greatest number of cases was reported during July and August. The 25–34-year age group had the highest incidence, and farmers were prominently represented. TPF incidence in Yunnan Province showed a significant decrease and spatial clustering. From 2005 to 2022, 13 county-level cities/counties/municipal districts in 5 prefectures (cities) in Yunnan Province were identified as statistically significant H-H spatial clusters of TPF incidence. A total of 24 TPF outbreaks were reported in Yunnan Province from 2005 to 2022.

Conclusions: The incidence of TPF in Yunnan Province showed a significant decrease and spatial clustering. Control strategies should focus on high-incidence areas, seasons, and populations to reduce the incidence of TPF.

Typhoid and paratyphoid fever (TPF) are categorized as Class B notifiable infectious diseases in China. They are caused by the *Salmonella enterica* subspecies serovars Typhi and Paratyphi A, B, and C. TPF is characterized by a predominantly

gastrointestinal reaction, high infectiousness, long duration of illness, multiple complications, and a substantial disease burden. The global incidence of TPF has declined, with approximately 14.3 million cases and 135,900 deaths reported in 2017 (1). Since the 1990s, the incidence of TPF in China has declined annually and is at a low level according to World Health Organization classification criteria (2). However, the incidence of TPF in southwestern PLADs, such as Yunnan Province, is among the highest in the country and remains a priority infectious disease for prevention and control (2). Therefore, understanding the epidemiological trends of TPF and analyzing population and regional distribution characteristics is important for devising effective control plans, strategies, and interventions. Herein, these topics were examined using TPF data collected from 1989 to 2022. Descriptive, temporal trend, and spatial autocorrelation analyses were performed.

METHODS

Data on TPF for 1989–2004 were obtained from the Compendium of Infectious Disease Epidemics in Yunnan Province. Reported TPF cases for 2005–2022 were obtained from the infectious disease surveillance system of the CISDCP (3). Additionally, reported TPF outbreaks for 2005–2022 were obtained from the emergent public health event information management system of the CISDCP. Outbreak definitions followed the National Public Health Emergency Information Reporting and Management Specification issued by the Ministry of Health of the People's Republic of China in 2005 (4). Demographic data were derived from the Yunnan Statistical Yearbook (1989–2022). Administrative division codes and geographical coordinates were acquired from the National Catalogue Service for Geographic Information (<https://www.webmap.cn/>). The crude incidence rate (per 100,000 population) was calculated as the number of annual TPF cases divided by the total annual

population.

Joinpoint regression models were employed to identify incidence trends from 1989 to 2022 using Joinpoint software (version 4.9.1.0; National Cancer Institute, Bethesda, US) (5). The number of joinpoints, joinpoint locations, and *P* values were determined using Monte Carlo permutation tests. The Bayesian information criterion was used to select the best-fitting model. To explore temporal trends, the APC and AAPC in reported TPF cases and their 95% confidence intervals (CIs) were calculated. An increasing or decreasing trend indicates a statistically significant trend slope (two-sided $P < 0.05$). A stable trend indicates a non-significant APC (two-sided $P \geq 0.05$), representing stable incidence or sporadic case reporting (6).

Spatial autocorrelation analysis, using GeoDa 1.18.0.0, explored the spatial correlation strength of TPF. Details on the spatial autocorrelation analysis have been previously published (3). Briefly, global autocorrelation, using Global Moran's *I* statistics, analyzed the clustering characteristics of the research objects across the entire region. Anselin's Local Moran's *I* (LISA) test statistics were used for spatial autocorrelation analysis. LISA analyzed the specific cluster types and regions; LISA cluster maps showed four cluster modes: H-H, L-L, L-H, H-L, and not significant. The H-H and L-L regions represent spatial clustering, while the L-H and H-L regions were outliers (3,7).

RESULTS

General Characteristics

From 1989 to 2022, Yunnan Province reported 206,066 TPF cases, with an incidence of 32.80 per 100,000 in 1989 and 2.29 per 100,000 in 2022. The

average annual incidence was 13.98 per 100,000. A total of 508 deaths were reported, resulting in a case fatality rate of 2.5 per 1,000. Joinpoint regression analysis revealed an overall decreasing trend in TPF incidence, with an AAPC of -6.78% ($P < 0.05$) (Figure 1).

From 2005 to 2022, a total of 75,747 TPF cases were reported in Yunnan Province, including 43,767 laboratory-confirmed cases and 31,980 clinically diagnosed cases. Of these, 48,452 had typhoid fever, with incidence decreasing from 14.44 per 100,000 population in 2005 to 1.88 per 100,000 in 2022. The remaining 27,295 cases had paratyphoid fever, with incidence decreasing from 8.24 per 100,000 population in 2005 to 0.41 per 100,000 in 2022. Additionally, joinpoint regression analysis revealed an overall decreasing trend in both typhoid and paratyphoid fever incidence from 2005 to 2022, with average annual percent changes (AAPCs) of -12.51% and -16.79% , respectively (all $P < 0.05$) (Figure 2).

Population and Seasonal Distribution

From 2000 to 2022, Yunnan Province reported 112,160 TPF cases, with an incidence rate of 20.13 per 100,000 in females and 19.58 per 100,000 in males. Incidence was elevated in the 0–44 age group, peaking in the 25–34 age group (Table 1). From 2005 to 2022, the primary occupations of TPF cases were farmers, students, and children, comprising 44.01%, 19.08%, and 11.35% of cases, respectively. TPF cases were consistently reported from January to December each year, demonstrating clear seasonality. Peak incidence occurred in July and August (Supplementary Figure S1, available at <https://weekly.chinacdc.cn/>).

Spatial Distribution

From 1989 to 2022, TPF cases were reported in 8

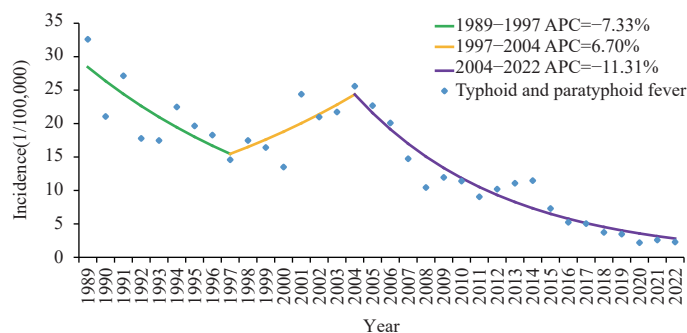


FIGURE 1. Joinpoint regression showing trends in the overall incidence of typhoid and paratyphoid fever in Yunnan Province, China, 1989–2022.

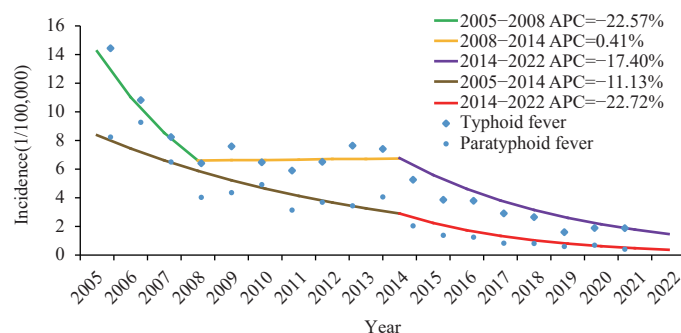


FIGURE 2. Joinpoint regression showing trends in the overall incidence of typhoid fever and paratyphoid fever in Yunnan Province, China, 2005–2022.

Abbreviation: APC=annual percent change.

TABLE 1. Age and gender characteristics of typhoid and paratyphoid fever cases in Yunnan Province, China, 2000–2022.

Age (years)	Total			Male			Female		
	Cases (n)	Percentage (%)	Incidence (per 100,000)	Cases (n)	Percentage (%)	Incidence (per 100,000)	Cases (n)	Percentage (%)	Incidence (per 100,000)
0–4	7,518	6.70	10.70	4,276	56.88	11.77	3,242	43.12	9.55
5–9	9,536	8.50	12.88	5,282	55.39	13.66	4,254	44.61	12.04
10–14	8,734	7.79	11.47	4,894	56.03	12.23	3,840	43.97	10.64
15–19	10,134	9.04	12.02	5,158	50.90	11.67	4,976	49.10	12.39
20–24	11,022	9.83	12.72	5,225	47.41	11.60	5,797	52.59	13.94
25–29	12,007	10.71	15.59	5,861	48.81	14.51	6,146	51.19	16.78
30–34	11,454	10.21	13.69	5,699	49.76	12.95	5,755	50.24	14.52
35–39	9,991	8.91	11.35	4,944	49.48	10.64	5,047	50.52	12.15
40–44	7,957	7.09	10.00	3,954	49.69	9.45	4,003	50.31	10.61
45–49	6,348	5.66	8.83	3,114	49.05	8.32	3,234	50.95	9.38
50–54	5,121	4.57	9.59	2,428	47.41	8.84	2,693	52.59	10.37
55–59	3,709	3.31	7.84	1,801	48.56	7.50	1,908	51.44	8.19
60–64	2,841	2.53	8.10	1,389	48.89	7.84	1,452	51.11	8.37
65–69	2,087	1.86	7.24	1,104	52.90	7.77	983	47.10	6.72
70–74	1,769	1.58	8.01	954	53.93	9.00	815	46.07	7.10
75–79	1,126	1.00	7.62	696	61.81	10.24	430	38.19	5.38
80–84	559	0.50	6.72	352	62.97	9.89	207	37.03	4.35
≥85	247	0.22	6.68	166	67.21	11.87	81	32.79	3.52
Total	112,160	100.00	19.84	57,297	51.09	19.58	54,863	48.91	20.13

autonomous prefectures and 8 cities in Yunnan Province. In terms of average annual incidence, the top 5 prefectures (cities) were Xishuangbanna Dai Autonomous Prefecture (37.50 per 100,000), Dehong Dai-Jingpo Autonomous Prefecture (28.34 per 100,000), Yuxi City (26.88 per 100,000), Nujiang Lisu Autonomous Prefecture (22.39 per 100,000), and Honghe Hani and Yi Autonomous Prefecture (21.29 per 100,000). Joinpoint regression analysis revealed a statistically significant decreasing trend (all $P < 0.05$) in the reported incidence of 13 prefectures (cities) from

1989 to 2022, except for Yuxi City ($P = 0.288$), Diqing Tibetan Autonomous Prefecture ($P = 0.332$), and Nujiang Lisu Autonomous Prefecture ($P = 0.468$) (Table 2). Furthermore, there was a positive spatial correlation and significant spatial clustering distribution of TPF incidence in all county-level cities/counties/municipal districts of Yunnan Province from 2005 to 2010 (Moran's $I = 0.291$, $P = 0.001$), 2011 to 2016 (Moran's $I = 0.269$, $P = 0.001$), 2017 to 2022 (Moran's $I = 0.241$, $P = 0.001$), and 2005 to 2022 (Moran's $I = 0.315$, $P = 0.001$). Supplementary

TABLE 2. Joinpoint regression showing the incidence and trends of typhoid and paratyphoid fever in the prefectures (cities) of Yunnan Province, China, 1989–2022.

Prefecture/city	Cases (n)	Incidence (per 100,000)	Trend	Average annual percent change (95% CIs)	t	P
Xishuangbanna Dai Autonomous Prefecture	12,722	37.50	Decrease	-8.41 (-13.27, -3.28)	-3.16	0.002
Dehong Dai-Jingpo Autonomous Prefecture	10,745	28.34	Decrease	-8.80 (-15.18, -1.95)	-2.49	0.013
Yuxi City	19,356	26.88	Stable	-7.28 (-19.34, 6.59)	-1.06	0.288
Nujiang Lisu Autonomous Prefecture	3,804	22.39	Stable	-5.17 (-17.83, 9.44)	-0.73	0.468
Honghe Hani and Yi Autonomous Prefecture	30,503	21.29	Decrease	-4.72 (-7.09, -2.30)	-3.77	<0.001
Kunming City	34,463	18.12	Decrease	-6.59 (-8.83, -4.31)	-5.53	<0.001
Wenshan Zhuang and Miao Autonomous Prefecture	17,335	15.07	Decrease	-11.69 (-20.50, -1.91)	-2.32	0.020
Baoshan City	10,826	13.17	Decrease	-12.38 (-16.29, -8.28)	-2.27	0.023
Dali Bai Autonomous Prefecture	11,151	9.78	Decrease	-5.91 (-10.74, -0.82)	-2.27	0.023
Lijiang City	3,856	9.71	Decrease	-4.02 (-6.00, -1.99)	-4.00	<0.001
Qujing City	18,613	9.52	Decrease	-2.18 (-3.92, -0.40)	-2.39	0.017
Diqing Tibetan Autonomous Prefecture	1,168	9.43	Stable	-11.89 (-15.18, -1.95)	-0.97	0.3319
Chuxiong Yi Autonomous Prefecture	7,768	8.82	Decrease	-7.18 (-10.55, -3.68)	-3.95	<0.001
Pu'er City	7,456	8.82	Decrease	-8.27 (-11.76, -4.64)	-4.53	<0.001
Zhaotong City	12,737	7.53	Decrease	-10.41 (-12.23, -8.55)	-10.89	<0.001
Lincang City	3,563	4.53	Decrease	-5.09 (-6.82, -3.33)	-5.78	<0.001

Abbreviation: CIs=confidence intervals.

Table S1 (available at <https://weekly.chinacdc.cn/>) presents the statistically significant H-H spatial clusters of TPF incidence in a total of 13 county-level cities/counties/municipal districts of 5 prefectures (cities) in Yunnan Province from 2005 to 2022 and the statistically significant L-L spatial clusters of TPF incidence in a total of 22 county-level cities/counties/municipal districts of 8 prefectures (cities) in Yunnan Province from 2005 to 2022.

Outbreaks

From 2005 to 2022, Yunnan Province reported 24 TPF outbreaks (12 typhoid fever and 12 paratyphoid fever), with a median duration of 21 days (Supplementary Table S2, available at <https://weekly.chinacdc.cn/>). These outbreaks involved 1,273 cases, an exposed population of 203,519, and an incidence rate of approximately 625.49 per 100,000. Occurring in 14 counties (districts) across 7 prefectures (cities) in Yunnan Province, the outbreaks primarily affected rural areas (17 outbreaks) and schools (6 outbreaks).

CONCLUSIONS

The overall TPF incidence in Yunnan Province, China, shows a significant decrease, potentially attributable to national disease prevention and control

policies, public health service development, the inclusion of rural water and latrine improvements in disease prevention and control agencies' national code of practice (8), immunization, and improved sanitation and hygiene awareness (9). Despite annual declines in TPF incidence rates both nationally and in China, Yunnan Province remains the highest-ranking provincial-level administrative division (PLAD) for these diseases (2). The emergence of TPF as a significant public health issue in Yunnan Province highlights the critical need for effective epidemic control measures. Successfully managing the TPF epidemic in Yunnan Province is pivotal in diminishing the overall incidence of these diseases across China. Indeed, several possible reasons may explain the highest TPF incidence in Yunnan Province. First, Yunnan Province experiences peak TPF incidence during summer due to high temperatures and rainfall, creating ideal conditions for disease transmission (9–10). Second, abundant karst landforms in Yunnan Province increase the vulnerability of underground water sources to pathogenic bacterial contamination, amplifying the risk of TPF epidemics (2,9). Third, the epidemic's cause may also stem from differences in dietary and water hygiene practices among populations in Yunnan Province's multiethnic areas (11).

From 1989 to 2022, the top five average annual

incidences of TPF were observed in Xishuangbanna Dai Autonomous Prefecture, Dehong Dai-Jingpo Autonomous Prefecture, Yuxi City, Nujiang Lisu Autonomous Prefecture, and Honghe Hani and Yi Autonomous Prefecture. The four prefectures, excluding Yuxi City, are border prefectures with a high concentration of ethnic minorities. The elevated TPF incidence in these areas could be linked to prolonged case accumulation, heightened exposure rates, and changes in dietary and drinking practices among ethnic minorities (11). Additionally, the high TPF incidence between border county-level cities/counties/municipal districts in these prefectures (cities), such as Kunming City, Yuxi City, Honghe Hani and Yi Autonomous Prefecture, and Wenshan Zhuang and Miao Autonomous Prefecture, may be attributed to similar risk factors and provides a hypothesis for cross-regional transmission (12). The high incidence among farmers, students, and children is consistent with the findings of a national study (12) and may be linked to poor living conditions, increased outdoor exposure, and inadequate dietary and hygiene practices.

However, this study has limitations. First, data on TPF cases were acquired from the CISDCP infectious disease surveillance system via passive surveillance, potentially introducing reporting bias (3). Second, differences in testing, diagnostic, and reporting capabilities of hospitals at different levels in various regions lead to bias in identifying and reporting TPF. Third, the spatial autocorrelation analysis scale selection depends on the researcher's subjective judgment and does not consider the temporal characteristics of clustering; false positives are inevitable, so these results should be interpreted cautiously. Finally, this study did not include driving factors (e.g., pathogen resistance) and facilitating factors (e.g., meteorology) (10) that may influence TPF incidence; therefore, the causes of TPF incidence could not be analyzed. In conclusion, while the reported TPF incidence in Yunnan Province has decreased notably, it remains high, with noticeable spatial clustering in certain prefectures (cities).

Conflicts of interest: No conflicts of interest.

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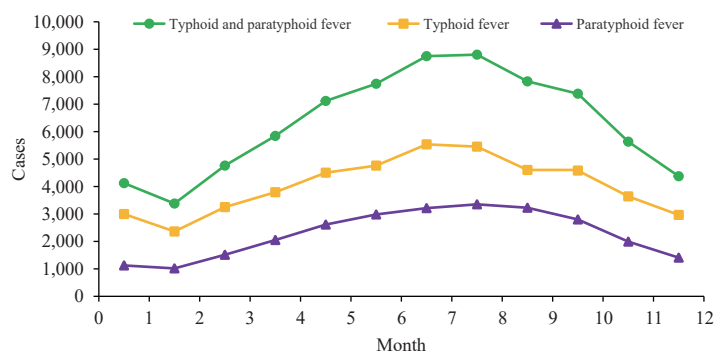
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SUPPLEMENTARY MATERIAL



SUPPLEMENTARY FIGURE S1. Monthly reported cases of typhoid and paratyphoid fever in Yunnan Province, China, 2005–2022.

SUPPLEMENTARY TABLE S1. Statistically significant high-high and low-low spatial clusters of typhoid and paratyphoid fever in Yunnan Province, China, 2005–2022.

Year	High-High (H-H)	Low-Low (L-L)
2005–2010	Yuxi City (Jiangchuan District, Tonghai County, Huaning County and Eshan County), Kunming City (Chenggong District and Jinning District), Dehong Dai-Jingpo Autonomous Prefecture (Lianghe County and Ruili County-level City), and Xishuangbanna Dai Autonomous Prefecture (Jinghong County-level City).	Zhaotong City (Yanjin County, Yongshan County, Zhenxiang County, Yiliang County, Weixin County, and Shuifu County-level City), Lincang City (Linxiang District, Fengqing County, Yun County, Shuangjiang County, and Gengma County), Pu'er City (Ning'er County, Jinggu County, Zhenyuan County, and Jingdong County), Chuxiong Yi Autonomous Prefecture (Nanhua County, Chuxiong County-level City, and YaoAn County), Diqing Tibetan Autonomous Prefecture (Weixi County, Shangri-La County-level City, and Deqin County), Dali Bai Autonomous Prefecture (Nanjian County and Weishan County), Nujiang Lisu Autonomous Prefecture (Gongshan County and Lanping County), and Lijiang City (Gucheng District and Yulong Naxi Autonomous County).
2011–2016	Honghe Hani and Yi Autonomous Prefecture (Kaiyuan County-level City, Mengzi County-level City, Jiashui County, Mile County-level City, and Luxi County), Kunming City (Chenggong District, Yiliang County and Shilin County), Yuxi City (Huaning County), Wenshan Zhuang and Miao Autonomous Prefecture (Qiubei County), and Xishuangbanna Dai Autonomous Prefecture (Jinghong County-level City).	Zhaotong City (Zhaoyang District, Ludian County, Qiaojia County, Yanjin County, Dagan County, Yongshan County, Suijiang County, Zhenxiang County, Yiliang County, Weixin County, and Shuifu County-level City), Nujiang Lisu Autonomous Prefecture (Fugong County, Gongshan County and Lanping County), Chuxiong Yi Autonomous Prefecture (Chuxiong County-level City and Shuangbai County), Diqing Tibetan Autonomous Prefecture (Weixi County and Deqin County), Lincang City (Yun County), and Pu'er City (Jingdong County).
2017–2022	Honghe Hani and Yi Autonomous Prefecture (Kaiyuan County-level City, Mile County-level City, and Luxi County), Qujing City (Luliang County and Shizong County), Wenshan Zhuang and Miao Autonomous Prefecture (Yanshan County and Qiubei County), Lijiang City (Yongsheng County and Ninglang County), Kunming City (Shilin County), and Chuxiong Yi Autonomous Prefecture (Dayao County).	Zhaotong City (Yanjin County, Yongshan County, Suijiang County, Zhenxiang County, Yiliang County, Weixin County, and Shuifu County-level City), Lincang City (Yun County and Fengqing County), Nujiang Lisu Autonomous Prefecture (Fugong County and Gongshan County), Pu'er City (Mojiang County and Jingdong County), Yuxi City (Xinping County), Baoshan City (Shidian County), Chuxiong Yi Autonomous Prefecture (Chuxiong County-level City), Dali Bai Autonomous Prefecture (Nanjian County), and Diqing Tibetan Autonomous Prefecture (Deqin County).
2005–2022	Honghe Hani and Yi Autonomous Prefecture (Kaiyuan County-level City, Mengzi County-level City, Jiashui County, Mile County-level City, and Luxi County), Yuxi City (Jiangchuan District, Tonghai County, Huaning County, and Eshan County), Kunming City (Chenggong District and Jinning District), Dehong Dai-Jingpo Autonomous Prefecture (Ruili County-level City), and Xishuangbanna Dai Autonomous Prefecture (Jinghong County-level City).	Zhaotong City (Zhaoyang District, Yanjin County, Yongshan County, Zhenxiang County, Yiliang County, Weixin County, and Shuifu County-level City), Lincang City (Linxiang District, Fengqing County, Yun County, and Gengma County), Nujiang Lisu Autonomous Prefecture (Fugong County, Gongshan County and Lanping County), Pu'er City (Zhenyuan County and Jingdong County), Diqing Tibetan Autonomous Prefecture (Weixi County and Deqin County), Dali Bai Autonomous Prefecture (Nanjian County and Weishan County), Chuxiong Yi Autonomous Prefecture (Chuxiong County-level City), and Lijiang City (Yulong Naxi Autonomous County).

SUPPLEMENTARY TABLE S2. Typhoid and paratyphoid fever outbreaks in Yunnan Province, China, 2005–2022.

Year	Prefecture/City	County-level City/County/Municipal District	Outbreaks (<i>n</i>)	Cases (<i>n</i>)	Exposed population (<i>n</i>)	Incidence (%)
2005	Honghe Hani and Yi Autonomous Prefecture	Mile County-level City	2	83	2,206	3.76
	Qujing City	Luliang County	2	51	4,100	1.24
2006	Qujing City	Xuanwei County-level City	1	53	2,301	2.30
	Zhaotong City	Yongshan County	1	22	3,000	0.73
2007	Honghe Hani and Yi Autonomous Prefecture	Yuanyang County	1	19	548	3.47
	Yuxi City	Chengjiang County-level City	1	15	946	1.59
	Wenshan Zhuang and Miao Autonomous Prefecture	Maguan County	3	44	647	6.80
2008	Kunming City	Guandu District	1	92	3,026	3.04
	Zhaotong City	Yanjin County	1	18	454	3.96
	Honghe Hani and Yi Autonomous Prefecture	Gejiu County-level City	1	42	384	10.94
	Qujing City	Luliang County	1	34	386	8.81
2009	Qujing City	Shizong County	1	63	368	17.12
	Wenshan Zhuang and Miao Autonomous Prefecture	Maguan County	1	21	237	8.86
2010	Kunming City	Jinning District	1	13	2,500	0.52
2012	Wenshan Zhuang and Miao Autonomous Prefecture	Yanshan County	1	14	1,198	1.17
2014	Wenshan Zhuang and Miao Autonomous Prefecture	Yanshan County	2	559	178,592	0.31
2016	Baoshan City	Changning County	1	27	410	6.59
	Qujing City	Shizong County	1	49	2,076	2.36
2017	Wenshan Zhuang and Miao Autonomous Prefecture	Maguan County	1	14	140	10.00