Analysis of the mountain sickness of tourists in China from 2015-2017

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Research article

Keywords: mountain sickness, tourists, plateau areas, China

Posted Date: July 14th, 2020

DOI: https://doi.org/10.21203/rs.3.rs-40343/v1

Abstract

Background: Mountain sickness significantly affects tourists who travel in plateau areas. Most studies have researched patients, climbers and local residents to analyse the identification, causes, symptoms and effects of mountain sickness, and only a few have assessed tourists.

Methods: This study used the Jiangtai Insurance Broker, an exemplary underwriting platform for travel agency liability insurance in China, as the data acquisition platform to analyse tourist altitude sickness from an epidemiological perspective. The chi-square test was used to test the distribution of mountain sickness diseases and symptoms among different genders and ages. A geographic information system (GIS) was used to generate a spatial distribution map of tourist mountain sickness.

Results: From 2015 to 2017, there were 361 cases of tourist mountain sickness, which were distributed in 4 altitudinal classes. The incidence of mountain sickness was higher in women than in men. Tourists aged 40-69 years were the main group of patients. Acute mountain sickness (AMS) and high-altitude pulmonary edema (HAPE) were the main high-altitude diseases and mainly occurred in the 2nd and 3rd class altitude regions. Hypoxia, dizziness, headache and chest tightness were the main symptoms of mountain sickness. Spring, summer and autumn were the peak seasons for the onset of mountain sickness. Mountain sickness cases were concentrated in a few cities in Western China.

Conclusion: This study analysed the genders and characteristics of the main tourist population that suffered from mountain sickness and investigated the diseases and the temporal and spatial regularity of disease from an epidemiological perspective. The research showed that the onset of mountain sickness was related to the individual physique and age of tourists, speed of entering the plateau, season and altitude. This study is significant as a reference for the risk assessment of tourists visiting plateau areas.

Introduction

In recent years, an increasing number of people have visited plateaus. Mountain sickness is the main threat faced by people visiting plateau areas, and both high-altitude migrants and native residents may suffer from mountain sickness [1]. Hypoxia is the main physiological challenge in plateau environments, but the pathogenesis of mountain sickness has not yet been clearly determined [2]. Existing literature has studied the incidence and characteristics of high-altitude diseases among high-altitude residents [3], high-altitude pilgrims [4] and high-altitude hikers [5–7]. The unique natural environment and cultural customs on plateaus are favoured by many tourists. Due to the tight travel times, tight schedule sand the difference between the plateau environment and the tourists' usual environments, tourists have developed a high incidence of mountain sickness. However, there are few studies on the mountain sickness of tourists visiting plateau areas.

In geography, a plateau refers to an area with an altitude of more than 1,000 metres [8] with relatively flat terrain or some rolling hills [9]. Plateaus have low atmospheric pressure and thin air [10], and the oxygen content decreases with increasing altitude [11]. In China, the plateau areas are mainly located in the Western China, including the Qinghai-Tibet Plateau, Inner Mongolia Plateau, Yunnan-Guizhou Plateau and Loess Plateau [12]. Mountain sickness, which is also known as high-altitude disease, is caused by the low oxygen levels in high-altitude area [13]. People could be afflicted by acute mountain sickness because they travel too fast to plateau areas (2500 m or above) [14–16]. As a major public health problem in high-altitude areas, the mountain sickness generally encompasses three forms: acute mountain sickness (AMS), high-altitude cerebral edema (HACE), and high-altitude pulmonary edema (HAPE) [17, 18]. High-altitude heart disease (HAHD), a form of chronic mountain sickness, occurs in lowlanders who reside at altitudes above 3000 m [19].

The pathogenesis and prevention of mountain sickness are popular research topics in academic circles. The pathogenesis includes the identification, factors, symptoms and impacts of mountain sickness. In research on mountain sickness identification, researchers use the Lake Louise score (LLS) [20–23]and visual analogue score (VAS) [24–26] to identify acute

 t affect acute altitude sickness include obesity [27], age [28–30], sleep [31], hydration and inflammatory response [32], and psychological factors [33]. The external factors include low temperature, dryness, hypoxia [33]. When moving from low-altitude areas to high-altitude areas, individuals show headaches, nausea, anorexia, dizziness, lethargy, fatigue, sleep disorders [34]. In a high-altitude environment, acute altitude sickness is most likely to develop into high-altitude pulmonary edema or high-altitude cerebral edema [35]. Researchers believe that slow entry into the plateau region, reduced activity, increased rest time [36] maintaining a positive mindset [37] can effectively prevent acute plateau diseases. Returning to low-altitude areas is the principle treatment for relieving high-altitude diseases [38]. Acetazolamide [39], dexamethasone [40], nifedipine [41], and *Rhodiola rosea* [42, 43] effectively alleviate the symptoms of mountain sickness. Influenced by internal and external factors and limited by travel time and route, the types and symptoms of tourist mountain sickness and the period and region of onset require further study.

The prevention and control of mountain sickness is an important research direction in this field. However, the current literature is less focused on the types and causes of mountain sickness among tourists or on its temporal and spatial distribution. It is of great significance to analyse the spatial and temporal distribution characteristics of mountain sickness among tourists in a specific region to prevent and control mountain sickness among tourists. In view of this, this study intended to understand the characteristics of and dynamic changes in mountain sickness among Chinese tourists by studying the incidence of cases of mountain sickness among the liability insurance and travel accident insurance cases of China travel agencies from 2015 to 2017 to provide a reference for the future management of tourists to the plateau area.

Materials And Methods

Data analysis

This study used the data from travel agency liability insurance in China, which covers nearly 80% of the Chinese travel agency liability insurance. Based on the data acquisition platform, 361 cases of mountain sickness of tourists were obtained from 2015–2017, which included the gender and ages of tourists, when and where the disease occurred, and a detailed description of each case. The study matched the average altitude of the record site.

Statistical analysis

Based on the insurance data, the cases of mountain sickness in tourists were analysed and counted. Using Microsoft Excel 2007 and SPSS 25.0 to input and analyse the data, descriptive analysis was performed on the gender of the tourists, the time of the accidents and the types of mountain sickness. The chi-square test is often used to analyse the difference between the two variables. Chi-square contingency tables were used to test whether there were any differences between genders, among ages or at different altitudes. The calculation formula for the chi-square value is as follows

$$\chi^2 = \sum\sum\frac{(f_0-f_e)^2}{f_e}$$

where f_0 is the number of observations and f_e is the expected number of observations. If the P value is less than 0.05, the results are considered to have significant differences. Fisher's exact probability method was used when the total sample size (n) was less than 40 or when the minimum theoretical frequency (t) was less than 5 or more than 25%.

All the specific information related to the personal identity of tourists, such as name ID card, telephone number, have been hidden from the case materials provided. This can ensure the researcher's anonymity and research objectivity to the greatest extent. This research did not require institutional review board approval or oversight.

Result

Characteristics of tourists suffering from mountain sickness

Gender distribution of tourists

The proportion of male tourists with altitude sickness increased year by year ($P < 0.001$) and that of the female patients increased first and decreased later ($P < 0.001$). The ratio of males to females rose from 0.66:1 to 0.94:1 (Table 1).

Table 1

Year	Male (%)	Female (%)	Gender Ratio	Total (%)
2015	37 (39.78)	56 (60.22)	0.66:1	93 (100.00)
2016	61 (44.20)	77 (55.80)	0.79:1	138 (100.00)
2017	63 (48.46)	67 (51.54)	0.94:1	130 (100.00)
Total	161	200	-	361
Value	322.000***	400.000***	-	-

Age distribution of tourists

The age group composition changed over the 3-year study period. The proportion of the age group with individuals under 10 years old and that of individuals between 10 and 20 years old first decreased and later increased ($P < 0.001$). The proportion of the 20-30 age group and the 30-40 age group first increased and decreased then (P=0.000), but the number of patients increased yearly. The proportion of the 40-50 age group and the 50-59 age group decreased year by year ($P < 0.001$). The proportion and the number of patients of the 60-69 age group first decreased and later increased ($P < 0.001$). The proportion and the number of patients of the over 70 age group first increased and later decreased ($P < 0.001$) (Table 2).

Table 2

Year	‹10	10-19	20-29	30-39	40-49	50-59	60-69	≥70	Total
2015	5 (5.38)	3 (3.23)	4 (4.30)	6 (6.45)	22 (23.66)	35 (37.63)	12 (12.90)	6 (6.45)	93 (100.00)
2016	2 (1.45)	1 (0.72)	12 (8.70)	15 (10.87)	26 (18.84)	45 (32.61)	32 (23.19)	5 (3.62)	138 (100.00)
2017	4 (3.08)	7 (5.38)	13 (10.00)	14 (10.77)	21 (16.15)	36 (27.69)	29 (22.31)	6 (4.62)	130 (100.00)
Total	11	11	29	35	69	116	73	17	361
Value	22.000***	22.000***	58.000***	70.000***	138.000***	232.000***	146.000***	17.000***	-

Distribution of mountain sickness disease types

The altitude was classed according to the 500-metre intervals, and the cases in the study were distributed throughout a range of 3 altitude classes (Table 3). AMS was the most frequent disease type, which mainly occurred in the 2nd and 3rd altitude classes. HAPE, HAHD were the main disease types. HAPE mainly occurred in the 2nd and 3rd altitude classes. HAHD mainly

 No incidents of HACE were recorded in the cases.

Table 3

Class	AMS	HAPE	HAHD	Total
First	31(91.18)	3(8.82)	0(0.00)	34
Second	129(91.49)	10(7.09)	2(1.42)	141
Third	171(91.94)	11(5.91)	4(2.15)	183
Total	331	24	6	361
Value	662.000***	48.000***	6.000*	-

During the three years, the proportion of AMS decreased yearly, but the number of patients first increased and then decreased ($P < 0.001$). The proportion and the number of HAPE increased yearly ($P < 0.05$). The proportion of HAHD first decreased and then increased, but the number of patients was still 2. (Table 4).

Table 4

Year	AMS	HAPE	HAHD	Total
2015	87(93.55)	4(4.30)	2(2.15)	93(100.00)
2016	128(92.75)	8(5.80)	2(1.45)	138(100.00)
2017	116(89.23)	12(9.23)	2(1.54)	130(100.00)
Total	331	24	6	361
Value	662.000***	48.000***	-	-

Distribution of mountain sickness symptoms

As seen in Table 5, the most frequent symptoms of mountain sickness included vomiting, headache, dizziness, hypoxia, chest tightness, nausea and malaise. The symptoms occurred in different parts of the body, including the chest, lower limbs, limbs, head, abdomen, neck and body. Among the head symptoms, dizziness was the most common (8; 11.43%), hypoxia (6; 8.57%) and headache (4; 5.71%) were also common. Among the chest symptoms, chest tightness (4; 5.71%) was the main disease, and angina pectoris, arrhythmia, haemoptysis and chest pain (1; 1.43%) occurred. In the limbs, trembling limbs and limb weakness (1; 1.43%) were the main symptoms. For the abdomen, vomiting (13; 15.24%), nausea (7; 10.00%) and Gastrectasia (2; 2.86%) were the main symptoms. Malaise (8; 11.43%) was the most frequent of all symptoms that occurred in the whole body, followed by dehydration and muscle pain (1; 1.43%). Other types included blunt force injury (1; 1.43%).

Table 5

Body part	Symptom	No.	Body part	Symptom	No.
Head	Dizziness	8(11.43)	Chest	Chest tightness	4(5.71)
	Hypoxia	6(8.57)		Angina pectoris	1(1.43)
	Headache	4(5.71)		Chest pain	1(1.43)
	Fainting	1(1.43)		Arrhythmia	1(1.43)
	Nose bleeding	1(1.43)		Haemoptysis	1(1.43)
	Carsickness	1(1.43)	Limbs	Limb weakness	1(1.43)
	Cerebral apoplexy	1(1.43)		Trembling limbs	1(1.43)
Whole body	Malaise	8(11.43)	Abdomen	Vomiting	13(18.57)
	Dehydration	1(1.43)		Nausea	7(10.00)
	Muscle pain	1(1.43)		Gastrectasia	2(2.86)
Neck	Neck swelling	1(1.43)		Gastrorrhagia	1(1.43)
Genitals	Haemorrhage	1(1.43)	Others	Blunt force injury	1(1.43)
Lower limbs	Inability to walk	1(1.43)			

Temporal distribution of mountain sickness

In response to the growth rate of tourists in the case area, the number of tourists suffering from mountain sickness increased from 2015 to 2017, which had 93, 138 and 130 incidents, respectively. As seen in Figure 1, the number of tourists was lowest in February. From March to June, it grew rapidly. The highest peak usually occurred in June and July. The number of tourists decreased slightly in August and September, and it increased in October and then declined after November.

Spatial distribution of mountain sickness

As seen in Figure 2, the quantitative range of tourists suffering from mountain sickness was unevenly distributed in space, which was mainly concentrated in high-altitude regions in Western China, such as the Tibet Autonomous Region, Sichuan Province and Qinghai Province. In particular, the incidence of mountain sickness was concentrated in one or several cities in the above provinces, such as Lhasa, Ngawa and Garzê. There were no cases or cases occurred below 2500 m in the cities, which are shown in white in Figure 2.

According to the abovementioned altitude classification, the mountain sickness in the study period was statistically analysed. Within the three-year period, the proportion of mountain sickness cases from 2500 m to 3000 m (1^{st} class) first decreased and later increased ($P < 0.001$), and the number of patients increased. The proportion of mountain sickness cases and the number of patients first increased and later decreased from 3000-3500 m (2^{nd} class) ($P < 0.001$). The proportion of mountain sickness above 3500 metres (3^{rd} class) first decreased and then increased, and the number of patients with mountain sickness increased slightly ($P < 0.001$) (Table 6).

Table 6

	Classification of Altitude			
Year	First	Second	Third	No.
2015	10 (10.75)	21 (22.58)	62 (66.67)	93 (100.00)
2016	10 (7.25)	67 (48.55)	61 (44.20)	138 (100.00)
2017	14 (10.77)	53 (40.77)	63 (48.46)	130 (100.00)
Total	34	141	186	361
Value	34.000***	282.000***	372.000***	-

As seen in Table 7, Tibet (197, 54.57%) ranked first among the provinces with large numbers of tourists, and Sichuan ranked second (137, 37.95%) followed by Qinghai (23, 6.37%), Gansu (3, 0.83%). In addition, a small number of mountain sickness cases occurred in Xinjiang (1, 0.28%). The cases of mountain sickness that occurred in Tibet were mainly concentrated in Lhasa (165, 45.71%) and Linzhi (25, 6.93%). The cases in Sichuan were mainly concentrated in Ngawa (79, 21.88%) and Garzê (58, 16.07%). Qinghai’s mountain sickness incidence areas were mainly concentrated in Haibei (14, 3.88%), Hainan (7, 1.94%) and Haixi (2, 0.55%). Gansu’s were mainly concentrated in Gannan (3, 0.83%).

Table 7

Province	City	No.	Class	Province	City	No.	Class
Gansu	Gannan Tibetan Autonomous Prefecture	3(0.83)	1	Tibet	Ngari Prefecture	3(0.83)	3
Qinghai	Tibetan Autonomous Prefecture of Haibei	14(3.88)	3		Lhasa	165(45.71)	3
	Haixi Mongolian and Tibetan Autonomous Prefecture	2(0.55)	1		Linzhi	25(6.93)	1
	Tibetan Autonomous Prefecture of Hainan	7(1.94)	1		Changdu	1(0.28)	2
Sichuan	Tibetan Qiang Autonomous Prefecture of Ngawa	79(21.88)	2		Shannan	1(0.28)	3
	Tibetan Autonomous Prefecture of Garzê	58(16.07)	2		Rikaze	2(0.55)	3
Xinjiang	Bayingol Mongolian Autonomous Prefecture	1(0.28)	3				

Figure 3 shows the altitude class of each city. The 1st class mainly covered Tibet and Qinghai, including Linzhi, Hainan and Haixi (Table 6). The 2nd class covered Gansu, Sichuan and Tibet, including Ngawa, Garzê, Changdu, Gannan. The 3rd class covered Tibet, Xinjiang and Qinghai, including Ngari. Lhasa, Rikaze, Shannan, Bayingol and Haibei.

Discussion

Mountain sickness is not only an important public health problem in plateau areas but also a serious risk for tourists to plateau areas. The 361 cases of mountain sickness among Chinese tourists from 2015 to 2017 showed that the proportion of male tourists first increased and that of female tourists decreased, causing the ratio of cases of mountain sickness in males to females to increase.

In terms of the age distribution, the three most common age groups were 50–59, 60–69 and 40–49, indicating that age is an important cause of mountain sickness [29]. The middle-aged and elderly were the population with the highest incidence of mountain sickness, mainly because in addition to changes in the natural conditions, their own diseases, such as history of

 disease and cardiac insufficiency, were the main causes of mountain sickness

[45]. The incidence of mountain sickness in young adults aged 20–29 and 30–39 accounted for nearly one-fifth of all cases. Although the physical fitness of this group was better than that of the middle-aged and elderly tourists, young tourists ignored their physical limits and engaged in high-intensity tourism activities. Their physical activity levels easily led to the occurrence of mountain sickness [46, 47]. Children under the age of 10 were vulnerable to acute altitude sickness [48], mainly due to poor physical strength and weakened resistance caused by their activities in anoxic environments, upper respiratory tract infections, cardiac damage and heart failure caused by myocardial fibre anoxic ischaemia [49].

In addition to the study period, the incidence of mountain sickness was higher in women than in men. This differed from previous results in related studies that the incidence of mountain sickness was lower in women than that in men [50, 51]. In fact, men generally have stronger body structures, more efficient physiological functions and greater physical fitness than women [52]. In the process of short-term tourism, the adaptability and resistance of men to the natural environment are higher than those of women [53], and women have higher sensitivity than men. Women are prone to anxiety, tension and other emotions [54], so the incidence rate of diseases is lower for men than for women. This was similar to the result of this study. Therefore, in travel organized by travel agencies, women and short-term travellers have more rigorous pre-travel consultations to prevent the occurrence of mountain sickness [39].

The statistical results showed that AMS was the most common disease after tourists had entered a plateau area. The main reason was that tourists entered plateau areas too quickly [55], which makes it difficult for an individual to adapt to the low-pressure environment and the lack of oxygen after leaving their habitual environment [56]. The main symptoms of mountain sickness were hypoxia, dizziness, headache, chest tightness and physical discomfort. The aggravation of the disease further leads to fatal diseases such as HAPE [38, 57]. HAPE is a kind of noncardiogenic pulmonary edema that usually occurs at altitudes of more than 2500 metres [58]. This is consistent with the results of this study. HAPE is the most common cause of death due to exposure to high-altitude areas [55], so tourists' adaptation to high-altitude areas and physical exercise must be considered [36]. During the study period, the number of mountain sickness events increased because of the increasing number of tourists that regarded plateau areas as tourist destinations.

In terms of the temporal distribution, there was a monthly peak in the incidence of mountain sickness. April to May (spring) was the first small peak, and July to October (summer and autumn) was the second peak, which was consistent with the characteristics shown by the relevant reports [59]. There was a close relationship between the incidence of mountain sickness and the seasons [60]. In spring, the temperature in most areas of China rises and the number of tourists travelling increases; the number of green plants on plateaus in spring is lower and the air content is low, and the temperature in high-altitude areas is still low, which leads to the high incidence of mountain sickness in spring. In summer, the temperature difference between the north and the south is relatively small, but the temperature difference between day and night is large in plateau areas. Summer vacation, the Mid-Autumn Festival, and National Day are the main tourist peak seasons. The tourists from plains areas or low-altitude areas that are not acclimatized to the altitude are prone becoming ill due to the sudden changes in humidity and temperature, which leads to mountain sickness, such as lung infections.

In terms of the spatial distribution, mountain sickness mainly occurs in the Western China, and the incidence of mountain sickness among tourists in differed among altitude regions and was concentrated in a few cities, which were the popular tourist destinations. The highest incidence of tourists was in the 3rd class (above 3000 m), followed by the 2nd class (3000–3500 m) and 1st class (2500–3000 m); the above three altitudes include many famous scenic spots and tourist destinations, such as Lhasa, Daocheng, Jiuzhaigou, Huanglong and Rikaze. There were more tourists at these scenic spots, so the incidence of mountain sickness was greater. The number of cases in the 1st altitude area was relatively small and concentrated in Linzhi. Linzhi has high levels of precipitation, high humidity and high vegetation coverage all year round, and its oxygen content is generally higher than that in the same altitude region, and tourists' altitude reactions were not obvious [61, 62].

Conclusion

From 2015 to 2017, the incidence of mountain sickness among Chinese tourists was generally higher in females than in males, and tourists aged 40–69 were the main incidence groups. AMS was the main high-altitude diseases, and hypoxia, dizziness, headache and chest tightness were the main symptoms of mountain sickness. Spring, summer and autumn were the peak seasons for mountain sickness, and the cases were mainly concentrated in a few cities in Western China. In light of the above characteristics, it is necessary to take preventive measures against mountain sickness in key populations and peak seasons. The limitation of the study lies in that the group study was based on the absolute altitude of the risk areas and the high-altitude disease categories; the analysis of the characteristics of the single disease and the description of time and space were not adequate. In the future, studies can conduct deeper analyses of single mountain sickness diseases according to the relative altitude changes of the tour paths.

Abbreviations

AMS
Acute mountain sickness
HAPE
High-altitude pulmonary oedema
HAHD
High-altitude heart disease
HACE
High-altitude cerebral edema
LLS
Lake Louise score
VAS
Visual analogue score

Declarations

Ethics approval and consent to participate

Not applicable

Consent for publication

Not applicable

Availability of data and materials

Data sharing not applicable to this article as no data-sets were generated or analyzed during the current study.

Funding

This study was supported by the National Natural Science Foundation of China (Grant No. 41971182) and Humanities and Social Sciences Foundation of Ministry of Education of China（Grant No. 19YJAZH097).

Authors' contributions

XL carried out the writing of the article. CWX participated in critical review, and approval of the final version. All authors read and approved the final manuscript.

Acknowledgements

Not applicable

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CWX is a professor in College of Tourism of Huaqiao University. The research interest includes tourism safety, tourism service and smart tourism.

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Competing interests

The authors declare that they have no competing interests.

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Figures

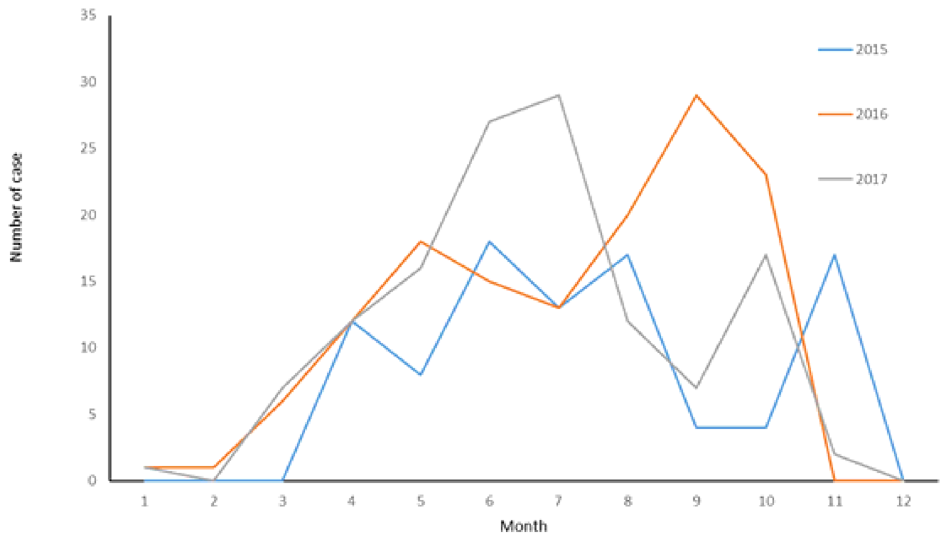

Figure 1

The number of tourists per month

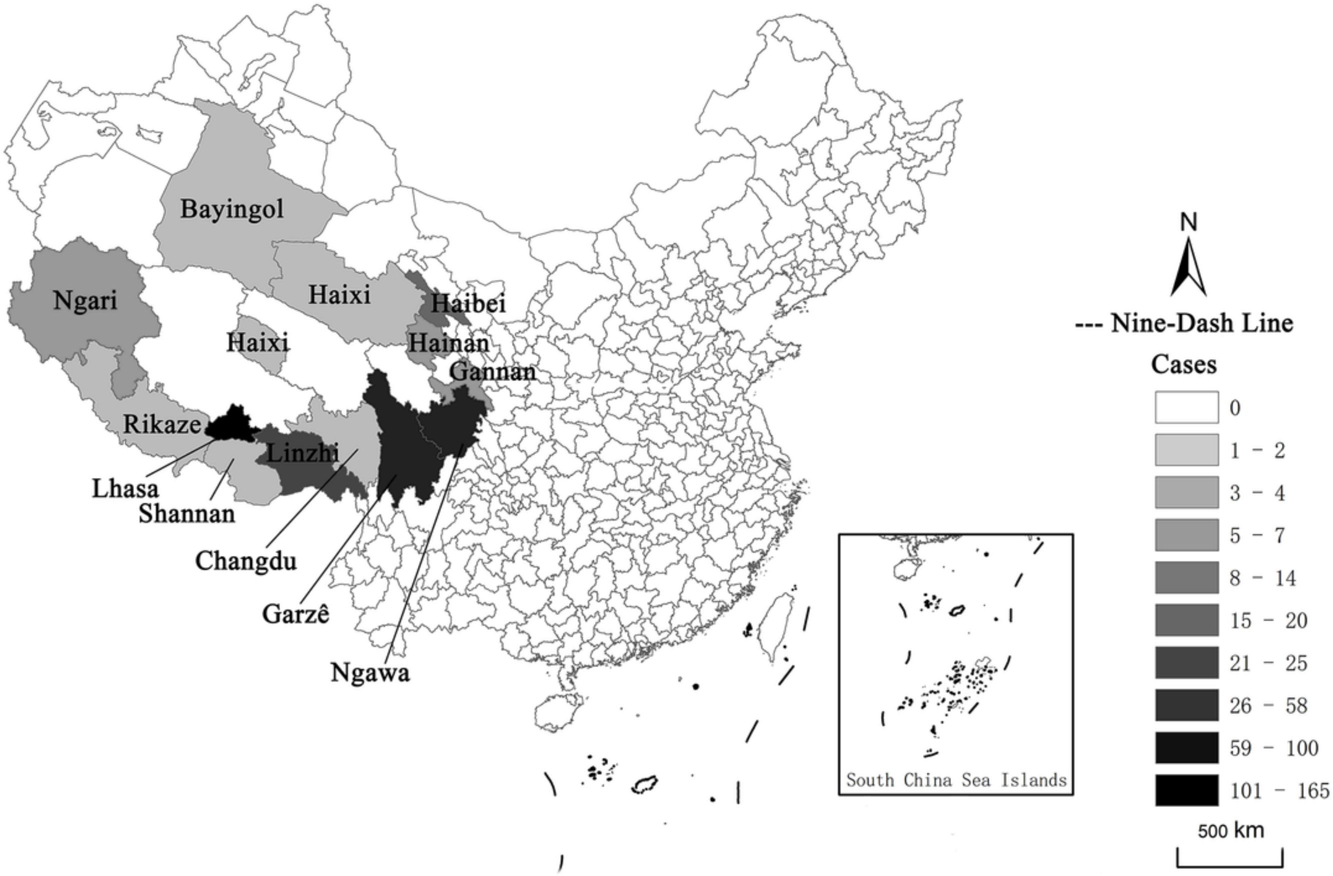

Figure 2

Cases by region. Note: The designations employed and the presentation of the material on this map do not imply the expression of any opinion whatsoever on the part of Research Square concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. This map has been provided by the authors.

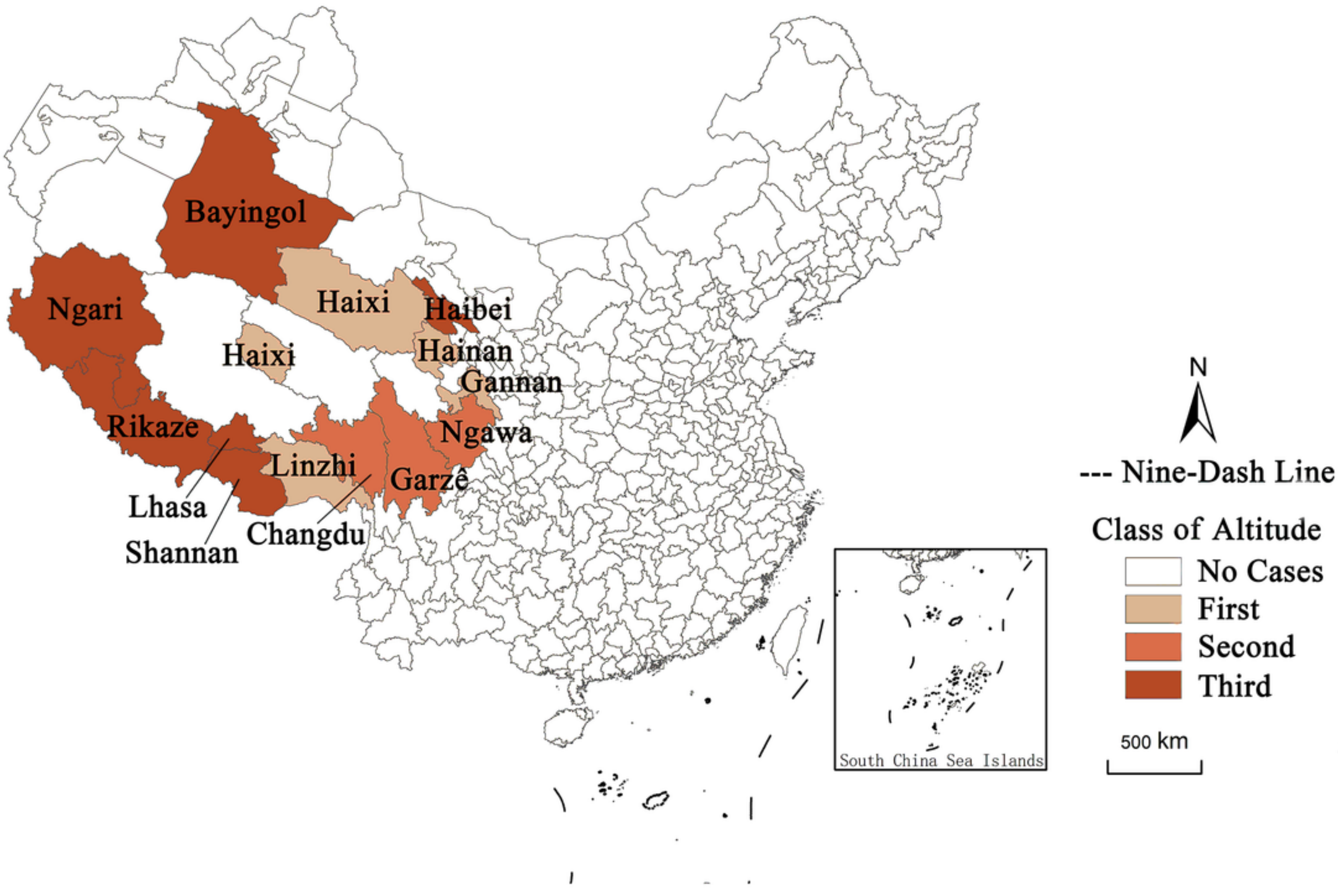

Figure 3

The altitude class of each city. Note: The designations employed and the presentation of the material on this map do not imply the expression of any opinion whatsoever on the part of Research Square concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. This map has been provided by the authors.