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# Temporal and spatial patterns and influencing factors of intangible cultural heritage: Ancient Qin-Shu roads, Western China

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## Abstract

The ancient Qin-Shu roads corridor is one of the important cultural main corridors in China. Throughout China's long historical and cultural evolution, today's ancestors created a rich intangible cultural heritage along this route. Studying its intangible cultural heritage has important theoretical and practical significance for the protection and innovation of cultural heritage in this region. The purpose of this study is to analyze the spatial and temporal distribution characteristics of intangible cultural heritage along the ancient Qin-Shu roads and explore the main factors affecting its distribution. The nearest neighbor index, kernel density estimation, standard deviation ellipse, location entropy, buffer analysis and other methods were used. The results show that (1) The types of intangible cultural heritage of the ancient Qin-Shu roads are expressed in three echelons. Traditional handicrafts are the most numerous, folk custom and traditional music are the second most numerous, the other categories of ICH are third in quantity overall, among which traditional medicine and sports recreation competition are the scarcest. (2) The overall spatial distribution of intangible cultural heritage along the ancient Qin-Shu roads shows an agglomeration distribution. Its distribution pattern places the central cities (Xi'an, Chengdu and Chongqing) at the core, gradually spreading out and decreasing in density as it reaches peripheral districts and counties. There are significant differences in the core areas of different types of intangible cultural heritage. (3) In the process of historical development, the intangible cultural heritage of the ancient Qin-Shu roads demonstrated an overall change pattern of "three rising and three falling". That is, during Qin and Han Dynasties, Sui, Tang and Five Dynasties, and Ming and Qing Dynasties, culture flourished, while in Wei, Jin, Southern and Northern Dynasties, Song and Yuan Dynasties, modern times culture developed slowly. The overall trajectory of the center of gravity of intangible cultural heritage shifted from the northeast to the southwest. (4) Natural and human factors, such as topography, climate, transportation, traditional villages and population evolution, have an important impact on the spatial pattern of the intangible cultural heritage of the ancient Qin-Shu roads. The results of this study provide a useful reference for the theoretical research and practical management of intangible cultural heritage.

**Keywords:** Intangible cultural heritage, Spatial and temporal pattern, Influencing factors, Ancient Qin-Shu roads, Utilization and protection

## Introduction

Intangible cultural heritage (hereafter referred to as ICH) is the heritage and embodiment of living culture. It is also the carrier of national memory and historical witness. The protection of intangible cultural heritage is essential for maintaining the diversity of human civilization and promoting the reproduction and effective

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and sustainable development of human civilization. The ancient Qin-Shu roads were an important channel for military, commercial and cultural exchanges in Chinese history and are one of the earliest large-scale traffic relics preserved to date [1]. The cultures of eight historical periods, the prehistoric period, pre-Qin period, Qin and Han Dynasties, Three Kingdoms Dynasties, Southern and Northern Dynasties, Sui, Tang and Five Dynasties, Song and Yuan Dynasties, Ming and Qing Dynasties and modern times, are fused via these roads [2–4]. They have accumulated and preserved many precious historical and cultural factors. A rich and unique culture has been formed, and a large number of valuable ICH have been developed and handed down. This area has a subtle impact on the production and life of the local people. In the context of globalization in recent years, foreign cultures have impacted local culture to some extent. The uniqueness and differences of the ICH of the ancient Qin-Shu roads are rapidly weakening and disappearing. The ability to protect the ICH and its inheritance faces significant challenges. Therefore, studying the ICH of the ancient Qin-Shu roads has extremely important theoretical value and practical significance.

With increasing attention to ICH around the world, the study of ICH has gradually become a popular topic of concern in the academic world. Throughout past studies, most of the early studies focused on basic aspects, such as conceptual definition, typological classification, utilization and value evaluation of ICH [5–9]. In recent years, ICH studies have begun to delve into deeper issues, such as research on the theoretical construction of intangible cultural heritage, reflection and suggestion research on intangible cultural heritage protection systems, experience in intangible cultural heritage protection and management [10–12], the impact of intangible cultural heritage declarations on local economic and social development, intangible cultural heritage re-innovation, intangible cultural heritage tourism, and research on intangible cultural heritage education and teaching [13–15]. The scope of the study can be as large as the whole continent or as small as a village [16, 17]. However, most scholars prefer to study a specific ICH or the ICH of a particular region. The research methodology mainly uses literature induction, in-depth interviews, case studies, model simulations, sample surveys, and other means [13–20]. From a research perspective, studies are mostly implemented from humanities fields including sociology, nationality and folklore, economics and management, tourism, and education. These research results are useful for the conservation and development of ICH in a holistic way, but they cannot provide sufficient guidance for ICH at a localized level.

There are few scientific documents about the ancient Qin-Shu roads. The sociological literature mainly focuses on fundamental research work such as historical geography. It includes sorting out the historical context of the ancient Qin-Shu roads [2, 21–23], demonstrating the route trend [24–28], and exploring the remains of the route [29]. For example, Yan examined all the routes of the ancient Qin-Shu roads one by one, these results with substantial impacts at home and abroad [30]. Li published many works on Shu Road transportation lines and became an expert in Shu Road research [31]. Since the beginning of the twenty-first century, when relevant departments organized the application of “Shu Road” for World Cultural Heritage, related research on the ancient Qin-Shu roads gradually increased. This research has been expanded to include the composition and protection of route heritage [32–35], tourism development [36–38] and other aspects. For example, Shan researched the conservation and status of Shu Road then pointed out the challenges to preserving Shu Road [39]. Wang et al. sorted and classified the tourism resources of the ancient Shu Road and initially explored the tourism development and conservation model of the ancient Shu Road [40]. Luo advocates that the development of the ancient Qin-Shu roads tourism route can be used to drive industrial upgrading in towns along the route. By radiating from core cities, a small urban agglomeration dominated by “culture + tourism” can be constructed to realize the transformation of historical and cultural resources [41]. It can be seen that scholars mainly focus on the textual research, protection and development of material carriers and have not yet involved ICH. In addition, the research methods are mainly literature induction or field surveys and rarely involve geographical methods and techniques.

At present, some studies have examined cultural heritage [42–44] and intangible cultural heritage based on the spatial analysis and influencing factors of geographic information systems (GISs) [45]. In a study by Yao et al. [42], 81.9% of Christian cultural heritage was concentrated in Europe. Liang et al. [43] concluded that the number of cultural heritage sites is much higher in Europe and North America than in Asia and the Pacific. Heritage sites are affected by many factors, such as global political, political and economic crises. Xu et al. [44] believed that China’s intangible cultural heritage is more distributed in the economically developed eastern coastal areas and less distributed in the west. Tian et al. [45] argued that the spatial and temporal distribution of national heritage conservation units in China is influenced by a combination of natural factors, such as topography, climate change, hydrology and rivers, and human factors, such as government governance, economic development, and population evolution.

However, there are few studies on the ICH of the ancient Qin-Shu roads, and there is no research on the temporal and spatial distribution. In addition, the spatial heterogeneity of the ICH of the ancient Qin-Shu roads is affected by many complex factors, and these factors have not been fully explored. In view of this, an empirical study of the ancient Qin-Shu roads was carried out by means of spatial analysis. The temporal and spatial pattern of ICH along the ancient Qin-Shu roads and its influencing factors were explored. To this end, this study performed the following steps:

- (1) We used statistical data to analyze the structural characteristics of ICH types along the ancient Qin-Shu roads.
- (2) Geographical methods and techniques such as the nearest neighbors index and kernel density estimation were used to analyze the distribution characteristics of the ICH of the ancient Qin-Shu roads.
- (3) According to the standard deviation ellipse data, the temporal distribution and evolution characteristics of the ancient Qin-Shu roads ICH were analyzed.
- (4) The influencing factors of ICH of the ancient Qin-Shu roads were explored by means of location entropy, buffer analysis, and layering.

This study attempts to develop a spatiotemporal analysis of ICH in the field of spatial information and further deepen the concept of ICH protection and development. In addition, this study can provide technical support for the preservation and development of ICH of the ancient Qin-Shu roads and contribute to cultural revitalization.

## Materials and methods

### Research area

In ancient China, Shaanxi was called Qin, and Sichuan was called Shu. Therefore, historical documents refer to a series of very important communication lines connecting the Guanzhong Plain and Sichuan Basin in ancient China as “the ancient Qin-Shu roads”. It was also known as Zhou Road, Qin Road, and Shu Road in different eras [29].

The ancient Qin-Shu roads starting from the Guanzhong region, they pass through Chang'an (now Xi'an) and Baoji before converging in Hanzhong and then southward to Chengdu and Chongqing. They have a total length of approximately 4000 km [46, 47]. They are a combination of humanity and nature, passing through the Qinling Mountains, known as the “north–south division of China's geography”, over the Daba Mountains, and crossing the Yellow River and the Yangtze River, two of China's most important rivers. They are blessed with

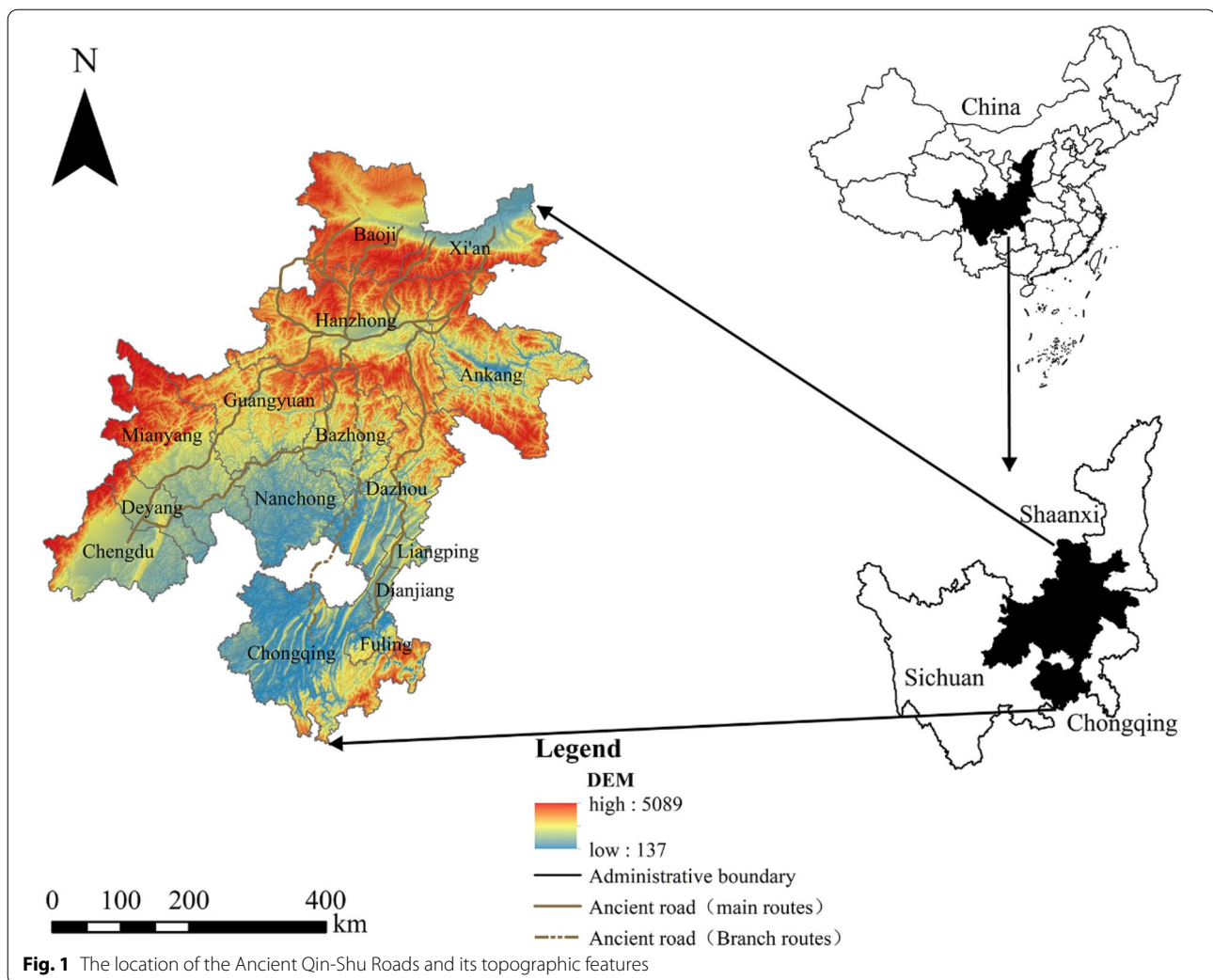
natural ecological conditions. As a carrier of cultural transmission, they have left a mark of a specific era in all places along the route, especially in regard to folk crafts, poetry and literature, stories and legends and historical events and other ICH [35, 48]. They play an extremely important role in the protection of ICH.

The scope of the ancient Qin-Shu roads is ambiguous. In this paper, the division of the ancient Qin-Shu roads range determined by Li [24], Li [25], and Wang [49] is used as the research standard; this division is generally recognized by the current academic community. It is believed that there are seven main routes on the ancient Qin-Shu roads: four ancient northern roads crossing the Qinling Mountains (Ziwu Road, Tangluo Road, Bao Inclined Road and Chencang Road) and three ancient southern roads crossing the Daba Mountains (Litchi Road, Micang Road and Jinniu Road). According to the route direction, parts of the ancient Qin-Shu roads belong to areas of Shaanxi, Sichuan and Chongqing in the current geographical administrative divisions. Therefore, the area covered by the ancient Qin-Shu roads in this paper includes 12 prefecture-level cities and 3 districts and counties in southern Shaanxi, northeastern Sichuan and northwestern Chongqing (Fig. 1).

### Data source

The data for this paper were collected from the China ICH network (<http://www.ihchina.cn>), Shaanxi Province ICH network (<http://www.sxfycc.com>), Sichuan Province ICH network (<https://www.ichsichuan.cn>) and the national and provincial representative ICH projects announced by the Chongqing Municipal People's Government as of 2021. The ICH projects successfully declared by Shaanxi, Sichuan and Chongqing Provinces along the ancient Qin-Shu roads were collected, including five sets of national and six sets of provincial ICH projects. Some of the ICH are both national ICH and in the provincial ICH list. To more accurately study the geographical distribution characteristics of the ancient Qin-Shu roads, in this study, overlapping items were integrated into one item, and no double counting was performed [50, 51]. Ultimately, 567 ICH items were collected. According to the national classification standards, the categories of ICH items before 2008 were corrected. The projects were uniformly classified into 10 types: folk literature, traditional music, traditional dance, traditional drama, quyi, sports recreation competition, traditional art, traditional handicraft, traditional medicine and folk custom [52].

The geographic coordinates of the ICH declaration units were obtained from the Baidu coordinate selection tool. For ICH projects that could not be accurately located, the location of the administrative center was



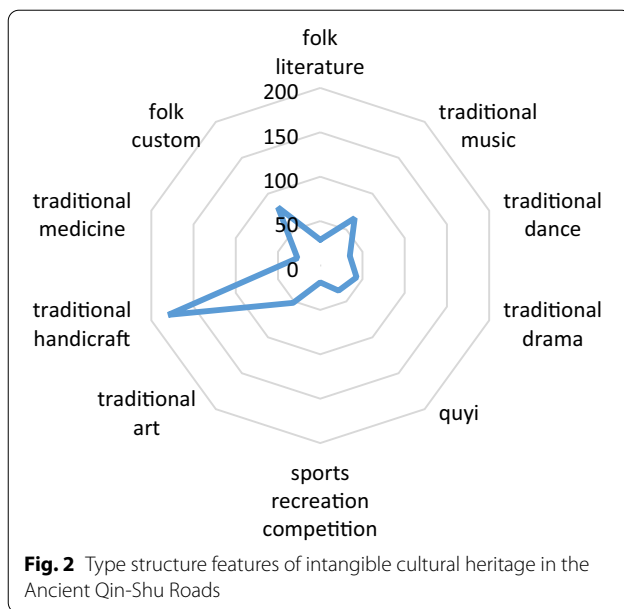
selected for spatial positioning. Vector base maps of Shaanxi, Sichuan and Chongqing in the national basic Geographic Information System database were adopted as working base maps. ArcGIS10.2 software was used to establish the ancient Qin-Shu roads ICH database and create the ancient Qin-Shu roads ICH distribution map. In terms of influencing factors, the geomorphic data of the study area were obtained from the Chinese 1:1,000,000 geomorphic spatial distribution data of the Resource and Environmental Science Data Center of the Chinese Academy of Sciences (<http://www.resdc.cn/>). River data and traffic data were obtained from the latest vector data provided by Open Street Map and Bigemap. The climatic and other natural zones were derived from the Atlas of China. The distribution data of the ancient Qin-Shu roads were collated according to the historical Atlas of Shaanxi Province and An Investigation of Qin and Shu ancient roads in Early China. The population data were obtained from the statistical

yearbooks of Shaanxi, Sichuan and Chongqing (2020). The list of traditional villages was derived from the list of three groups of traditional villages in China published by the China Traditional Villages Network. For period divisions, we referred to Xiaobo et al. [44] and Ju et al. [53] on the historical period divisions of cultural heritage. ICH can be divided into eight periods: prehistoric period, pre-Qin period, Qin and Han Dynasties, Wei, Jin, Southern and Northern Dynasties, Sui, Tang and Five Dynasties, Song and Yuan Dynasties, Ming and Qing Dynasties, and modern times. In terms of natural and humanistic influencing factors, based on previous research results [45, 51, 54] and the special characteristics of the local environment of the ancient Qin-Shu roads, topography, climate, rivers, transportation, traditional villages, and population evolution were finally selected for analysis.

**Table 1** Numbers-types of intangible cultural heritage in the Ancient Qin-Shu Roads

Province (municipality directly under the central government)	Folk literature	Traditional music	Traditional dance	Traditional drama	Qiyi	Sports recreation competition	Traditional art	Traditional handicraft	Traditional medicine	Folk custom	Quantity/percentage (%)
Shaanxi	13	18	13	17	14	9	19	89	9	53	254/44.80
Sichuan	10	30	17	17	17	6	11	51	10	20	189/33.33
Chongqing	6	18	5	9	4	4	22	40	8	8	124/21.87





## Research methods

### The nearest neighbor index

The nearest neighbor index is an important method for judging the spatial distribution types of intangible heritage sites. It is obtained by comparing the ratio of the actual distance between the ICH point-like elements and the random average distance. The calculation formula is as follows [45]:

$$NNI = \frac{\{\sum_{i=1}^n Q_i\}/n}{0.5/\sqrt{n/A}} \quad (1)$$

$Q_i$  represents the distance between any distance and the nearest neighbor point,  $n$  is the number of points, and  $A$  is the area of the region.  $NNI \leq 0.5$  is generally considered to be an agglomeration distribution.  $NNI \geq 1.5$  is uniformly distributed,  $0.5 < NNI \leq 0.8$  is an aggregation-random distribution,  $0.8 < NNI < 1.2$  is a random distribution, and  $1.2 \leq NNI < 1.5$  is a randomly discrete distribution.

### Kernel density estimation

Kernel density estimation is often used to determine the density of a point element in its surrounding field [27]. It clearly reflects the spatial aggregation trend of ICH items in different types and periods of the ancient Qin-Shu roads. The denser the intangible heritage sites are, the greater the nuclear density  $f(x)$ . The calculation formula is as follows [45, 55]:

$$f_n(x) = \frac{1}{nh} \sum_{i=1}^n k\left(\frac{x-x_i}{h}\right) \quad (2)$$

$k(x)$  is the kernel function;  $H > 0$  is the search radius, and  $x-x_i$  is the distance between valuation point  $x$  and sample point  $x_i$ .

### Standard deviation ellipse

The standard deviation ellipse can be used to express spatial characteristics such as the center of gravity position and transition direction of geographical elements [44, 56]. In this paper, standard deviation ellipses are used to analyze the center of gravity migration direction of the intangible heritage resource distribution of cultural relics in different dynasties. The calculation formula is as follows [57]:

$$x = \frac{\sum_{i=1}^n x_i}{n} \quad Y = \frac{\sum_{i=1}^n y_i}{n} \quad (3)$$

$X_i$  and  $Y_i$  represent the coordinates of the distribution of intangible heritage points, and  $n$  is the total number of intangible heritage points in a certain period.

### Location entropy

Location entropy is an indicator used to measure the degree of concentration of a factor [58]. In this paper, it is used to simulate the ratio of the ICH quantity in each statistical range to the ICH quantity in the research area relative to the proportion of the area in the statistical range to the total research area. The calculation formula is as follows [59]:

$$R = \frac{p_i / \sum_i p_i}{m_i / \sum_i m_i} \quad (4)$$

$R$  is the advantage of the number of ICH in each statistical range relative to the average level of the research area, and the variable  $I$  ranges from 1 to  $n$  and is the ordinal number of the county-level area. When  $R > 1$ , the number of ICH in this statistical range is higher than the average level of the research area; when  $R = 1$ , the number of ICH is the same as the average level of the research area; and when  $R < 1$ , the number of ICH is lower than the average level of the research area.

### Buffer analysis

Buffer analysis is an analytical method used to determine the proximity of different geographical elements [60, 61]. This paper takes rivers, traffic patterns and traditional

villages as the analysis objects and takes intangible cultural heritage projects as the objects affected by the subject, that is, adjacent objects. First, a buffer ring layer was created at a certain distance around rivers, traffic patterns and traditional villages, and then the number of ICH items in the buffer zone was calculated by intersection analysis. The calculation formula is as follows:

$$D_{(x,y)} = \sqrt{\sum_{i=1}^n [w_i(x_i - y_i)]^2} \quad (5)$$

$D(x, y)$  represents the distance between samples  $x$  and  $y$ ,  $n$  is the characteristic dimension, and  $x_i$  and  $y_i$  are the  $i$ -th attributes of samples  $x$  and  $y$ .

### Type structure and temporal and spatial pattern characteristics of the ancient Qin-Shu Road ICH

#### Scale and type structure

To date, the ancient Qin-Shu roads have been included in 567 national and provincial ICH, of which 116 are national (20.5%) and 451 are provincial (79.5%). According to the classification standard of the “National ICH List”, the ICH along the ancient Qin-Shu roads is divided into 10 categories. According to the statistics of quantity proportion, it can be divided into three echelons. The first order is traditional handicraft (180 items), which have the largest number of all types, accounting for approximately 31.7% of the total number. The second echelon is folk custom and traditional music, with 81 items and 66 items, accounting for 14.3% and 11.6% of the total, respectively. The third echelon is traditional drama (43 items), traditional dance (35 items), quyi (35 items), folk literature (29 items), traditional medicine (27 items), and sports recreation competition (19 items), accounting for 7.6%, 6.2%, 6.2%, 5.1%, 4.8% and 3.4% of the total, respectively. The ICH of the ancient Qin-Shu roads presents the structural characteristics of traditional handicrafts as the main body and folk custom and traditional music as supporting types (Fig. 2). The ICH of traditional handicraft, folk custom and traditional music are rich in quantity and provide a strong sense of experience and potential for development and utilization, which can become a key type of cultural tourism development of the ancient Qin-Shu roads. Traditional drama, traditional dance, quyi, folk literature, traditional medicine and sports recreation competition are relatively scarce items. It is necessary to further strengthen the protection and cultural excavation of these projects.

We further calculated the number of the ancient Qin-Shu roads ICH at the regional level (Table 1). In terms of the number of regions, Shaanxi had the largest number of ICH, with 254 items, accounting for 44.8% of the total.

There were 189 ICH in Sichuan, accounting for 33.3% of the total. Chongqing scored the lowest, with 124 items, accounting for 21.9% of the total. In terms of type, the region with the most traditional music was Sichuan, with 30 items, and the region with the least traditional music was Chongqing, with only 6 items. The traditional dance had the most items in Sichuan, at 17. The regions with the most traditional drama ICH were Shaanxi and Sichuan, with 17 in both provinces. The highest number of quyi was in Sichuan (17), and the lowest was in Chongqing (4). Sports recreation competition did not vary much among the three provinces and cities, and all of them had a low number. Shaanxi had the most traditional handicraft (89 items), while Sichuan and Chongqing were similar (51 items and 40 items, respectively). Traditional medicine was less common in the three provinces, and the folk custom ICH of Shaanxi (53 items) far outnumbered those of Sichuan and Chongqing.

On the whole, Shaanxi showed traditional handicraft and folk custom as the main types. Sichuan showed traditional handicraft and traditional music as the main types, and Chongqing showed traditional handicraft as the main types. The distribution characteristics of ICH types in these three places show that the spatial distribution of ICH items are closely related to the origin of regional civilization and culture.

From the perspective of traditional handicraft, Shaanxi, as the ancient capital of 13 dynasties, has always been an important cultural and economic city in China. With a large population and easy access to the city, its restaurant culture has flourished. In addition, there have been few wars in the region since ancient times, allowing their skills to be passed down in an orderly manner, providing fertile ground for a rich variety of traditional handicrafts. In terms of folk customs, Shaanxi was the location of the capitals of the Zhou, Qin, Han and Tang Dynasties. The ritual system of these dynasties laid the cornerstone of traditional Chinese etiquette. The concept of a ritual system is deeply rooted in the hearts of the people. Therefore, Shaanxi folk customs mainly focus on sacrificial activities and festivals; examples include the Yan Emperor sacrificial ceremony, Lou Guan Tai worship Lao Tze etiquette, etc.

The humid climate, fertile land and developed water system in Sichuan provide good conditions for traditional handicraft such as sericulture and grain brewing. A large number of traditional handicraft ICH items of weaving and brewing have been produced. For example, Shu brocade weaving techniques, Jiannanchun traditional brewing techniques, Pi County bean paste techniques and other traditional skills are produced in traditional ways. In terms of traditional music, Sichuan has a dense network of rivers and developed shipping traffic. The

**Table 2** Nearest neighbor index of intangible cultural heritage in the Ancient Qin-Shu Roads

Categories	Overall values	Folk literature	Traditional music	Traditional dance	Traditional drama	Quyi	Sports recreation competition	Traditional art	Traditional handicraft	Traditional medicine	Folk custom
Quantity	567	29	66	35	43	35	19	52	180	27	81
NNI	0.1857	0.5133	0.5859	0.5914	0.4424	0.3785	0.5549	0.6355	0.3346	0.2078	0.5363
Distribution types	A	A-R	A-R	A-R	A	A	A-R	A-R	A	A	A-R



workers used music to express their emotions. As a result, a large number of traditional music ICH were produced. For example, river songs and Chuanjiang songs. In addition, Qingcheng Mountain in Sichuan is the birthplace of Taoism in China and has a flourishing Taoist culture. It has produced religious traditional music such as the ancient music of Qingcheng Cave Scripture and Chengdu Taoist music.

Chongqing is located at the confluence of the Yangtze and Jialing Rivers, a meeting point for materials. The wharf culture is flourishing and has formed a wealth of traditional handicraft related to food. Examples include Chongqing hot pot, Wu wonton traditional techniques, and Liangping Zhang duck traditional handicraft.

### **Spatial distribution characteristics**

#### ***Spatial distribution types***

According to the calculation formula of the *NNI*, the average nearest neighbor in the ArcGIS10.2 software spatial statistical tool was used to calculate and process each intangible heritage type and the whole. The proximity *NNI* of ICH resources was obtained (Table 2), and the *NNI* value of the ancient Qin-Shu Roads ICH was 0.1857, less than 0.5, indicating that the ICH of the ancient Qin-Shu roads belongs to the agglomeration distribution types.

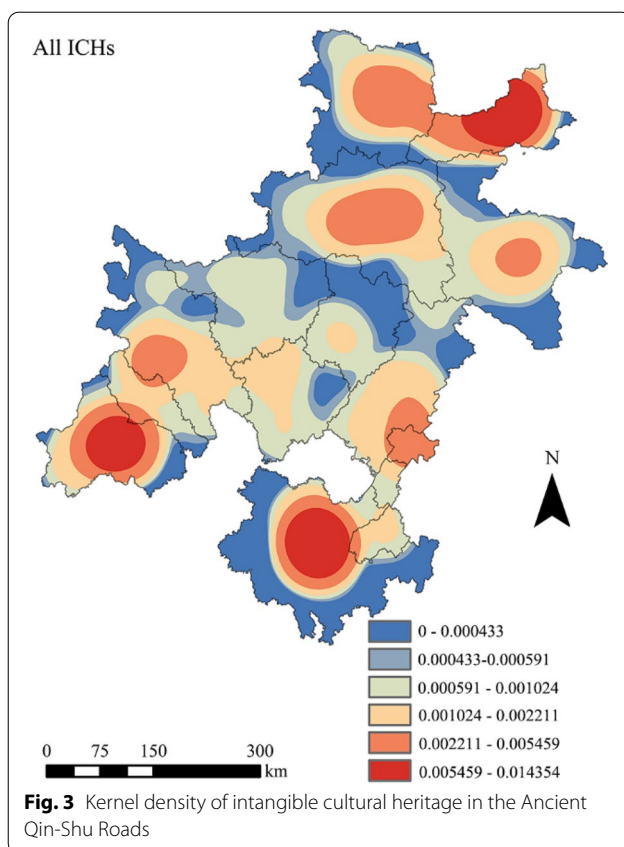
Different types of ICH resources differ in their distribution patterns. The nearest proximity index of traditional drama, quyi, traditional handicraft, and traditional medicine was 0.5 and below, showing a clear spatial aggregation distribution characteristic. The nearest proximity index of folk literature, traditional music, traditional dance, sports recreation competition, traditional art, and folk custom resources was between 0.5 and 0.8 and tended to be an aggregation-random distribution. On the whole, ICH of the ancient Qin-Shu roads show an agglomeration distribution in space. However, the degree of agglomeration varies and differs among types, and agglomerative and agglomerative-random distributions coexist. The formation of this distribution feature is significantly related to the characteristics of each type of ICH, the difficulty of spreading and other factors.

#### ***Spatial density distribution characteristics***

Kernel Density in the ArcGIS10.2 the Spatial Analyst module was used to estimate the kernel density distribution of the ancient Qin-Shu roads intangible heritage resources as a whole and the characteristics of each type (Figs. 3, 4). As a whole, the intangible heritage resources of the ancient Qin-Shu roads formed three high-density circles and five sub-high-density circles. The high-density circles were Xi'an, Chengdu and Chongqing. The sub high-density circles were located in Baoji, Hanzhong,

Ankang, Mianyang, and Dazhou-Liangping Counties. As a whole, the provincial capital city was the core, and other cities and counties were evenly distributed. As a living culture, ICH is often diffused through the exchange of people and trade, thus creating a radiation zone. The distribution of ICH of the ancient Qin-Shu roads may be related to the large population base and frequent production activities in the capital cities of Xi'an, Chengdu and Chongqing.

From the perspective of type distribution, folk literature resources formed four core areas in Xi'an-Baoji, Hanzhong and Dazhou. At the same time, Chongqing, Chengdu, Shenyang, and Bazhong formed secondary core areas. Traditional music was widely distributed in the ancient Qin-Shu roads area, especially in the southern plank. Three high-density core areas formed in Chongqing, Chengdu and Xi'an. Traditional dance and traditional drama were fewer in number and more scattered along the ancient Qin-Shu roads. The former had Baoji and Chongqing as the high-density core areas, and the latter had a high-density core area in Chongqing. Quyi had Xi'an-Baoji, Chengdu and Chongqing as high-density core areas and was also densely distributed in Hanzhong and Ankang. Sports recreation competition and traditional medicine were the lowest in quantity and the highest in concentration. The former were distributed in Xi'an-Baoji, Chengdu, Mianyang, Dazhou, Chongqing and Liangping Counties, with Xi'an as the high-density core area. The latter formed three core areas in Xi'an, Chengdu, and Chongqing and secondary core areas in Hanzhong and Mianyang, and the rest of the region had no distribution of these intangible heritage resources. Traditional art had core areas in Xi'an-Baoji, Chengdu and Chongqing and showed uneven distribution characteristics, with more in the east and less in the west. Traditional handicraft were the most abundant ICH type on the ancient Qin-Shu roads and were widely distributed in 15 cities, counties and districts. Xi'an-Baoji, Hanzhong, Chengdu, and Liangping County formed five core areas, and Chongqing, Ankang, Mianyang, and Nanchong formed secondary core areas. The main representatives of Traditional handicraft on ancient Qin-Shu roads were the techniques of making Tong Sheng Xiang mutton and bread pieces in soup, JianNanChun Chiew brewing techniques, Pixian doubanjiang, Fuling pickle and other folk delicacies as well as Xiqin embroidery, Hanzhong rattan weaving, Sichuan figured satin weaving, Chengdu lacquer art, Liangping bamboo mats and so on, which were located mainly in the above areas. Folk custom had the highest distribution density in Xi'an-Baoji, Mianyang, and Chengdu and formed secondary core areas in Mianyang, Dazhou, Chongqing, and Liangping County, with a wider overall distribution.



The above characteristics show that different types of ICH resources have strong regional and type differences in spatial distribution. The internal characteristics and inheritance degree of different types of ICH resources also have an impact on their spatial distribution patterns, which is also an important reason for the formation of the spatial distribution pattern of ICH.

### Analysis of the time series pattern

#### Scale and type structure

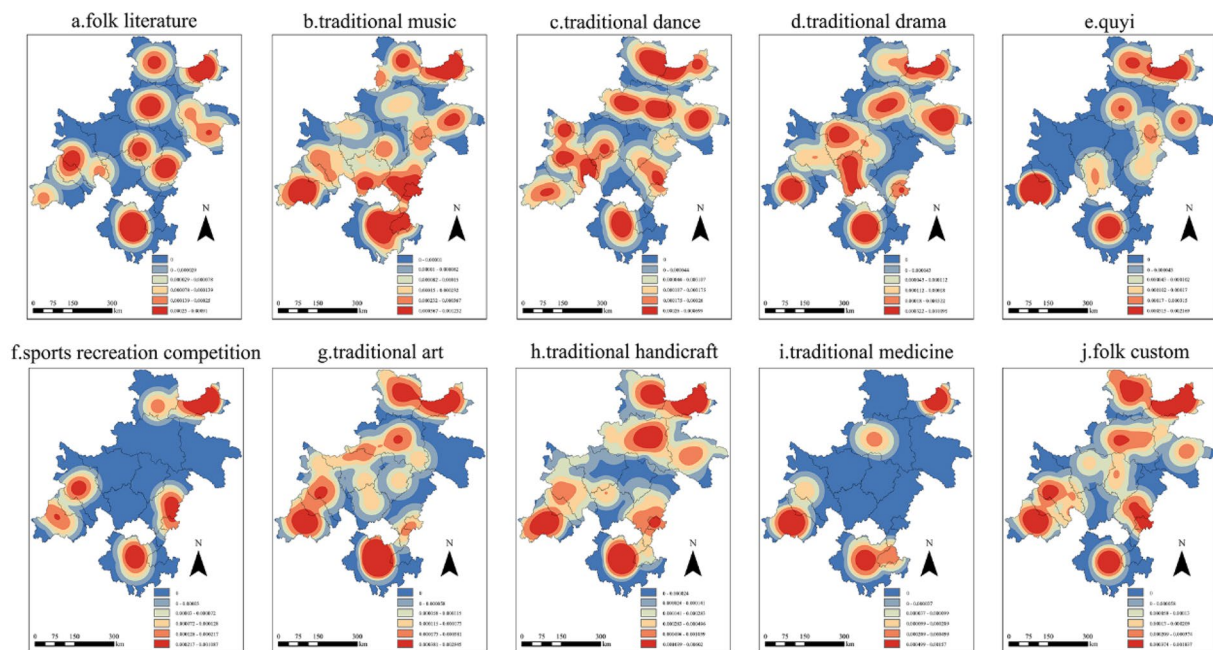
The long history of the region has created rich ICH along the ancient Qin-Shu roads. In terms of the proportion of ICH, the distribution along the ancient Qin-Shu roads was uneven in various historical periods, with significant fluctuations. The overall distribution shows the characteristics of three rises and three falls, peaking in Qin and Han Dynasties, Sui, Tang and Five Dynasties, and Ming and Qing Dynasties. In the Wei, Jin, Southern and Northern Dynasties, Song and Yuan Dynasties, and modern times, the development fell in a trough pattern.

The Qin, Han, Sui and Tang Dynasties were the most prosperous and powerful periods in Chinese history; Shaanxi became the political, economic and cultural center during these periods, resulting in a rich and diverse ICH. The Ming and Qing dynasties were

developed based on previous historical periods, thereby inheriting and accumulating a wealth of ICH. As an ancient road connecting Shaanxi and the surrounding areas, the ancient Qin-Shu roads naturally gave birth to numerous ICH. In Wei, Jin, Southern and Northern Dynasties, Song and Yuan Dynasties and modern times, the ancient Qin-Shu roads have seen frequent wars and regime changes, challenging economic stability. These events have had a negative impact on the transmission and dissemination of ICH, so the number of ICH in these periods was low.

According to the characteristics of the proportion of types of ICH in historical stages (Table 3), traditional music and folk literature accounted for the largest proportion of ICH resources in prehistoric period, accounting for 28.57% and 23.81%, respectively, for a total of 52.38%. In pre-Qin period, traditional handicraft accounted for an absolute majority, accounting for 42.50%. In Qin and Han Dynasties, traditional music had the highest proportion (27.78%), followed by traditional handicraft (22.22%), with the two accounting for 50.00%. The proportions of traditional art and traditional handicraft in Wei, Jin, Southern and Northern Dynasties were the largest and the same, accounting for 30.77%. In Sui, Tang and Five Dynasties, traditional handicraft accounted for the highest proportion at 23.64%, with traditional music and traditional drama in second place, accounting for 16.36% and 56.36%, respectively. In Song and Yuan Dynasties, traditional music, traditional handicraft and folk custom were the most common, accounting for 17.24% each and 51.72% in total. In the Ming and Qing Dynasties, traditional handicrafts became the absolute leader at 34.80%, followed by traditional arts at 10.80% and traditional drama at 9.60%. In modern times, traditional handicraft have remained the main body, accounting for as much as 50%.

On the longitudinal scale of the historical development of ICH types, folk literature accounted for the highest proportion, 44.00%, in Ming and Qing Dynasties. This was followed by prehistoric period and Qin and Han Dynasties, which each accounted for 20.00%. The ICH of folk custom in the three periods accounted for 84.00% of the total number of such ICH. Traditional music was highest in Ming and Qing Dynasties, Qin and Han Dynasties; and Sui, Tang and Five Dynasties, accounting for 26.15%, 23.08% and 13.84%, respectively, and 63.08% in total. The proportions of traditional dance, traditional drama, quyi and traditional art in Ming and Qing Dynasties were 47.50%, 60.00%, 62.50% and 56.25%, respectively. In Ming and Qing Dynasties, sports recreation competition accounted for 47.37%, followed by modern times, accounting for 26.32%, and



**Fig. 4** Kernel density of different types intangible cultural heritage in the Ancient Qin-Shu Roads

accounting for 73.69% in both. Traditional handicraft appeared mainly in Ming and Qing Dynasties, followed by modern times and Qin and Han Dynasties, accounting for 78.66% of the total.

On the whole, the number of traditional handicraft has been increasing since ancient times; two notable periods of increase occurred during pre-Qin period and Ming and Qing Dynasties. During the first of these two periods, pre-Qin period, the quantity of traditional handicraft increased by 37.74%. During the second of these two periods, Ming and Qing Dynasties period, the quantity of traditional handicraft increased by 17.7% compared with its previous historical period. Because traditional handicraft ICH are integrated with daily life, the number of traditional handicraft ICH has increased as the population has grown. The number of folk literature, traditional dance and folk custom ICH decreased with the evolution of history, from 23.81%, 14.29% and 19.05% in prehistoric period to 2.00%, 2.00% and 2.00% in modern times, respectively. This may be related to the gradual disappearance of the carrier and function of these ICH.

#### Changes to the center of gravity

On the whole, the standard deviation ellipse rotation angle of ICH resources is 35.2°. This shows that the ICH resources of the ancient Qin-Shu roads present a long and narrow northeast–southwest pattern. The elliptical center of the standard deviation of ICH resources is

located in Nanjiang County, Bazhong city, Sichuan Province (32.083°N, 106.888°E) and is 655.49 km east of the center of gravity of China (36.03°N, 103.40°E). From the viewpoint of the gravity and evolutionary trends of historical stages, the ICH of the eight periods of the ancient Qin-Shu roads present a trend of northwest–southwest–south–northeast–southwest–southeast (Fig. 5). The historical development of Qin and Han Dynasties served as the boundary. Before the Qin and Han Dynasties, ICH resources in all periods were distributed mostly in Shaanxi. After the Qin and Han Dynasties, ICH resources in all historical periods were distributed in Sichuan. Further analysis of the position of the intangible heritage centroid in each period showed that the center of ICH resources in prehistoric times was located in Nanjiang County, Bazhong city, Sichuan Province (32.565°N, 107.087°E). It was transferred to Nanzheng (32.839°N, 106.947°E) in Hanzhong city, Shaanxi Province, during Qin Dynasty; to Nanjiang (32.620°N, 106.749°E) in Bazhong city, Sichuan Province, during Qin and Han Dynasties; to Jiange County (31.826°N, 105.618°E) in Guangyuan city, Sichuan Province, during Wei, Jin, Southern and Northern Dynasties; and to Bazhong in Sichuan during Sui, Tang and Five Dynasties. From Song and Yuan Dynasties and Ming and Qing Dynasties to modern times, the center of ICH resources was still located in the Bazhong urban area of Sichuan Province, 32.1625°N, 106.717°E, 31.963°N, 106.609°E, 31.995°N,

**Table 3** Types and proportion of intangible cultural heritage in the Ancient Qin-Shu Roads

Historical periods	Quantity (percentage)	Folk literature	Traditional music	Traditional dance	Traditional drama	Quyi	Sports recreation competition	Traditional art	Traditional handicraft	Traditional medicine	Folk custom
Prehistoric period	21 (4.10%)	5 (23.81%)	6 (28.57%)	3 (14.29%)	0 (0.00%)	0 (0.00%)	1 (4.76%)	1 (4.76%)	1 (4.76%)	0 (0.00%)	4 (19.05%)
Pre-Qin Dynasties	40 (7.81%)	1 (2.50%)	6 (15.00%)	1 (2.50%)	2 (5.00%)	1 (2.50%)	1 (2.50%)	2 (5.00%)	17 (42.50%)	1 (2.50%)	8 (20.00%)
Qin and Han Dynasties	54 (10.55%)	5 (9.26%)	15 (27.78%)	8 (14.81%)	1 (1.85%)	2 (3.70%)	1 (1.85%)	4 (7.41%)	12 (22.22%)	0 (0.00%)	6 (11.11%)
Wei, Jin, Southern and Northern Dynasties	13 (2.54%)	0 (0.00%)	2 (15.38%)	1 (7.69%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	4 (30.76%)	4 (30.76%)	0 (0.00%)	2 (15.38%)
Sui, Tang and five Dynasties	55 (10.74%)	1 (1.82%)	9 (16.36%)	4 (7.27%)	9 (16.36%)	4 (7.27%)	0 (0.00%)	7 (12.73%)	13 (23.64%)	0 (0.00%)	8 (14.55%)
Song and Yuan Dynasties	29 (5.66%)	1 (3.45%)	5 (17.24%)	2 (6.90%)	3 (10.34%)	4 (13.79%)	2 (6.90%)	2 (6.90%)	5 (17.24%)	0 (0.00%)	5 (17.24%)
Ming and Qing Dynasties	249 (48.83%)	11 (4.42%)	16 (6.43%)	19 (7.63%)	24 (9.64%)	20 (8.03%)	9 (3.61%)	27 (10.84%)	87 (34.94%)	17 (6.83%)	19 (7.63%)
Modern times	50 (9.77%)	1 (2.00%)	5 (10.00%)	2 (4.00%)	1 (2.00%)	1 (2.00%)	5 (10.00%)	1 (2.00%)	25 (50.00%)	8 (16.00%)	1 (2.00%)



106.939°E, 31.835°N, and 107.282°E. The center of gravity moved 467 km during the eight periods.

In general, the historical track of ICH of the ancient Qin-Shu roads is the development path of “Northeast to southwest”. The shift of the center of gravity of ICH of the ancient Qin-Shu roads to the southwest after the Sui and Tang dynasties may be related to the beginning of the southward shift of the political and economic center of China during this period. This result is also similar to the evolution of Chinese tangible cultural heritage in historical periods [44].

### The influencing factors of ICH spatial distribution along the ancient Qin-Shu roads

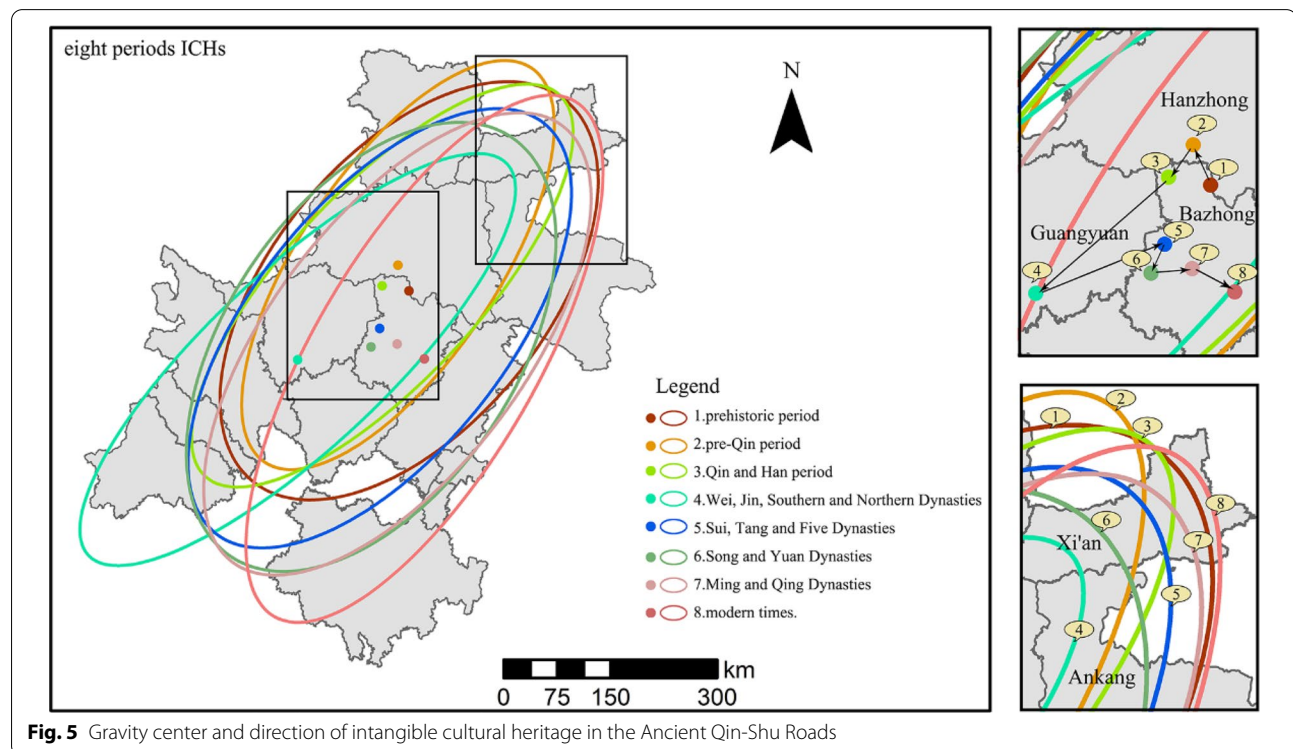
#### Natural Factors

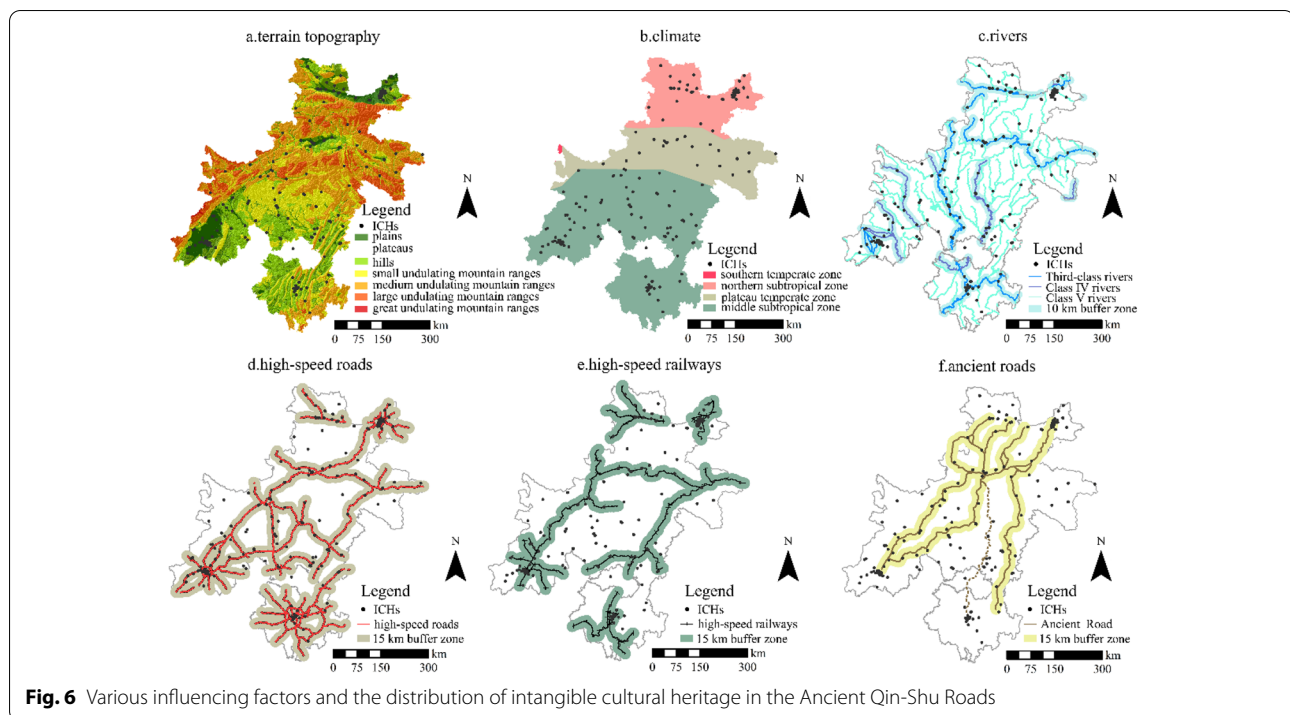
##### *Influence of topography on the distribution of ICH*

The ancient Qin-Shu roads are located on the second ladder of topography in China, forming geomorphic features of three rivers and two mountains. Guanzhong Plain, Weihe Basin, and the Qinling Mountains are to the north; the Hanshui Valley and Danjiang Plain are in the center; and the Daba Mountains and Sichuan Basin are to the south. The overall landforms are complex and varied: there are mainly plains, plateaus, hills, small undulating

mountain ranges, medium undulating mountain ranges, large undulating mountain ranges and great undulating mountain ranges, accounting for 7.35%, 9.72%, 1.68%, 21.84%, 31.53%, 12.61% and 0.11%, respectively. Since the areas of different types of topographic areas are quite different, this study adopts location entropy for analysis. Location entropy can measure the spatial distribution of a certain regional element and reflect the degree of agglomeration of a certain element. The higher the value is, the higher the agglomeration level. After superposition of the ICH map and terrain type map (Fig. 6a), the location entropy result shows that there are 283 ICH in the plain along the ancient Qin-Shu roads, for which the location entropy is 6.05. There are 114 plateaus and 115 hilly ICH, respectively, for which the regional entropy is 2.68 and 1.29, respectively. There are 37 ICH in small undulating mountain ranges and 12 ICH in medium undulating mountain ranges are 37 and 12, for which the location entropy is 0.19 and 0.08, respectively. The large undulating mountain ranges and great undulating mountain ranges have no distribution of ICH.

Topography has a significant impact on the distribution of ICH. The distribution of intangible cultural heritage decreases with increasing altitude. Flat terrain is





**Fig. 6** Various influencing factors and the distribution of intangible cultural heritage in the Ancient Qin-Shu Roads

beneficial to the production and dissemination of ICH, while mountains hinder the development of ICH.

#### **Influence of climate on the distribution of ICH**

Based on the 14 climatic zones in China, the ancient Qin-Shu roads can be roughly divided into 4 climatic types: northern temperate, northern subtropical, plateau temperate and middle subtropical regions, accounting for 17.53%, 25.55%, 0.10% and 56.82%, respectively. After superimposing the ICH map and climate type map (Fig. 6b), the result of location entropy shows that there are 169 ICH in the northern temperate zone, for which the location entropy is 5.68, which is the largest distribution of intangible heritage. There are 304 ICH in the northern subtropical zone and 88 ICH in the highland temperate zone, for which the locational entropy is 0.77 and 0.73. In contrast, there is no ICH distribution in the highland temperate zone, hence, the locational entropy is 0.

The ICH of the ancient Qin-Shu roads is mainly concentrated in temperate regions with good climate conditions and decreases with increasing climate discomfort. Generally, a temperate climate with four distinct seasons that is warm and humid is more conducive to productive lives and to the formation and dissemination of ICH.

#### **Influence of rivers on the distribution of ICH**

There are many rivers along the ancient Qin-Shu roads, including two main streams and five tributaries of the

Yellow River and Yangtze River. The Yellow River Basin mainly has the Wei River, and the Yangtze River Basin mainly has the Han River, Jialing River, Minjiang River, and Wujiang River. Many rivers interconnect, creating good conditions for the river network of the ancient Qin-Shu roads and for traffic and commerce on the ancient roads. To have a clearer understanding of the relationship between rivers and ICH, rivers above level 4 are taken as data sources, and buffer zones of 1 km, 3 km and 10 km are established by using the ArcGIS10.5 buffer tool (Fig. 6c). The intersection analysis in Analysis Tool is then used to calculate the number of ICH in different buffer layers. Within 1 km from the river, 124 ICH were distributed, accounting for 21.87% of the total projects. Within 3 km from the river, 82 ICH were distributed, accounting for 14.46% of the total projects; within 10 km of the river, 279 ICH were distributed, accounting for 49.21% of the total. The results show that the river has an auxiliary effect on the ICH of the ancient Qin-Shu roads.

#### **Human factors**

##### **The influence of transportation on the distribution of ICH**

Based on basic traffic data of expressways, the buffer tool was used to establish 15 km buffer zones of expressway, high-speed railways and the ancient road, and the spatial distributions of the transportation network and the ICH project were superimposed (Fig. 6d-f). The intersection analysis in Analysis Tool is then used to calculate the number of ICH in different buffer layers. The results



show that there were 404 ICH projects in expressway and high-speed railway buffer zones, accounting for 71.37% of the total number. There were 281 ICH projects in the 15 km buffer zone of the seven north–south ancient roads, accounting for 49.65% of the total. These results show that the ICH of the ancient Qin-Shu roads is distributed along the transportation route. The ancient Qin-Shu Roads ICH have a significant relationship with the distribution of modern transportation routes, ancient traffic may have affected the distribution of ICH of the ancient Qin-Shu roads.

#### ***The influence of population evolution on ICH distribution***

The population of ancient societies was both a necessary condition and an important marker of socioeconomic development. The size of the population often determines the different modes of social production and then determines the different forms of social organization and social structure [62]. In Chinese history, the population reached its peak in Qin and Han Dynasties, Sui and Tang Dynasties, Song and Yuan Dynasties, Ming and Qing Dynasties, and modern times. The total number of the ancient Qin-Shu roads ICH in these periods accounts for 93.36%. In the population trough period of pre-Qin period, Wei, Jin, Southern and Northern Dynasties, the number of ICH was small, accounting for only 6.64%. To quantitatively reflect this correlation between the two, the population numbers in historical periods were taken from “Statistics on Household, Field, and Field Assignment in China through the Ages” and “Population Geography of China” as data sources. Fitting analysis with ICH in various historical periods shows that there is a significant correlation between them:  $R^2=0.8783$  (Fig. 7). The change in population size can explain 87.83% of the variation in ICH, indicating that population change greatly affects the spatial and temporal distribution and evolution of ICH.

#### ***Influence of traditional villages on the distribution of ICH***

As places with concentrated population distributions, villages usually retain relatively good living environments and cultural customs. ICH also reflects the cultural concept and lifestyle of the original residents of local villages. Based on the five batches of traditional village lists jointly released by the Ministry of Housing and Urban–Rural Development of China and other departments, buffer zones of 15 km, 30 km and 50 km were established by using the ArcGIS 10.2 buffer tool. The intersection analysis in Analysis Tool is then used to calculate the number of ICH in different buffer layers. In the buffer zone 15 km away from traditional villages, there are 87 ICH resources, accounting for 15.37% of the total. In the

buffer zone 30 km from traditional villages, there are 297 ICH resources, accounting for 52.47%. Within the buffer zone 50 km from traditional villages, 405 ICH resources are present, accounting for 71.55% (Fig. 8). The distribution of ICH items along the Qin-Shu ancient roads is well coupled with the distribution of traditional villages.

## **Discussion and conclusion**

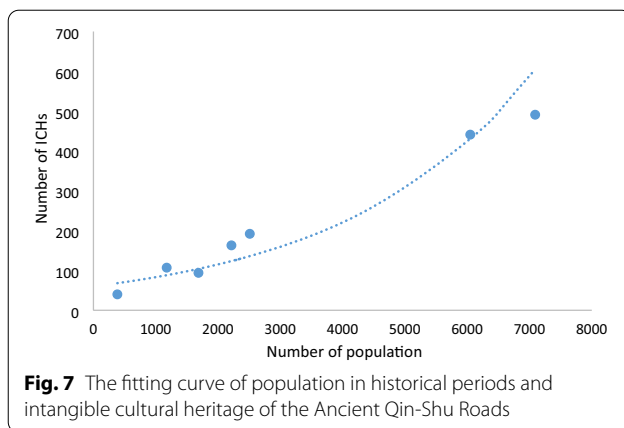
### **Discussion**

#### ***Comparison with previous studies***

ICH is the living embodiment of the special production and lifestyle, character and aesthetic habits of different nationalities. It is of great significance to explore the emergence and evolution of its culture for the promotion of cultural protection and development [44]. This paper analyzes the spatial and temporal distribution characteristics of the ICH of the ancient Qin-Shu roads in China and discusses the main factors affecting its distribution. As a case study, the ancient Qin-Shu Roads is a living fossil of the world's ancient road, which provides the possibility for the communication and integration between the Sanqin civilization in north China and the Bashu civilization in south China. A wealth of ICH has been nurtured along this route. Methods such as the nearest neighbor index, kernel density estimation, standard deviation ellipse, location entropy, and buffer analysis are used to ensure that the above problems are comprehensively and deeply studied.

The structure of ICH types reflects that the ancient Qin-Shu roads have a complete range of ICH types, but the distribution is uneven and in a stepped pattern. The results of this study are consistent with those of Zhang et al. [54] and Wang et al. [63]. In this study, traditional handicraft ICH was the most common type of ancient road, accounting for 31.7% of the total. This may be because this type of ICH is closely correlated with daily life and will increase as the population continues to grow. Traditional medicine and sports recreation competition were the least common ICH types, accounting for 4.8% and 3.4% of the total, respectively. These two types of ICH mostly rely on word-of-mouth transmission or inheritance among individuals, which is easily lost, resulting in fewer projects of these types of ICH.

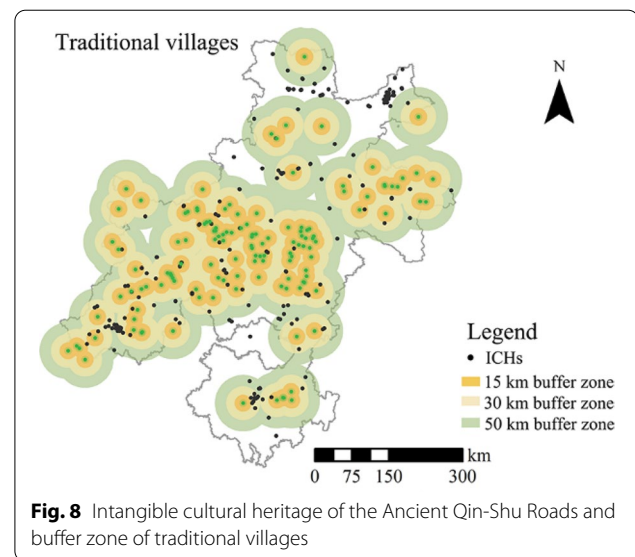
The spatial distribution of ICH of the ancient Qin-Shu roads has strong heterogeneity, which is consistent with the results of Marzeion and Levermann [64] and Zhang et al. [54]. Marzeion's study confirmed that the world's cultural sites are characterized by agglomeration and are mainly located in coastal areas. Zhang et al. found that the national ICH of music in West Xiangxi, China, is mainly found in the south of Xiangxi, while the provincial ICH is distributed in the west. In the study of the ancient Qin-Shu roads, the overall distribution of ICH is



agglomeration, and the majority of all types of ICH are the same; only a few are agglomeration–random distribution. Meanwhile, ICH is mainly concentrated in Xi'an, Chengdu and Baoji. In addition, there are spatial differences in the density of different types of ICH. For example, the density of quyi is characterized by two sub-high-density areas surrounding three high-density areas.

The temporal and spatial changes in heritage essentially reflect the spatial directionality and regional changes in social and economic development [44]. Different historical periods have had a strong influence on the distribution of the ICH of the ancient Qin-Shu roads. The overall ICH distribution is characterized by fluctuations. This result is consistent with the results of Tian et al. [44] and Li et al. [65]. In this study, ICH reached its peak in three historical periods: Qin and Han Dynasties, Sui, Tang and Five Dynasties, and Ming and Qing Dynasties. Wei, Jin, Southern and Northern Dynasties, the Song and Yuan Dynasties and three historical periods since the modern era were associated with the troughs. The historical track is the “northeast–southwest” development path. The variation in the quantity of ICH in different historical periods may be related to the war and peace in each period. The shift of the historical track also accords with the historical background of the southward shift of the political and economic center of gravity in China after the Sui and Tang Dynasties.

In terms of the main influencing factors, topography, climate, transportation and population evolution have the most profound impact on the distribution of ICH along the ancient Qin-Shu roads. This result is consistent with the results of previous studies [44, 64, 65]. In the study of Cho and Sung [66], ICH was mainly concentrated in areas with flat terrain, sufficient water and suitable climate, such as coastal areas or plains. The results of Zhang et al. [67] show that topography is an



important factor affecting ICH in the Yellow River Basin. In addition, population and transportation accessibility are closely related to the distribution of cultural heritage [68], and they have a significant positive correlation [69].

Overall, the results of this study are consistent with those reported in previous studies and are also scientifically sound.

#### Theoretical and practical implications

Spatial analysis and visual expression research based on GIS have been widely used in various research fields [70–75]. This study introduces geography into the theoretical study of intangible cultural heritage, which is of great significance to enrich the theoretical research of intangible cultural heritage. The methods used and the results produced in this study demonstrate effective tools and provide references for obtaining the spatial and temporal distribution characteristics and influencing factors of intangible cultural heritage of the ancient Qin-Shu roads.

This study can provide a reference and suggestions for the protection and management of ICH. On the one hand, according to the analysis of the type structure of ICH, the differences in the quantity of various kinds of ICH can be used to promote targeted protection and utilization plans for different categories. On the other hand, through the analysis of spatial and temporal distributions, the relationship between ICH can be established. These methods are conducive to the formation of distinctive ICH areas, deriving cultural tourism brands, and bringing ICH tourism resources into play; they promote the development of cultural tourism and regional economic development.

### Future research

This study focuses on the temporal and spatial distribution of ICH along the ancient Qin-Shu roads and its influencing factors. However, it may not include the extent to which these factors influence ICH and the impact of multiple factors together on ICH. Future research can be carried out using the geographical detector method. In addition, there are numerous linear cultural heritage sites along ancient roads worldwide, such as the “Silk Road” in China, the “Frankincense Road” in Oman, etc. However, the natural and human conditions of different regions vary greatly, so the study of different environmental factors influencing the spatial and temporal distribution of the ICH of ancient roads is another direction for future research.

### Conclusion

The main conclusions of this study are as follows: (1) the ICH of the ancient Qin-Shu roads are complete in type and are distributed in a stepwise manner. Traditional handicraft include 180 ICH, which is the largest number of ICH, accounting for 31.7%. Folk custom and traditional music are the second most numerous, at 81 and 66 ICH, respectively, accounting for 25.9%. The other categories of ICH are third in quantity overall, among which traditional medicine and sports recreation competition are the scarcest, accounting for only 4.8% and 3.4%, respectively. (2) The ancient Qin-Shu roads ICH have typical clustering distribution characteristics. On the whole, three high-density circles have been formed in Xi'an, Chengdu and Chongqing. There are significant differences in the core areas of different types of ICH. (3) In the process of historical development, the ICH of the ancient Qin-Shu roads shows a trend of “three rises and three falls”. It reached its peak in Qin and Han Dynasties, Sui, Tang and Five Dynasties, and Ming and Qing Dynasties and reached its low point in Wei, Jin, Southern and Northern Dynasties, Song and Yuan Dynasties, and modern times. The number of traditional handicraft increased with the dynasties, while the numbers of folk literature, traditional dance and traditional medicine gradually decreased. During the eight periods, the overall center of gravity trajectory of the ICH moved 467 km from northeast to southwest. (4) In the natural geographical environment, topography and climate play an important role in the distribution of ICH, while rivers play an auxiliary role in the distribution of ICH. In the ancient Qin-Shu roads, the higher the altitude is, the lower the ICH. The more suitable the climate is, the more intangible cultural heritage. Among the human geography, transportation, traditional villages and population evolution have a high impact on ICH. Expressway and high-speed

railroads have the greatest influence on the distribution of ICH, with 71.37% of ICH located within the 15 km buffer zone of expressway and high-speed railroads. A total of 71.55% of the ICH is distributed in the 50 km buffer zone of traditional villages. The significant positive impact of demographic evolution on the generation of ICH can explain 87.83% of the changes in ICH.

### Abbreviation

ICH: Intangible cultural heritage.

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### Author contributions

L.Y.: conceptualization, data collection and quality, and formal analysis; C.M.: interpretation, visualization and methods; T.Y.G.: editing the manuscript. All authors read and approved the final manuscript.

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### Availability of data and materials

Not applicable.

### Declarations

#### Ethics approval and consent to participate

Not applicable.

#### Consent for publication

Not applicable.

#### Competing interests

The authors declare no competing interests.

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