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The Impact of Public Health Digitization on Urban Residents' Travel Demand

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Abstract: The novel coronary pneumonia epidemic has led to dramatic changes in both the order of life and consumer behavior. Major public health and safety issues are a serious impediment to a healthy tourism industry. Therefore, it is necessary to study the impact of digitization of public health on the tourism demand of urban residents. In this paper, we develop a tourism demand model and analyze the factors influencing tourism demand. Based on data related to urban residents' tourism collected from statistical yearbooks, the impact of public health digitization on urban residents' tourism demand is studied using methods such as the attractiveness of tourist destinations. The validation session is carried out in terms of both time series and spatial distribution. The results of the impact on the time series tourism demand show that the number of tourists increased by 287.63% in just one year. The total number of tourists in China reached 1,844,900. The growth rate of total tourism consumption was up to 582.47%. The tourism trip rate increased to 213.47%. The results of the spatial distribution impact narrowed the ratio of the share of different value zones to the total number of tourists in the country, minimizing from 0.33, 0.49, 0.11 to 0.35, 0.38, 0.31, and from 0.71, 0.2, 0.1 to 0.37, 0.34, 0.33, respectively. it is thus clear that digital technology is a powerful tool for the full recovery of tourism in the post-epidemic era. Digital transformation of public health can better contribute to the revitalization of tourism and enhance the safety of consumers' travel.

Keywords: Digital Technology; Public Health; Urban Dwellers; Travel Demand; Novel Coronary Pneumonia Outbreak

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1.Introduction

The sudden outbreak of a novel coronary pneumonia epidemic has caused a huge impact on the economy in all sectors, and more so on the tourism industry [1-4]. The World Economic Trends in Tourism report mentions a signifi cant decline in global tourist arrivals and tourism revenues in 2020, down 39.76% and 43.19% respectively from the same period. The level of economic benefi ts is straightforward to WWII. Meanwhile, the Report on the Development of China's Travel Service Industry mentions that the new coronary pneumonia epidemic not only gave a double shock to the tourism industry on the demand side and supply side, but also put more pressure in reconstructing tourists' confi dence and behavioral preferences [5-6]. The recovery of the tourism industry is facing unprecedented challenges. The epidemic has completely awakened the awareness of life and public health and safety of the whole population, and people have started to focus on public health and safety in tourist places [7-10]. Safety needs have now become the fi rst consideration for all travelers. In addition to the novel coronary pneumonia epidemic, public health safety issues in the tourism development process include health events such as food poisoning and

infectious diseases [11-15]. These public health problems can not only ruin tourists' mood of travel and create a bad impression of the scenic spot, but also hinder the development of tourist places [16-19]. Therefore, it is necessary to strengthen the public health safety of the industry in today's rapidly developing tourism industry.

Since the outbreak of SARS, scholars at home and abroad have been paying higher attention to tourism safety. As the research continues, the perspectives and methods of inquiry are getting richer and the system is getting better. For example, literature [20] integrated flood scenario simulation and GIS network analysis for different river flood scenarios in the central area of the outer ring of Shanghai to assess the spatial accessibility of emergency response for key urban public services. After an experimental study, this quantitative assessment method can provide a basis for decision making in flood tourism emergency management. The literature [21] interviewed stakeholders of local tourism interests. The theoretical basis and development of natural disaster management was advanced by investigating stakeholders' consideration of the role of tourism before and after the earthquake, and the disaster management actions they took. The literature [22] selected Shijiazhuang Jintawan scenic area as the target, in order to analyze and predict the traffic demand of the scenic area, a two-layer optimization model of one-way traffic organization was constructed. Based on the model solution results of the simulated annealing algorithm, the contingency plan is developed. The feasibility of the contingency plan is verified by VISSIM simulation. The model can effectively solve traffic congestion, avoid secondary accidents and ensure the economic benefits of scenic spots. The literature [23] aimed to analyze the negative effects of urbanization, disasters on tourism in RCEP countries, using ADF and PP for 1995-2018 data, causality tests, quantile regression and fixed effects panel models. In response to the increasing temperature, rainfall and carbon emissions, they propose corresponding disaster prevention measures in order to facilitate sustainable tourism development. The literature [24] used the municipality of Aljezur, located in the Algarve Nature Reserve in Portugal, as a study area to investigate multiple surfers and swimmers regarding personal safety, conflicts between beach users, and management strategies for surf tourism activities. By reaching a consensus on the security of the tourism area, conflicts can be effectively reduced and the sustainable management of surf tourism in the territory can be enhanced. The literature [25] identifies the best risk management options regarding natural disaster events based on the raw data collected from surveys. Research data shows that tourism risk management strategies have greater utility in reducing the impact of natural disasters and protecting life and property, and are an effective means of preventing and controlling potential risks. By compiling the literature, it is clear that the current more mainstream perspective on tourism safety control is more limited, focusing mostly on natural disasters and risk management, and less on public health safety and the needs of tourists under its premise. Exploring tourism safety issues in the new situation from a public health perspective has become a hot topic of discussion in the tourism industry.

To break the barrier that public health and safety issues pose to the tourism industry, public health is beginning to transform digitally. This paper is aimed at exploring the tourism demand of urban residents. The attractiveness of tourist places is used to reflect the range of attractiveness of the target places to tourists. A spacing cumulative curve was used to cumulatively analyze the travel demand of urban residents before and after the digital transformation of public health. Spatial autocorrelation and other research methods are used to detect the spatial distribution patterns and clustering characteristics of tourists. Based on the selected tourism data and tourism demand impact factors such as direct data, indirect data and supplementary data, the impact of public health digitization on tourism demand of urban residents is explored in terms of time series and spatial distribution. This paper is dedicated to this research topic, mainly to provide effective improvement measures and suggestions for the management of public health and safety in tourist places, and to provide a reference for carrying out public health and safety management. At the same time, to further promote the sustainable development of tourism.

2.Research Methodology and Research Data

2.1 Research Methodology

2.1.1 Attractiveness of tourist places

Tourist place attractiveness is used to reflect the range of attraction of the target place to tourists and is usually expressed as a radius [26]. The attractiveness increases with the increase of the radius value. Assume that the share of tourism demand in the

n st tourist origin is *i*, and the spatial distance between the place and the x_i st tourist destination is *j* . Then the attractiveness of tourist place d_{ij} is calculated by the following formula.

$$AR = \sqrt{\sum_{i=1}^{n} x_i^{\,2} d_{ij}^{\,2} \Big/ \sum_{i=1}^{n} x_i^{\,2}} \tag{1}$$

In the above equation, the spherical distance can be described. The calculation formula is as follows.

$$d_{ij} = R \bullet \frac{\pi}{180} \bullet \arccos\left(\sin\varphi_i \sin\varphi_j + \cos\varphi_i \cos\varphi_j \cos\left(\lambda_j - \lambda_i\right)\right) \tag{2}$$

Where, *R* refers to the mean radius of the earth. (λ_i, ϕ_i)、(λ_j, φ_j)The geographic coordinates of the i first tourist origin and the *j* first tourist destination are indicated by the longitude and the latitude, respectively. λ is the longitude and ϕ is the latitude.

2.1.2 Spacing Accumulation Curve

The spacing accumulation curve is obtained by accumulating the amount of tourists based on the size of the distance between the sources of tourists and the spacing results. The function of this indicator is to cumulatively analyze the tourism demand of urban residents before and after the digital transformation of public health. Assume that the total tourism demand is *T* , and the tourism demand from the *i* st tourist source to the tourist target is X_i . Then the curve is calculated as shown below.

$$Y = \sum_{i=1}^{n} \frac{x_i}{T} \tag{3}$$

Within this equation, the value of the vertical coordinate of the curve is indicated.

2.1.3 Spatial autocorrelation

(1) Global spatial autocorrelation. To detect the spatial distribution pattern and clustering characteristics, the Moran index is used as a measure [27]. If there is a total of *N* study cell, the attribute values and spatial weight matrix of the *i* 、 *j* cell are x_i 、 x_j and ω_{ij} , respectively, and the average value of x_i is $\bar{x}$. The elements in the spatial weight matrix are summed to obtain S_0 . Then the Moran index is solved by the following equation.

$$I = \frac{N}{S_0} \times \frac{\sum_{i=i}^{N} \sum_{j=1}^{N} \omega_{ij} \left(x_i - \bar{x}\right)\left(x_j - \bar{x}\right)}{\sum_{i=1}^{n} \left(x_i - \bar{x}\right)^2} \tag{4}$$

(2) Local spatial autocorrelation. To compensate for the problem of incomplete access to the location of aggregation areas, the G-index and LISA index are used to describe the local spatial distribution of each study unit in more detail [28-29]. The function of the former is to distinguish cold spot areas from hot spot areas in space, while the latter is used to explore the agglomeration dynamics of local regional spatial units and neighboring spatial units.

For *n* study unit, the two indices are calculated as

$$G_i^*(d) = \sum_{j=1}^{n} \omega_{ij} x_j \Big/ \sum_{j=1}^{n} x_j \tag{5}$$

$$LISA_i = Z_i \sum_{j\neq 1}^{n} \omega_{ij} Z_j \tag{6}$$

Within the above equation, the standardized observations for the *i* and *j* spatial units are Z_i and Z_j . When G_i^* is positive and significant, location *i* has a relatively high value with respect to the surrounding area, i.e., the hot spot area. On the contrary, it is a cold spot area.

2.2 Data sources

Data related to the tourism industry in the target cities are analyzed using research methods such as tourist place attractiveness, spacing cumulative curves, global spatial autocorrelation and local spatial autocorrelation. The selected data are divided into three types: direct data, indirect data and supplementary data [30-32]. The first type of data mainly originates from the China Statistical Yearbook and the China Tourism Statistical Yearbook and copies, etc. Most of the data such as tourism trips, tourism income, and per capita spending are direct data. Data such as the proportion of travel transportation

consumption, the proportion of travel entertainment consumption, and the proportion of travel food and beverage consumption are all indirect data. Such data are obtained by calculation based on direct data. Supplementary data are usually missing items obtained by interpolation and other methods based on data from other years [33]. To ensure the reliability and scientific validity of the study results, the data units are treated uniformly. The logarithmic strategy is implemented for special data such as per capita consumption level and per capita GNP. Within this equation, the value of the vertical coordinate of the curve is indicated.

2.3 Analysis of factors influencing urban residents' tourism demand

The common goal of both tourism trip rate and tourism consumption is to realize the tourism demand of urban residents. Therefore, the tourism trip rate is set as *DTR*, tourism demand-side and supply-side factors as *D*、*S*, macro-environmental factors as *M*, and special event factors as *E*. The following defining equations for the tourism demand model are established.

$$DTR = f(D, S, M, E) \tag{7}$$

The influence factors contained in each factor are shown in Table 1.

Table 1 Tourism demand impact factors

Demand factors	Impact factors
Demand-side factors	Free time, income level, consumption habits, risk expectations
Supply-side factors	Prices and quality of products and services in the tourism industry
Macro environmental factors	Implementation efforts of relevant departments in marketing and mobility constraints
Special event factors	Major festivals, abnormal emergencies, etc.

3.The impact of public health digitization on tourism demand of urban residents

To obtain a precise analysis of the impact of public health digitization on urban residents' travel demand, the experiments are conducted from two perspectives: time series and spatial distribution, respectively. Time series is mainly to do regression or classification problems by the backward and forward order of time, and the main characteristic of the data is one-dimensional tabular data, and one column of the data is a clear amount of time. Spatial distribution is the distribution of geographical things with regions.

3.1 Impact of tourism demand based on time series

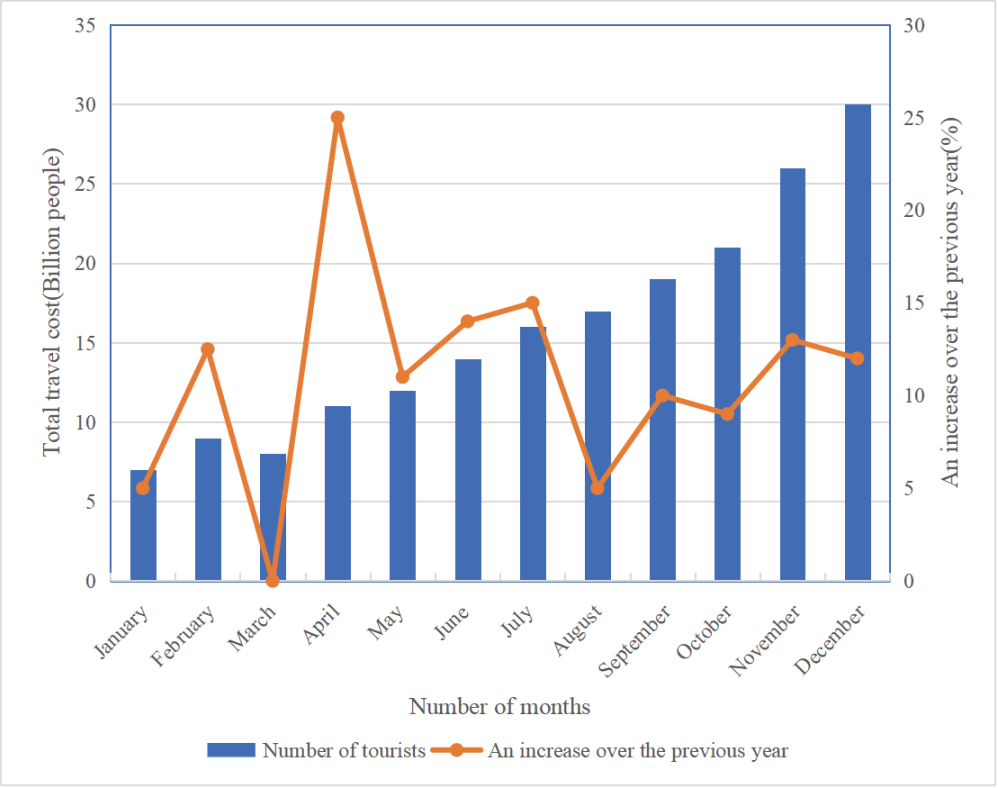
3.1.1 Number of tourists

Figure 1(a) shows the number of tourists and the growth rate after the digital transformation of public health. As can be seen, digital technology has significantly increased tourists' sense of security by visually showing them the current number of confirmed epidemics, suspected cases, and other public health information in the region through methods such as descriptive statistics and cluster analysis. This enables tourists to travel with confidence and pleasure. As a result, a good trend of exponential growth in the number of tourists is formed. Based on the changes in the number of tourists, it can be seen that the number of tourists has been rising after the digitization of public health. In the first month the number of tourists was 75,200 and in only one year it has increased by 287.63%. The number of tours in the 12th month has been as high as 291,500. It is 3.88 times more than the first month. In terms of the growth rate of tourism numbers, the growth rate is gradually stabilizing. Due to the recurrence of major public health events like the new coronary pneumonia epidemic, the growth rate fluctuated in the first period. From the ninth month onward, the growth rate of the number of tourists gradually stabilized and basically remained between 11% and 13%.

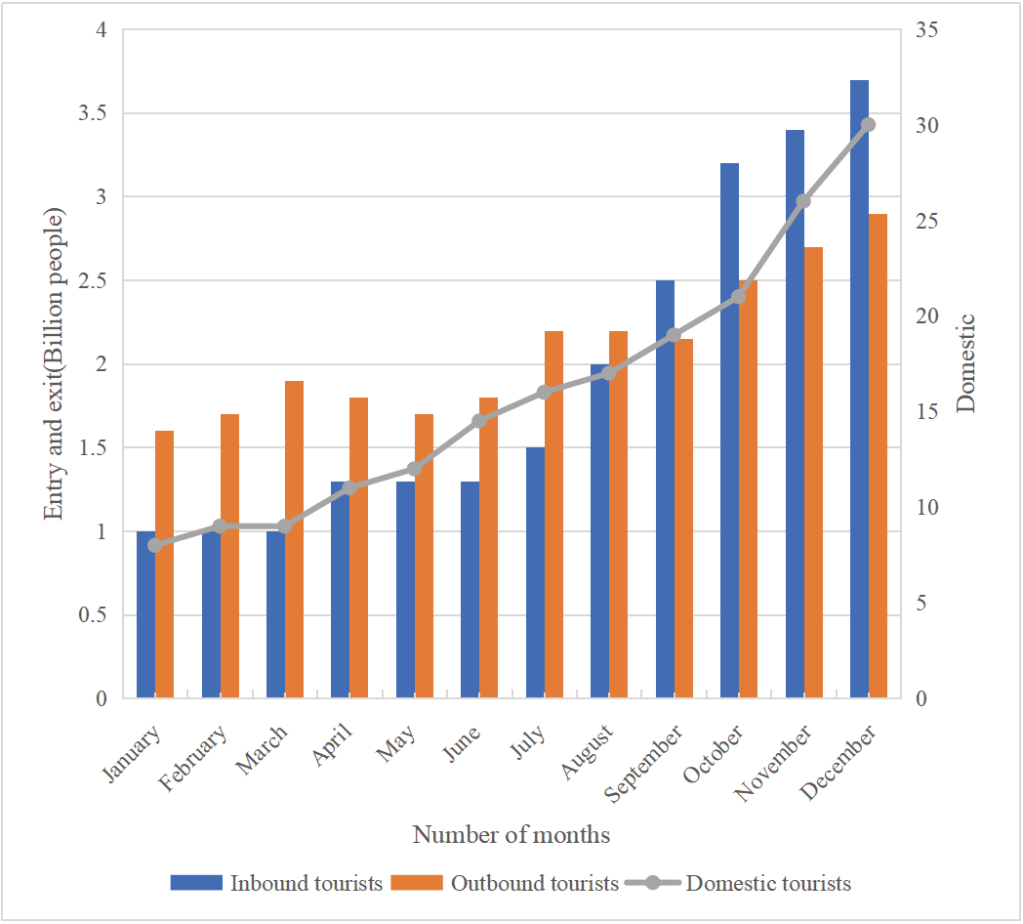
Figure 1(b) shows the number of tourists under different demands such as domestic tourism, inbound tourism and outbound tourism. It can be seen that domestic tourism dominates the tourism industry today. Compared to inbound and outbound tourism, domestic tourists are not only growing faster, but also in greater numbers. With a larger domestic population base, the importance of the domestic tourism market and its public health and safety cannot be overstated. Digital technology for public health allows tourists to visualize local epidemic developments and alleviate their anxiety and panic by displaying region-wide epidemic information in real time. As a result, the total number of domestic tourists reached 1,844,900 in the last year, 28.44 times and 29.13 times more than the number of inbound and outbound tourists, respectively.

Figure 1 Impact of public health digitization on the number of tourists

(a) Number of tourists and growth rate



(b) Number of tourists with different needs

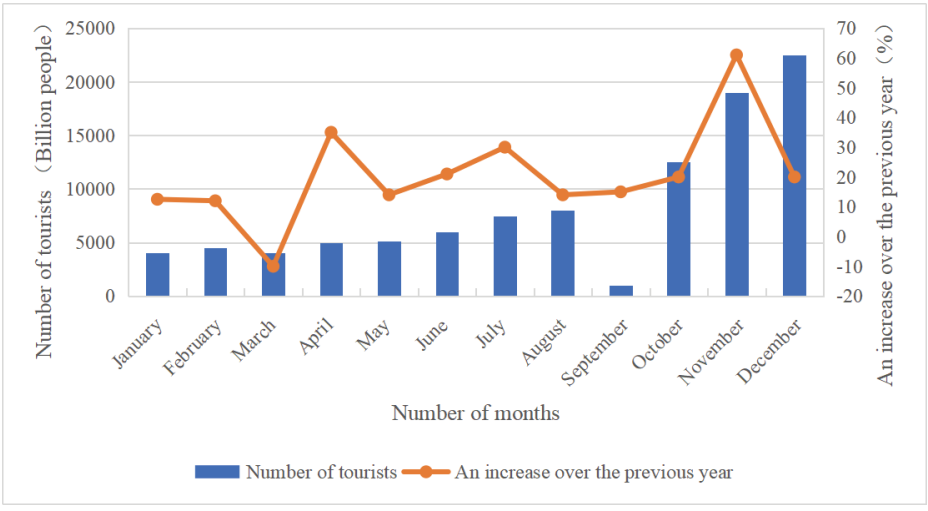


3.1.2 Tourism consumption

Figure 2 (a) shows the total tourism consumption and its growth rate. The changes show that the total tourism consumption has increased significantly. It increased from 34.22 million yuan in the first month of public health realization digitization to 233.54 million yuan in the 12th month, a growth rate of 582.47%. This shows that the consumption expenditure of urban residents on tourism has been on the rise under the influence of the digital transformation of public health. The total level of tourism consumption is constantly increasing. From the point of view of the growth rate, the total spending on tourism fluctuated a lot in the first period and stabilized by the movement. Despite some periods of negative growth rates, the majority of the time it stabilized between 15% and 22%, with an overall stabilization trend. This is because digital technology has contributed greatly to epidemic prevention and control by using big data association rules. By collecting personal travel information in a targeted manner, personal epidemic prevention and health information codes are formed. This enables the traceability of tourists' whereabouts records to avoid cross-infection and to grasp the "golden window" for emergency response to public health events.

Figure 2 Impact of the digitization of public health on the level of tourism consumption

(a) Tourism consumption and growth rate



(b) Per capita consumption and growth rate

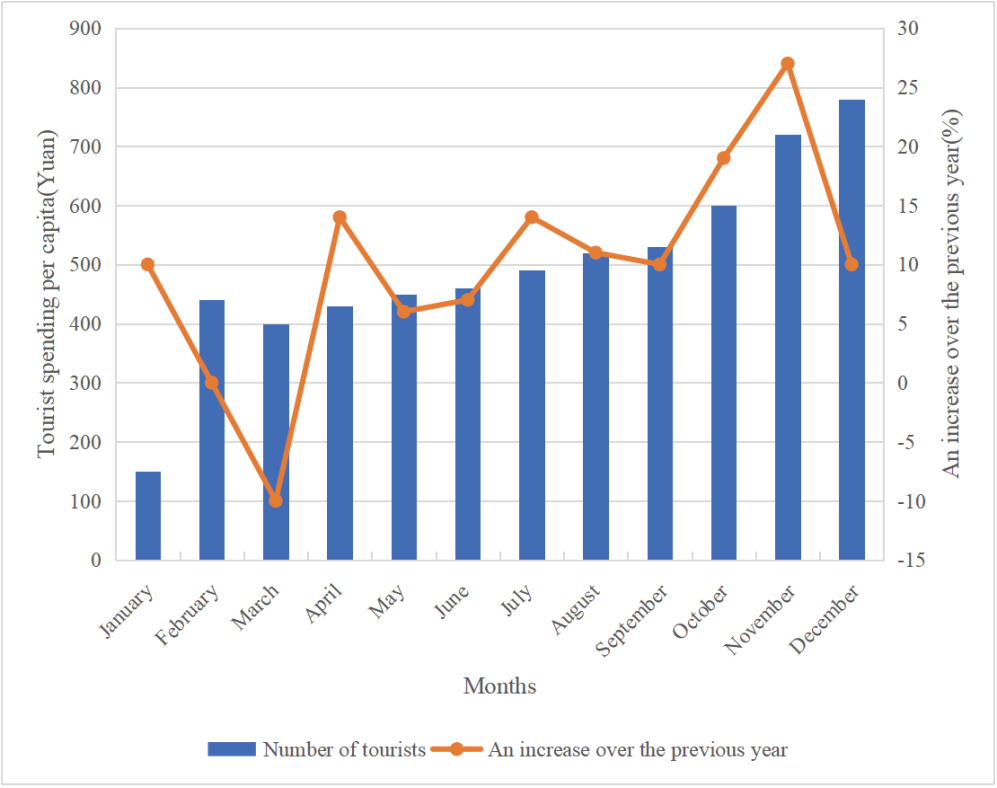
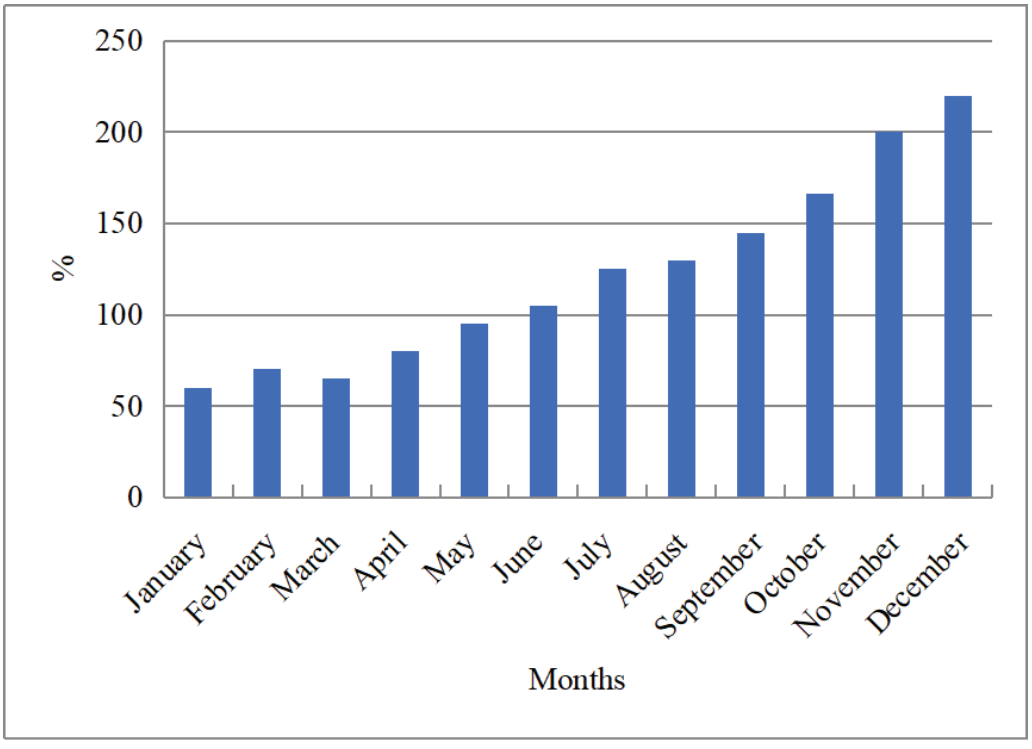


Figure 2(b) shows the per capita consumption of tourism and its growth rate. As can be seen from the changes, the level of travel per capita consumption has also shown a continuous increase. It increased from $434.2 in the first month to $782.5 in the 12th month. This is inextricably linked to public health's digital data sharing and communication strategy. Digital technology better empowers public health emergencies, ensures effective data sharing and interaction, and meets the needs of visitors to make dynamic travel decisions. In terms of the growth rate of per capita consumption, the variation of the growth rate of tourism per capita consumption is more similar to the trend of the growth rate of total consumption, showing the same small and steady growth. Although there were periods of negative growth, it was largely maintained at 2% to 6% in the later years.

3.1.3 Tourism travel rate

Figure 3 shows the travel trip rate of urban residents. The change of travel trip rate in the last year shows that the travel rate of urban residents has been increasing and reached an average of 2 trips per person. It has increased from 59.43% in the first month to 213.47% in the 12th month. That is, in the first month, the demand for travel by urban residents was 0.59 trips per person on average, and by the 12th month the demand for travel by residents reached an average of 2.13 trips per person. This means that digital technology has effectively improved the efficiency of resource deployment by virtue of blockchain's advantages of high synchronization, transparency of information transmission and non-tamperability. It enables the demand for accurate matching of material supply for public health events to be met, giving tourists maximum travel safety and accelerating the rapid growth of residents' travel demand. Overall, the travel demand of urban residents is on the rise.

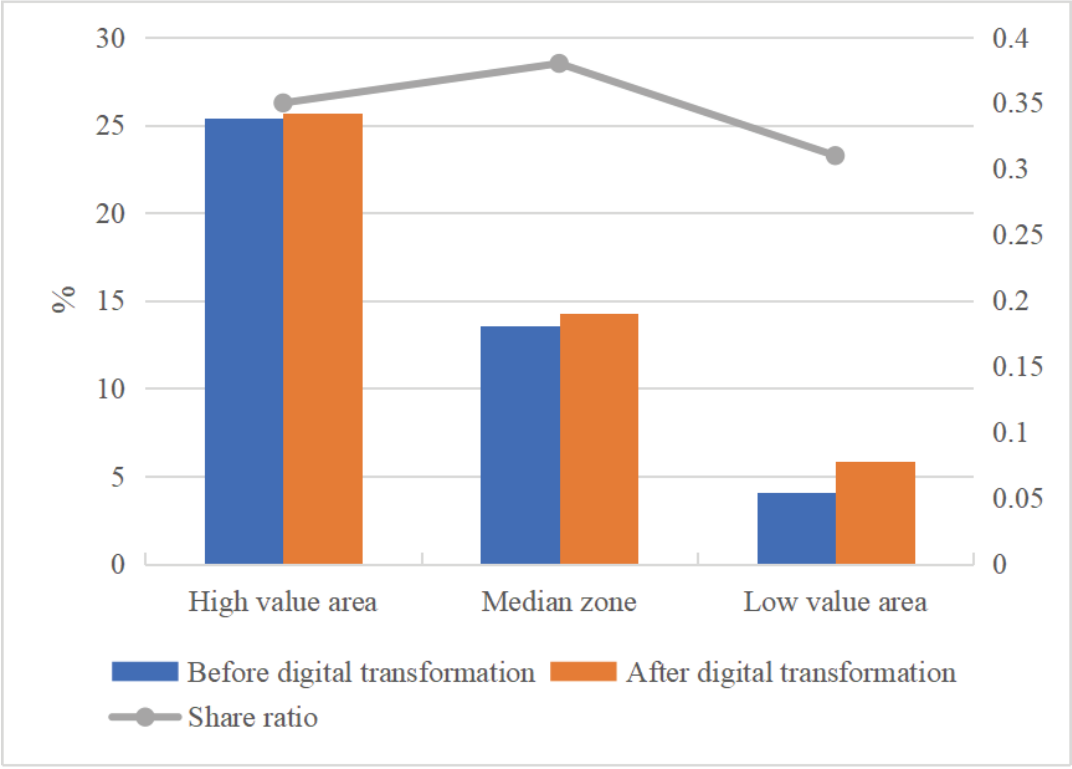
Figure 3 Impact of public health digitization on tourism travel rate



3.2 Tourism demand impact based on spatial distribution

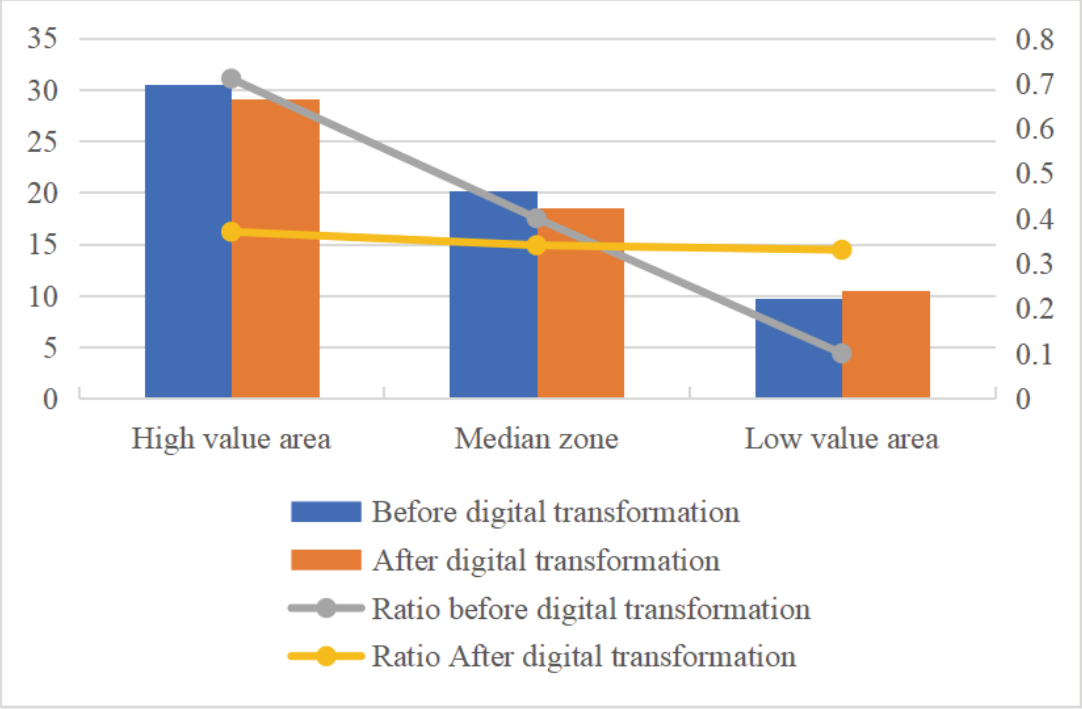
Using a provincial city as the research target, Arc GIS 11.1 was used to do spatial interpolation of relevant tourism data to explore the spatial and temporal distribution status of the research target. The relevant tourism data included data on the ratio of domestic tourist arrivals to total tourist arrivals from the province's domestic tourist sources before and after the digital transformation of public health practices, as well as data on the ratio of domestic tourist arrivals from each city to domestic tourist arrivals in the province. Surface analysis was used to extract interpolated contours, and the visitor volume share was divided into three zones by the natural interruption method, i.e., high value zone, medium value zone, and low value zone. The tourist demand of visiting city tourists is shown in Figure 4. The spatial structure characteristics of the tourist demand of the visiting city tourists are shown in Figure 5.

Figure 4 Tourist demand of visiting city tourists



From the changing characteristics of the spatial distribution of tourists in visiting cities in Figure 4, it can be seen that before digital transformation, the share of high value area in the source market ranges from 13.51% to 25.42%, the share of medium value area ranges from 4.11% to 13.51%, and the share of low value area ranges from 0% to 4.11%, except for the target provinces and cities to which they belong. The ratio of the share of different value zones to the total number of tourists in the China is 0.33, 0.49, and 0.11. The source cities in the high value zone have the strongest tourism demand due to the advantages of advanced technology, economic development, and convenient transportation, despite the existence of certain market distance and public health hazards. The source cities in the medium value zone are mostly distributed within thousands of kilometers from the target provinces and cities, and are distributed in a band. The source cities of tourists in the low value zone are mostly located in western urban areas with relatively backward economy and technology, poor transportation, little communication with the outside world, and long cultural and transportation distances, which further significantly weakened the tourism demand of residents under the influence of the new coronary pneumonia epidemic. This suggests a significant aggregation and spatial variation in tourism from source to target provinces and cities prior to upgrading the public health sector using digital technologies. The digital transformation of public health minimizes the share of high and low value areas in terms of the share of tourist volume, as seen in the tourism demand of tourists visiting cities after the digital transformation. This resulted in a small expansion of the range of high value area shares to 14.27% to 25.67%, a range of medium value area shares to 5.88% to 14.27%, and a significant expansion of the range of low value area shares to 0% to 5.88%. The ratio of the share of different value zones to the total number of national tourists is 0.35, 0.38, and 0.31, respectively, in which the source cities of the middle value zone and the low value zone are shifted to each other, and the spatial distribution form is also changed. The source cities of the median-value area are distributed in a dotted pattern, and the source places of tourists in the low-value area are partly transferred from the median-value area. Compared with the pre-transformation period, the spatial differences are significantly reduced. In summary, by relying on big data technology to create an intelligent public health and safety governance and service system and sound public health information, we can minimize the social harm caused by epidemics and prevent them before they happen. Thus, we can reduce the travel barriers brought by market distance and public health and other issues to tourists, and strengthen the tourism demand of urban residents.

Figure 5 Tourism demand of tourists in the host city



According to the characteristics of the change of spatial distribution of tourists in the receiving cities (see Figure 5), it can be seen that before digital transformation, only 4.86% of the target provinces and cities are above the average value, and 16.48% are below the average value. The total shares of the high value, medium value and low value areas of visitor reception are 0.71, 0.2 and 0.1, respectively. among them, the cities in the medium value area are generally distributed near the high value area, while the low value area is mostly distributed in a band or point-like distribution within the province. The spatial differences are extremely significant. While public health has undergone digital transformation, the range of high value areas of visitor reception has narrowed to 18.54%~29.16%, the range of medium value areas has expanded to 10.55%~18.54%, and the range of low value areas has expanded to 0%~10.55%. The total shares of different value zones are 0.37, 0.34, and 0.33, respectively. after digital technology to improve the epidemic feedback system based on big data and blockchain technology, public health safety issues are more precisely managed. It makes the spatial clustering of urban residents' travel demand in the target provinces and cities insignificant and reduces the spatial distribution differences. In summary, after the digital transformation of public health, the distribution of high, medium and low value areas of tourist reception in the province and city changed less and the share of tourists increased. The shares of target municipalities are increasingly balanced, and the spatial variability gradually diminishes.

4.Conclusion

The steady socio-economic development promotes the growing tourism demand. Accurate analysis of the impact of tourism demand of urban residents after the digital transformation of public health is not only important for the revival and reconstruction of tourism, but also plays a vital role in expanding domestic demand and promoting the sustainable development of the national economy. This paper is based on three types of tourism-related data: direct data, indirect data and supplementary data.

(1) The correlation between the digitalization of public health and the tourism demand of urban residents is investigated through the research methods of tourism place attractiveness, spacing cumulative curve, global spatial autocorrelation and local spatial autocorrelation, combined with tourism demand influence factors. Based on the impact analysis data, it is easy to see that digital technology has provided unlimited possibilities for the rapid development of tourism. It has led to a rising number of tourists in the post-epidemic era, and the number of tourists has reached 291,500 in just one year, an increase of 287.63%. The growth rate has gradually stabilized, basically remaining between 11% and 13%.

(2) The total number of domestic tourists reached 1,844,900, 28.44 times and 29.13 times more than the number of inbound and outbound tourists respectively. Total tourism spending increased significantly, with a growth rate of 582.47%, and was able to stabilize between 15% and 22% most of the time. Digital technology has improved public health security, given maximum travel safety to tourists and accelerated the rapid growth of tourism demand among the population.

(3) The change in the rate of travel trips in the last year shows that the rate of travel trips by urban residents has been increasing, reaching an average of 2 trips per person. From 59.43% in the first month, it has increased to 213.47% in the 12th month. That is, in the first month, the demand for travel by urban residents was 0.59 trips per person on average, and by the 12th month the demand for travel by residents reached an average of 2.13 trips per person. This means that digital technology has effectively improved the efficiency of resource deployment by virtue of blockchain's advantages of high synchronization, transparency of information transmission and non-tamper ability.

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no

Conflict of Interests

The author(s)declare(s) that there is no conflict of interest regarding the publication of this paper.

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