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A Study on the Online Attention of Emergency Events of Torrential Rain in Shanxi and Henan

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Abstract: To analyze the differences in the spatial and temporal distribution patterns of online attention to sudden torrential rain public events in Shanxi and Henan provinces in China, and their influencing factors, the Baidu index search platform was used to obtain the online attention of 31 provinces (autonomous regions and municipalities directly under the central government) nationwide for the 20 July 2021 to 9 August 2021 Henan torrential rain and the 5 October 2021 to 25 October 2021 Shanxi torrential rain. The geographical concentration index, the coefficient of variation, the Moran index, and the Pearson correlation were used to analyse the spatial and temporal distribution characteristics of the online attention of the floods in Shanxi and Henan and their influencing factors. The study shows that: (1) from a temporal perspective, the daily internet attention of both the Shanxi and Henan torrential rain reached its highest value on the third day, showing a sharp rise followed by a sharp fall in an inverted "V" pattern, and compared to the prolonged and continuous torrential rain in Shanxi, the short-lived precipitation and broken ring of the Henan torrential rain were seriously urgent, showing a higher internet attention. For example, the highest daily attention in Shanxi was only 73,643, while the highest daily attention in Henan was 56,054, which is 7.6 times higher than the former. The Geographical Concentration (G) index of internet attention for torrential rain in Shanxi increased from 1.55 to 8.25 within three weeks, with attention shifting from scattered to concentrated, while the G-index for torrential rain in Henan showed an inverted "V" shape; the Coefficient of Variation (CV) index for torrential rain in both provinces showed a downward trend within three weeks. (2) In terms of spatial distribution, the regional distribution of the network concern about the torrential rain in Shanxi and Henan is uneven. The provinces and cities with a higher concern about the torrential rain in Shanxi are mainly some eastern provinces and cities, such as Jiangsu, Beijing, Zhejiang, Fujian, Hainan, etc., who have signed coal protection agreements with Shanxi. The provinces and cities with a higher concern about the torrential rain in Henan are mainly the economically developed coastal provinces or provinces adjacent to Henan, such as Beijing, Zhejiang, Shandong, and Shaanxi, etc. The concern of each city for the torrential rain in the two provinces is in line with the law of distance decay. (3) In terms of influencing factors, the level of regional economic development, demographic factors, and Internet penetration and distance all have a certain influence on the level of attention to sudden torrential rain, and the study found that the level of economic development and demographic factors have the most significant influence on the level of internet attention.

Keywords: public emergencies; torrential rain; flood situation; Baidu index; public attention; spatial and temporal distribution characteristics; influencing factors; comparative study

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1. Introduction

In recent years, human activities have accelerated global warming as a result of the dramatic increase in population, accelerated urbanization, and land use changes, which

have increased the intensity of human modification of the natural environment [1,2]. Global warming has made the Earth's natural environment complex and the suddenness and frequency of natural disasters more intense than in previous millennia [3]. The report " 2020:thenon-COVIDYearinDisasters" (accessed on 21 April 2021) published by the Belgian Centre for Research on the Epidemiology of Disasters shows that the global trend of natural disasters has increased by 21 cases or 5.7% in 2020 compared to the average data of the past 20 years, with Asia ranking first in the number of natural disasters, the Americas having the most severe economic losses, and Europe having the highest number of casualties [4,5]. The economic losses and human casualties caused by the frequency of sudden public events have gradually attracted the attention of scholars both at home and abroad.

Internet attention refers to the statistical record of the number of keyword internet searches of a hot event by internet users through a certain search engine within a certain time and space [6], which can reflect the degree of public attention and participation in the event, as well as their opinions and views on the event, thus reflecting the trend of social opinion development [7]. Domestic scholars' research on internet attention is mainly focused on the field of tourism [8–10], and there are still relatively few studies that take the spatial and temporal distribution characteristics of public internet attention as a perspective in sudden public events, mainly applied to aspects such as the new crown epidemic that appeared in recent years. Based on the Baidu index, Su Hu et al. [11] used methods such as the coefficient of variation and Moran's I index to study the public's online attention to red tourism scenic spots from 2011 to 2020 that was steadily increasing, and the attention in the eastern region was higher than that in the central and western regions in that order, and finally verified the influencing factors of its macro aspects. Chu Chunjie et al. [12] took four 5A scenic spots in Henan Province as an example and used the geographic concentration index, Geographic Information Science spatial analysis, and multiple regression to compare and study the spatial and temporal distribution and differences of internet attention in mountainous scenic spots, confirming that the internet attention is consistent with the spatial distance decay effect, and the influencing factors are different for different scenic spots. Li Meng Cheng et al. [13] used the early stage of the outbreak of coronavirus disease 2019 (COVID-19) in 2020 as an example to study the spatial and temporal evolution of Chinese netizens' attention to the epidemic using the spatial autocorrelation analysis based on the Baidu index platform, introduced the spatial variation function to explore the mechanism of its spatial divergence, and investigated the influencing factors of its spatial and temporal evolution. The results of the study indicated that the spatial distribution of Internet attention to the epidemic showed a spatially significant positive correlation, with the population density and the real-time epidemic of coronavirus disease 2019 (COVID-19) being the core influencing factors. Foreign scholars have focused on population mobility [14], disease analysis [15,16], and policy [17] in their studies of network concern.

Since late July 2021, when Henan, China was hit by heavy rainfall, the maximum hourly rainfall in the local area of Zhengzhou was 201 mm, and the daily rainfall exceeded 600 mm. In early October, Shanxi, China was also hit by heavy rainfall, with a maximum rainfall of 285.2 mm. According to the classification criteria for precipitation intensity issued by the NationalMeteorologicalBureauofChina (accessed on 7 October 2008), both the Henan and Shanxi torrential rain and flood situation reached the level of very heavy rainfall ($\geq$250.0 mm) [18]. A search of the literature database reveals that current research on sudden public events such as torrential rain and flooding is mainly focused on analysing their causal mechanisms [19–23] and disaster risk assessment [24–28], providing a large number of scientific bases for preventing and mitigating disaster losses, but there are relatively few studies on the attention of other sudden disaster events such as torrential rain and floods based on the perspective of public online opinion. Based on this, this paper takes 31 provinces (autonomous regions and municipalities directly under the central government) in mainland China as the research unit, and obtains relevant data with the help of the Baidu index search platform, which is the largest in the world and has

the highest usage rate in the domestic market [29], to study the spatial and temporal distribution characteristics of the sudden torrential rain in Henan in July 2021 and the torrential rain in Shanxi in October 2021 by comparing the geographic concentration index, the coefficient of variation and spatial autocorrelation, and uses Pearson correlation analysis to study the influencing factors of the difference in spatial and temporal distribution. Using the holistic characteristics of geography, the aim is to elucidate the online attention of residents in 31 provinces (autonomous regions and municipalities directly under the Central Government) in China to the torrential rain in Shanxi and the torrential rain in Henan from a temporal and spatial perspective, and to analyse their influencing factors. The study of the degree of public influence on public emergencies will help the government to accurately grasp the development trend of online public opinion, thus providing scientific reference for the government to strengthen its online public opinion management work and create a good public opinion environment as well as for the response and management of public opinion on major public emergencies that may occur in the future.

2. Materials and Methods

2.1. Research Areas

2.1.1. Site Description (Shanxi Province)

Shanxi, abbreviated as "Jin", is a provincial administrative region of China, with its capital Taiyuan, located in northern China, bordering Hebei to the east, Shaanxi to the west, Henan to the south, and Inner Mongolia to the north. It lies between 34°34′–40°44′ N latitude and 110°14′–114°33′ E longitude, with a total area of 156,700 square kilometers (Figure 1) [30].

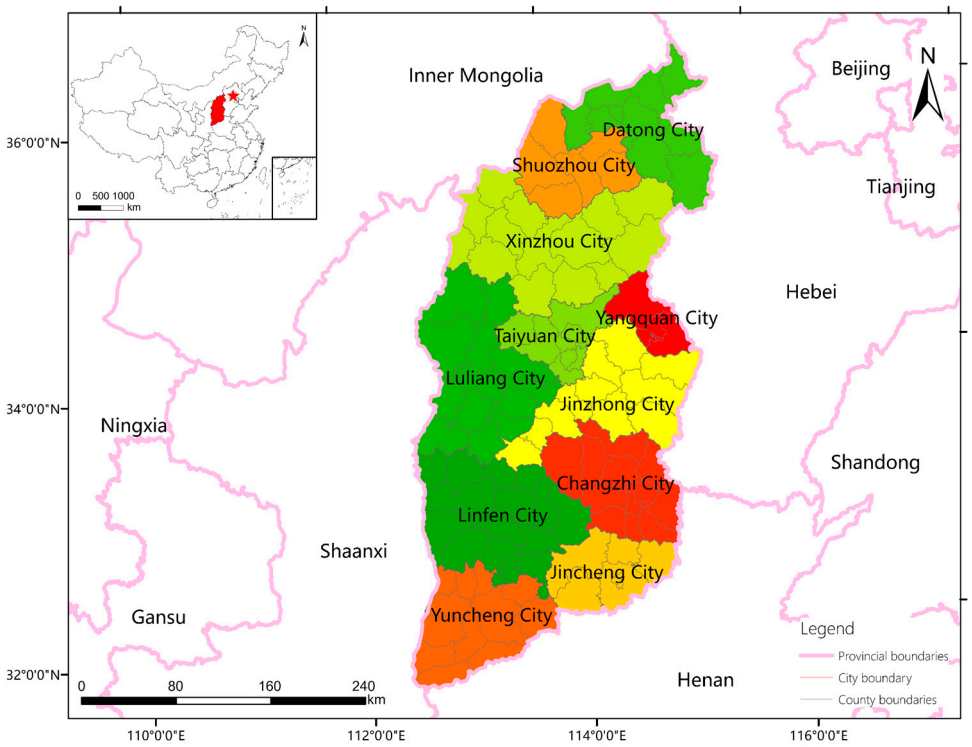

Figure 1. The location of Shanxi Province. The asterisks in the small picture represent Beijing, the capital of China. The different colours in the diagram represent each city in Shanxi Province. (The map is based on the standard map of the TechnicalReviewCentreforMapsoftheMinistryofNaturalResources (accessed on 26 August 2021) (review number: GS (2019) 1822), with no modifications to the base map).

Shanxi is a mid-latitude province, surrounded by mountains on three sides and relatively closed to traffic, with a northeast to southwest parallelogram, a typical mountainous plateau covered by loess, with a high northeast to southwest topography. The interior of

the plateau is undulating, with rivers and valleys running through it, and the landscape consists of mountains, hills, terraces, and plains, with mountainous areas accounting for 80.1% of the total area. Shanxi Province straddles two major water systems, the Yellow River and the Hai River, and the rivers are self-produced outflow type water systems. Shanxi Province is located inland in the mid-latitude zone and has a temperate continental monsoon climate [31].

2.1.2. Overview of Heavy Rainfall Disaster in Shanxi

Rainfall in Shanxi intensified significantly from 3 October to 5 October 2021, heavy rainfall led to a series of geological disasters, including landslides and mudslides in Jinzhong, Lvliang, and Linfen, and caused fatalities that quickly drew widespread attention from people across the country. On 6 October, Shanxi province released the emergency launch of a provincial-level geological disaster level III, with the government and relevant departments actively carrying out flood relief work [32]. The average precipitation of this extreme rainfall in Shanxi amounted to 119.5 mm, with an average of 185.6 mm in Taiyuan City and 18 counties in the province receiving more than 200 mm of precipitation. Especially with the maximum precipitation being 285.2 mm in Daning County, Linfen, it is five times over the normal year. The extreme heavy precipitation weather caused 1,757,100 people to be affected, damaging 19,500 houses, stopping production of a total of 60 coal mines, and seriously damaging 18,200 crops covering an area of 238,460 ha, with direct economic losses amounting to 5.029 billion RMB [33,34]. As a major coal province, the torrential rain led to the emergency shutdown of some coal mines, which will inevitably cause a short-term impact on the national coal supply as well as the electricity supply. In addition, the flooding caused by the torrential rain also affected the normal operation of transportation, with highways, provincial trunk roads and railway tracks in many places being hit by the torrential rain, causing heavy losses to economy. The outbreak of torrential rain in Shanxi coincided with the National Day holiday, which not only caused losses to the local tourism industry, but more importantly, the destruction of ancient buildings and cultural relics by the torrential rain, including the collapse of the ancient city walls of Pingyao and several other nationally important cultural relics [35].

Generally, there are three main reasons for this sustained and widespread heavy precipitation. Firstly, there is a stable atmospheric circulation situation, with the unusually strong western Pacific subtropical high pressure, a westward extension of the northward lift after stable maintenance in the Yellow and Huaihai areas, and the westerly belt low value system in Shanxi forming a stable east high west low circulation situation. Secondly, south-central Shanxi gathered from the South China Sea and the Bay of Bengal moisture was transported to provide favorable conditions for continued heavy precipitation weather. Thirdly, the complex topography of Shanxi played a role in pushing, and Taihang Mountains and Lvliang Mountains complex terrain conditions led to the central Shanxi and northern Linfen. The complex topography of the Taihang Mountains and Lvliang Mountains led to extreme heavy precipitation in central Shanxi and northern Linfen [36].

2.1.3. Site Description (Henan Province)

Henan Province, abbreviated as "Yu", is a provincial administrative region of the People's Republic of China. It is located in the central part of China, between latitude 31°23′–36°22′ N and longitude 110°21′–116°39′ E (Figure 2). It is bordered by Anhui and Shandong to the east, Hebei and Shanxi to the north, Shaanxi to the west and Hubei to the south, with a total area of 167,000 square kilometres. Henan is known as "the hinterland of nine states and the thoroughfare of ten provinces" and is an important comprehensive transportation hub and a centre for the flow of people, goods, and information [37].

Henan is located in the centre of China, with a topography that runs north to south, east to west, high in the west, and low in the east, and consists of plains and basins, mountains, hills, and water. Most of it is located in the warm temperate zone, while the southern part straddles the subtropical zone, which is a continental monsoon climate in

transition from the northern subtropical zone to the warm temperate zone; Henan is located in the combination of the open coastal areas and the central and western regions, and is the middle zone of China's economic development from east to west in a stepwise manner [38].

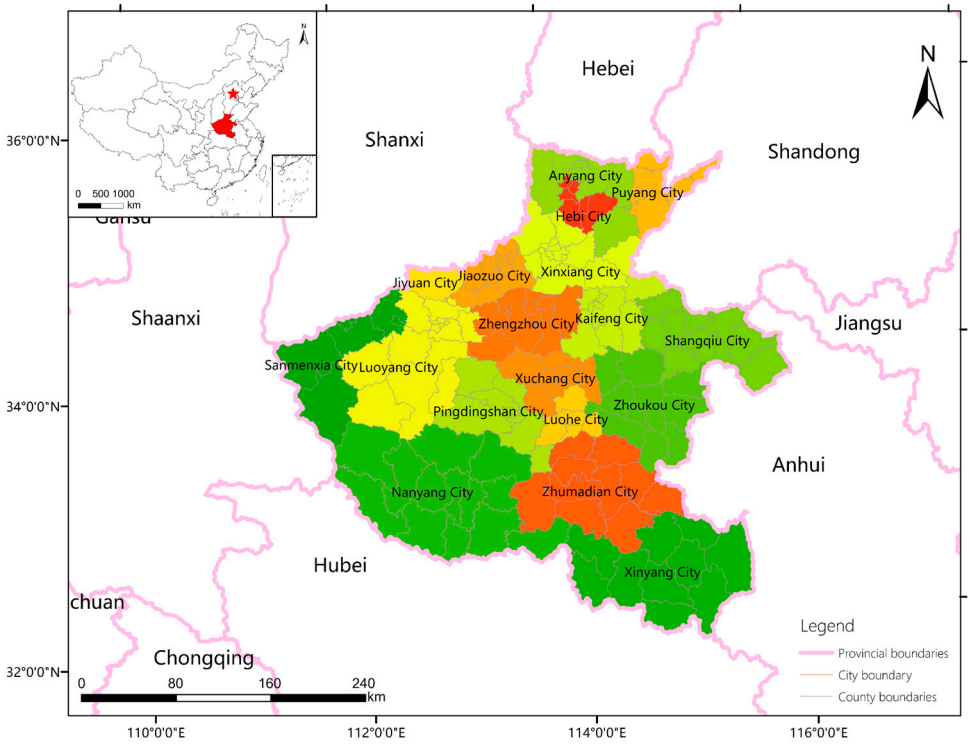

Figure 2. The location of Henan Province. The asterisks in the small picture represent Beijing, the capital of China. The different colours in the diagram represent each city in Henan Province. (The map is based on the standard map of the TechnicalReviewCentreforMapsoftheMinistryofNaturalResources (accessed on 26 August 2021) (review number: GS (2019) 1822), with no modifications to the base map).

2.1.4. Overview of Heavy Rainfall Disaster in Henan

The extreme rainfall that occurred in Henan on a large scale, especially in Zhengzhou, was a once-in-a-millennium disaster, with heavy precipitation occurring first in northern Henan (Jiaozuo, Xinxiang, Hebi, and Anyang) from 17 to 18 July and then moving south to Zhengzhou from 19 to 20 July, with a cumulative average rainfall of 449 mm. The torrential rain caused a number of disasters, including flooding of rivers, landslides, and other geological disasters, especially the Zhengzhou 5 underground and tunnels, which caused casualties nationwide; from the 21st to the 23rd the torrential rain center moved north again to Xinxiang, Kaifeng, Zhoukou, and Jiaozuo, gradually weakening to an end on the 23rd. The disaster covered a total of 150 counties in the province, and caused 14,786,000 people to be affected and 398 people died and disappeared, particularly, in Zhengzhou where 380 people died and disappeared accounting for 95.5% of the province. Besides this, there was a crop disaster area of 1,080,200 ha, 99,300 houses collapsed, and direct economic losses of 120.6 billion RMB. Among them, Zhengzhou lost 40.9 billion RMB, accounting for 34.1% of the province [39,40].

The conditions for the formation of this torrential rain in Henan were similar with Shanxi. Generally, it is also determined by three conditions. Firstly, a stable form of atmospheric circulation. Secondly, abundant water vapor conditions. Thirdly, significant topographic precipitation effects. The Western Pacific subtropical high pressure and continental high pressure are stably maintained in the Sea of Japan and northwest China, respectively, which results in low value weather systems between them stagnating and moving little in the Huang-Huai regions, causing prolonged precipitation in central and western Henan. Another reason for this extreme rainfall is that typhoon "fireworks" re-

motely controlled the heavy rainfall in Henan; the low-pressure center of the typhoon and the high-pressure center of the sub-pressure formed a very strong pressure gradient force, and a constant stream of water vapor came from the ocean to the mainland and gathered easterly in Henan. Under the influence of the mountains, the easterly airflow appeared in front of the Taihang Mountains and the Funiu Mountains in Henan, and the special topography made the heavy precipitation steadily concentrated in the western and northwestern areas along the mountains in Henan [41,42].

2.2. Data Sources

Baidu Index is a data sharing platform based on Baidu's massive internet user behavior data and is currently one of the most important statistical analysis platforms for data on the internet and the entire era [43]. Because of the ease of access, the Baidu index has been used in various disciplines in recent years. In this paper, we use the keywords "Shanxi torrential rain" and "Henan torrential rain" on the Baidu index platform to study the torrential rain in Henan and Shanxi that occurred in July and October 2021 in China. The public's internet attention data for 21 days were selected from "5 October to 25 October" and "20 July to 9 August", respectively, and a comparative analysis of the spatial and temporal aspects of the internet attention of the Shanxi and Henan torrential rain and their influencing factors was conducted.

Based on the accessibility of data related to impact factor analysis, this study uses data from 31 provinces and cities as the sample, excluding Taiwan, Hong Kong, and Macao. Among them, data on total regional population and regional Gross Domestic Product in 2018 were obtained from the ChinaStatisticalYearbook (accessed on 24 September 2019), data on internet penetration in 2018 were obtained from Netsuke:ChinaInternetDevelopmentReport (accessed on 21 April 2019) [44], and distances between Taiyuan, Shanxi and Zhengzhou, Henan, and the provincial capitals nationwide were obtained from BaiduMaps (accessed on 23 December 2021).

2.3. Research Methods

Current research on sudden public events such as heavy rainfall in Shanxi and Henan is actually a challenge to search for online and attention to sudden public events from literature databases, mostly on the topic of their natural environmental conditions or sudden mechanisms, focusing on the risk assessment of heavy rainfall floods. For example, Xu Min et al. [45] used two sudden rainfall events in August 2017 in Jizhong to study the environmental conditions and triggering mechanisms. For the study of heavy rainfall flooding there is a lack of research on the spatial and temporal distribution patterns of public network concern, this study used the geographical concentration index to study the spatial distribution of network concern for heavy rainfall in Shanxi and Henan, the coefficient of variation to study the temporal changes of network concern, and the Moran's I index to study the degree of spatial clustering of network concern Moran's I index method.

2.3.1. Geographical Concentration Index (G)

The geographic concentration index [46] is primarily used to characterize the degree of concentration in the spatial distribution of study objects and is calculated as follows.

$$G = 100 \times \sqrt{\sum_{i=1}^{n} \left(\frac{P_i}{P}\right)^2} \quad (1)$$

In the formula: G is the geographical concentration index; P_i denotes the flooding network concern of province i; P denotes the sum of the flooding network concern of 30 provincial administrative regions; and n is the total number of provinces. G takes a range from 1 to 100, with a value closer to 100 indicating a more concentrated spatial distribution of concern and a value closer to 1 indicating a more dispersed spatial distribution of concern.

2.3.2. Coefficient of Variation

The coefficient of variation [47] is a measure of the degree of variation between multiple regional economic scales and is calculated as follows.

$$CV = \frac{\sqrt{\frac{\sum_{i=1}^{n}(x_i-\overline{x})^2}{n}}}{\overline{x}} \quad (2)$$

In the formula: CV denotes coefficient of variation; x_i denotes the web attention of a province at time i. $\overline{x}$ denotes the mean value of x_i. A smaller value of CV indicates a smaller temporal variation in web attention, while a larger value of CV indicates a more significant temporal variation in web attention.

2.3.3. Moran's I Index

The Moran's I index [48] reflects the similarity of the attribute values of spatially contiguous or spatially adjacent regional units, with two indices, the global Moran's I index and the local Moran's I index. If there is a global autocorrelation present, then a local autocorrelation is done, with the local index reflecting which areas show outliers or where agglomeration occurs. The formula is as follows.

$$I = \frac{n\sum_{i=1}^{n}\sum_{j=1}^{n} w_{ij}(x_i-\overline{x})(x_j-\overline{x})}{\sum_{i=1}^{n}\sum_{j=1}^{n} w_{ij}(x_i-\overline{x})^2} \quad (3)$$

$$I_i = \frac{(x_i-\overline{x})}{\sum_{i=1}^{n}(x_i-\overline{x})^2}\sum_{j=1}^{n} w_{ij}(x_i-\overline{x}) \quad (4)$$

In the formula, I, I_i represent the global and local spatial autocorrelation Moran's I indices, respectively; i and j denote provinces (districts and cities). w_{ij} is the spatial weight matrix, and this paper adopts the method of Queen's adjacency to define the spatial weight matrix.

3. Results and Discussion

3.1. Analysis of the Temporal Difference in Flooding Internet Attention in Shanxi and Henan

3.1.1. Daily Differences in National Internet Attention

As shown in Figure 3, we can see that the attention of the network of Shanxi floods was single-peaked, with the fastest growth in the third day (73,643), and then declined after the fourth day. In general, the attention to the floods in Shanxi was highest in the first 7 days of the floods, after which it quickly dropped. The devastation caused by the sudden disaster event of heavy rainfall in Henan caused a high level of concern among netizens nationwide. From Figure 3, we can see that the internet attention of the Henan torrential rain rose rapidly on the 2nd day and reached its highest peak (560,054) on the 3rd day, which was due to the flooding into the Zhengzhou City Metro Line 5 in the evening of 20 July, resulting in 12 passengers being tragically killed, which immediately aroused a high degree of concern from people nationwide, while the 4th day showed a precipitous decline, falling back to 167,185. Overall, the trend shows a single-peak pattern of rapid rise and then a sharp fall.

On the whole, due to the different causes and characteristics of heavy rainfall in the two provinces, the short-time suddenness and ring-breaking serious urgency of heavy rainfall in Henan presented a higher internet attention compared to the long-time continuous rainfall in Shanxi. The highest daily attention in Shanxi was only 73,643, while the highest daily attention in Henan reached 56,054, which is 7.6 times over the former.

3.1.2. Comparative Analysis of Online Attention by Province Nationwide

In order to eliminate the effect of population size on internet attention, this study uses per capita internet attention to analyse the difference in internet attention between Shanxi

and Henan during the week of heavy rainfall, the results are shown in Figure 4. It is easy to see that most of these provinces and cities are Shanxi's counterparts in securing coal supply, so their internet attention is higher than that of other provinces. On 29 September 2021, Shanxi Province, to protect the supply of fourteen provinces and cities in the fourth quarter of the coal medium and long-term contract docking, held a signing in Taiyuan, Shanxi; the meeting adopted the "Shanxi and 14 provinces and cities signed a contract to protect the supply of coal" [49]. According to the relevant requirements, the central coal enterprises in Shanxi will guarantee the supply of Tianjin, Fujian, Hebei, Guangdong, Liaoning, and other five provinces and cities; the Jin Energy Holding Group Co., Ltd. (Shanxi, China). docked Guangxi, Jiangsu, Jilin, Anhui, Shanghai, Zhejiang, and other six provinces and cities, the Shanxi Coking Coal Group (Shanxi, China) undertook the task of guaranteeing the supply of Henan Province, the Huayang New Materials Group (Shanxi, China) undertook the task of guaranteeing the supply of Hainan Province, the Lu'an Chemical Group (Shanxi, China) undertook the task of guaranteeing the supply of Shandong Province, and the rest of the task of guaranteeing the supply was undertaken by coal enterprises in various cities of Shanxi Province. It can be seen that those provinces and cities have a high degree of concern about the torrential rain in Shanxi because of close ties with Shanxi, and the smooth operation of Shanxi's society and economy is directly related to the production and living energy security of the relevant provinces.

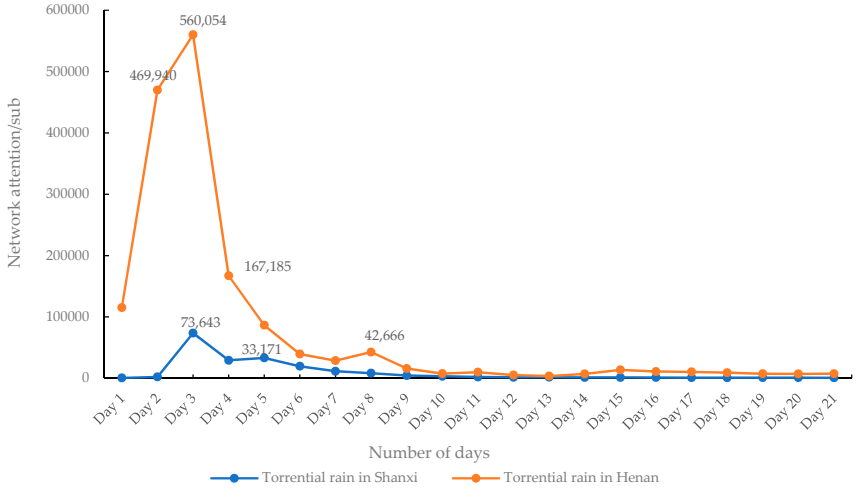

Figure 3. Trend of daily national internet attention for torrential rain in Shanxi and Henan.

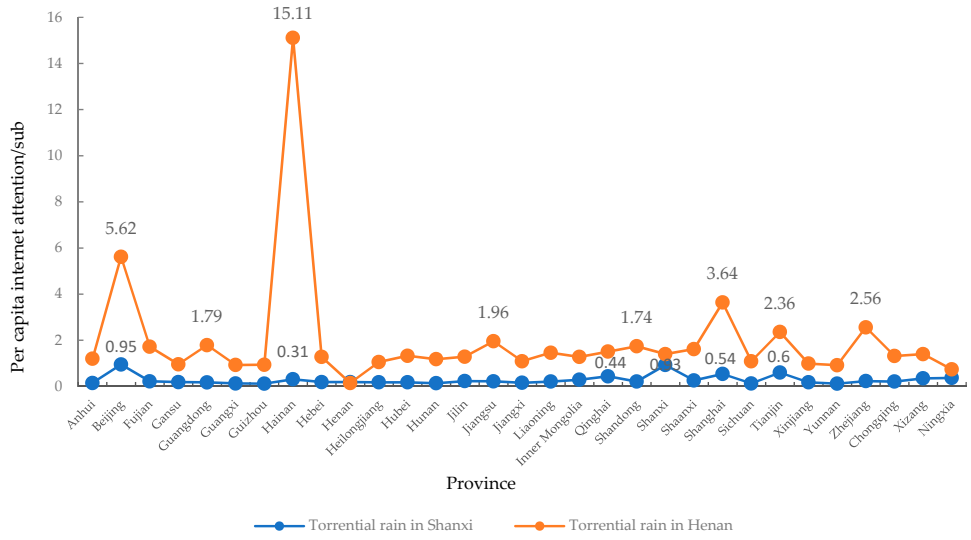

Figure 4. Trend of per capita internet attention by province in Shanxi and Henan torrential rain nationwide.

For the sudden and catastrophic event of heavy rainfall in Henan, especially when the city of Zhengzhou suffered severe flooding that led to the loss of many lives, the public's online attention to the matter was generally high, with the more prominent provinces and cities being Beijing, Guangdong, Fujian, Hainan, Jiangsu, Shandong, Shanghai, Tianjin, and Zhejiang. Most of these areas with a high internet attention are economically developed coastal provinces, such as Guangdong (1.79), Jiangsu (1.96), Shandong (1.74), and Zhejiang (2.56), as well as provinces closer to Henan with a high internet attention, such as Shaanxi (1.62). Provinces with lower levels of interest, such as Guizhou (0.94), Yunnan (0.92), Guangxi (0.93), and Ningxia (0.74), are all located in less economically developed regions in the west, farther away from Henan. On 21 July 2021, President Xi Jinping gave important instructions on flood prevention and relief work, clearly stating "the requirement to always put the safety of people's lives and property in the first place", which also makes the whole country highly concerned about the flood situation in Henan.

3.1.3. Weekly Difference in Internet Attention between Shanxi and Henan Torrential Rain

In this paper, we use the geographic concentration index and coefficient of variation to conduct weekly comparative analyses on the differences between various regions of Shanxi and Henan torrential rain internet attention, and calculate the geographic concentration index and coefficient of variation of Shanxi and Henan internet attention according to Formulas (1) and (2), and the results are shown in Table 1.

Table 1. Differences between regions in terms of internet attention to the torrential rain in Shanxi and Henan.

	Week 1		**Week 2**		**Week 3**	
	Shanxi	**Henan**	**Shanxi**	**Henan**	**Shanxi**	**Henan**
Geographical concentration index (G)	1.55	1.63	6.92	2.02	8.25	1.78
Coefficient of variation (CV)	0.6537	0.7575	0.4972	0.6529	0.4004	0.5400

From Table 1, we can see that the geographic concentration index of the internet attention to the Shanxi torrential rain has shown an increasing trend in the three weeks. The geographical concentration index for the three weeks of Henan torrential rain showed a trend of first increasing and then decreasing, showing an inverted "V" shape with little overall fluctuation, which indicates that the degree of concentration of online attention to Henan torrential rain in all regions of China is relatively small and the spatial distribution is relatively balanced.

From the values of the coefficient of variation, it can be found that the Internet attention of both the Shanxi torrential rain and the Henan torrential rain showed a decreasing trend within three weeks, with the coefficient of variation of the Shanxi torrential rain Internet attention decreasing from 0.6537 to 0.4004, and the coefficient of variation of the Henan torrential rain Internet attention decreasing from 0.7575 to 0.5400, which shows that the public's attention to the two public emergencies, the Shanxi torrential rain and the Henan torrential rain, has become less and less spatially different over a period of three weeks. This shows that the spatial difference between the public's concern for the two public emergencies, namely the Shanxi torrential rain and the Henan torrential rain, has become smaller and smaller.

3.2. Spatial Distribution Characteristics of the Flood Situation in Shanxi and Henan

3.2.1. Provincial Level

The same spatial distribution characteristics of internet attention in Shanxi and Henan were analysed using per capita internet attention to eliminate the influence of demographic factors. The Jenks natural breakpoint method using GIS technology was used to classify the per capita network concern of each province into five categories from low to high, and to draw a visualization chart (Figure 5). As can be seen from Figure 5a, the regions with the highest public per capita network concern for the Shanxi torrential rain (0.278–0.414)

include Beijing and Shanxi, followed by provinces with concern in the 0.135–0.277 range, namely Tianjin, Shanghai, Hainan, Ningxia, Qinghai, and Tibet, two provinces and four cities. Provinces with per capita internet attention in the 0.09–0.134 range include nine provinces (municipalities directly under the Central Government) in Jiangsu, Zhejiang, Fujian, Liaoning, Jilin, Shaanxi, Chongqing, Gansu, and Inner Mongolia. The provinces in Anhui and southwest China, on the other hand, had the lowest online attention to the Shanxi torrential rain (0.061–0.069). It is not difficult to find that 9 of the 15 provinces (autonomous regions and municipalities directly under the central government) that have a high internet concern for the Shanxi torrential rain have signed "Coal Supply Assurance Contracts between Shanxi and 14 Provinces and Municipalities" with Shanxi. The impact of the torrential rain disaster on the mining of coal in Shanxi is directly related to the development of other coal-using provinces. In recent years, the national coal market has seen a tight supply and high coal prices. At this time, Shanxi has a very important role to play in the economic development of the country, and it will give full play to its mission of being a major coal-producing province, striving to increase coal production, dynamically stabilise coal prices, safeguard national energy security, and support the economic construction of its brother provinces.

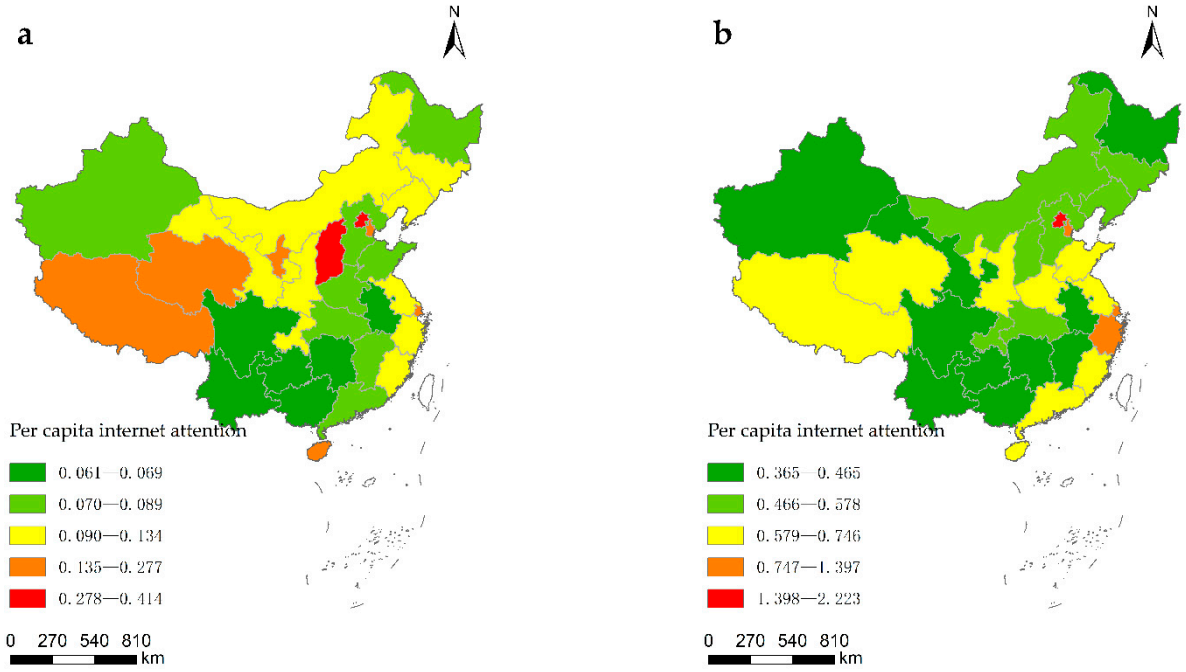

Figure 5. Provincial geographical distribution of per capita internet attention to torrential rain. (Note: (**a**) the per capita internet attention of Shanxi Province; (**b**) the per capita internet attention of Henan Province). (The map is based on the standard map of the Technical Review Centre for Maps of the Ministry of Natural Resources (review number: GS (2019) 1822), with no modifications to the base map).

According to the StatisticsLawofChina (accessed on 27 June 2009) and the RegulationsoftheNationalPopulationCensus (accessed on 13 August 2020), China conducted the seventh population census with the standard time point of 00:00 on 1 November 2020. The results show that the resident population of Henan Province totaled 99,366,000, ranking third in the country, with Zhengzhou, Nanyang, Shangqiu, and Luoyang ranking in the top five in terms of population in the province [50]. As can be seen in Figure 5b, the highest level of concern among the provinces nationwide for sudden major torrential rain in Henan Province, a province with a large population (1.398–2.223), is in Beijing, followed by Zhejiang and Tianjin (0.747–1.397), with higher levels in Shandong, Jiangsu, Fujian, Guangdong, Henan, Shaanxi, Hainan Qinghai, and Tibet, nine provinces (cities). These

provinces, with the exception of Qinghai and Tibet, are all economically developed coastal provinces or provinces adjacent to Henan. Henan is one of China's important granaries and a major labour-exporting province, its geographical location also plays a pivotal role in the country, especially Zhengzhou, which is the national transportation hub, it is the intersection of the Beijing–Guangzhou line and the Longhai line, two major railway lines, is the communication between the north and south, and the hub of the east and west. The heavy rainfall in Henan, especially the Zhengzhou Line 5 underground, which was hit by torrential rain and resulted in casualties and the underground being washed away, has caused widespread concern throughout the country.

3.2.2. Municipal Level

To analyse the national internet attention to the Shanxi and Henan torrential rain at the municipal level, a quintile geographical division of the 21-day internet attention to the Shanxi and Henan torrential rain was made using ArcGIS 10.8(Environmental Systems Research Institute, Redlands, California, United States). As shown in Figure 6a, the figure shows that the cities with public concern about the network of the Shanxi torrential rain ranging from 0.780 to 1.676 include Taiyuan, Changzhi, Jinzhong, Yangquan, Shenzhen, and Dongguan, while the cities with concern from 0.490 to 0.779 are mainly Beijing, Datong, Jincheng, Shuozhou, Linfen, Lvliang, Hohhot, Zhengzhou, Lanzhou, Suzhou, Hangzhou, Xiamen, Zhongshan, Zhuhai, Haikou, and Sanya. The cities with a high internet interest are mainly in Shanxi, the Inner Mongolia Autonomous Region, Henan, Jiangsu, Guangdong, and Hainan provinces, which are neighboring provinces or provinces with a strong interest in Shanxi. The cities with a lower internet attention are mainly in southwest China and inland southeast China; thus, it can be seen that the internet attention to Shanxi's torrential rain is in line with the law of distance decay, with areas further away from Shanxi having a lower internet attention.

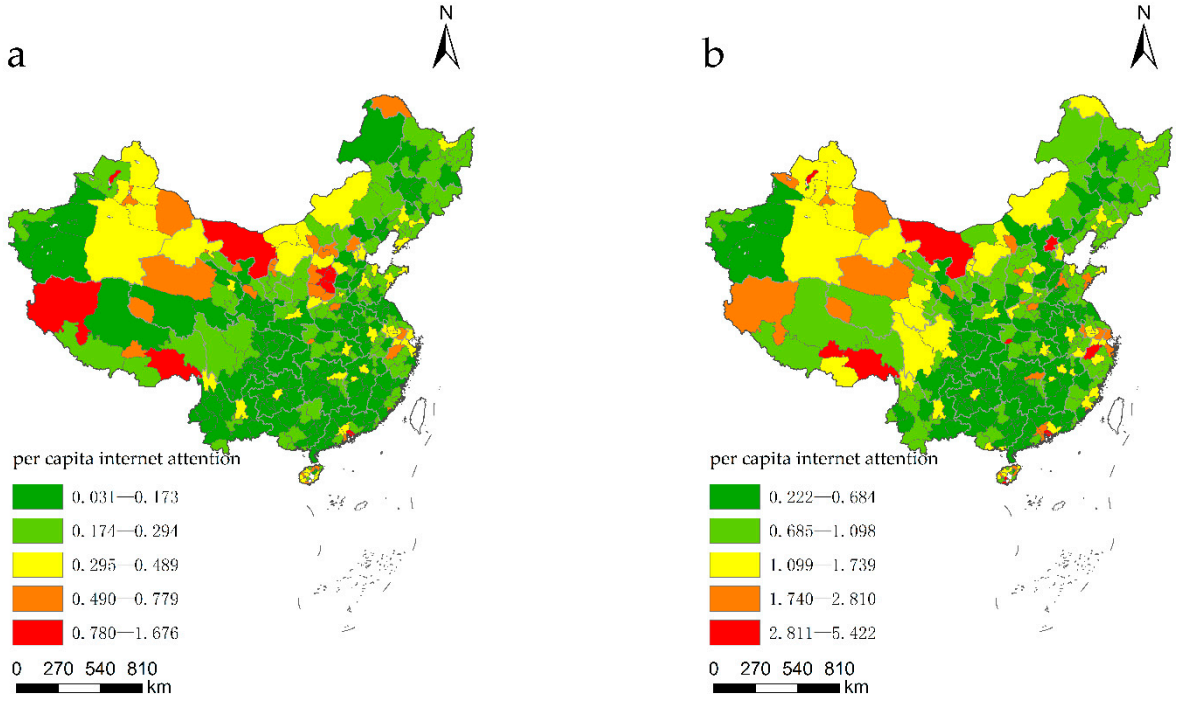

Figure 6. Municipal geographical distribution of per capita internet attention for torrential rain. (Note: (**a**) the per capita internet attention of Shanxi Province; (**b**) the per capita internet attention of Henan Province). (The map is based on the standard map of the Technical Review Centre for Maps of the Ministry of Natural Resources (review number: GS (2019) 1822), with no modifications to the base map).

From Figure 6b, it can be seen that the main cities with internet concern for the torrential rain in Henan ranging from 2.811 to 5.422 are Beijing, Hangzhou, Shenzhen, Dongguan, and Lhasa. The next cities with a higher internet concern (1.740~2.810) mainly include Taiyuan, Jinan, Qingdao, Zhengzhou, Shanghai, Nanjing, Suzhou, Changsha, Ningbo, Guangzhou, Changsha, and Urumqi; cities with concern from 1.099~1.739 include Lanzhou, Xi'an, Shijiazhuang, Wuxi, Changzhou, Hefei, Tianjin, and Wuhan. These cities are mainly the capital cities of large coastal economic provinces and some cities with prosperous economic development in the provinces. The distribution pattern of his internet attention also conforms to the law of distance decay.

3.2.3. Spatial Agglomeration Analysis

GeoDa1.12(Spatial Analysis Laboratory, Chicago, United States) software was used to do global spatial correlation and local spatial correlation analysis on the concerns of Shanxi and Henan floods at the municipal level. Firstly, the global Moran's I value of the network concern of the torrential rain in Shanxi and Henan were calculated (see Table 2). As can be seen from the table, the Moran's I value of both provinces are positive, the p-value < 0.05, and the z-value > critical value 1.65, indicating that the national Shanxi and Henan torrential rain network concern has a significant correlation, and from the value of Moran's index, the network concern distribution has a low spatial positive correlation, and the spatial clustering is not high, which is a spatially dispersed distribution pattern.

Table 2. Moran's I value of internet attention for torrential rain in Shanxi and Henan.

	Shanxi	**Henan**
Moran's I	0.278	0.170
p-value	0.001	0.001
z-value	8.262	5.470

In order to further reveal the spatial clustering effect of the network concern for torrential rain in Shanxi and Henan, a local spatial correlation analysis was conducted, and a Local Indicators of Spatial Association clustering analysis map (Figure 7) was derived by combining GIS software. From Figure 7, it can be seen that most cities in China have insignificant clustering characteristics for the network concern of torrential rain in Shanxi and Henan.

The high–high concentration area of internet attention in Shanxi torrential rain is clustered in four areas, Taiyuan, Yinchuan, Guangzhou, and Lhasa, with Taiyuan as the centre of the cities including Jinzhong, Changzhi, Lvliang, Yangquan, Datong, Shuozhou, and other cities in Shanxi province with a high internet attention, Yinchuan with Wuhai, Ordos, Bayannur, and Shizuishan Internet attention is high in the high–high concentration areas located in the Pearl River Delta including Guangzhou, Dongguan, Huizhou, and Zhongshan. The high–high concentration area of internet attention for the torrential rain in Henan is more scattered, with two high–high concentration areas in the eastern coastal region, two cities in the Yangtze River Delta region are Jiaxing and Huzhou in Zhejiang, and the Pearl River Delta region is centered on Dongguan with its four surrounding cities (Guangzhou, Shenzhen, Huizhou, and Zhongshan) are of high concern, and the high–high agglomerations located in the north are Shizuishan City and the three cities of Yinchuan, Wuhai, and Erdos in the Ningxia Hui Autonomous Region.

The Shanxi torrential rain internet attention high–low concentration area is mainly Yunnan Kunming, Guizhou Guiyang, Gansu Lanzhou, Guangxi Beihai, and Xinjiang Karamay City; except for Karamay and Beihai, the other three cities are provincial capital cities and economic development is better than the surrounding cities, so present a higher internet attention. The Henan torrential rain internet attention high–low concentration area is mainly Jiangxi Nanchang, Yunnan Kunming, Guangxi Beihai City, Hainan, and Wuzhishan City.

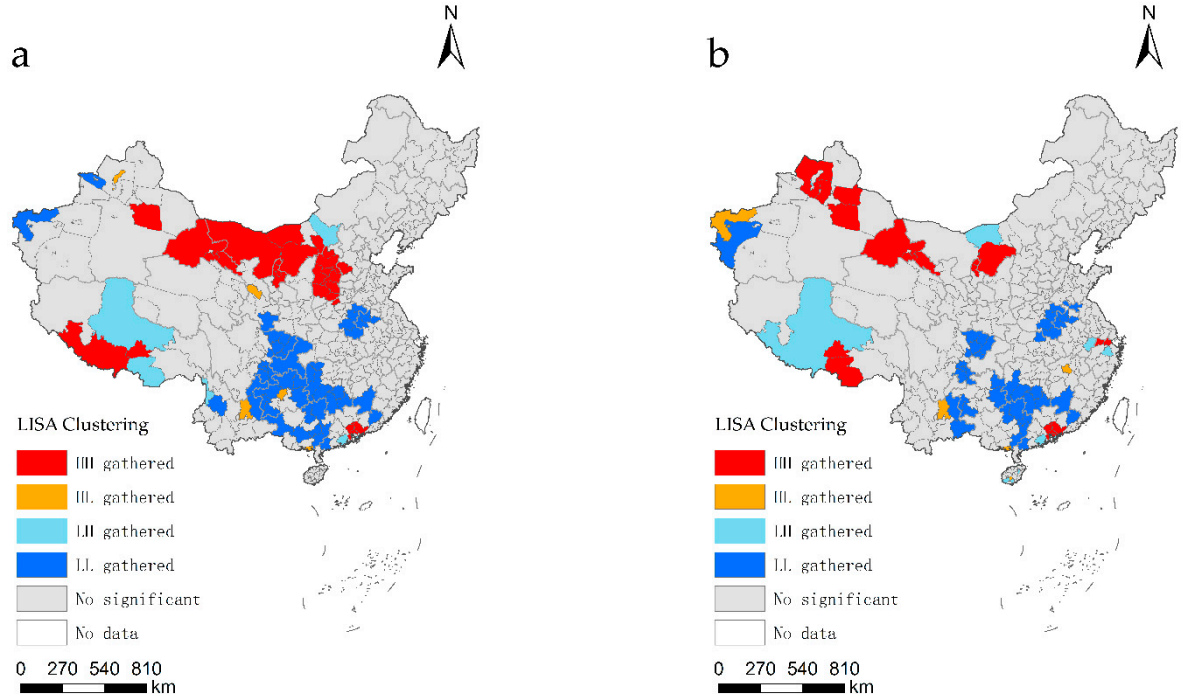

Figure 7. LISA Clustering of per capita internet attention for torrential rain. (Note: (**a**) the internet attention of Shanxi Province; (**b**) the internet attention of Henan Province). (The map is based on the standard map of the Technical Review Centre for Maps of the Ministry of Natural Resources (review number: GS (2019) 1822), with no modifications to the base map).

The low–high concentration area of internet attention to the torrential rain in Shanxi is mainly the city of Ulanqab in the Inner Mongolia Autonomous Region, Jiangmen in Guangdong Province, the Dehong Dai Jingpo Autonomous Prefecture in Yunnan Province, and Shannan and Nagchu in the Tibet Autonomous Region, where the internet attention is significantly lower than that of the surrounding cities; the low–low concentration areas mainly include cities in southern Henan Province, south–central Hunan, eastern Sichuan, Guizhou, Yunnan, and most cities in Guangxi. The low–high concentration areas of internet attention for the torrential rain in Henan are mainly Bayannur in Inner Mongolia Autonomous Region, Shaoxing in Zhejiang, Xuancheng in Anhui, Jiangmen in Guangdong, Anding and Ledong in Hainan, and Shigatse and Nagqu in Tibet. The distribution of low internet attention–low concentration areas has a great similarity to the internet attention in Shanxi.

3.3. Analysis of the Factors Influencing the Internet Attention of the Flood Situation in Shanxi and Henan

The internet attention of the Shanxi and Henan floods is a reflection of the public's concern for public emergencies. Relevant studies have shown that the internet attention of public health emergencies is related to the level of regional economic development, the size of the population, the distance between the two regions, the penetration rate of the Internet, and the severity of the events. This study combines the spatial and temporal distribution characteristics of the network concern of the Shanxi torrential rain and the Henan torrential rain and concludes that the influencing factors affecting the network concern of the Shanxi and Henan torrential rain include the level of economic development, population factors, the degree of network development, and spatial distance. Considering the accessibility of the data, this paper selects the relevant data in 2018 to analyze its influencing factors. The details are as follows: the scale of GDP and GDP per capita of 31 provinces (autonomous regions and municipalities directly under the central government) across the country are selected as indicators of the level of regional economic development, the number of

people in junior high school, high school, college, and above in each region are selected as indicators of literacy, the number of people in the age groups below 14, 15~64, and 64 and above are selected as indicators of age structure, the Internet penetration rate is selected to measure a region's Internet development, and the distance between the capital city of Shanxi Province and the capital city of Henan Province and the capital city of each province in China were obtained using the Baidu Map as indicators of geographical distance. Pearson correlation analysis was done using SPSS21.0 (International Business Machines Corporation, Armonk, New York, United States) to correlate the internet concern of the torrential rain in Shanxi and Henan with each influencing factor, and the results are shown in Table 3.

Table 3. Analysis of influencing factors of per capita internet attention.

Influencing Factors			Shanxi		Henan	
			Pearson Correlation	**Significance (Bilateral)**	**Pearson Correlation**	**Significance (Bilateral)**
Regional Economy Level of development	GDP size		0.699 **	0.000	0.949 **	0.000
	GDP per capita		0.481 *	0.019	0.487 **	0.005
	Population size		0.599 **	0.000	0.859 **	0.000
Socio-demographic Statistical characteristics	Education level	Junior High School	0.591 **	0.000	0.806 **	0.000
		High School	0.622 **	0.000	0.835 **	0.000
		Tertiary and above	0.758 **	0.000	0.920 **	0.000
	Age structure	Under 14 years	0.500 **	0.004	0.737 **	0.000
		15–64 years	0.612 **	0.000	0.850 **	0.000
		65 years and over	0.555 **	0.001	0.780 **	0.000
Internet development Extent	Internet penetration rate		0.474 **	0.007	0.475 **	0.007
Spatial distance	Geographical distance		−0.421 *	0.20	−0.381 *	0.038

Note: ** Significantly correlated at the 0.01 level (bilateral); * Significantly correlated at the 0.05 level (bilateral).

On the one hand, the factors influencing the online attention of the Shanxi and Henan torrential rain were consistent, with all 11 indicators selected in the paper passing the significance test (Table 3).

(1) The GDP size, population size, literacy level, age structure, and Internet penetration rate are all significantly and positively correlated with the Internet concern for the torrential rain in Shanxi and Henan at the confidence level of $p < 0.01$. GDP per capita is positively correlated with the Internet concern for the torrential rain in Shanxi at the confidence level of $p < 0.05$. This indicates that the higher the economic level, the larger the population, the higher the quality of the population, and the better the Internet informatization, the higher the concern for the torrential rain in these two provinces. This indicates that the higher the economic level, the larger the population and the better the quality of the population, and the better the network informatization, the higher the level of concern about the torrential rain in these two provinces. This is in line with the characteristics of the distribution of network concern in each province analyzed in the previous section, and the provinces in the eastern region with the highest level of network concern are both economically and populated provinces, such as Shandong, Jiangsu, Zhejiang, and Guangdong, and their per capita education level is also higher than that in the central and western regions.

(2) The distance between the two places and the online attention of the sudden torrential rain in the two provinces showed a negative correlation at the confidence level of $p < 0.05$, with the correlation coefficients of −0.421 and −0.381, respectively. It can be seen that the further the distance from Shanxi and Henan, the lower the online attention of the sudden torrential rain. For example, Hainan is 1991.8 km and 1670.6 km away from Shanxi and Henan, respectively, and its internet attention is 160 and 632, respectively, while Shandong is 426.5 km and 379.9 km away from Shanxi and Henan, respectively, and its internet attention is 900 and 6794, respectively, indicating that

the internet attention of Shanxi and Henan torrential rain is in line with the law of distance decay.

On the other hand, the influence of the regional economic development level, the population size, the literacy, the age level, the network development, and the spatial distance on the online attention to torrential rain in Henan is much higher than the influence on the attention to torrential rain in Shanxi (Table 3); in terms of population size, the resident population of Shanxi was 35.02 million at the end of 2018, while the resident population of Henan was 98.64 million, which is 2.8 times higher than the former. In terms of geographical location, Henan is located in the Central Plains region and is the central province of China (Figure 2), which plays a role in transport linking east to west and north to south, while Shanxi is located on the Loess Plateau and there are no railways in the province that affect national transport; in terms of the order of the sudden outbreak of events, torrential rain in Henan precedes torrential rain in Shanxi, and the public's attention to the torrential rain in Shanxi is influenced by the torrential rain in Henan. This can be seen from the temporal distribution of online attention to the Shanxi and Henan torrential rain across the country and provinces analysed in the previous section.

3.4. Limitation of the Study

This study also recognizes certain limitations: only two representative keywords, namely "torrential rain in Shanxi" and "torrential rain in Henan", were selected for the study, but it is still debatable whether they have the online attention of all Internet users; moreover, only the Baidu index platform was used as the only source of data acquisition, without involving data from other online social media such as Sina Weibo and WeChat, so the scope of coverage is limited and future research should be conducted in conjunction with more diversified media channels.

4. Conclusions

The disasters brought about by the extraordinarily heavy rainfall in Henan and the heavy rainfall in Shanxi have aroused widespread concern across the country. Based on the Baidu index, this study examines the characteristics of the spatial and temporal distribution of Internet attention to the heavy rainfall in Shanxi and the heavy rainfall in Henan and the influencing factors.

In the context of public emergencies, online attention has become increasingly important for the government to prevent, control, and manage online public opinion. In this paper, we systematically study the geographical distribution patterns of online attention in Shanxi and Henan based on the Baidu index of torrential rain 2021 using GIS technology, the geographic concentration index, the coefficient of variation, and Moran's I index.

It is found that (1) the daily internet attention of Shanxi torrential rain and Henan torrential rain shows an inverted "V" type of a unimodal peak, and most of the provinces with a higher attention to the Shanxi torrential rain network are those with coal trading with Shanxi; the provinces with higher attention to the Henan torrential rain network are mainly the coastal economic provinces and neighboring provinces (Shandong, Shaanxi, Zhejiang, Guangdong, etc.). (2) In terms of spatial distribution, Shanxi's storm water internet attention shows a lower spatial positive correlation, with a high and higher attention concentrated in coastal provinces and northwestern provinces; Henan's storm water internet attention also shows a lower spatial autocorrelation, with high–high concentration areas distributed in the area around Jiangsu and Zhejiang and the Pearl River Delta, while most other cities are not sufficiently concerned about the matter. On the whole, the eastern region pays high attention to the occurrence of heavy rainfall floods in both Shanxi and Henan, while the central and western regions pay more attention to the sudden rainfall disaster events in the two provinces. (3) The spatial and temporal distribution pattern of sudden torrential rain internet attention is affected by the combination of regional economic development level, population size and quality, Internet penetration rate and distance, etc. GDP size and

population literacy have a significant enhancing effect on the spatial pattern of internet attention.

With the rapid development of online media, news about sudden public events can quickly spread throughout the country and even the world, among which there are inevitably some false and exaggerated fake news, which will have an impact on the development of online public opinion in a good direction. If the government and media departments do not pay enough attention to online public opinion and do not guide and respond to public opinion in a timely manner, it will be extremely easy to form online public opinion crisis events and aggravate the harm caused to people by disaster events, so it is important to study the online attention of sudden public events for the government to deal with the issue of online public opinion.

In the face of sudden public events, Internet users tend to obtain relevant information from the Internet and express their own opinions. Therefore, it is important to fully grasp the characteristics of the interaction of various influencing factors in the development of online public opinion on sudden public events, use comprehensive analysis and mathematical models, and combine geographic software to analyze online attention, so as to provide guidance for the development of a continuous improvement of online public opinion monitoring system on sudden public events in the future.

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