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Determination of effective management strategies for scenic area emergencies using association rule mining

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ABSTRACT

Appropriately handling unexpected events during the construction, development, and operation stages of scenic areas and ensuring the personal and property safety of tourists are the primary problems faced by scenic managers. An important feature of scenic area emergencies is that they are prone to evolve into various secondary and derivative disasters, affected by natural and social uncertainties. Although different types of scenic area emergencies are unique, they all experience the process of occurrence, development and evolution of events, and the corresponding emergency activities have similarities. In the course of emergency management, if we can grasp the common law and select the appropriate coping strategies, it will be conducive to deal with the emergency in a scientific way. This paper firstly collected the typical emergencies in all kinds of scenic areas all over the world, classified the event scenarios, and summed up the evolution mechanism and coping strategies in different stages. Then the association rule mining was used to explore the strong association rules between the emergency mechanism and coping strategies. Finally, it is concluded that most scenic area emergencies have complex strong association rules, and the mechanism of occurrence coupling and transmission spreading is the most common. For this reason, the resistance strategy, isolation strategy, and superimposition strategy of reform and domination are the best strategies to deal with scenic area emergencies.

1. Introduction

With the improvement of people's quality of life, tourism is developing more and more rapidly. In this paper, “scenic areas” refer to travel destinations, which can be made up of natural gifts and artificial construction, for meet the needs of the tourists or as places where tourists travel to in order to experience particular features or experiences [1]. Forest parks, theme parks, national parks, zoos and other kinds of tourist areas, with beautiful natural scenery and humanistic characteristics, provide people with places to visit, have a leisurely vacation, and receive national education. At the same time, there are also various dangers and safety risks. Nowadays, scenic areas have Safety Manuals, Standard Operation Procedure (SOP) and Emergency plans to deal with daily risks and routine safety incidents. However, the possible evolution trend and possibility of emergencies in scenic areas cannot be predicted and the secondary and derivative disasters caused by emergencies are often underestimated. Therefore, it is impossible to adopt timely and effective disposal measures to prevent the deterioration and aggravation of emergencies. The consequences are often catastrophic, and not only negatively impact tourists, but also impact the scenic spot managers, local governments and relevant tourism departments.

The emergencies include natural disasters such as earthquakes, floods and mudslides; accidents caused by vehicles or entertainment equipment; incidents of over-crowding and trampling arising from exceeding the maximum capacity of the scenic areas; drowning, falls and other accidents. On the one hand, these events endanger public safety and cause negative social impact; on the other hand, they seriously

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affect the daily business activities of the scenic area and not conducive to the sustainable development of natural ecology. With the growth of the amount of tourists and the development of emerging risks in various scenic areas, the loss caused by emergencies is also increasing year by year, which brings difficulties to the safety management of scenic areas.

Emergency management has formed a relatively perfect scale system after more than 40 years of development, however, specific emergency management in scenic areas is still underdeveloped. Although the amount of injuries or deaths in scenic areas for various reasons is increasing every year, there remains a lack of systematic strategies to deal with emergencies and reduce losses. On the basis of classifying the cases of emergencies in scenic areas across the globe, this paper dedicated to finding the common law of cases and coping strategies in different stages. In this process, association rule mining were used as an innovatively method.

2. Literature review

An extensive literature review of security incidents in scenic areas and construction of scenic area emergency database was conducted in order to understand the key points of scenic area security research.

2.1. Progress of scenic area safety research

After the Second World War, with the increase in people's income and the changes of consumption concepts, mass tourism was on the rise, and the construction of various scenic spots were booming. In the 1960s, the global tourism industry suffered a heavy blow due to the worldwide energy crisis. The International Tourism Studies Association (ITSA) began to pay attention to the crisis, and introduced the disaster topic in tourism science research [2]. Since the 1990s, with the acceleration of economic globalization, the construction of scenic spots has surged once more. Complex terrain and unstable climate environment are the keys to attracting tourists, but they also carry risks and dangers, which make accidents more likely. In the face of the increasing number natural disasters and the rise in number of accidents involving tourists, scholars from all over the world have increased the in-depth study on the safety of tourists.

Current researches are focused on the investigation of the security situation and existing risks of scenic areas. As most scenic spots are located in mountainous forest areas, forest fires present the greatest risk. Abdul Mukti et al., (2016) developed a forest and land fire vulnerability map of Alas Purwo National Park on the basis of spatial-based variables [3]. In addition to the study of specific disaster risks, the individual perception of risk research has also been paid attention to. If tourists feel that a particular destination is dangerous, the image of the scenic area shall be affected and tourists may also send this negative message to others. The research by Ilangkeeran Bithushan and others aimed to identify the factors influencing the tourism risk in the Jaffna Keerimalai sea area. They used both qualitative and quantitative methods to analyze and found that the risk for tourists may affect revisits and recommendation [4]. Semi-structured interviews and self-administered questionnaire were used to investigate the perceived risks of tourists, employees, tour guides and administrators [5–8].

Based on the analysis of the current security situation of scenic areas, research in China focuses on the following aspects: The first is disaster risk and prediction [9–11]. Secondly, from the perspective of tourists [12]. LIU Qiuping et al. (2015) explored the crowding of tourists in open scenic areas in the city and the impact of crisis on tourists' perceived accessibility through field investigation, on-site interview and GPS path tracking.

The third part is the study from the perspective of accidents, such as CAO Hui (2013), who used panel data to formulate statistics on the tourism safety accidents and their main characteristics in forest park scenic areas from 2002 to 2011 [13]. Based on the statistics of the characteristics of tourism activities in forest parks, the trend of safety accidents is forecasted by Analytic Hierarchy Process (AHP).

The studies above mainly focus on a particular scenic spot or choosing a single type of scenic area for risk horizontal comparison or safety accident statistics. The research methods include comprehensive evaluation, field research, interviews or questionnaire surveys. The conclusion has certain reference value, but it is not enough to provide reference for all types of emergency response strategies of every scenic area.

2.2. Research of scenic area emergency database

Emergencies events have the characteristics of unexpectedness, harmfulness, complexity and so on. Although each emergency possesses its own unique environmental factors and the law of development, different events also share common characteristics. In order to obtain empirical knowledge from similar emergency disposal, the case-based reasoning, emergency strategy information processing, case base construction and other methods emerged. The construction of emergency case database belongs to the construction of basic resources, which is oriented to the needs of emergency management. A large number of "unstructured" and "semi-structured" data regarding emergencies are "structurally" processed. From one aspect, we can easily grasp the occurrence and development of all kinds of emergencies at home and abroad accurately and comprehensively, obtain temporal distribution of all kinds of emergencies, analyze the evolution trend in-depth, so as to improve people's ability of collecting information, conducting risk assessments and releasing information on emergencies. On the other hand, it can provide scientific data basis for relevant departments of local governments at all levels to enable them to formulate emergency strategies and make timely decisions, which is conducive to improving the emergency response and disposal ability of command and decision-making departments, as well as generating emergency decision-making plans rapidly and comprehensively. CHEN Zuqin, SU Xinning et al. (2014) put forward the method of constructing an emergency response strategy database based on emergency scene partition. The strategy is clustered by the similarity of scene areas corresponding to the strategy, and the strategy pattern is divided. Then the strategy under the same mode is evaluated and optimized to form the optimal strategy under each policy class, which can be reused for the emergent events that are suitable for the new policy pattern [14].

There are also many studies that have formulated statistical analysis based on the past records of emergencies of a scenic area [15–17]. For example, the study on 609 significant backcountry accidents that occurred in remote areas of the Grand Teton National Park from 1950 to 1996. Researchers made an in-depth overview of the current accident trend from 1994 through to 1996, which includes a male and female accident profile, cause and location summary, cost analysis, and other information. It is of great significance for identifying risks and preventing future accidents. Equally significant is the study based on the data from Yosemite Search and Rescue Patient Care Reports from 2000 to 2009. They investigated the gender of patients, details of injury events, accident factors, etc. and put forward preventive measures to mitigate potential future risks. Cara Cherry et al. (2018) analyzed narrative case incident records from law enforcement regarding bison-human encounters in Yellowstone during 2000–2015. Data regarding demographics, personnel activities, number of participants, types of injuries, and safety distance were extracted from the records, and the high-risk behaviors leading to injury were evaluated. Fransiskus A.C Waku Moan and Tjipto Suwandi (2015) researched accidents which occurred involving staff at Komodo National Park during 2009–2014. They aimed to determine the cause of the accidents through descriptive qualitative research. The direct causes of accidents were that staff members did not comply with standard operating procedures and did not use personal protective equipment. The secondary reason is the lack of occupational health and safety training and regular supervision. In addition to procuring information regarding injured people from relevant authorities, accident investigation reports are usually the most effective way to obtain detailed information about the accident [18]. Travis W. Heggie (2008) examined search and rescue operations from National Park Service units in Alaska during 2002. By analyzing the types of accidents and rescue operations, it is concluded that the search and rescue operations in Alaska can be expensive and result in severe health consequences. Moreover, the preventive education work in park tourist centers and camps should be continued [19].

Similar studies have actually formed a case database, but they are limited to a single object and a single type of event, while they focus on the description of incident injury, and less on emergency strategies.

In this study, we selected many types of emergencies in various scenic areas all over the world as the research object, which made up deficiency of single research object in the study of scenic area emergency strategy. Furthermore, we used the association rule mining technology to analyze the strong rules of scenic emergencies. The results will enable scenic managers, governments and tourists to choose the best strategy when they encounter similar emergencies.

3. Application of association rules

Association rules reflect the interdependence between an object and others. If there is a certain relationship between multiple objects, it is possible to predict one of them through other objects [20]. The most typical application of association rules is Market Basket Analysis, which can grasp customers' buying habits by analyzing the goods they put into their baskets. Currently, association rules have been applied in marketing, e-commerce, case analysis, risk management and other fields [21].

Ahmad Mirabadi and Shabnam Sharifian (2010) applied association rule mining technology to analyze approximately 6500 accident records from the Iranian Railway from 1996 to 2005, in order to discover and reveal unidentified relationships and patterns between data [22]. Similarly, M. V. Sarode et al. (2016) analyzed the association rules of Indian traffic accident data sets. They analyzed 155 accident cases, selected 13 attributes related to traffic accidents, and identified which factors were more likely to lead to accidents through association rules [23]. Similar, Chengcheng Xu et al. (2018) collected the annual reports of road traffic accidents issued by the Ministry of Public Security of China from 2009 to 2013, selected 126 reports of serious casualties, made descriptive statistics from driver characteristics, vehicle conditions, road conditions and environmental conditions. Association rule mining technology was used to further reveal the causes of accidents, in order to formulate effective policies, measures and projects, and reduce the occurrence of major casualties [24].

In addition to accident analysis in the traffic field, CHENG Chingwu (2009) used the association rule mining to analyze 1347 accidents in Taiwan's construction industry from 2000 to 2007. The research results can assist the administration to formulate effective safety policies for management faults and staff training [25]. Milad Doostan and Badrul H. Chowdhury (2017) proposed a method for fault analysis of distribution facilities using association rules mining. According to its potential causes, the fault is characterized and the important variables that strongly influence the fault frequency are identified. Compared with the basic statistical analysis methods, the application of association rules describes the subtle factors leading to failure [26]. Xibin JIA et al. (2018) used association rules to analyze users' cross-domain emotional data. By studying strong association rules between domain-shared words and domain-specific words in the same domain, they established indirect mapping relationships between domain-specific words in different domains, so as to un-earth users' interests and attitudes towards products and provide useful information to customers, companies and experts for systematic decision-making [27].

Applying the association rule method to accident case analysis can uncover potential causes and effects among many influencing factors, which is comparably more scientific than the traditional statistical analysis method. However, the application of association rules to case studies of scenic areas is rare. This study improved the application of association rules to explore effective management strategies for scenic area emergencies.

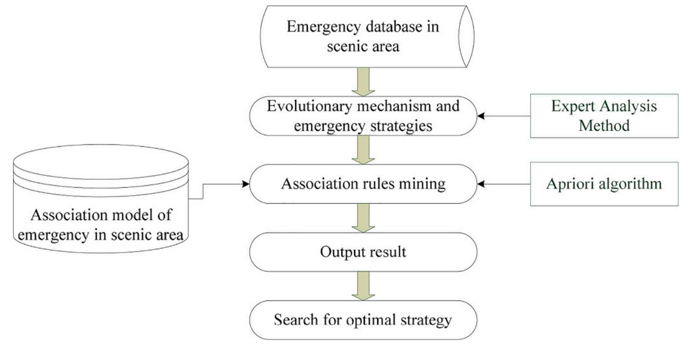

Fig. 1. Frame diagram of research method.

3. Methodology

In this paper, the main research methods are emergency mechanism and strategy combing, and association rule mining. Firstly, multi-regional, multi-object and multi-type emergencies in scenic area were selected to set up a database. According to the mechanism of event evolution in different stages of spreading, coupling and derivation, the coping strategies of events are sorted out with expert analysis method. Secondly, in association rule mining, the Apriori algorithm is used to find the frequent item sets. An association model of emergency and strategy database in scenic areas is established. Finally, analyzing the results to draw a conclusion. A general process flow of research is shown in Fig. 1.

3.1. Evolutionary mechanism and emergency strategies of unexpected events

Mechanisms refer to the internal logic of things. Research on the mechanism of unexpected events is conducive to find out the source of events and the motive force of development, so as to take the corresponding strategies in emergency management. The evolution mechanism of emergencies includes spread mechanism, coupling mechanism and derivation mechanism.

Spread refers to the occurrence of similar incidents caused by the original event. It should be noted that new events are the same type as the original ones, such as a fire in a building that causes a fire in a nearby building. The spread can be an expansion of the spatial extent or the impact time.

According to the causes of the spread, emergencies can be divided into two types: occupancy types and transitive types. Occupancy type refers to original things which occupy the time or space of other similar things. The reason for this mechanism is that the total capacity is limited, the demand for the same resource for all things cannot be met, and the original thing is disturbed. In response to this, the capacity expension strategy, adjustment strategy and abandonment strategy will be adopted [28].

(1) **Capacity expension strategy.** This refers to increasing the amount of resources required by original things and similar things in common. When the amount of resources increases, the things that can be accommodated per unit time increases, which will reduce or no longer occupy the time of the former things occupying the latter things.
(2) **Adjustment strategy.** It is an adjustment to optimize the chronological or spatial location of the original event and spread event to maximize buffer time or make better use of resources. With the

using of buffer time and alternative resources to meet the needs of things, the extent of spread can be reduced.

(3) **Abandonment strategy.** This involves removing several things from the space-time sequence of the original or spread event in order to reduce the number of things that consume resources. The essence of abandonment strategy is to increase buffer time.

Transitive spread refers to the effect of the original things transmitted to the associate things through the material, energy or information. The condition is that things can be connected through media. Transitive spread will be prevented by the isolation strategy, resistance strategy and dredging strategy.

(1) **Isolation strategy.** This entails isolating the original thing from the latter thing, to ensure that the function of the original thing cannot affect the following things.
(2) **Resistance strategy.** This refers to that during process of spreading, weaken the impact of the event by reducing the energy transmitted to the latter things or increasing the resistance ability of the latter things.
(3) **Dredging strategy.** This involves reducing the energy of the original things transmitted to other things by allowing this energy transmission.

Coupling stage is a phenomenon in which two or more factors interact and influence each other, eventually leading to emergencies or causing emergencies to become more severe. When the coupling factor increases the energy of the disaster source and reaches a critical value that can trigger an event, it will lead to an emergency. For an emergency that has already occurred, when the coupling factor increases, the incident will be more serious. According to the characteristics of coupling objects, it can be divided into three types: event-event coupling, event-factor coupling and factor-factor coupling. The difference between the factors and the events mentioned here is that the factors themselves are not harmful, and the events are harmful. According to the role of the coupling object, it can be divided into four types: occurrence coupling, acceleration coupling, aggravation coupling and transformation coupling. The isolation strategy, insurance strategy (including the proofreading strategy, sequential strategy, conformity strategy, buffer strategy), hedging strategy, domination strategy, reform strategy and transition strategy will be adopted to cope with the coupling of events [29].

(1) **Isolation strategy.** This involves isolating the coupling factors from their objects to avoid the factors affecting one another. It includes spatial isolation, time isolation, media isolation etcetera. Unlike the isolation strategy in the spread mechanism, which isolates two specific things, the isolation strategy here aims at avoiding factors.
(2) **Insurance strategy.** The insurance strategy includes the proofreading strategy, sequential strategy, conformity strategy and buffer strategy. 1) Proofreading strategy: This is a means to avoid errors by adding a verification procedure in each step of an event, so as to eliminate the factors caused by various errors. 2) Sequential strategy: This refers to the joint or sequential execution of more than two actions to complete the work. 3) Compatibility strategy: This uses different measures of shapes, mathematical models, and quantities to prevent human error. 4) Buffer strategy: It means to reduce the possibility of error by adding time buffers or a forced buffer.
(3) **Hedging strategy.** Hedging strategy refers to applying a neutralization reaction to counteract the effect of coupling factors.
(4) **Domination strategy.** This uses a certain inhibitory factor to inhibit the role of factor and its target.
(5) **Reform strategy.** The reform strategy refers to changing the state of characteristics of the factor itself, including the structure, energy, speed and other attributes, so that the factor cannot exert a coupling effect.
(6) **Transition strategy.** This involves changing the environment of factors, so that the factors cannot take effect.

Emergency derivation refers to the measures taken to deal with an emergency leading to other harmful events. It emphasizes the subjective of human coping and the negative effects of the influence.

According to the effect of response measures on derivative events, it can be divided into two types: excessive derivation and harmful derivation of measures. The excessive derivative of measures is that the excessive response of the original events lead to new hazard events. The domination strategy or neutralization strategy should be implemented for excessive derivation of measures [30].

(1) **Domination strategy.** The domination strategy in derivation stage involves controlling the speed, degree or quantity of response measures to prevent excessive measures from being taken. The domination strategy in the coupling mechanism is to control the interaction of coupling factors, but the control strategy in the derivation mechanism is to prevent excessive response measures.
(2) **Neutralization strategy.** This refers to the use of another measure to neutralize or buffer the destructive power of excessive coping strategies.

The elimination strategy or pre-evaluation strategy should be adopted to restrict harmful derivatives of measures.

(1) **Elimination strategy.** The elimination strategy refers to the adoption of other measures to eliminate the harmful effects of response measures. It can take the following forms: the strategy acts on the response measures directly to reduce their harmfulness; the strategy adopts a protective role on the disaster bearing body of derivative events; and the strategy adopted acts on the original emergencies to prevent them from evolving into new ones.
(2) **Pre-evaluation strategy.** If eliminating the derivative effect of harmful strategies is impossible, only the pre-evaluation strategy can be adopted to gage the hazards caused by adopting or not adopting the counter measures, to then decide whether to implement the measures or not (Table 1).

3.2. Association rule mining

Through association rules, we can identify an implicit association relationship between the items in the data set. Let $I = \{I_1, I_2, \ldots I_n\}$ be a set of binary attributes, called items. Item sets containing k items are

Table 1
Evolution mechanism and coping strategies of emergencies.

Mechanism			Strategies
spread mechanism	occupancy type		capacity expension strategy adjustment strategy abandonment strategy
	transitive type		isolation strategy resistance strategy dredging strategy
coupling mechanism	type	event-event event-factor factor-factor	isolation strategy insurance strategy domination strategy
	effect	occurrence acceleration aggravation transformation	reform strategy hedging strategy transition strategy
derivation mechanism	excessive type		domination strategy neutralization strategy
	harmful type		elimination strategy pre-evaluation strategy

called k-length item sets. The correlation A→B is defined as an association rule, where A is the antecedent of association rules and B is the consequent, $A \subseteq I$, $B \subseteq I$ and $A \cap B = \emptyset$ [31,32].

The support (S) of association rule A→ B, refers to the probability that event A and event B occur simultaneously. That is, the proportion of the transactions that contain both items of A and B in the total transactions, as follows:

$$S(A \rightarrow B) = \frac{\sigma(\{A, B\})}{D} \tag{1}$$

Among them, D is the data set, σ is the frequency.

Confidence (C) is defined as the probability of occurrence of event B based on the occurrence of event A. The proportion of transactions that contain both A and B in those transactions that contain A. The formula is as follows:

$$C(A \rightarrow B) = \frac{\sigma(\{A, B\})}{\sigma(A)} \tag{2}$$

Lift (L) is defined as the ratio of *confidence* to support, which reflects how the occurrence of event A affects the probability of event B. The formula is as follows:

$$L(A \rightarrow B) = \frac{C(A \rightarrow B)}{S(A \rightarrow B)} \tag{3}$$

When $Lift = 1$, events are independent and unrelated. When $Lift > 1$, the event A has positive correlation on B, and the higher the value, the greater the correlation between item sets; when $Lift < 1$, the event A has a negative correlation on B.

Leverage represents the proportion of instances that are both covered by the antecedent and the consequent over the expected value, under the assumption that the antecedent and the consequent are statistically independent.

$$Leverage(A \rightarrow B) = P(A \cap B) - P(A)P(B) \tag{4}$$

If event A contains k elements and satisfies the minimum support, event A is called frequent k-length item set. Support is a measure of the importance of the association rule, indicating the frequency of the association rule; *confidence* is a measure of the accuracy of the association rule, indicating the strength of the rule [33]. When the support and confidence of the rule are not less than the user setting, the obtained rule is a strong association rule as the follows.

$$Strong\ rule\ (A \rightarrow B) = \begin{cases} S(A \rightarrow B) \geq Minimum\ support \\ C(A \rightarrow B) \geq Minimum\ confidence \end{cases} \tag{5}$$

According to the collection of emergencies in scenic areas, the evolution processes of emergencies under different coping strategies are analyzed, and the strong association rules among them enable the establishment of a strategy database related to emergencies. This is achieved by using the Apriori algorithm with frequent item sets and an iterative method called layer-by-layer search. The fundamental idea is to scan case records, starting with frequent item sets containing only one item, which are recorded as L_1, obtain candidate 2-item sets C_2 by self-joining and pruning. Then L_2 is obtained by scanning the data sets. And L_2 is used to obtain L_3 … until no more frequent item sets can be found. Finally, strong rules are found in all frequent sets. For example, suppose that the mechanism and coping strategies of five scenic area emergencies are as follows in Table 2:

Minimum support is set as 0.9, and the Apriori algorithm is executed as follows:

(1) Firstly, find out the frequent item set L_1. Removing items that do not satisfy the minimum *support*, the items L_1 are obtained as shown in Table 3.

Table 2
Mechanism and coping strategies of emergencies.

Event	Mechanism and coping strategies
E1	event-factor coupling，domination strategy
E2	factor-factor coupling，insurance strategy
E3	factor-factor coupling，domination strategy + reform strategy
E4	factor-factor coupling，domination strategy
E5	event-factor coupling + factor-factor coupling，domination strategy

Table 3
The frequent item set L_1.

(2) Secondly, generate C_2 by L_1, and scan the data set to find frequent 2-item sets, remove items that do not satisfy minimum *support*, and acquire frequent 2-item sets L_2 as shown in Table 4.

Sets	Support
factor-factor coupling	4
domination strategy	4

Table 4
Frequent 2-item sets.

(3) The third step is self-joining of L_2, the candidate three item sets are empty and the algorithm ends.

Sets	Support
factor-factor coupling，domination strategy	3

The following strong association rules are obtained:
{factor-factor coupling} = > {domination strategy}
Confidence = 0.75 and *Lift* = 0.94.

3.3. Association model of emergency strategy in scenic area

The construction of the association model of the scenic area emergency strategy is obtained through the processing of the historical data of scenic area emergencies, and the establishment of the general relationship between the mechanism and the response strategy. By strong association rule mining, we are able to ascertain the connotative relationship between event mechanisms and strategies.

The specific method necessary is to pre-process the collected accident cases, screen the accident information, and classify the events and the scenarios. Then, to extract the key information from the accidents in the evolutionary stage. Based on the experts' analysis, each case can be identified whether the accident involves the spread mechanism, coupling mechanism or derivative mechanism, and which emergency strategies are used in the disposal process (there may be some mechanisms which have no corresponding strategy in the accident evolution). The sample database of emergencies for scenic areas is integrated and the data undergoes two-dimensional processing (the result is shown in supplement material). We used WEKA 3.8 Explorer to find correlation between event mechanism and coping strategy, run the Apriori algorithm operation to construct the scenic area emergency strategy model. The model is shown in Fig. 2.

4. Data and results

On the basis of establishing the association model of emergency mechanism and strategy in scenic areas, case samples are collected for data preprocessing, and association rule is mined by WEKA 3.8 Explorer.

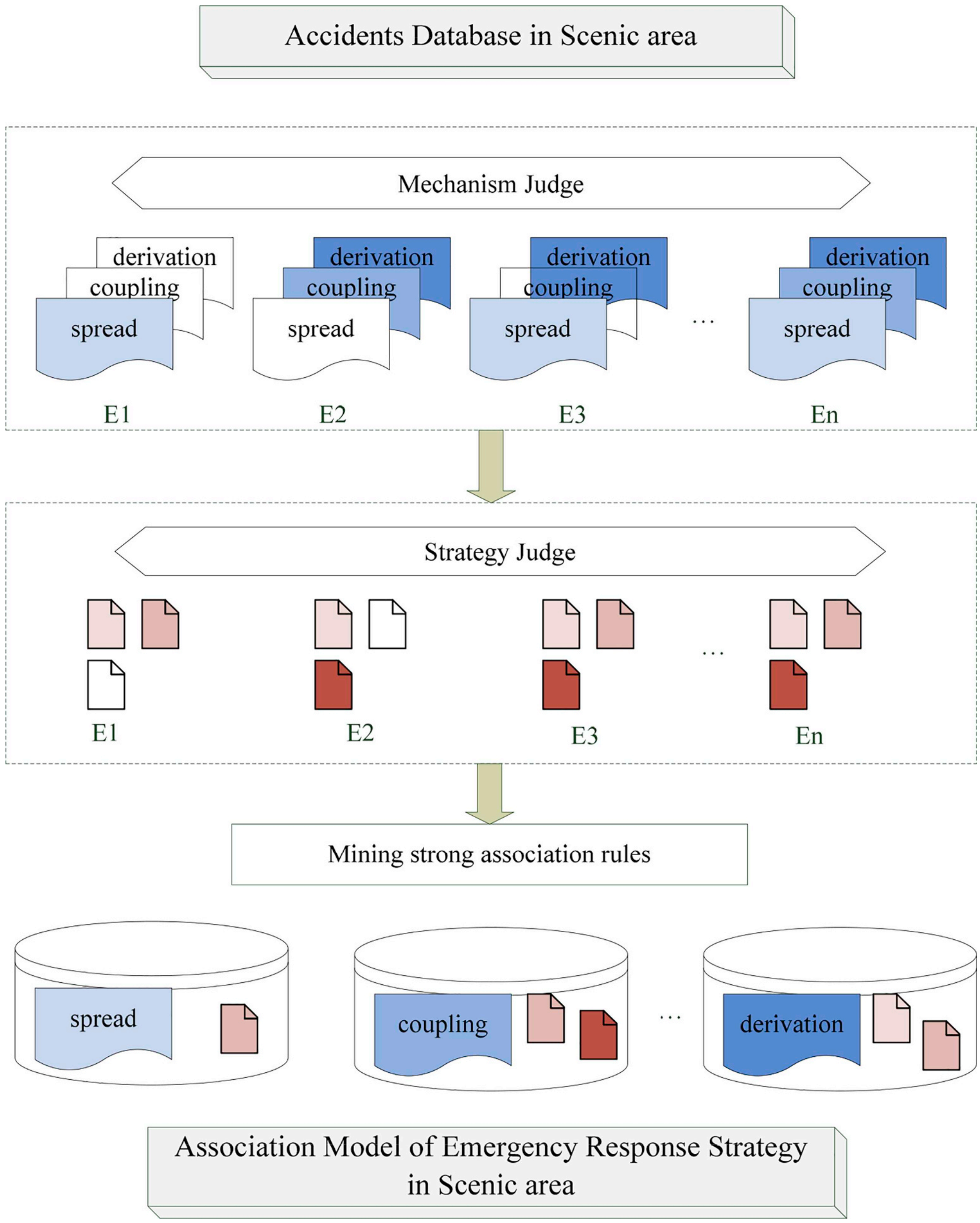

Fig. 2. Association Model of Emergency Response Strategy in Scenic area.

4.1. Data acquisition and preprocessing

By collecting 36 years of accident investigation reports from 1983 to 2018 from news websites, emergency management department and tourism websites around the world, seventy-five typical emergency cases of scenic areas were screened.

The criterion of case collection is directly or indirectly related to the security of scenic areas. The narration of event is as complete as possible and can reflect the cause, process and result of the event in detail. "Typical" means the events that occur suddenly and have great harm and wide influence. No special requirements are imposed on the administrative area where the accident is located or type of it. However, on the one hand, the description of most cases reported on the website is brief, only have the general course of the incident, without the detailed process of rescue, it is difficult to analyze the mechanism of the incident and the response measures. On the other hand, the government issued scenic accident reports are lengthy and complex, from which researchers need to extract key information for analysis. These both increase the time and difficulty of case collection.

Finally, 75 pieces of qualified cases were obtained. The scenic areas involved are located in the United States, the United Kingdom, China, Thailand, Japan, Malaysia, Singapore and various other countries. They include 9 types of accidents: traffic accidents, amusement facilities accidents, cable car accidents, natural disasters, accidents involving collapses and trampling, fire accidents, accidents involving animals attacking humans, drowning accidents and social safety accidents (Excel in supplement material). The expert evaluation method was used to assess the mechanism and strategies of events according to Table 1. The results are expressed by binary variables with the value 0 and 1. The bar graph of the types is shown as Fig. 3, and the distribution map of mechanism and strategy is shown as Fig. 4.

It is evident that among the emergencies in scenic areas, the most common types are amusement facilities accidents, traffic accidents and natural disasters, accounting for 64% of all cases. In terms of the event mechanism, the occurrence coupling is the most frequent, followed by the transitive spread and event-factor coupling mechanism. In the coping strategies, the domination strategy, isolation strategy (coupling) and insurance strategy are most frequent.

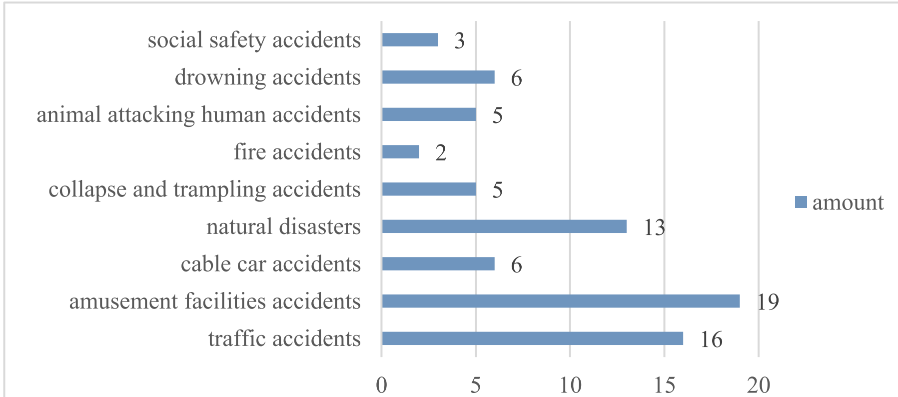

Fig. 3. Number of emergencies in different types of scenic areas.

4.2. Operational results

After transforming the emergency case data into ARFF format file and loading it into the WEKA 3.8 Explorer, the histograms in Fig. 5 can be obtained, which show the number and proportion of all attributes and related events in the data set. Each histogram shows the result of one attribute, and the column on the right means the number of events with the value 1. The column on the left means the number of events with the attribute value of 0. For instance, in the attribute of "Eve Spre Occupancy Spread" the column on the right means that there are 62 events have this mechanism, the column on the left means 13 events do not have this mechanism. Histogram is a complement to the final output

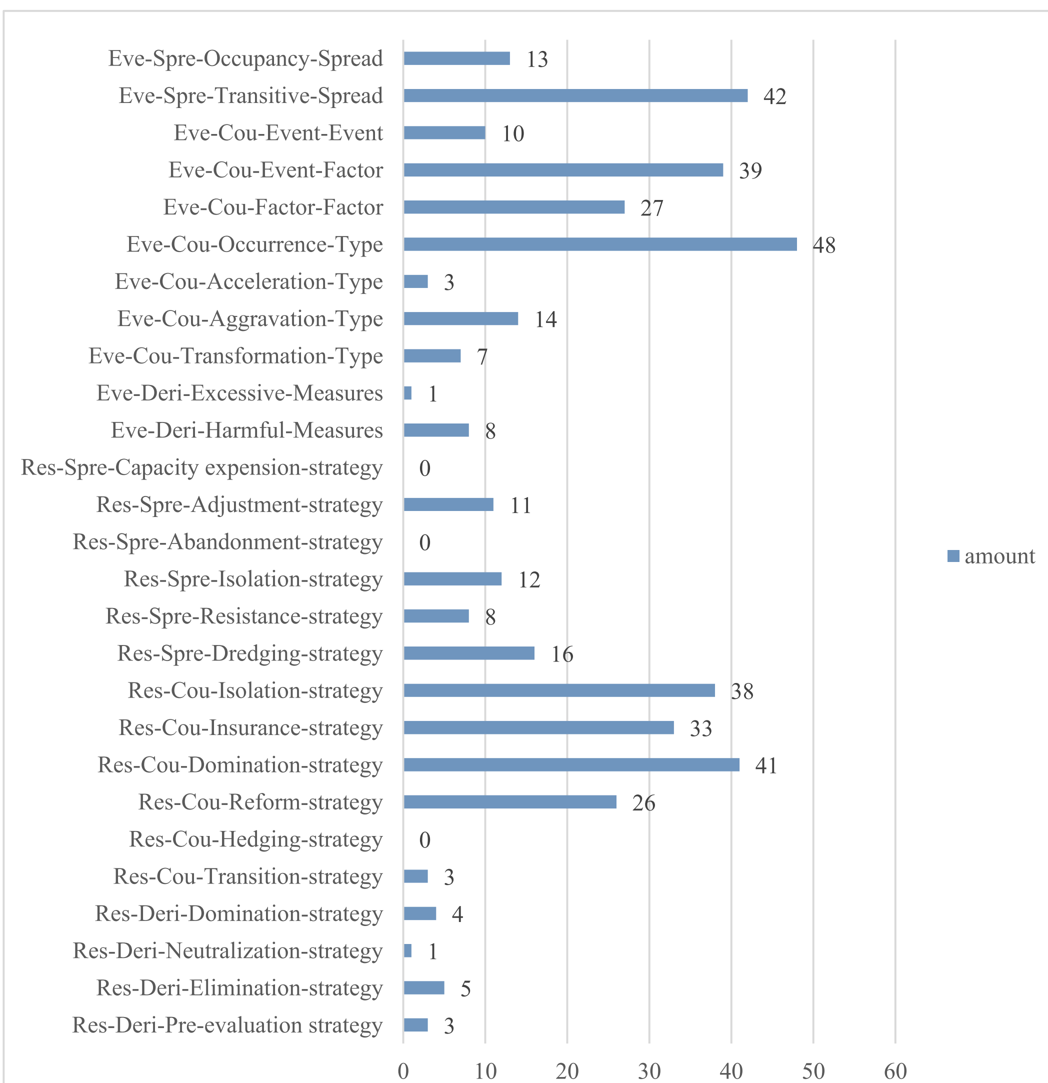

Fig. 4. Mechanism and strategy distribution chart.

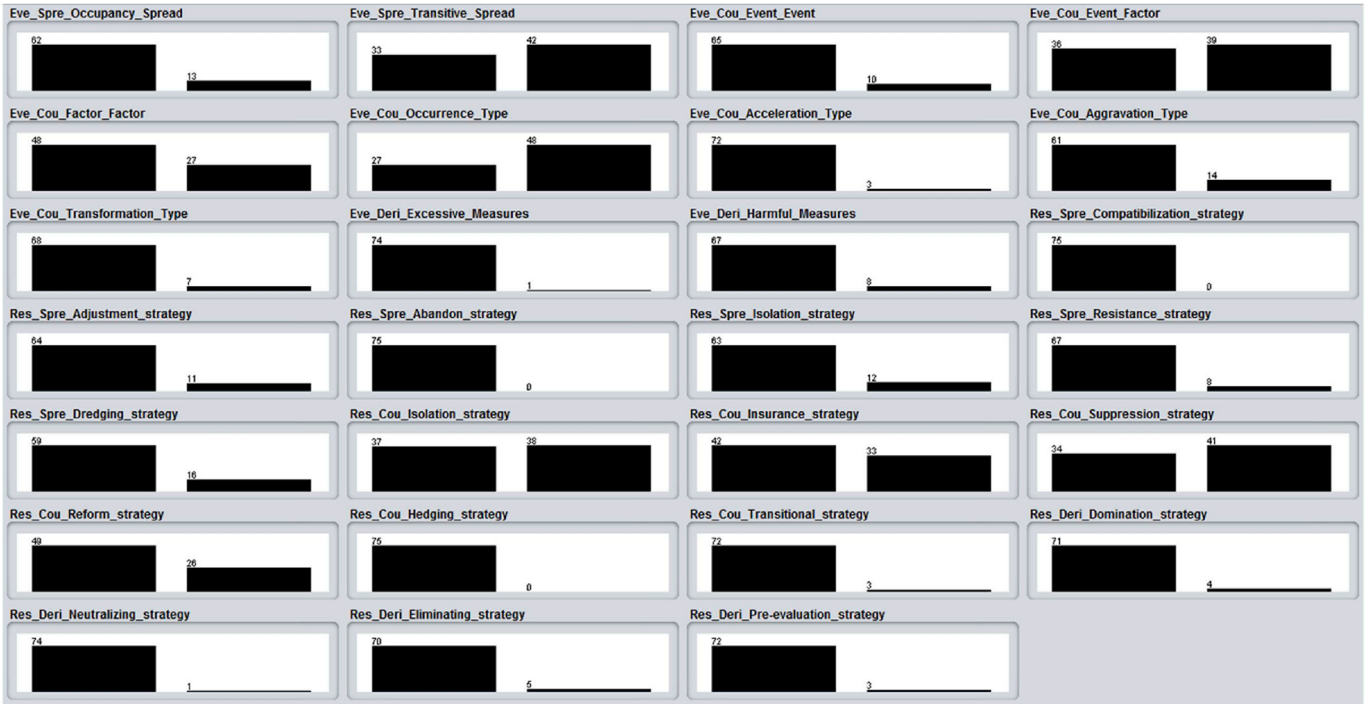

Fig. 5. Histogram of mechanism and response strategy in scenic areas.

Table 5
Strong association rules between Emergency Mechanism and Coping Strategies in Scenic Spots.

NO.	Strong association	Conf	Lift	Lev	Conv
Rule 1	Res_Spre_Resistance_strategy = > Eve_Spre_Transitive_Spread	1	1.79	0.05	3.52
Rule 2	Res_Spre_Isolation_strategy = > Eve_Spre_Transitive_Spread	0.92	1.64	0.06	2.64
Rule 3	Eve_Cou_Event_Factor + Eve_Cou_Aggravation_Type = > Eve_Spre_Transitive_Spread	0.89	1.59	0.04	1.98
Rule 4	Res_Spre_Isolation_strategy + Res_Cou_Isolation_strategy = > Eve_Spre_Transitive_Spread	0.89	1.59	0.04	1.98
Rule 5	Eve_Cou_Factor_Factor + Res_Cou_Isolation_strategy = > Res_Cou_Domination_strategy	0.89	1.63	0.04	2.04
Rule 6	Eve_Spre_Transitive_Spread + Res_Cou_Reform_strategy = > Eve_Cou_Occurrence_Type	0.88	1.37	0.05	1.92
Rule 7	Eve_Spre_Transitive_Spread + Eve_Cou_Factor_Factor = > Eve_Cou_Occurrence_Type	0.85	1.32	0.04	1.56
Rule 8	Res_Cou_Domination_strategy + Res_Cou_Reform_strategy = > Eve_Cou_Occurrence_Type	0.83	1.3	0.03	1.44
Rule 9	Res_Spre_Adjustment_strategy = > Eve_Spre_Occupancy_Spread	0.82	4.72	0.09	3.03
Rule 10	Res_Spre_Dredging_strategy + Res_Cou_Insurance_strategy = > Eve_Spre_Transitive_Spread	0.82	1.46	0.04	1.61

of association rules and help us visualize the distribution of events.

Confidence is used as a measure of ranking rules under association rules. $MinMtric = 0.85$, $NumRules = 10$, decreasing iteration value $Delta = 0.05$, upper bound minimum support $U = 1.0$, lower bound minimum support $M = 0.1$, significance level $S = -1.0$. Ten strong association rules are obtained by implementing the algorithm as shown in Table 5.

According to the 10 strong association rules, the following results are summarized:

(1) Highly strong association rules. The rules with $confidence > 1$ and $conviction > 2$ are selected as highly strong association rules. For example, Rule 1 and Rule 2 belong to strong association rules with high *confidence* and *conviction.*

Rule 1: Resistance strategy = > Transitive spread, which means that when the resistance strategy is adopted in the emergency management of scenic areas, the transitive type spreading mechanism appears in the case base. $confidence = 100\%$, $conviction = 3.52$, $Lift = 1.79$ indicates that there is a high positive correlation between the antecedent and consequent. The resistance strategy is to increase the obstruction of transmission or the resistance of affected things themselves in the process of spreading. It is a common method used to prevent the deterioration and spread of events. During scenic area emergencies, the strategy of resistance is mainly reflected in the timely rescue of the victims and the wounded to prevent the spread of hazards. For example, in the case of a tourist ship capsizing in Missouri, the staff of many institutions in Missouri used professional equipment to promptly rescue the people that fell into the water, and the medical staff dealt with the injured and sent them to the hospital for treatment. These resistance strategies are also commonly adopted during similar scenic area emergencies.

Rule 2: Isolation Strategy (Spread) = > Transitive spread. It indicates that when scenic areas adopt the isolation strategy in spread stage, there will most likely be a transitive spread mechanism. $confidence = 92\%$, $conviction = 2.64$, $lift = 1.64$, which was positively correlated. The isolation strategy in scenic area emergencies is to isolate tourists and risk sources in order to prevent more people from harm. For example, during accidents at amusement park facilities, isolation strategies involve shutting down equipment and closing scenic spots.

(2) Composite strong association rules. The antecedent is superimposed by two types of mechanisms or strategies, which have combined action on the consequent. Rule 3, Rule 4, Rule 5, Rule 10 in the table are composite strong association rules.

Rule 3: Event-factor coupling, aggravation = > Transitive spread. It indicates that the probability of the transitive spread mechanism of scenic area emergencies occurring on the basis of event-factor coupling and aggravation.

Rule 4: Isolation Strategy (Spread) + Isolation Strategy (Coupling) = > Transitive spread. It indicates that when the scenic area emergency adopts both the spread-type isolation strategy and the coupling-type isolation strategy, the transitive spread mechanism exists in the emergencies.

Confidence, *lift* and *conviction* of the both rules are the same, 89%, 1.59 and 1.98, which belong to a high positive correlation. Most of the strong association rules of scenic area emergency mechanisms and strategies belong to composite strong association rules. These types include multiple mechanisms (Rule 3, Rule 7), or multiple coping strategies (Rule 4, Rule 8, Rule 10), as well as multiple mechanisms and strategies (Rule 5, Rule 6). Due to the particularity of risk exposure in scenic areas, most emergencies are caused by a variety of risk factors, or, after these events take place, the incident will escalate with the addition of other factors. For example, adverse weather and overloading can cause cruise ships to sink; improper operation and aging of equipment can lead to tourists being injured and so on. Therefore, the cooperation and superposition of various strategies should also be considered in management.

(3) Strong association rules of occurrence coupling mechanism, that is, the rules contain strong association rules of occurrence coupling mechanism. Rules 6, 7 and 8 belong to it.

Rule 6: Transitive spread + Reform strategy = > Occurrence coupling. *Confidence* of the rule is 88%, which indicates that 88% of the sudden events in scenic areas may have occurrence coupling when transitive spread occurs and the reform strategy is adopted. *Conviction* = 1.92, *lift* = 1.37, which was positively correlated.

Rule 7: Transitive spread + factor-factor coupling = > Occurrence coupling. *Confidence* of the rule is 85%, indicating that 85% of the scenic area emergencies may have occurrence-type coupling when the transitive-type spread occurs and the coupling type is factor-factor type. *Conviction* = 1.56, *lift* = 1.32, which was positively correlated.

Rule 8: Domination strategy + reform strategy = > Occurrence coupling. *Confidence* of the rule is 83%, which indicates that the probability of occurrence-type coupling of emergencies is 83% when both the domination strategy and reform strategy are adopted. *Conviction* = 1.44, *lift* = 1.30, which was positively correlated.

Rules show that when there is an occurrence type of coupling mechanism in scenic areas, the probability of simultaneous occurrence of the transitive spread mechanism is high. For example, in 2016, the collapsing accident of the Honghai scenic spot in Pengxi county was due to the improper fixing of the steel tower and the sliding of steel rope at the top of the tower, leading to the displacement, tilt and collapse of the steel frame. At the Dreamworld theme park in Queensland, Australia, two pleasure boats collided and capsized, resulting in the death of tourists. The main coupling factor of the two accidents is the untimely troubleshooting of the projects.

(4) Strong association rules of transitive spreading mechanism. A large number of scenic area emergencies have the rule of transitive spreading mechanism, that is, after the original things are disturbed, the effect is transmitted to the related things through materials, energy or information. Among the security incidents in scenic areas, the most common phenomenon is that the energy transmitted to the tourists after the failure of the vehicles, recreational facilities or special equipment due to their own reasons or external disturbances, resulted in the personal casualties of tourists. In Table 5, rule 1, Rule 2, Rule 3, Rule 4, Rule 6, Rule 7 and Rule 10 all contain transitive spreading mechanism. For example, Rule 10: Dredging strategy + Insurance strategy = > Transitive spread. It indicates that when scenic area emergencies adopt both the dredging strategy and insurance strategy, the event evolution appears to transitively spread. *Confidence* = 82%, *lift* = 1.46, *conviction* = 1.61. It belongs to the general strong rule, and the probability of adopting the dredging strategy and insurance strategy simultaneously to cope with the transmission spread is 82%.

5. Discussion

Using association rule mining to analyze scenic area emergencies, according to the case database, it is concluded that there are discernible transitive spread characteristics of scenic area emergencies, and a superposition relationship between transitive spread and occurrence coupling. Among the types of emergencies coupling, event-event coupling and factor-factor coupling are the most common. Through the relationship between mechanism and strategies, the optimal strategies for dealing with scenic area emergencies are put forward as follows:

(1) Under the highly strong association rules, in view of the transitive spread in scenic emergencies, the strategy of resistance should be adopted. In the process of event spreading, increase the obstruction of the things to reduce energy of transmission, or increase the resistance ability of the latter things in order to weaken the impact of unexpected events. Secondly, the isolation strategy should be adopted so that the role of the original things can not affect the latter. In the emergency management of scenic areas, measures such as closing down the area, shutting down equipment and quarantining tourists are usually taken to ensure that emergency risk sources cannot affect other people.
(2) The occurrence coupling mechanism is often accompanied by transitive spread. When they both exist, it is suggested to adopt reform and domination strategies. On the one hand, the state characteristics of the coupling factor itself are changed so that the coupling effect cannot be exerted. On the other hand, some inhibiting factors are used to inhibit the transmission of energy or alter the factor itself. When dealing with emergencies in scenic areas, the domination strategy usually includes medical rescue and assistance. The reform strategy is manifested in the inspection and maintenance of accident equipment and the investigation of potential safety hazards.
(3) The isolation strategy is important in the spreading stage and coupling stage. Isolation strategies should be superimposed to separate the roles of things and factors, especially in the case of transitive spreading. In order to avoid the spread and coupling of emergencies in scenic areas, measures such as evacuating tourists, closing down the accident scene and shutting down equipment are effective isolation strategies. Secondly, attention should be paid to the overlapping of guidance strategy and insurance strategy to avoid errors, including regular inspection, the allocation of security personnel, security training before entering the scenic area, and setting up warnings and so on, which will help to reduce the security incidents in the scenic area and reduce personal and property losses.

6. Conclusion

Based on 75 scenic area accident cases, this paper divides the cases into emergency mechanism and emergency strategy evaluation, then uses the Apriori algorithm to mine association rules to explore the relationship between the mechanism and strategies in scenic areas. The study chose multi-regional, multi-type and multi-object scenic area emergencies as cases, in order to ensure that the rule more applicable and universal. The strong association rules reflected the representative law of development mechanism and coping strategies of scenic area emergencies, and provided a reference for future scenic area safety emergency management.

At the same time, there are still some shortcomings in the study. Firstly, due to the difficulty of sample collection, the number of cases is still small. In the future, we will endeavor to build a larger database to further improve the scientific nature of the analysis. Secondly, in the case text analysis stage, the expert analysis method is mainly used to analyze the event process qualitatively. In the future, intelligent text mining will be considered to automatically analyze the cases in order to improve the accuracy of case analysis. Thirdly, the study does not carry out dynamic simulation of emergencies. Based on the establishment of the emergency strategy database, the future study will attempt to predict the evolution of emergencies under different strategies by changing the boundary conditions, and carry out dynamic simulation and deduction of emergencies, so as to make predictions and provide reference for the safety management of scenic areas.

Conflicts of interest

The authors declare that there is no conflict of interests regarding the publication of this paper.

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Appendix A. Supplementary data

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