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Safety Risks of Primary and Secondary Schools in China: A Systematic Analysis Using AHP–EWM Method

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Abstract: Owing to the frequent accidents in primary and secondary schools (PSS) in China in the past decades, a systematic analysis of indicators influencing safety risks in PSS is critical to identifying preventive measures. A two-hierarchy structure of indicators was identified by analyzing various cases, intensive interviews, and related previous literature. A combination of the analytic hierarchy process and the entropy weight method was developed to synthetically assess the primary and secondary risk indicators through a case study of Ma Shan School in China. The results are as follows: (1) the primary risk indicators, namely, natural disasters, public health, facility safety, accidental injury, public security, school bullying, and individual health constitute the evaluation framework of the safety risks in PSS. (2) Public health risks and accidental injury risks are the most critical factors that should be prioritized. In addition to providing academic implications, several managerial implications are proposed for these stakeholders to reduce the safety risks in PSS.

Keywords: primary and secondary schools (PSS); safety risks; campus safety; influencing factors; preventive measures

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1. Introduction

With the rapid growth of safety risks from natural disasters and man-made accidents, the last decades have seen numerous reports of accidents in primary and secondary schools (PSS) that have posed devastating threats to school-aged children and youth [1]. In particular, they are highly vulnerable and dependent on adult care due to their physical fragility, immature mental state, and developing emotional capacity [2]. According to a World Health Organization report, most causes of death for these people aged 5–29 are accidental injury-related, including injuries from road traffic, falls, drowning, burns, poisoning, and violence [3]. For instance, a crowd stampede accident occurred at the Experimental Primary School in Puyang, China in 2017, resulting in one student dead and 22 injured [4]. A 7.5-magnitude earthquake hit Central Sulawesi, Indonesia, on 28 September 2018; more than 1500 schools collapsed and 184,000 pupils were affected [5]. More recently, the COVID-19 pandemic has led to numerous mental health problems, including anxiety, loneliness, and social difficulties, for countless students [6–9]. Casualties of schoolchildren often grab the attention of the whole family and society, resulting in social instability. Therefore, preventing the safety risks in PSS has become an issue worthy of attention.

Statistical studies on PSS have been developed to explore the frequency distributions of issues such as accident analysis, disaster causes, and demographic characteristics. Bahar [10] identified school safety as one aspect of urban safety, considering the threats to safety inside the school and its outside environment by analyzing the data collected by the Istanbul Urban Safety Project from 2008 to 2012. Hundeloh and Hess [11] summarized the key factors and characteristics of promoting school safety by emphasizing practical changes in construction and fittings, education, training, organization, and politics. Mubita [12] clarified conceptual terms such as school safety and school security based on a literature review. He illustrated school safety from the physical, psychological, social, and environmental dimensions, while defining school security as all measures taken to avoid threats to stakeholders in educational environments. Birel and Erçek [13] presented a scale on the perceptions of teachers working in PSS related to school safety. More recently, there has been increasing interest in applying Game-based learning and serious games for school safety management [14,15]. For example, Khan et al. [16] approved the positive effect of an adaptive game-based learning strategy in improving the road crossing behavior of the children. Massively multiplayer online role playing games (MMORPGs) were found to be more effective compared to lectures when motivating the students to learn [17].

Case studies were conducted to investigate the influencing mechanisms of safety risks through specific unsafe events occurring in PSS. For example, Caymaz [18] took 136 public secondary students in Kastamonu Province, Turkey as a sample to analyze their risk perception for laboratory safety by using an open-ended questionnaire. Bonell et al. [19] conducted a cluster randomized controlled trial in 40 English PSS in South East England. They found that interventions that promote student health by modifying the whole-school environment may be one of the most effective ways to address closely related risks among pupils. To understand the safety risks in school environments, a two-dimension questionnaire was conducted in the PSS of the Büyükçekmece County in Istanbul, Turkey, indicating that regulations should be revised and the risk perception level of managers on school safety should be raised [20].

Although traditional statistical studies and case studies have identified the safety risks of PSS from a qualitative perspective, few studies have evaluated these risk factors by combining qualitative analysis with quantitative methods. The safety risks of PSS are much more complex due to various multiple influencing factors rather than one single dimension. Further understanding of these influencing dimensions and finding a more feasible risk assessment approach are crucial for school safety construction.

As a combination of qualitative and quantitative analysis methods with systematic and hierarchical characteristics, the analytic hierarchy process (AHP) has been widely used to evaluate risks with multiple influencing factors, distinct levels, and clear boundaries [21,22]. A clear hierarchy of PSS safety risks has been identified. Ideally, the weight of each risk indicator can be calculated with the help of AHP. The entropy weight method (EWM) is an important application of entropy theory, and it has high accuracy in determining factor weights [23]. For the safety risk evaluation of PSS, the greater the data difference, the greater the effect of the risk indicators. In this paper, the AHP–EWM method was combined to evaluate the safety risks of PSS by using a case in China.

To address the above needs, this paper presents a set of analyses with the following specific objectives: (1) to overview and identify risk indicators of PSS in China according to previous literature; (2) to evaluate these risks by employing the AHP–EWM method based on the questionnaire data collected from Ma Shan School (MS), Wuhan, China; and (3) to propose preventive measures, providing a managerial application for the safety management of PSS.

The remainder of the paper is organized as follows. Section 2 introduces the taxonomy, indicators, and evaluation approaches for safety risks of PSS. We develop the questionnaire and collect data from MS in Section 3, then discuss the main findings of safety risks evaluated from the survey using the AHP–EWM approach. Section 4 presents the academic and managerial implications to provide school managers with policy suggestions. Section 5 outlines the main conclusions of this paper.

2. Methods

2.1. Taxonomy of Safety Risks in PSS

Risk classification plays a critical role in determining risks. The systematic taxonomy of risks according to the characteristics of research objects is helpful to analyze the causes. However, no unified taxonomy for safety risks of PSS has been published due to the different types of incidents, triggering factors, and hazard results. Mubita [12] divided school safety risks into physical, psychological, environmental, and social dimensions. The physical dimension is reflected in physical violence, corporal punishment, and bullying. The psychological dimension refers to the safety of students and staff in the school. The social dimension refers to the school-like construction. The environmental dimension indicates that schools may be affected by natural disasters. According to regulations such as the *Law of the People's Republic of China on Emergency Response* and the *National Overall Emergency Response Plan for Public Emergencies*, school incidents are divided into four categories: natural disasters, accident disasters, public health incidents, and social security incidents.

Through the investigation of previous literature that introduces and discusses the classification of school safety, we found that existing safety risk classifications were mainly based on disaster types, accident losses, and emergency events. Although the coverage is relatively extensive, from the perspective of safety risk prevention and control, the definition of several categories is vague and the division of events is repeated, thereby excluding the new risks that have emerged in recent years. Hence, existing classifications are not conducive to the construction and implementation of the school safety risk prevention and control system.

Therefore, as shown in Figure 1, we combed the experience of previous relevant studies and regulations, such as the National Overall Emergency Response Plan for Public Emergencies, the Education System Overall Emergency Response Plan for Public Emergencies, and the China Emergency Education and Campus Safety Development Report (2016–2019), with the characteristics of school safety and typical incidents that recently occurred at PSS. Then, we summarized the taxonomy for safety risks of PSS into risks of natural disasters, public health, facility safety, accidental injury, public security, school bullying, and individual health.

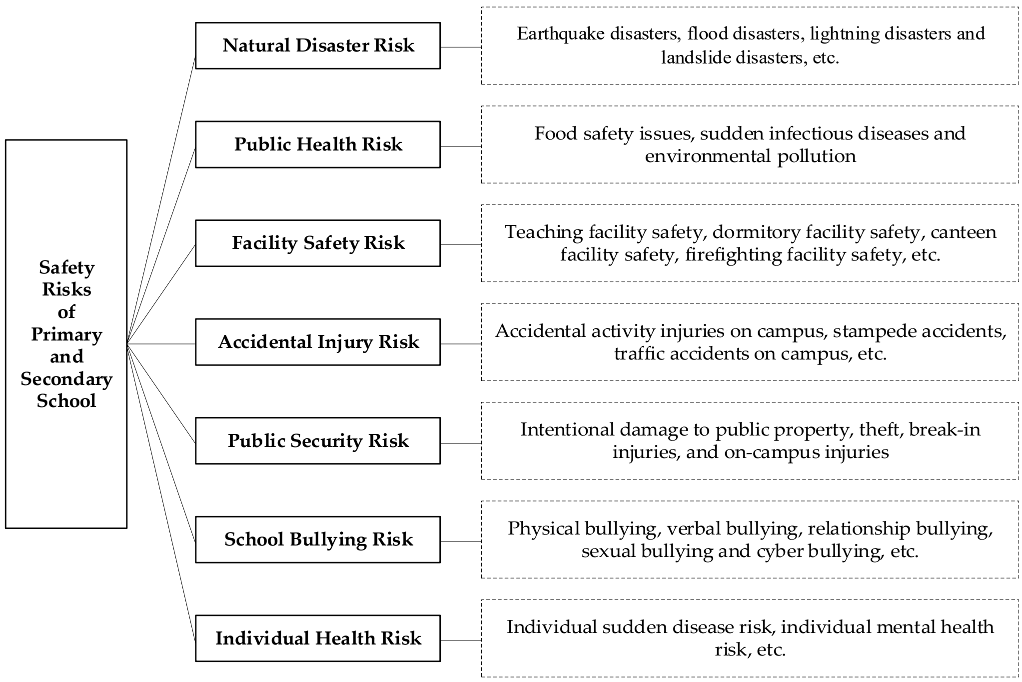

Figure 1. Taxonomy of safety risks in PSS.

2.1.1. Natural Disaster Risks

Natural disasters cover most types of catastrophic events, such as earthquakes, floods, tsunamis, epidemics, and wildfires, that are related to the education system [24,25]. Hence, the natural disaster risk of PSS refers to losses of personnel, materials, and teaching order caused by natural hazards occurring at PSS. Examples are as follows. In the 2008 Wenchuan earthquake, about 10,000 teachers and students died. Shexian County, China, suffered a severe flood on 7 July 2020, resulting in the postponement of several college entrance examination subjects. Natural disasters have brought great threats to the lives and health of teachers and students in PSS.

2.1.2. Public Health Risks

Public health events usually include outbreaks of major infectious diseases, unidentified mass diseases, food poisoning, occupational poisoning, and other events with serious public health implications. Public health risks in PSS generally refer to events that cause serious damage to the physical health of teachers, students, and staff. Such events mainly include food safety, infectious diseases, and environmental pollution. Food safety risks include food poisoning, food-borne disease, food contamination, and other risks harmful to health caused by eating expired or spoiled food that does not meet health and quarantine standards in PSS [26]. The risk of sudden infectious disease refers to threats of contagious diseases (e.g., SARS and COVID-19) or unknown diseases that affect the normal teaching order and the physical health of teachers and students [27]. Similarly, environmental pollution risks refer to the health threats caused by exposure to pollutants (e.g., harmful gases, radioactive substances, and plastic pollution) [28].

2.1.3. Facility Safety Risks

Campus facilities are made up of the materials and equipment that are provided for teaching, learning, and living in PSS (e.g., classroom, teaching instrument, and auxiliary facilities). As the name implies, facility safety risks usually refer to threats caused by the failure of campus facilities, such as injuries caused by collapsing buildings, fire explosions, defective laboratory facilities, and school bus traffic accidents [29,30].

2.1.4. Accidental Injury Risks

School accidents are usually caused by factors outside the parties' control and are extraneous, sudden, and accidental [31]. Therefore, accidental injury risks can be defined as threats of non-human factors or individual injury caused by human factors but not intentionally occurring in PSS [32]. Common school accidental injury risks include school stampedes, sports injuries, and school traffic accidents other than those involving school buses.

2.1.5. Public Security Risks

Public security incidents are initiated by specific groups and threaten social security and stability. Public security incidents that damage the personal safety and property safety of teachers and students will lead to corresponding risks, namely public security risks of PSS. Common forms of public security risks include intentional damage to public property, theft, injuries caused by trespassers, and terrorist attacks [33–35].

2.1.6. School Bullying Risks

School bullying is a type of behavior in which powerful individuals or groups deliberately bully vulnerable groups or individuals through various means, causing physical or psychological harm [36]. Common forms of school bullying include physical, verbal, relationship, sexual, and cyberbullying. In actual school bullying incidents, bullying usually occurs in a mixed way, causing serious and lasting harm to the bullied [37,38].

2.1.7. Individual Health Risks

In the context of school safety management, individual health risk refers to the damage caused by innate vulnerability factors of students. Individual health events will cause harm to the physical condition of the parties, interfere with the normal school teaching order, and bring secondary risks to society. It is mainly manifested in the form of individual sudden physical or psychological diseases, including cognitive errors, emotional loss of control, interpersonal tension, and other risks caused by these diseases [39,40].

2.2. Indicator Design for Safety Risks in PSS

In summary, we divided safety risks in PSS into seven main sub-risks according to the aforementioned definitions of natural disasters, public health, facility safety, accidental injury, public security, school bullying, and individual health risk. Then, we further developed the specific indicators based on the literature review as shown in Table 1.

Table 1. Risk Indicators for Safety Risks in PSS.

Primary Indicator	Symbol	Secondary Indicator	References
Natural Disaster Risks (X_1)	X_{11} X_{12} X_{13} X_{14} X_{15}	Weather condition Topographic conditions Socioeconomic conditions Disaster prevention awareness Risk early warning capability	[24,25]
Public Health Risks (X_2)	X_{21} X_{22} X_{23} X_{24} X_{25}	Poisonous food Epidemic disease Environmental pollution Hygiene management level Awareness of public health prevention	[26–28]
Facility Safety Risks (X_3)	X_{31} X_{32} X_{33} X_{34} X_{35}	Defects in the quality of campus facilities Routine maintenance of campus facilities School facility safety management system Personal safety protection Operational use of school facilities	[29,30]
Accidental Injury Risks (X_4)	X_{41} X_{42} X_{43} X_{44} X_{45}	personal safety risk awareness Teacher–student misbehavior The facility is operating abnormally Accident investigation mechanism On-school facility safety hazards	[31,32]
Public Security Risks (X_5)	X_{51} X_{52} X_{53} X_{54} X_{55}	Chaos around PSS School access management loopholes Defects in the school monitoring system Inadequate security facilities on PSS Weak risk response capability	[33,34]
School Bullying Risks (X_6)	X_{61} X_{62} X_{63} X_{64} X_{65}	Poor school discipline School bullying punishment mechanism Low legal awareness among students Individual psychological disorder School bullying prevention mechanism	[35–38]
Individual Health Risks (X_7)	X_{71} X_{72} X_{73} X_{74} X_{75}	Unsafe event scenes Academic life stress Individual physical vulnerability Individual psychological vulnerability Regular health checks	[39,40]

2.3. Evaluation Approach for Safety Risks in PSS

The safety risk evaluation of PSS is characterized by complexity and uncertainty. Consequently, its analysis is subjective to a certain extent, with insufficient accuracy in the evaluation results. To improve the reliability of risk assessment results, combining qualitative and quantitative analysis methods is necessary. Hence, we developed the evaluation approach for safety risks in PSS based on AHP–EWM. The framework of the AHP–EWM method is illustrated in Figure 2.

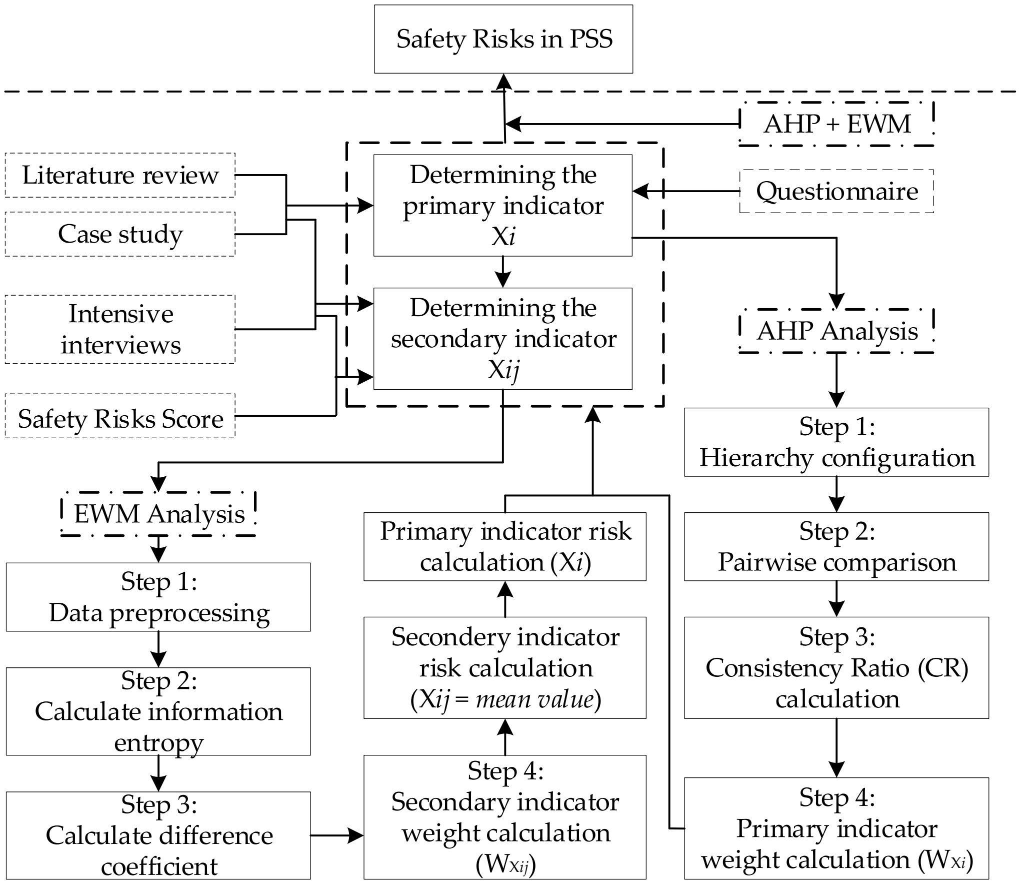

Figure 2. Framework of AHP–EWM method.

Equations (1)–(6) for evaluating the weight of risk indicators are listed below. The detailed calculation process of the EWM method [41,42], and the process of AHP analysis [22,43] can be found in previous literature.

It was supposed that n evaluation objects existed, providing m evaluation indicators to obtain the original data matrix as follows:

$$R = \left(r_{ij}\right)_{m\times n} = \begin{bmatrix} r_{11} & r_{12} & \cdots & r_{1n} \\ r_{21} & r_{22} & \cdots & r_{2n} \\ \cdots & \cdots & \cdots & \cdots \\ r_{mn} & r_{m2} & \cdots & r_{mn} \end{bmatrix} \tag{1}$$

The normalization of R matrix data was as follows:

$$S = \left(s_{ij}\right)_{m\times n} = \begin{bmatrix} s_{11} & s_{12} & \cdots & s_{1n} \\ s_{21} & s_{22} & \cdots & s_{2n} \\ \cdots & \cdots & \cdots & \cdots \\ s_{mn} & s_{m2} & \cdots & s_{mn} \end{bmatrix} \tag{2}$$

In Equation (2), s_{ij} is the standard value of j evaluation objects on i evaluation indices:

$$s_{ij} = \left(s_{ij} - \min\left(s_{ij}\right)\right) / \left(\max\left(s_{ij}\right) - \min\left(s_{ij}\right)\right) \tag{3}$$

In the evaluation of n evaluated objects with m indicators, the entropy of i indices was defined as follows:

$$P_{ij} = \frac{s_{ij}}{\sum_1^n s_{ij}} \tag{4}$$

$$e_i = -\frac{1}{\ln n}\sum_{j=1}^{n} P_{ij} \times \ln P_{ij} \tag{5}$$

where e_i is the information entropy of the index and s_{ij} is the standard value. Following the entropy definition of index i, the entropy weight definition of the index can be obtained as follows:

$$w_i = \frac{1 - e_j}{m - \sum_{i=1}^{m} e_j} \tag{6}$$

3. Results

3.1. Statistical Analysis

MS is a nine-year compulsory education school, covering an area of more than 20,000 square meters in Wuhan, China. The layout of MS meets various teaching needs with a computer room, a music room, a library, a physics laboratory, a chemical laboratory, and a biological laboratory. The school has full medical and sports equipment, with a plastic ring track and a fully functional sports field. The average high school entrance rate for the senior high school entrance examination has remained above 70% throughout the year, one of the highest in the city.

Combined with the actual situation of MS and the risk indicators in Table 1, we developed the safety risk rating table of MS and collected data through questionnaires and in-depth interviews. In total, 20 interviews were conducted on one day, i.e., on 28 October 2021 in MS school, in a room specially dedicated to this study and based on a walk-in procedure (convenience sampling method). Two interviews (10%) had to be excluded as they did not fulfil the inclusion criterion of being a stakeholder (i.e., they were unable to understand and answer the interview questions accurately). Participants were on average 30 years old (range 6–51), and most of them were female (n = 13, 72.2%). Additionally, participants were first directed to review and provide their consent using an informed consent form, which was pre-approved by a panel of experts and the institutional review board, before answering the survey questionnaire [44].

From 15 October 2021 to 15 December 2021, the questionnaire was distributed to MS teachers, students, and administrators. Considering the limited cognitive level of primary school students, the questionnaire was only distributed to middle school students. The questionnaire mainly comprises two parts. One part is the basic information of the participants, such as gender, age, and occupation. The other part is a risk assessment scale. A total of 206 completed responses were received with an effective rate of 82.40%, after excluding suspected unreal answers. The response scale for all the survey items was a five-point Likert scale with categories ranging from 1 = "very low risk" to 5 = "very high risk".

As shown in Table 2, the majority (81.07%) of the respondents were students, with staff (including administrative staff and logistics managers) being the least represented at 5.34%. Teachers made up 13.59%. The female participants constituted 47.09% of the sample, while 52.91% were male. Most of the participants were young people, with 81.07% belonging to the age group below 18 years. A total of 9.22% belonged to the age group of 18–35 years, and 2.43% were more than 55 years old.

A reliability analysis was used to evaluate the reliability of a measuring item and the internal consistency of the questionnaire. The Cronbach's alpha ($\alpha > 0.7$) was used to estimate the internal consistency. Validity analysis was employed to examine the accuracy of the measurement instrument, namely, the validity of the scale. The content validity was supported by the expert panel's recommendations and pre-tests. The Bartley sphericity test and Kaiser–Meyer–Olkin (KMO) value were adapted to examine the validity.

Table 3 shows that the questionnaire has good reliability (α = 0.82 > 0.7) and high validity (KMO = 0.907 > 0.5), indicating that the questionnaire can be used for further analysis.

Table 2. Statistical analysis of participants.

Terms	Characteristics	Frequency	Percentage (%)
Role	Teacher	28	13.59%
	Student	167	81.07%
	Administrative staff	4	1.94%
	Logistics manager	7	3.40%
Gender	Male	109	52.91%
	Female	97	47.09%
Age	$\leq$18	167	81.07%
	19–35	19	9.22%
	35–55	15	7.28%
	$\geq$56	5	2.43%

Table 3. Results of reliability and validity analysis.

	Fit Index	Recommended Value	Test Value
Reliability test	α	>0.7	0.82
Validity test	Sig.	<0.01	<0.001
	KMO	>0.5	0.907

3.2. Secondary Risk Indicators Weight Calculation Based on EWM

Based on data collected from 206 valid questionnaires, the indicators of seven sub-risks of MS were calculated. Table 4 presents the values of descriptive statistics (e.g., the value of the mean, variance, maximum, minimum, and median) of these indicators. In Table 4, we found that the mean value of most indicators was between 2.5 and 3.5, indicating that most of the participants were conservative in evaluating the risks. In particular, the mean value of public health risks achieved the highest risk score, which may be related to the long-lasting COVID-19 pandemic. The indicators of a facility safety risk, and accidental injury risk also have high-risk values, while the mean values of natural disaster risk and individual health risk indicators were low. Based on Equations (1)–(5), the weights of all risk indicators were calculated as shown in Table 4 (see Supplementary Materials).

In Table 4, The weights of MS school safety risks indicators were different, but the difference was not large, mostly in the range of 10–30%. Based on the results in Table 5, the mean value was taken as the index to calculate the weights of seven main sub-risks in MS using EWM as follows:

$$\text{Natural Disaster Risks } (X_1) = 0.1918 \times X_{11} + 0.3090 \times X_{12} + 0.1957 \times X_{13} + 0.1595 \times X_{14} + 0.1441 \times X_{15}$$

$$\text{Public Health Risks } (X_2) = 0.3223 \times X_{21} + 0.2659 \times X_{22} + 0.2205 \times X_{23} + 0.1224 \times X_{24} + 0.0688 \times X_{25}$$

$$\text{Facility Safety Risks } (X_3) = 0.2450 \times X_{31} + 0.3885 \times X_{32} + 0.1091 \times X_{33} + 0.0838 \times X_{34} + 0.1735 \times X_{35}$$

$$\text{Accidental Injury Risks } (X_4) = 0.1232 \times X_{41} + 0.4331 \times X_{42} + 0.2071 \times X_{43} + 0.1158 \times X_{44} + 0.1208 \times X_{45}$$

$$\text{Public Security risks } (X_5) = 0.1139 \times X_{51} + 0.3521 \times X_{52} + 0.1216 \times X_{53} + 0.1433 \times X_{54} + 0.2691 \times X_{55}$$

$$\text{School Bullying Risks } (X_6) = 0.2154 \times X_{61} + 0.2305 \times X_{62} + 0.2513 \times X_{63} + 0.1708 \times X_{64} + 0.1319 \times X_{65}$$

$$\text{Individual Health Risks } (X_7) = 0.1118 \times X_{71} + 0.2825 \times X_{72} + 0.3156 \times X_{73} + 0.1525 \times X_{74} + 0.1377 \times X_{75}$$

Table 4. Risk indicators descriptive statistics and weights.

Primary Indicator	Symbol	Mean	σ	Max	Min	Median	Weight
Natural Disaster Risks (X_1)	X_{11}	2.5728	0.9814	4	1	2	0.1918
	X_{12}	2.6068	1.0593	4	1	3	0.3090
	X_{13}	2.5388	0.9684	4	1	3	0.1957
	X_{14}	2.6359	0.8914	5	1	3	0.1595
	X_{15}	2.6505	0.8385	4	1	3	0.1441
Public Health Risks (X_2)	X_{21}	2.8835	1.0409	5	1	3	0.3223
	X_{22}	4.4029	0.6136	5	2	4	0.2659
	X_{23}	3.2379	0.9688	5	1	3	0.2205
	X_{24}	3.9320	0.8787	5	2	4	0.1224
	X_{25}	3.8301	0.6501	5	2	4	0.0688
Facility Safety Risks (X_3)	X_{31}	2.9175	0.9180	5	1	3	0.2450
	X_{32}	3.4951	0.8688	5	2	3	0.3885
	X_{33}	3.6311	0.7567	5	2	4	0.1091
	X_{34}	3.7039	0.6496	5	2	4	0.0838
	X_{35}	3.3447	0.8828	5	1	3	0.1735
Accidental Injury Risks (X_4)	X_{41}	3.5000	0.7552	5	1	4	0.1232
	X_{42}	3.7864	1.0159	5	1	4	0.4331
	X_{43}	3.5097	1.0275	5	2	4	0.2071
	X_{44}	3.5243	0.7739	5	1	3	0.1158
	X_{45}	3.5728	0.7709	5	1	4	0.1208
Public Security Risks (X_5)	X_{51}	2.7184	0.5471	5	2	3	0.1139
	X_{52}	3.4515	0.5168	5	3	3	0.3521
	X_{53}	2.8107	0.5896	5	2	3	0.1216
	X_{54}	3.5049	0.7552	4	2	4	0.1433
	X_{55}	2.7476	0.8727	5	2	2	0.2691
School Bullying Risks (X_6)	X_{61}	2.3835	0.5604	4	1	2	0.2154
	X_{62}	3.3447	0.6774	5	1	3	0.2305
	X_{63}	3.5874	0.8003	5	1	4	0.2513
	X_{64}	2.2136	0.4756	4	1	2	0.1708
	X_{65}	3.6068	0.6120	5	1	4	0.1319
Individual Health Risks (X_7)	X_{71}	2.8641	0.4526	4	1	3	0.1118
	X_{72}	2.4466	0.5699	5	1	2	0.2825
	X_{73}	2.9951	0.8155	4	2	3	0.3156
	X_{74}	3.6019	0.6586	5	2	4	0.1525
	X_{75}	2.6650	0.4720	3	2	3	0.1377

Table 5. Risk Assessment Results.

Primary Indicator	X_1	X_2	X_3	X_4	X_5	X_6	X_7	Weight
X_1	1	0.33	0.33	0.5	4	3	3	0.1256
X_2	3	1	5	0.5	5	4	7	0.3104
X_3	3	0.2	1	0.5	2	2	2	0.1359
X_4	2	2	2	1	4	3	3	0.2548
X_5	0.25	0.2	0.5	0.25	1	1	0.5	0.0482
X_6	0.33	0.25	0.5	0.33	1	1	3	0.0716
X_7	0.33	0.14	0.5	0.33	2	0.33	1	0.0535
			λ_{max} = 7.7177		C.R. = 0.0906			

The evaluation results are shown in Figure 3. Accidental Injury Risks (X_4) were the biggest source of risk in MS with an evaluation value of 3.6377, followed by Public Health Risks (X_2), while Individual Health Risks (X_7) and Natural Disaster Risks (X_1) were the two smallest sources. We received similar feedback in the in-depth interviews.

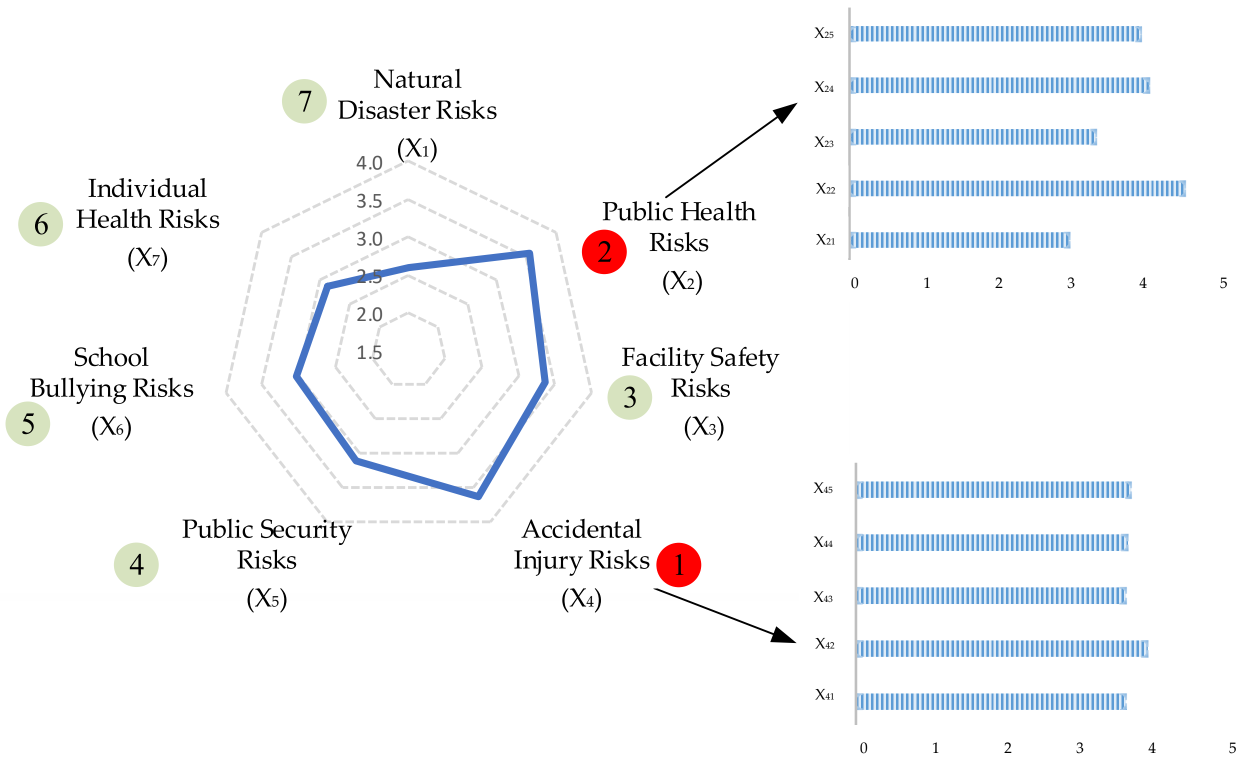

Figure 3. Campus Security Risk Radar Map.

> "[Interviewer: What do you think is the biggest source of risk in school safety?] Well, I thought, yes, I'm most worried about children being hurt in accidents"
>
> (A senior primary headteacher, 51 years old).

> "Ok, I do think public health risks are the biggest. [Interviewer: Why?] Well, as you know, the COVID-19 has affected us too much"
>
> (A student, 12 years old).

Only one of the participants thought that the risk of natural disasters was of the greatest concern, which may be related to his experience with it.

> "I think natural disasters are the worst. [Interviewer: Why?] Ehm, because I have lived through the Wenchuan earthquake . . . "
>
> (An administrative staff, 42 years old).

Students in PSS are lively and active, with strong curiosity and immature thinking. The students are at a high risk of accidental injury. In addition, the mean value of five secondary indicators of X_4 is at around 3.5, indicating that MS urgently needs to improve the accident investigation management mechanism, the school safety risk management mechanism, and the safety awareness management of teachers and students. Public Health Risks (X_2) ranked second, possibly due to the frequent outbreak of the COVID-19 pandemic in densely populated PSS and the fact that the children were not vaccinated in time, leading to high safety risk issues in MS. In particular, the mean values of X_{22}, X_{24}, and X_{25} were relatively high, all close to 4, reflecting that the low level of health management and the lack of awareness of epidemic prevention were the main factors that resulted in high X_2. Additionally, once facilities and public safety were threatened in PSS, the consequences were often more serious, so the risk levels of X_3 and X_5 were relatively high. A senior secondary school teacher highlighted:

> "Health is wealth. Students will perform exceptionally well when free from COVID-19 and other diseases"
>
> (A senior secondary school teacher, 48 years old).

Different from these factors, MS has a good campus culture and medical facilities, so students are less threatened by campus bullying and individual health. MS also is located in a plain area, with a superior geographical location and topographic conditions, low frequency of large-scale natural disasters, and strong response warning and prevention ability to natural disasters. Therefore, the level of Natural Disaster Risks (X_1) was the lowest.

3.3. Primary Risk Indicators Weight Calculation Based on AHP

In Section 3.2, the values and weights of the secondary indicators were presented using EWM, enabling the values of the primary indicators to be calculated. Based on the results, the weights of the primary indicators were evaluated through AHP. We merely compared the scores of the specific seven primary risk indicators in pairs because only the weight estimation of the first-level indicators was involved. Data were collected by issuing questionnaires to 10 experts, including administrators, teachers, and relevant scholars in PSS, who have long been engaged in PSS education and research can objectively compare and assess the risks. The questionnaire was sent to the experts and passed a consistency analysis. Considering the heterogeneity between expert knowledge and experience, the arithmetic mean of experts scores was taken as the final evaluation scale, and the evaluation matrix was finally obtained as shown in Table 5.

The largest eigenvalue of matrix $\lambda_{\max}$ matrix was then estimated using Equation (7):

$$\lambda_{\max} = \frac{1}{n}\sum_{i=1}^{n}\frac{\sum_{j=1}^{n} a_{ij}w_i}{w_i}(i, j = 1, 2 \ldots, n) \tag{7}$$

where w_i is the transpose of the vector of weights. Thus, $\lambda_{\max}$ was be obtained as 0.7177. Then, the consistency ratio (C.R.) can be calculated using Equation (8):

$$\text{C.R.} = \frac{\lambda_{\max} - n}{(n-1)R.I.} \tag{8}$$

where *R.I.* represents the random index value, referring to the random index proposed by Saaty [45] in Table 6. Finally, we calculate that C.R. = 0.0906, which meets the consistency requirements (C.R. $\leq$ 0.10) [46].

Table 6. Random consistency index (RI).

Primary Indicator	1	2	3	4	5	6	7	8
R.I.	0	0	0.58	0.90	1.12	1.24	1.32	1.45

As shown in Table 5, the weights of primary indicators were different from each other. Similar to the ranking of risk values in Section 3.2, the weights of X_2 and X_4 were the largest, indicating that experts have paid more attention to the damage caused by these two risks. The result was closely related to the impact of the current COVID-19 pandemic and the frequent campus accidents in recent years. On the contrary, risk weights of X_7 and X_5 were the lowest, showing that with the promotion of building law-based schools in China, bullying has been brought into campus governance, achieving positive results. Furthermore, with the rapid progress of medical treatment in China in recent years, students, as the key group of concern to society and their families, have been guaranteed good health. For instance, in November 2011, a large-scale "Nutrition Improvement Plan for Rural Students Receiving Compulsory Education" was launched in poverty-stricken areas across China, contributing to the improvement of nutrition and health of 26 million rural students in PSS.

4. Discussion

Based on our three research objectives, the results are summarized and demonstrated from the perspective of academic implication and managerial implications.

4.1. Academic Implications

The safety risks in PSS were assessed using the proposed AHP–EWM method. To achieve objective one, primary and secondary indicators were identified based on literature review, case study, and intensive interviews. Then, corresponding to objective two, with EWM, various secondary indicator risks and weights were calculated using the data collected through a questionnaire collected from MS, Wuhan, China. The weights of primary indicators were evaluated by employing AHP. Finally, the safety risks were obtained by combining the risk value and weights through EMW and AHP, respectively.

The distinguishing features of the AHP–EWM method are that it is systematic and quantitative. First, the approach stems from system theory, which systematically provides a hierarchical structure system by summarizing the safety risk indicators in PSS. This indicator system enriched the existing foundation [12] for understanding the safety risks in PSS.

Second, combining the advantages of qualitative research and quantitative analysis, the risk evaluation model is proposed based on AHP–EWM. The integration of two approaches to assess safety risks in PSS is more objective and authentic than traditional methods [21–23], expanding risk assessment methods on safety risks in PSS.

4.2. Managerial Implications

The safety risk evaluation model based on AHP–EWM provides a quantitative analysis of risk indicators in PSS. It can serve as a guideline for managers to reduce school injuries, fulfilling objective 3.

(1) Preventive measures in the short term. The results show that stakeholders and related scholars are highly concerned with the risks to public health and accidental injury, which are the main causes of injuries in PSS. These results are consistent with other studies [32,40]. The risk value of public health has received special attention due to the impact of the current COVID-19 pandemic. However, due to the weak immunity of pupils and the large population density within PSS, other epidemic risks, such as those affecting the respiratory system and digestive tract, must be the focus of school administrators. A joint prevention and control mechanism can be established among schools, communities, and authorities with PSS as the main body of prevention and control. An independent isolation area should be set up to cut off the transmission route in time, and cooperation with the local centers for disease control (CDC) should be promoted to carry out quarantine observation and tracking management by standards. Precise prevention and control work plans should be formulated. Strict daily prevention and control management of key places, such as teaching areas, dormitory areas, office areas, gymnasiums, conference rooms, and school hospitals, should be conducted. The public safety responsibility system should be strengthened with a traceability mechanism for canteens, infirmaries, and other places involving public health. Basic information on important ingredients and medical equipment involved should be published. Supervision and spot checks should be conducted on business institutions, such as supermarkets and self-service shopping machines. Close communication with local CDCs needs to be strengthened and improved.

For accidental injuries, the school safety inspection system should be improved, with regular checks of campus facilities, vehicles, and fire facilities to prevent potential safety hazards. As several studies have emphasized [2,11], schools should strengthen the construction of school safety risks monitoring and early warning systems with the help of information and communication technologies, such as big data, the Internet of things, new generation of sensors, monitoring equipment, and artificial intelligence, which can accurately identify and trace various abnormal behavior information [47,48]. A full range of emergency plans should be updated from the perspective of emergency prevention, handling, and post-recovery [49]. Drills should be regularly arranged to ensure that the systems can be operated. Teachers and students should also strengthen safety education, increase risk perception, and firmly establish safety prevention and control awareness.

(2) Preventive measures in the long-term. The establishment of school safety is a systematic project that needs to be promoted in the long run. “Black swan” events should be

especially guarded against other risk indicators with less weight (e.g., natural disasters and individual health). In particular, the implementation of prevention measures is dependent on social and family support. At the social level, the legislative department should continue to improve the laws and regulations on school safety in PSS, and actively issue special provisions in combination based on actual cases. This finding concurs with the study conducted by Tabancalı and Bektaş [20]. For example, relevant laws and regulations focusing on juvenile crimes, school fraud, and school bullying should be set up promptly to ensure that they can be followed in school governance. The government should also strengthen supervision.

At the family level, as also found by Mubita [12], special attention should be paid to the important role of family education in constructing school safety. Parents should consistently focus on the education of safety and provide a positive and healthy family environment for their children. Parents should also actively participate in the safety education activities organized by the government and schools and take the initiative to learn safety knowledge on food and drugs, household electricity, and traffic rules. Finally, as guardians, parents need to clearly understand their responsibilities. They can also express their suggestions and urge managers to improve the prevention and control level of school safety risks.

5. Conclusions

The primary purpose of this study was to identify and systematically analyze the safety risks of PSS in China. The study revealed and assessed the two-hierarchy structure of indicators influencing these risks. Primary risk indicators, namely, natural disasters, public health, facility safety, accidental injury, public security, school bullying, and individual health, were identified and assessed using the AHP–EWM method. The comprehensive evaluation results suggest that the values and weights of public health risks and accidental injury risks are relatively high, and they should be prioritized when taking preventive measures. The managerial implications confirmed that the safety risks in PSS can be reduced in the short term by promoting health awareness among stakeholders and in the long term by enhancing safety education. The proposed targeted preventive measures provide theoretical and practical implications for managing the safety risks in PSS. The findings contribute to school safety research by offering a deeper understanding and an evaluation framework of systematic indicators of risks.

Despite the theoretical and managerial contributions of this study, it still has several limitations. First, the samples were mainly from MS, Wuhan, China, and participants from other regions were not included. Secondly, more comprehensive and quantitative approaches for dealing with interview data can be considered. Finally, the effect of these sub-indicators on safety risks in PSS can be explored in future research.

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