

# Analyzing Safety Factors of Pedestrian Bridge Users in Asia: A Systematic Literature Review

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**ABSTRACT:** Pedestrian safety at the People Crossing Bridge (JPO) in Asia is a crucial issue that requires serious attention given the high number of accidents around this facility. This study aims to conduct a systematic literature review to identify and analyze the main factors that impact the safety of pedestrian bridge users in Asia using VOSviewer software. The analysis process is carried out with the PRISMA approach to ensure a systematic and relevant selection of literature. The findings of the study show that several main factors affect the safety of pedestrian bridge users, including the physical condition of the bridge, social and environmental factors, pedestrian behavior, the existence of supporting facilities such as lighting and signs, and the effectiveness of law enforcement on the use of the pedestrian bridge. In addition, emotional and psychological factors, such as the user's level of awareness and perception of risk, also contribute to safety. Evaluation of demographic factors, such as age, gender, and education level, also showed a relationship with the level of compliance in using pedestrian bridges. An analysis of the trends of pedestrian bridge safety-related publications shows an increase in attention to this topic in recent years, signaling the urgency for policy and infrastructure improvements. Overall, this systematic review suggests a holistic approach to designing and managing pedestrian bridge facilities, taking into account physical, social, emotional, and legal factors to create a safer environment for pedestrians in Asia.

**Keywords** – Pedestrian Bridges, Pedestrian Facility, Safety Bridges, Systematic Literature Review

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## 1. INTRODUCTION

Pedestrian safety at the People Crossing Bridge or pedestrian bridge in Asia is a crucial issue that requires serious attention given the high number of accidents around this facility. Various efforts have been made to improve safety, such as the development of better infrastructure designs and the implementation of stricter traffic policies [1]. However, there are still various challenges in ensuring the safety and security of pedestrians who cross the pedestrian bridge in various regions.

Previous research has identified several factors that affect safety in pedestrian bridges, including human behavior factors, environmental conditions, and technical aspects such as bridge design and maintenance [2]. Nonetheless, the relationship between these factors and their effects on pedestrian safety still needs to be further researched with a holistic and multidisciplinary approach [3], [4].

The development of modern technology, such as sensor-based monitoring systems and smart infrastructure concepts, offers great potential to improve safety in pedestrian bridges. However, the effectiveness of the implementation of this technology depends on a deep understanding of the risk factors that exist. This study aims to conduct a systematic literature review to identify and analyze the main factors that impact the safety of pedestrian bridge users in Asia [5], [6].

Bibliometric analysis methods with the help of software such as VOSviewer will be used to explore research patterns and identify gaps in the existing literature. The findings of this study are expected to provide insight for stakeholders, including governments and city planners, in designing more effective mitigation measures [7]. Although research on pedestrian bridge safety has been conducted in various countries, there are still limitations in understanding the interaction between factors that affect pedestrian safety. Therefore, this study aims to provide a comprehensive synthesis of existing research, identify gaps in the current literature, and offer evidence-based recommendations to assist stakeholders in formulating more effective policies and intervention programs to improve the safety of pedestrian bridge users in Asia.

## 2. METHODS

This study uses a systematic literature review approach to identify and analyze factors that affect the safety of pedestrian bridge users in Asia by following the PRISMA (The Preferred Reporting Items for Systematic Reviews and Meta-Analysis) guidelines to ensure a transparent and systematic approach in the selection and analysis of literature [8]. This study uses the help of VOSviewer software to analyze research trends related to the safety of pedestrian bridge users in Asia [9]. Bibliometric analysis allows for identifying publication patterns, relationships between research topics, and potential research gaps that need further exploration. This research process includes several stages as follows:

### a. Identification

A literature search was carried out in the Scopus database using the keywords "Pedestrian Bridge Safety," "Crossing Bridge Safety," and "Pedestrian Bridge Safety in Asia." The publication year range is limited to 2019–2024 to obtain relevant up-to-date data.

The query used is:

(TITLE-ABS-KEY ( pedestrian AND bridge AND safety ) AND TITLE-ABS-KEY ( crossing AND bridge AND safety ) ) AND PUBYEAR > 2018 AND PUBYEAR < 2025 AND (LIMIT-TO (SUBJAREA, "ENGI")) AND (LIMIT-TO (DOCTYPE, "ar")) OR LIMIT-TO (DOCTYPE, "cp")) AND (LIMIT-TO (LANGUAGE, "English")) AND (LIMIT-TO (OA, "all"))

### b. Screening

Documents obtained from the search results will be filtered based on relevance to the research topic and deduplication. Articles that are not related to the safety factor of pedestrian bridge users will be excluded from the analysis.

### c. Eligibility

At this stage, articles will be further checked based on the availability of full access as well as the language used (only English-language articles are considered).

### d. Interpretation of Results

Only articles that meet the selection criteria will be included in further analysis using VOSviewer software to explore patterns of relationships between research topics through co-occurrence keyword analysis and research network visualization.

The systematic process flow based on the PRISMA approach in this study is shown in Figure 1 below:

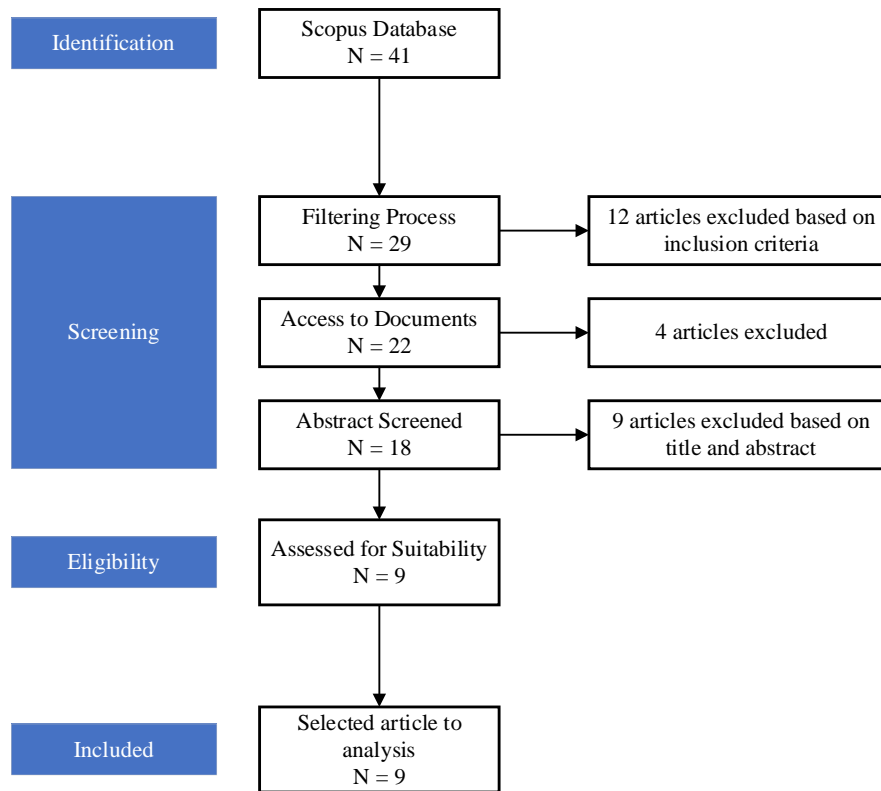


Figure 1 Systematic Process Flow

### 3. RESULTS AND DISCUSSION

#### 3.1 Analysis of Selected Literature

The analysis of the selected literature provides an in-depth examination of the various factors affecting pedestrian safety on pedestrian crossing bridges in Asia. A summary of the results of the systematic review can be seen in Table 1.

Table 1 Summary of Systematic Study Results

No	Author	Country	Objective	Safety Factor Analysis
1	[10]	Indonesia	To assess the impact of pedestrian bridges on pedestrian safety in Sungai Panas, Batam, and measure changes in pedestrian behavior and accident rates before and after the construction of the bridge.	<ul style="list-style-type: none"> <li>The factors analyzed included the number of bridge users, pedestrian behavior patterns, accident data before and after construction, and traffic speed around the study area.</li> <li>Bridge design factors and lighting availability are also evaluated as part of safety.</li> </ul>
2	[11]	Hong Kong	Investigate the effects of pedestrian bridges and underpasses on pedestrian safety using a three-dimensional digital map of pedestrian networks.	The variables analyzed included population density, traffic volume, pedestrian lane density, and accessibility of facilities such as bridges and underpasses.
3	[12]	Jordana	Assess the level of safety of pedestrian bridges in Karachi, especially based on pedestrian perceptions. The main focus of this study is to identify the various	The main factors analyzed include physical hazards, such as the absence of guardrails, which can increase the risk of accidents or incidents. In addition, social dangers are also considered, such

			physical and social hazard factors that influence pedestrians' views of bridge safety.	as the presence of beggars, addicts, and stray dogs that can add to fear or insecurity. Crossing times (morning, noon, or evening) and demographic factors such as the age and gender of pedestrians are also evaluated to understand their impact on safety perceptions.
4	[13]	Malaysia	Identify the driving factors influencing the use of pedestrian pedestrian bridges among urban commuters in Kuala Lumpur.	The physical safety of pedestrians is highly dependent on the condition of the bridge itself, including factors such as the safety of the bridge structure, good maintenance, and adequate lighting. Bridges that are unsafe, or that appear to be damaged, will reduce commuters' interest in using them, even if they are theoretically safer than crossing on the road.
5	[14]	Malaysia	Identify the key factors that influence pedestrian behavior when crossing the road.	The main factors found affecting pedestrian safety are the condition of the pedestrian bridge itself, the ease of access to the bridge, and the level of law enforcement that encourages pedestrians to use the facility
6	[15]	Kazakhstan	Evaluating the quality of safe and convenient access to pedestrian infrastructure facilities in the Bostandyk district, Almaty, with a focus on safety and convenience.	Assessing the condition of sidewalks, street lighting, accessibility of public facilities, as well as obstacles such as parking lots, road equipment, and signs. Safety criteria also include the separation of pedestrian flows from vehicles.
7	[16]	Iran	Explain pedestrians' perceptions of the factors that affect the use of pedestrian bridges, using planned behavior theory as a foundation.	The safety factors analyzed were the physical and emotional aspects of the use of the pedestrian bridge.
8	[17]	Oman	Identify the key factors that affect pedestrians' intentions in using pedestrian crossing facilities.	Safety is greatly influenced by factors such as facility cleaning, adequate lighting, and good facility design.
9	[18]	Singapura	Educate and raise awareness among bridge designers about the importance of considering accessibility in the design of pedestrian bridges.	Bridges that are not universally accessible can create physical barriers, reduce comfort, and increase the risk of accidents for their users.

A total of 9 documents were analyzed using VOSviewer software which allows for a comprehensive understanding of research trends, key themes, and gaps in the literature. The analysis was conducted based on several important aspects, including the focus of the research, the methodology used, the geographic coverage, and the main findings of each study. The following is Figure 2 which produces a visualization related to the relationship of keyword co-occurrence analysis.

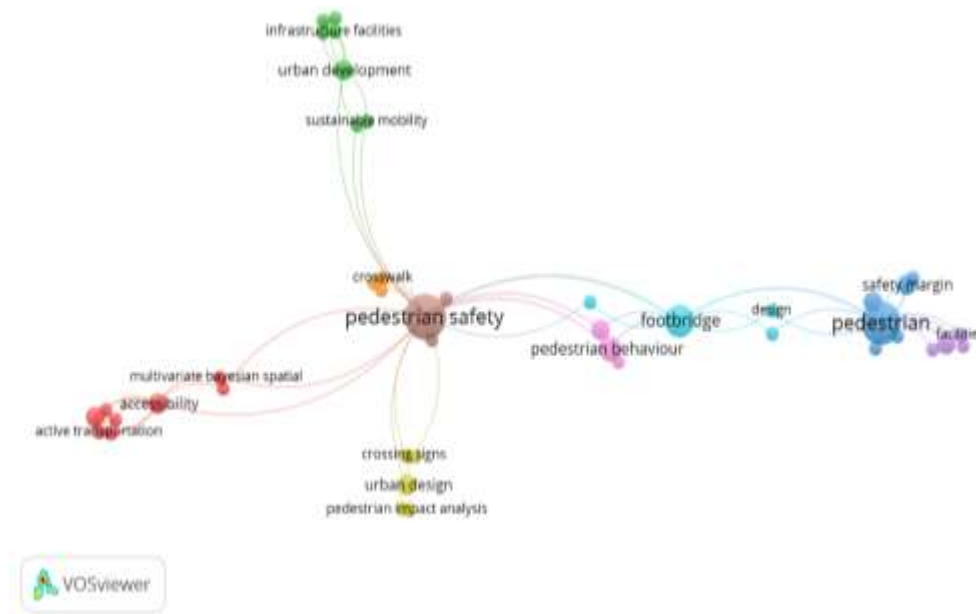


Figure 2 Network Visualization with VOS Viewer

The results of the analysis show that there are nine clusters formed based on the co-occurrence of keywords, each of which represents the main theme in this study. Each cluster reflects the conceptual relationships and research trends that are developing in this field, helping to unravel the dominant research focus as well as the interconnectedness between topics. The following is an explanation for each cluster.

1. Red Cluster: accessibility and design

The keywords in this cluster show that recent research highlights the importance of providing facilities that support access for all community groups, including the elderly and people with disabilities. Elements such as ramps and stairs are a major concern in supporting active transportation such as walking as part of urban mobility.

2. Green Cluster: sustainable infrastructure and mobility facilities

This cluster links urban infrastructure factors with safe pedestrian safety and accessibility reflecting a holistic approach in urban planning oriented towards urban growth and urbanization.

3. Dark blue cluster: safety and structure of the crossing bridge

This cluster emphasizes technical factors such as safety margins and effective bridge design to reduce the risk of accidents when crossing the road.

4. Yellow cluster: pedestrian interaction with road attributes

This cluster focuses on crossing signs and urban design, as well as the analysis of road user behavior related to safety factors.

5. Purple cluster: basic infrastructure of pedestrian bridges

This cluster reflects the focus on the linkage between the available facilities and the ease of use of the flyover by pedestrians.

6. Light blue cluster: bridge design and user preferences

The cluster considers various aspects of pedestrian safety in the use of these facilities.

7. Orange cluster: pedestrians and vehicles

This cluster focuses on the interaction between pedestrians and vehicles in the crossing area, as well as psychological factors such as gap acceptance when crossing.

8. Brown cluster: pedestrian safety in the context of urban transportation

This cluster discusses the design of roads and transportation systems to help reduce the risk of accidents.

9. Pink cluster: pedestrian behavior and attitude towards traffic safety

This cluster focuses on the use of bridges and their safety perception of the facility.

### 3.2 Report of Findings

Based on the explanation above, the findings that can be taken related to pedestrian safety on the pedestrian bridge are as follows:

#### 1. Condition of the Pedestrian Bridge

**Physical Condition and Safety of Bridges:** The safety of bridges is highly dependent on their physical condition, including the bridge's structure being strong and free from damage. Bridges that appear unsafe or damaged will reduce users' interest in using them, although they may be safer than crossing on the highway. Poor maintenance can increase fear and affect the perception of safety [19].

**Adequate Lighting:** Poor lighting at night can be a major hazard factor that increases insecurity, especially for pedestrians. Therefore, adequate lighting along the pedestrian bridge is essential to ensure the physical and emotional safety of bridge users.

**Bridge Design:** Bridge design must consider the aspects of comfort and ease of access for all users, including people with disabilities. If the bridge is not universally accessible, this could cause physical obstacles and increase the risk of accidents [20].

#### 2. Social and Environmental Factors

**Presence of Beggars, Addicts, and Stray Dogs:** Social factors such as the presence of groups of beggars, addicts, or wild animals such as dogs can exacerbate insecurity or add to fear for pedestrians, especially when crossing bridges at night or when conditions are quiet.

**Population Density and Traffic Volume:** The high population density and traffic volume around the bridge affect the level of safety. Crowded or congested roads can cause accidents or tension, especially if pedestrians have to share the road with vehicles [21], [22], [23].

#### 3. Pedestrian Behavior

**Behavior Patterns and Crossing Timings:** Crossing times (morning, noon, evening) play a big role in pedestrian safety. Certain times, such as at night, may increase the risk of crime or accidents due to limited lighting and surveillance. Additionally, the gender and age of pedestrians can affect how they use bridge facilities, as well as how they feel safe when crossing [24], [25].

#### 4. Existence of Supporting Facilities

**Separation of Pedestrian Flow from Vehicle:** Clear separation between pedestrian paths and vehicular lanes is important to reduce the risk of accidents. Pedestrian bridges that have a clear separation between these two streams are safer compared to roads that do not have similar facilities [26], [27].

**Accessibility and Ease of Access to Bridges:** Easy access to bridges is essential to encourage pedestrians to use them. If the bridge is difficult to reach or obstructed by factors such as parking or road equipment, then pedestrians tend to avoid using the bridge and prefer to cross the road directly, which is more risky [28].

#### 5. Influence of Law Enforcement

**Proper Law Enforcement:** A high level of law enforcement will motivate pedestrians to comply with safety rules, including the use of crossing facilities. Without consistent law enforcement, pedestrians may prefer to cross the road carelessly, increasing the risk of accidents [29], [30].

#### 6. Emotional and Psychological Factors

**Insecurity and Fear:** Fear or insecurity often arises due to social (such as the presence of beggars or stray dogs) and physical (such as lack of lighting or roadblocks). This feeling can reduce the use of facilities that should be safer, such as pedestrian bridges.

#### 7. Infrastructure Availability and Quality

**Quality of Sidewalks and Surrounding Infrastructure:** The quality of sidewalks and the presence of obstacles such as parking lots, road equipment, and signs are also very important to ensure the comfort and safety of pedestrians. Damaged or poorly maintained infrastructure can reduce comfort and increase the risk of accidents [31].

**Accessible Public Facilities:** Facilities such as bridges and underpasses should be designed to be easily accessible to everyone, including people with disabilities. If the facility is inaccessible, this can hinder safe use and increase the risk of accidents [32].

## 8. Evaluate Demographic Factors

User Demographics: Demographic factors, such as the age and gender of pedestrians, can influence how they use bridges and how they feel about safety [33]. For example, parents or children may feel more vulnerable and need safer and more accessible facilities.

### 3.3 Implications of Findings and Recommendations

Pedestrian safety in using pedestrian bridges is influenced by various factors, both physical, social, and psychological. Poor bridge conditions, such as lack of maintenance and inadequate lighting, can reduce interest in use and increase the risk of accidents due to risky behavior, such as crossing the highway. Social factors, such as the presence of beggars, addicts, and stray dogs, create fear and discomfort that impact the emotional safety of users. In addition, crossing times and demographic factors, such as age and gender, also affect the sense of safety and comfort in using these facilities. Accessibility barriers, such as non-strategic locations or obstacles in the form of illegal parking and inappropriate signs, also reduce the effectiveness of bridge use [34]. Therefore, bridge repairs and maintenance are needed that include safe and well-maintained designs and adequate lighting, accompanied by the arrangement of the social environment through supervision and cleanliness of the surrounding area. Increasing accessibility with a universal design that is friendly to all groups, as well as a clearer separation of pedestrian and vehicle lanes, is very important to reduce the risk of accidents. Stricter law enforcement, such as the implementation of traffic regulations and safety education for the community, must be carried out to increase compliance with the use of crossing facilities. Evaluation of the usage time and demographic needs of users should also be considered in designing safer and more comfortable facilities [35], [36]. In addition, improving the quality of road and sidewalk infrastructure with pedestrian-friendly designs is essential to ensure the safety and comfort of pedestrian bridge users.

## 4. CONCLUSION

This systematic review provides insights into factors that influence pedestrian safety when using pedestrian bridges in Asia. Based on a systematic review of factors that influence safety, it was found that pedestrian safety is not only dependent on the physical condition of the bridge, but is also influenced by social, and psychological factors, and the quality of the supporting infrastructure. The physical condition of the bridge, such as safe design, good maintenance, and adequate lighting, plays a significant role in enhancing the physical safety of bridge users. In addition, social and emotional factors, such as the presence of social nuisances (beggars, addicts, stray dogs) and the level of user's sense of safety, greatly influence the decision to use a pedestrian bridge facility. Psychological factors related to fear or discomfort, especially at certain times or in poorly lit locations, are also important aspects to consider in designing safe and comfortable facilities. Overall, this systematic review suggests a holistic approach to designing and managing pedestrian bridge facilities, taking into account physical, social, emotional, and legal factors to create a safer and more comfortable environment for pedestrians in Asia.

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