Review Article

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A System Approach on Safe Emergency Evacuation in Subways: A Systematic Literature Review

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Abstract

Background: Due to the extensive use of subway transportation in high- and middle-income countries, the safety of passengers has become one of the important challenges in emergency management of subway station. Therefore, the present systematic review aimed to identify environmental and organizational management factors that affect the safe emergency evacuation in subway stations. **Materials and Methods:** In this systematic literature review, PubMed, Scopus, Web of Science, ProQuest, Google Scholar, Iran Medex, Magiran, and Scientific Information Database from 1990 to 2019 were searched to identify effective emergency management factors in safe emergency evacuation of the subways. A thematic content analysis was employed for data analysis. **Results:** Of 763 publications retrieved from the searches, 149 studies were included for data analysis. According to the findings, effective environmental and organizational management factors in safe emergency evacuation were discussed in eight subcategories, including infrastructure properties, evacuation-assisting resources, prevention of injuries and mitigation, preparedness for emergency evacuation, emergency response and reconstruction, and maintenance of evacuation facilities. **Conclusion:** The design of an optimal route for emergency evacuation is the main theme of most studies focusing on environmental factors. While a system approach for designer is needed for effective subway emergency evacuation, human-related factors focusing on injury prevention are also crucial.

Keywords: Emergency evacuation, environmental factors, organizational factors, subway

Introduction

Although subway transition services in high- and middle-income countries accelerate the transportation of passengers and thus reduce the time spent in urban traffic, they have also turned subway stations into crowded and busy public places.[1-3] Currently, crowded subway stations, especially in peak hours, are quite prevalent.[4] The high density of passengers and the psychological burden of a massive crowd in the limited space of stations and on platforms can easily lead to congestion, formation of queues[5] at bottlenecks and narrow passages, and even a threat to the health of passengers.[6] Therefore, emergency evacuation has found an important place in pedestrian safety research, and timely and effective evacuation of stations will be an important measure for preventing injuries.[7,8]

Nowadays, ensuring the safe evacuation of pedestrians from public places, such as subway stations, is a major factor contributing to the quality of services in the development of a healthy and safe rail transportation system.[8-10] The design and construction of emergency exit and egress paths as the shortest path for exit are safety-related issues in the design

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and implementation of public places.[11,12] During emergency evacuation, certain unpredictable situations, for example, fire, smoke, or the destruction and partial or complete collapse due to natural disasters or anthropogenic hazards, may make it impossible to use predetermined emergency evacuation.[13] Moreover, the unpredictability of human behavior in emergency conditions as well as uncertainty with regard to all environmental and intrinsic variables that affect human behavior leads to the high complexity of emergency evacuation from subway stations and has become a major challenge for planning emergency evacuation.[8,14-18]

As in many domains of organizational performance management, in evaluating the performance of emergency evacuation, the concepts of efficiency and effectiveness are common in determining the level of success or failure of operations.[13] Efficiency is a basic need in emergency evacuation operations.[19] The efficiency of emergency evacuation refers to the ratio of the total number of people evacuated to the total number of people expected to be evacuated through available resources, for example, exit and egress paths, in the time available for evacuation.[19,20] In emergency evacuation aiming at the safe evacuation of people, evacuation with minimum injuries as well as the effectiveness of evacuation operation is of special significance.

In emergency situations such as fire, emergency evacuation is a serious challenge for crowd safety.[21] Thus, the reexamination of capacities and emergency exit paths based on the increased passenger load for each station as well as the identification and clarification of factors promoting the safety of emergency evacuation in subway systems can be applied in planning for promoting crowd safety during emergency evacuation. Accordingly, the present study was designed to identify environmental and organizational management factors affecting the safe emergency evacuation from subway stations by a systematic literature review.

Materials and Methods

Eligibility criteria

This systematic review included all studies that were conducted from 1990 to 2017, in which the emergency crowd evacuation has been an important dependent or independent variable, ,or those which have studied emergency evacuation of subway stations using an experimental or simulation approach.

Literature search and data extraction

The search strategy consisted of two steps including electronic search and manual search. The search syntax was conducted using emergency evacuation, safety, and subway as main keywords. Furthermore, appropriate synonyms for keywords were identified through Medical Subject Headings terms, popular and common words and phrases stated in related literature, and expert opinion.

The search of electronic databases was performed through PubMed, Scopus, Web of Science, Google Scholar, Iran Medex, Magiran, and Scientific Information Database to identify related articles and literatures. Furthermore, we searched ProQuest for dissertations and other sources such as national and international congresses such as International Conference of Chinese Transportation Professionals and CICTP. Tables of contents of key journals in this field and gray literatures were searched through handsearching. The search strategy was developed and completed in PubMed, and then the same strategy was applied to other databases. Finally, reference lists of relevant articles and systematic reviews were searched as well. The search syntax of databases is given in Appendix 1a and b.

Then, the search was conducted and the publications of interest were selected based on the titles and abstracts. After screening, the full texts of all the selected publications were examined. The relevant data were extracted from identified publications based on the PRISMA flowchart [Figure 1].

All the searched studies included quantitative and qualitative methods, which have aimed for the safety of crowd during emergency evacuation with minimum injuries. Accordingly, studies on emergency evacuation in places other than subway stations and underground stations were not included. Therefore, all studies on emergency evacuation of bus stations, urban tunnels, and public buildings were excluded. Moreover, this study focused on the safe emergency evacuation after the exploitation of subway lines. Therefore, all studies focusing on emergency evacuation in the construction phase of subway stations were excluded. To avoid language bias, non-English publications were also included, and Google Translate was used to extract the data in these articles.

Review, data extraction, and quality assessment

All studies' records transmitted in (EndNote X7™, Thomson Reuters) software and initially duplicated records were extracted. In the next step, primary article screening was conducted by two authors independently. They reviewed the title and abstract of the articles independently and categorized the selected articles into relevant, irrelevant, and unsure groups. Irrelevant articles were eliminated from the study, and for unsure categories, the third author decided the articles. Then, after reviewing the full text of relevant articles by each reviewer, they made a list of included articles.

From each included study, the following information of studies including the name of the author, the type of the study, study design, and outcome has been extracted [Table 1].

Moreover, factors affecting the safe evacuation of the subway under emergency conditions were extracted from the included papers and entered into data sheets [Appendix 2] by two reviewers. To do data synthesis of findings, a six-phase framework of thematic analysis was used based on Braun and Clarke (2006) recommendations.[22] Therefore, the following steps were employed by a three-researcher team. These steps followed becoming familiar with the data, generation of initial codes, searching for themes, reviewing themes, defining themes, and writing up the manuscript.[22] Two reviewers performed data extraction independently and

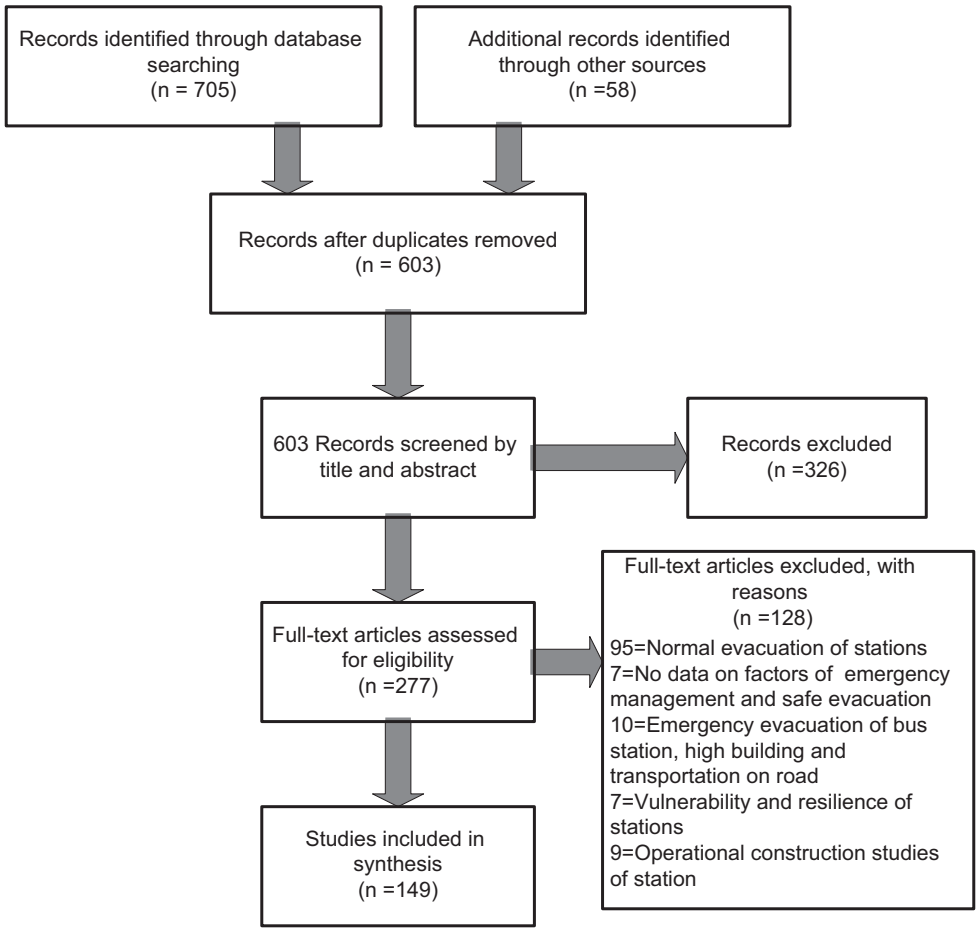

Figure 1: PRISMA flowchart of systematic review of environmental and organizational management-related factors affecting safe emergency evacuation of the subways

consensus reached. In some instances, when reviewers did not get consensus about codes and categories, coding procedures have been revised by the third researcher. Moreover, reviewing of emerging data and data analysis among the research group was discussed.

Critical appraisal of articles was performed by the authors employing a developed checklist [Appendix 3] to assess the quality of each article based on four categories, including screening question, study design/type of the study, findings, and strength of recommendation. All of the studies included were reviewed on the basis of this checklist's questions.

Results and Discussion

Search results

Based on the PRISMA flowchart, from 763 studies searched using the syntax search on databases, the full texts of 277 studies were examined based on the correspondence of title and abstracts with inclusion and exclusion criteria. Finally, 149 articles were included in this study, and emergency management factors affecting safe emergency evacuation of subway stations were extracted from their results sections and were analyzed based on thematic analysis.

Of all studies searched after the removal of duplications, 326 studies were excluded as they did not meet inclusion criteria.

A total of 277 studies entered the risk of bias assessment phase, and the full texts of these studies were examined based on the critical appraisal checklist; seven studies were excluded as they did not include factors related to the present systematic review and seven were excluded as they focused on the vulnerability of subway stations and resilience of the public transportation system. Furthermore, 95 studies examined the subway evacuation in normal condition and 9 studies investigated evacuation during the construction operations of subway stations. As emergency evacuation occurs after the exploitation of stations, these studies were excluded. Moreover, of 277 studies whose full texts were examined, only four studies had a qualitative method; three of them meet the inclusion criteria. Therefore, all majority of studies included here were quantitative.

Among the primary studies, 90 studies were journal articles, 42 were conference paper, 2 were book section, and 6 were thesis. The majority of study designs of publications were 91 simulation studies, 6 mathematical modeling, 10 cross-sectional and 26 case studies and 6 reviews and 1 trial were also considered. The studies were mostly conducted in subway stations of China [Table 1].

Table 1: Specifications of studies included in the systematic review of environmental and organizational management-related factors in safe emergency evacuation from subways

Authors	Years	Country	Type	Design	Finding focus of articles
Zhang, Limao[22]	2019	China	Journal article	Simulation/case study	Prevention of injuries and mitigation
Wang W[23]	2018	China	Journal article	Simulation	The effect of environmental factor in emergency response
Lee HS[24]	2018	South Korea	Journal article	Simulation	The effect of environmental factor in emergency response
Yang J[25]	2017	China	Journal article	Mathematical modeling/case study	Emergency response
Wang Z[26]	2017	United States	Conference paper	Simulation	Emergency response
Wang, Qiquan[27]	2017	China	Journal article	Case study	Prevention of injuries and mitigation
Sui J[28]	2017	China	Journal article	Simulation	Preparedness
Ma L[29]	2017	China	Journal article	Simulation	Preparedness
Li Q[30]	2017	China	Journal article	Simulation	Emergency response
Chen SK[31]	2017	China	Journal article	Simulation	Emergency response
Butler K[32]	2017	United States	Journal article	Case study/qualitative	Emergency response
Baffoe BOK[33]	2017	China	Journal article	Case study/FGD/qualitative	Preparedness
Zhang *et al*.[17]	2017	China	Journal article	Mathematical modeling	Safe egress time of emergency evacuation
Wu *et al*.[9]	2017	China	Journal article	Simulation	Estimate evacuation capacity under emergency conditions
Jevtic, Radoje B[34]	2017	Serbia	Journal article	Simulation	The possible evacuation situation and calculate minimum time needed for evacuation
Chen YX[35]	2017	China	Journal article	Simulation	Resources assisting evacuation to arrive at safety zones
Chen T[36]	2017	China	Conference paper	Cross-sectional	Prevention of injuries and mitigation by improve the safety equipment effectiveness
Chen SK[37]	2017	China	Journal article	Simulation	Effectiveness of infrastructure properties in emergency evacuation
Ye QW[38]	2016	China	Conference paper	Case study	Preparedness
Yang YD[39]	2016	China	Journal article	Case study	Emergency response
Qian Q[40]	2016	China	Journal article	Case study	Prevention of injuries and mitigation
Luo H[41]	2016	China	Conference paper	Ontology/qualitative	Preparedness
Lu K[13]	2016	China	Journal article	Case study	Prevention of injuries and mitigation
Li, Qiming[42]	2016	China	Journal article	Simulation/case study	Emergency response
Karagiannidis L[43]	2016	Greece	Conference paper	Case study	Emergency response
ju Kim, Hyun[44]	2016	South Korea	Journal article	Factor analysis	Preparedness
Haghani M[45]	2016	Australia	Journal article	Random-utility analysis random-coefficient nested logit	Emergency response
Fridolf K[46]	2016	Sweden	Journal article	Cross-sectional	Emergency response
Brüne M[47]	2016	Germany	Journal article	Simulation	Emergency response
Maslak V[48]	2016	Russian Federation	Conference paper	Simulation	The effect of environmental structure in safety of evacuation
Ma J[49]	2016	China	Journal article	Simulation	The efficient passenger emergency evacuation process
Lin-na, CHENG[50]	2016	China	Journal article	Simulation	The effect of environmental factors in a subway station fire emergency evacuation process
Hong L[51]	2016	China	Journal article	Simulation	Improving emergency response
Chang HP[52]	2016	Taiwan	Journal article	Simulation	The effect of incidents features on emergency evacuation
Cai Yu[53]	2016	China	Journal article	Simulation	The effect of incidents features on emergency response
BAYSAL TÜRKÖLMEZ, Gökçe[54]	2016	Turkey	Journal article	Simulation	The safe egress time
Sharma S[55]	2015	United States	Conference paper	Simulation	Preparedness
Chen YY[56]	2015	China	Journal article	Simulation	The environmental and managerial requirement for safe evacuation
Cłapa, Iwona[57]	2015	Poland	Journal article	Case study	Emergency response

Contd...

Table 1: Contd...

Authors	Years	Country	Type	Design	Finding focus of articles
Yin K[58]	2015	China	Conference paper	Trial	The environmental requirement for prevention of injuries and mitigation
Yin K[59]	2015	China	Conference paper	Simulation	The environmental requirement for prevention of injuries and mitigation
Yang X[60]	2015	China	Journal article	Simulation	The environmental requirement for prevention of injuries and mitigation
Wang ZL[61]	2015	Amsterdam	Book section	Simulation	Emergency response
WANG, Qi-quan[62]	2015	China	Journal article	Mathematical modeling	Emergency response
Tong R[63]	2015	China	Journal article	Simulation	The environmental requirement for prevention of injuries and mitigation
Xu, Yan Ying[64]	2014	China	Conference paper	Case study	Emergency response
Wang Z[65]	2014	China	Conference paper	Simulation	Preparedness
Sun XB[66]	2014	China	Journal article	Cross-sectional	Preparedness
Li, Zhu Huan[67]	2014	China	Conference paper	Simulation	Prevention of injuries and mitigation
Li Q[68]	2014	China	Conference paper	Case study	Emergency response
Han X[69]	2014	China	Journal article	Simulation	Emergency response
Charlton J[70]	2014	United Kingdom, England	Journal article	Cross-sectional	Emergency response
Zeng S[71]	2014	China	Conference paper	Simulation	The effect of incidents feature on safe evacuation
Xie, Hua[72]	2014	China	Conference paper	Review	The safe emergency evacuation strategies
Xie, Hua[73]	2014	China	Conference paper	Review	The evacuation strategy of safe emergency evacuation
Wang WL[74]	2014	China	Conference paper	Simulation	The environmental requirement for emergency response
Qu Yunchao[75]	2014	China	Journal article	Simulation	The effect of incidents feature on safe evacuation
Lo SM[76]	2014	China	Journal article	Simulation	The effect of design on prevention of injuries and mitigation
Liu Fang Lin[77]	2014	China	Journal article	Simulation	The effect of design on prevention of injuries and mitigation
Liao Weichen[78]	2014	China	Journal article	Simulation	The environmental requirement for emergency response
Zhang Su Li[79]	2013	China	Journal article	Fuzzy network analysis	Emergency response
Yi SL[80]	2013	China	Journal article	Simulation	Emergency response
Yang H[81]	2013	China	Conference paper	Case study	Emergency response
Wang X[82]	2013	China	Conference paper	Simulation	Emergency response
Song Y[83]	2013	China	Journal article	Simulation	Emergency response
Li YF[84]	2013	China	Journal article	Cross-sectional	Emergency response
He, Jian-Fei[85]	2013	China	Journal article	Case study	Prevention of injuries and mitigation
Yue H[86]	2013	China	Journal article	Simulation	The environment requirement for safe emergency evacuation
Yang, Peizhong[87]	2013	China	Journal article	Simulation	The effect of environmental factors on emergency evacuation
Tachibana, H[88]	2013	Japan	Conference paper	Review	The environmental requirement to prevention of injuries and mitigation
Ronchi, Enrico[89]	2013	Sweden	Journal article	Simulation	Prevention of injuries and mitigation
Pflitsch, Andreas[90]	2013	Germany	Journal article	Simulation	The effect of incidents feature on safe evacuation
Jiahui, W[91]	2013	China	Conference paper	Simulation	The effect of incidents feature on safe evacuation
HE, Li-gong[92]	2013	China	Journal article	Case study	The effect of environmental design on emergency response
Fridolf, K[93]	2013	Sweden	Journal article	Mathematical modeling	The environmental requirement to prevention of injuries and mitigation
Choi, J[94]	2013	Japan	Conference paper	Simulation	The environmental requirement to prevention of injuries and mitigation

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Table 1: Contd...

Authors	Years	Country	Type	Design	Finding focus of articles
Wang, Y[95]	2012	China	Conference paper	Case study	Emergency response
Kadokura, H[96]	2012	Japan	Journal article	Simulation	Emergency response
Okada, N[97]	2012	Japan	Journal article	Case study	Emergency response
Nguyen, Manh Hung[98]	2012	Vietnam	Conference paper	Simulation	Prevention of injuries and mitigation
Yiheng, Wang[99]	2012	China	Journal article	Mathematical modeling	The effect of evacuation capacity on emergency evacuation
Qu, L[100]	2012	China	Journal article	Simulation	The environmental requirement to prevention of injuries and mitigation
Liu, Jun Feng[101]	2012	China	Conference paper	Simulation	Emergency response
Liang, H[102]	2012	China	Journal article	Simulation	The effect of incident feature on emergency evacuation
Li, Y. F[103]	2012	China	Book section	Simulation	The effect of environment on safe emergency evacuation
Han, X[104]	2012	China	Conference paper	Simulation	The effect of incident feature on emergency evacuation
Guo, C[105]	2012	China	Conference paper	Case study	Prevention of injuries and mitigation
Gao, R[106]	2012	China	Journal article	Simulation	The environmental requirement to prevention of injuries and mitigation
Cheng, Huan[107]	2012	China	Journal article	Simulation	Prevention of injuries and mitigation
Shoaei, Mozhdeh[108]	2012	Iran	Conference paper	Simulation	The environmental requirement to safe emergency evacuation
Tian, Juan-Rong[109]	2011	China	Journal article	Simulation	Prevention of injuries and mitigation
Li, He[110]	2011	China	Book section	Cross-sectional	Preparedness
Hong, Ling[111]	2011	China	Conference paper	Cross-sectional	Prevention of injuries and mitigation
Li *et al*.[6]	2011	China	Conference paper	Simulation	The effect of environment on crowd congestion during emergency evacuation
Tsukahara, M[112]	2011	Japan	Journal article	Simulation	The effect of environment design on emergency evacuation
Yang, J. T[113]	2011	China	Conference paper	Simulation	The environmental requirement to prevention of injuries and mitigation
Wang, Chao[114]	2011	China	Thesis	Simulation	The environmental requirement to prevention of injuries and mitigation
Marsella, S[115]	2010	Italy	Conference paper	Cross-sectional	Prevention of injuries and mitigation
Liu, Y[116]	2010	China	Conference paper	Simulation	Emergency response
Zhang, Hong[117]	2010	China	Journal article	Simulation	Emergency response
WU, Jiaorong[118]	2010	China	Journal article	Case study	Preparedness for emergency response
Roh, J. S[119]	2010	South Korea	Journal article	Simulation	The environmental requirement to prevention of injuries and mitigation
ZHANG, Peihong[120]	2009	China	Journal article	Case study	Preparedness
Weiwei, Kong[121]	2009	China	Journal article	Case study	Emergency response
Ishigaki, T[122]	2009	Japan	Conference paper	Simulation	Prevention of injuries and mitigation
Huan, Pei[123]	2009	China	Journal article	Literature review	Preparedness
Ceng, Sheng[124]	2009	China	Thesis	Simulation	The safe egress time
Dezhi, Zhang[125]	2009	China	Journal article	Case study	The effect of environment factor on Prevention of injuries and mitigation
Xu, X[126]	2009	China	Conference paper	Cross-sectional	The environmental requirement to prevention of injuries and mitigation
Wang, B. H[127]	2009	China	Book	Simulation	The environmental requirement to prevention of injuries and mitigation
Vittori, F[128]	2009	Venezuela	Conference paper	Simulation	The effect of incident feature on emergency evacuation
Tan *et al*.[1]	2009	China	Conference paper	Simulation	The environmental requirements for emergency response
Roh, J. S[129]	2009	South Korea	Journal article	Simulation	The environmental requirement to prevention of injuries and mitigation
Ma, Jun-Chi[21]	2009	China	Journal article	Simulation	The safe evacuation time

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Table 1: Contd...

Authors	Years	Country	Type	Design	Finding focus of articles
Jiang, C. S[130]	2009	China	Journal article	Simulation	The environmental requirement to prevention of injuries and mitigation
Jeon and Hong[15]	2009	South Korea	Journal article	Case study	The effect of environmental factors in emergency evacuation
Shi, Wei Bo[131]	2008	China	Thesis	Simulation	Prevention of injuries and mitigation
Shi, C. L[132]	2008	China	Book	-	Emergency response
Liu, S[133]	2008	China	Journal article	Simulation	Emergency response
Liu, Q. Q[134]	2008	China	Book	-	Emergency response
Bao, L[135]	2008	China	Conference paper	Simulation	Emergency response
Zhou, R[136]	2008	China	Journal article	Simulation	The environmental requirement to prevention of injuries and mitigation
Zhou, R[137]	2008	China	Journal article	Simulation	The effect of incident feature on emergency evacuation
Zhong, M. H[138]	2008	China	Journal article	Simulation	The possibility of safe emergency evacuation
Zhao, Liang Jin[139]	2008	China	Thesis	Simulation	The environmental requirement to emergency response
Song, B[140]	2008	China	Journal article	Case study	Prevention of injuries and mitigation
Shi, C[141]	2008	China	Conference paper	Simulation	The effect of environment design on Prevention of injuries and mitigation
Nie[11]	2008	China	Thesis	Case study	The effect of safety egress design on emergency evacuation
LIAO, Yan-fen[142]	2008	China	Journal article	Simulation	The environmental requirement of emergency response
Chow, W. K[143]	2008	China	Journal article	Simulation	The effect of waiting time on safety management
Tokunaga, Takeshi[144]	2007	Japan	Journal article	Cross-sectional	Prevention of injuries and mitigation
Chang, S[145]	2007	Taiwan	Journal article	Simulation	The effect of incident feature on emergency evacuation
Chen, J. H[146]	2007	China	Book	Simulation	The effect of incident feature on emergency evacuation
Li, Y. F[147]	2007	China	Journal article	Simulation	The environmental requirement to safe emergency response
Mao, J[148]	2007	China	Journal article	Simulation	The effect of incident feature on emergency evacuation
Zhang, P[149]	2007	China	Journal article	Simulation	The environmental requirement to prevention of injuries and mitigation
Yan, TONG[150]	2006	China	Journal article	Mathematical modeling	Prevention of injuries and mitigation
Xie, J[151]	2006	China	Book	-	Emergency response
Haack, A[152]	2006	Germany	Journal article	Case study	Prevention of injuries and mitigation
Landow[5]	2006	United States	Conference paper	Review	The prevention requirement for emergency evacuation
Li, J. F[153]	2006	United States	Book	Simulation	The safe egress time
Li, Yao-zhuang[154]	2006	China	Journal article	Simulation	Prevention of injuries and mitigation
Miclea, P. C[155]	2006	United States	Conference paper	Review	The effect of incident feature on emergency evacuation
Xie, J[156]	2005	China	Book	-	Prevention of injuries and mitigation
Castle, C. J. E[157]	2005	United Kingdom	Book section	-	Preparedness
Moriyama, S[158]	2005	Japan	Conference paper	Simulation	The effect of incident features on safe evacuation
Rie, D. H[159]	2005	China	Book	-	Disaster prevention at subway platform
Chien, S[160]	2004	Taiwan	Journal article	Simulation	Preparedness
Yang and Lee[12]	1999	Taiwan	Journal article	Simulation	The effect of egress design in emergency evacuation

FGD: Focus group discussion

Thematic analysis

Based on the findings of the present study, factors affecting the safe emergency evacuation of subway stations are classified into two main categories and eight subcategories, including

environmental factors (infrastructure properties, resources assisting evacuation, time, and features of incidents) and organizational management-related factors (prevention of injuries and mitigation, preparedness for emergency evacuation, emergency response, and reconstruction and maintenance of evacuation facilities) [Table 2].

Environmental factors

Based on the findings, subway station infrastructure properties, evacuation-assisting resources, time, and features of incidents were the most important environmental factors affecting the safe emergency evacuation from subway stations.

Infrastructure properties

In general, based on the examination of the studies, 131 studies investigated the effects of subway station infrastructure properties on the effective and safe emergency evacuation. Based on the results, the identification of safe evacuation paths and identification and evaluation of safety egress paths are the most important features related to the infrastructure of emergency evacuation from subway systems, mentioned by multiple studies.[11,24-26] In evaluating evacuation paths, the number of exits, width of exits, passing capacity, walking distance to the exit or the length of the evacuation path, width of corridors, and identification of bottlenecks and connecting corridors' capacity of the evacuation path were examined. The design of an optimal path for emergency evacuation was also identified as a factor increasing the efficiency and reliability of emergency evacuation.[9,25-41]

Other station infrastructure features include emergency facilities such as stairs, ramps, escalators, and elevators. Increasing the number of evacuation paths, width and size of stairs and exits, and number of escalators for improving the emergency evacuation capacity were simulated in numerous studies as variables affecting the duration of evacuation.[4,6,42-47] Diversity and design of evacuation facilities for emergency situations must be proportionate to the need and demand of the population using the subway system, especially regarding those with special needs.[25,48-50] The safety of passengers, prohibiting the use of elevators in fire, evacuation through emergency exit stairs, and transfer of crowd to a predetermined safety zone have been recommended. Moreover, the results of simulation case studies of subway station emergency evacuation show that evacuation has a better performance with escalators than with stairs; therefore, in case of failure of elevators, access to escalators as an alternative facility is essential.[51-54]

Another infrastructure that affecting the duration of effective evacuation in most subway stations is turnstiles and exit gates, which effects on evacuation duration and crowd safety during evacuation, which have been examined in case studies and experimental studies on stations in terms of type, number, and location. Furthermore, the effects of availability of a platform shield door system, platform screen doors, and fire-resistant doors on preventing the spread of smoke and enhancing the safety of passengers in normal and emergency situations have been investigated by numerous studies.[1,55-70]

The use of wireless sensor network technology in stations as an effective infrastructure for the safe evacuation of subway stations allows the monitoring of all parts of the station, especially blind spots; improves decision-making duration and implementation of emergency response commands by the timely identification of danger; and promotes the efficiency of evacuation.[71,72]

The physical properties of the design of subway stations and complicated structure of each station in terms of number of stories, depth, architecture, obstacles considered in the design of the building, location of exits, location and layout of ticket inspectors in the internal space, and the width of the platform

Table 2: Environmental and organizational management-related factors in safe evacuation from subway stations based on a systematic review

Category	Subcategory	Examples from the code/data		
Environmental factors	Infrastructure properties	Identification and evaluation of evacuation routes	Features of subway station	Determine safe zones in subway tunnels and stations
	Evacuation-assisting resources	Rescue equipment for emergencies	Emergency exit signs	Staff who guides evacuation
	Time	Accident time	Duration of time the exits blocked	Total evacuation process time
	Features of incidents	Type of accident (terrorist attack, fire, etc.)	Location of accident (platform, tunnel, train, etc.)	Severity and extent of the accident
Organizational management-related factors	Mitigation of injuries	Safety risk management	Establishment of laws and regulations for safety	Determining congestion level for station evacuation
	Preparedness for emergency evacuation	suitable emergency evacuation plan	Organizing emergency rescue teams	Emergency drillings
	Emergency response	decision-making for response operations	Crowd management as well as accident management	Effective and timely response
	Reconstruction and maintenance of evacuation facilities	Continues reconstruction plans	Rebuilding of egress facilities	Calibration of firefighting equipment of stations

are the other infrastructure features of stations whose effects on evacuation capacity and duration of safe evacuation have been analyzed in simulation case studies of emergency evacuation of certain stations, including those in China.[47,75-78] The results of a case study in Japan also indicated that the acoustics of the space affect the effective notification and safety of evacuation.[79] In the domain of emergency evacuation safety, from among the infrastructure features of stations, the number of stories (due to increasing duration of emergency evacuation) and the architecture of the space (due to the importance of identification of bottlenecks) received special attention. For instance, angular or winding paths affect the formation of bottlenecks and lead to the aggregation of the crowd.[80-82]

With regard to the effects of subway station infrastructure properties, the features of the underpasses of the subway stations affect the safe evacuation of crowd. In addition to the effects of underpass evacuation capacity on the required safe egress time (RSET), based on a survey of the subway system in China, filling the space of underpasses by street vendors highly affected the efficiency of emergency evacuation by limiting the space available for evacuation.[83] Therefore, our findings concluded that the removal of all obstacles limiting exit paths is essential in terms of the safety of evacuation. Furthermore, another factor affecting safe evacuation in normal and emergency conditions emphasized by different studies is the necessity of respecting station design safety codes, including evacuation path design codes, evacuation safety zone codes, and the American National Fire Protection Association standard codes (NFPA130) in the design of stations.[5,27,52,84-92]

Ventilation systems in the station and tunnel ventilation are subway station design, construction, and exploitation requirements.[73,93] The number, conditions, and effective performance of this infrastructure in relation to the safety of passengers in emergency conditions and ventilation strategies were discussed in numerous studies as factors that affect the effective emergency evacuation.[25,61,73,94-105] On the other hand, installation of emergency lights in the infrastructure of subway stations and its effective performance affect the safety of passengers during evacuation at the time of power outage in stations, trains, and tunnels.[36,84,98]

Evacuation-Assisting Resources

In this systematic review, resources assisting evacuation were another environmental factor that affects the safe emergency evacuation and discussed in thirty studies. These resources are divided into two groups, physical and human resources. Physical resources include emergency equipment in the station, covering alarm bell, fire extinguishers , and emergency ladder; emergency equipment in the tunnel, including loudspeakers with alarm signal and notification of voice messages; and relief and rescue resources, covering evacuation mattresses, all serving as safety requirements of subway stations. The importance of the availability and functioning of this equipment is undeniable in emergency situations.[36,86,106-109] In signage systems for subway stations, instructions, emergency exit signs, and ground signs are the physical resources assisting emergency evacuation. The quick and smooth evacuation of passengers depends on instruction services provided by signage systems. These systems are a tool for static direction finding, accelerating evacuation by reducing the time to find directions and increasing the certainty of passengers during escape.[108,110-116] The effects of the position of these signs and their visibility on the facilitation and acceleration of evacuation have been discussed by several studies on subway station emergency evacuation.[111,115,117-119] Furthermore, the positive effect of direction-finding lighting facilities on the safety of evacuated people has been studied.[120,121] It is important to note that the importance of visibility have discussed in prevention of other type of accidents. In addition, emergency notification audio systems in stations, including the adequacy of loudspeakers in terms of quality and quantity, and smart public alarm systems are among physical resources examined with regard to emergency evacuation.[51,79] In terms of human resources, the directive, assistive, and relaxing role of the personnel and the help of evacuation assistants in emergency situations have been identified in several studies as facilitating the dynamism of emergency evacuation operations.[122-125]

Time

Another environmental factor affecting emergency conditions discussed in the studies included in the present review is time. Twenty studies discussed the importance of time in subway station emergency evacuation in their results sections. In studies on emergency evacuation, time considerably affects the efficiency of evaluation.[27,33] The effect of the time of incidents (e.g. rush hour and duration of blockage of exits) on the severity of incidents has been discussed in relevant studies, and the results have demonstrated that minimization of wait time for passengers in crowded situations is effective on the implementation of emergency evacuation safety management at the time of incident.[126] Furthermore, emergency situation response time and analysis of evacuation time, i.e., the duration of time taken to fully evacuate the station, have been examined in studies as variables affecting evacuation safety.[25,28,33,100,127-129] For a safe evacuation, the required safe egress time (RSET) must be shorter than the available safe egress time (ASET).[21,130] ASET is the time duration of hazard occurs until the time in which it starts eliminating the safety of the crowd. In the theory of evacuation process, RSET includes the identification of hazard and evacuation response. Total alarm time is the response time and evacuation action time, varying based on smoke control, increased ambient temperature, and the change in smoke concentration, thereby affecting the possibility of effective evacuation.[17,131]

Features of incidents

The final category of studies examining the effects of environmental factors on subway station emergency evacuation comprises studies on the conditions of emergency evacuation based on the features of the accident. In 32 studies, the features of the accident have been investigated as factors affecting the efficiency of evacuation. In accidents leading to the emergency evacuation of subway stations, the safety of the crowd has been

examined in relation with the location of accident, which may be the tunnel, platform, or inside the train. Depending on the type of hazard, the location of accident, situation of evacuation in the tunnel or on the platform, and the distance from the source of hazard to the crowd greatly affect the safety of crowd during emergency evacuation.[27,73,94,101,132-135]

In terrorist attacks or the accidental dissemination of hazardous substances in the subway, the effects of the position of the source of gas and dispersion of the toxic agent in the system with or without the movement of the train provide key data for helping rescue and escape procedures.[136,137]

In simulation of fire accidents in subway stations, the degree, intensity, and spread of accident, including the fire growth rate, heat transfer rate, increase in ambient temperature, and smoke layer height and visibility, are features of the accident examined as factors affecting the efficiency of evacuation.[15,138-144] In some studies, the effects of smoke in emergency evacuation during fire have been modeled, and the effects of smoke spread have been examined on the safety of passengers.[24,100,145-149] Smoke of fire and its direction in evacuation paths increase the duration of evacuation and disrupt the evacuation process, because it limits the possibility of accessing and using exits, and therefore, passengers select a safe passage free from smoke increased of the shortest passage. Because of the limitations on the use of exists due to congestion in other exits, the evacuation safety of passengers will be affected.[12,15,68,94,144,150,151]

Factors related to the features of the accident, including the type, source, and location of hazard, seriously affect evacuation duration, effectiveness, and efficiency. Researchers conclude that, in most studies, the effects of the features of accidents on human reaction and physiologic tolerance of human health have been neglected. For example, smoke affects psychological and physiological conditions, increasing fear and difficulty breathing for those caught in fire, thereby reducing the speed of movement in evacuation.[150] Alternatively, the threshold of humans' tolerance of ambient temperature affects their walking speed during evacuation and may even stop human functioning in case of exacerbation of accidents. Thus, future studies on safety and health in disasters and emergencies must further examine the effects of the features of accidents on human health and functioning in different accidents by identifying variables affecting human health in subway station emergency evacuation.

In general, with regard to studies that examine and simulate subway station emergency evacuation in the form of case studies and experimental studies, it can be concluded that environmental modification is among the most effective factors for improving subway evacuation processes, because the results of most studies in this systematic review confirm that, by changing and modifying the environment, the level of human error can be largely compensated for, and effective measures can be taken to ensure a higher degree of safety. In addition to studies in the domain of rail transport, in the majority of studies examining the promotion of crowd safety in busy public places, including hospitals, estimation of the structural safety status of the location in crowd safety during disasters and emergencies as modifiable or adjustable variable has attracted the attention of researchers in the domain of health.[152]

Organizational management-related factors

The results extracted from these studies show that some factors related to urban tail transport system and subway station management affect the safe emergency evacuation. In the present study, these factors were classified under the following four categories: prevention of injuries and mitigation; preparedness for evacuation; emergency response; and equipment and rail transport system reconstruction, maintenance, and updating.

Mitigation of injuries

Mitigation of passengers' injuries and evacuation risk reduction are factors affecting the performance of a safe emergency evacuation during accidents or emergency situations. In this systematic review, numerous studies have been found on mitigation actions and measures affecting the safe emergency evacuation of subway stations.[153-155] The safety risk management of underground stations and the use of innovation safety risk management of underground transportation are discussed in literatures as factors affecting the mitigation of injuries during emergency evacuations.[80,156-159] Design of safety risk management regulations, implementation of safety risk management strategies and plans in subway stations, and the development of a decision support system for emergency evacuations have been proposed as injury mitigation strategies during emergency evacuations.[157,160] In many studies on simulations of subway station emergency evacuation, controlling the number of passengers entering and exiting trains and stations, management of crowd movement flow in bottlenecks, improvement of passenger movement between lines, and identification of crowd aggregation patterns in stations have been examined as factors affecting the efficiency of evacuation during emergency situations.[161-163] Evaluating the safety of evacuation paths, optimization of evacuation paths based on subway safe evacuation requirements in order to optimize the performance of emergency evacuation, and estimation of the stations' evacuation capacity have been examined by several relevant studies.[9,148,164-166]

Despite the existence of several studies on safety risk management in underground stations, there is still a dearth of research in determining the level of emergency for notifying early warning to evacuation or presentation of a decision-making tool for notifying emergency evacuation. This demonstrates the necessity of examining these topics in future studies.

Preparedness for emergency evacuation

Preparedness for emergency evacuation is a factor related to the management of rail transportation systems affecting the safe evacuation during emergencies.[167] In studies on subway station emergency evacuation, the development of a suitable program

for responding to emergency situations, planning for determining evacuation paths during emergencies, and the development of an emergency evacuation plan for the station have been considered as preparedness activities for safe emergency evacuation.[23,168,169] Similarly, identification of optimal escape paths in station evacuation maps (e.g., determining evacuation paths as separate from smoke paths or a safe evacuation route) and organizing emergency rescue teams and emergency drilling have been discussed as factors affecting the preparedness of stations for performing emergency evacuation.[30,84,86,153,164,170-175] Although the identification and mitigation of station vulnerabilities are important factors for the preparedness and development of emergency evacuation programs,[170] few studies have focused on the mitigation of evacuees. It implies on more research in this area, of which the current researchers are conducting with a focus on the stakeholders' perception on factors affecting mitigation of passengers.

In addition to organizational preparedness, personnel and passenger preparedness for an emergency evacuation response is important. In some studies, the effects of educational programs on railway safety and awareness programs for passengers have been examined in preparedness for emergency response.[176]

Emergency response

According to this systematic review, emergency response is an important factor related to subway station management.[170] To ensure the life safety and safe functioning of the subway system in emergency situations, the capability of emergency evacuation and quick and effective evacuation are highly important.[177-179] Identification of emergency response processes appropriate for the incident and implementation of emergency evacuation procedures,[106,170,180] management of crowd movement flow during emergency evacuation in exit paths,[181,182] and management of facilities (passages, escalators, and stairs) for evacuation in emergencies can affect the emergency management and efficiency of emergency evacuation.[48,183]

In emergency response of subway systems, the selection of appropriate strategies for emergency evacuation and accurate evacuee guidance strategies is essential.[87,184-187] Evacuation and accurate evacuee guidance strategies are also essential in other types of incidents.[152] The results of a case study indicated that, if the entrance passage of relief forces to the station is blocked, the process of relief will be delayed. Therefore, guided evacuation can reduce the number of deaths in terrorist or chemical attacks.[188] Identification of alternative evacuation paths and selection of appropriate station evacuation strategies in responding to emergency situations, exit selection strategy, or appropriate use of any available exit can greatly improve the efficiency of evacuation.[32,145,189]

Other factors contributing to the safe evacuation of passengers determining their response to emergencies including the identification of airflow conditions inside the system, smoke evacuation, controlling smoke spread, selecting strategies for station and tunnel ventilation, and using evacuation methods (e.g. elevators or not) are subjects related to the type of response to emergency situations, which are significant in effective evacuation with minimum injuries to the crowd in subway stations.[51,101,190-194] Decision-making for evacuation in emergencies is vital and completely different from evacuation in normal situations. In emergencies, the passengers' decision in selecting various paths highly affects evacuation duration. Therefore, in addition to decision-making in a short time, optimal decision-making, i.e., selecting the shortest uncrowded path, is essential.[27,45,106,195-198] Other studies also indicated on the critical status for decision-making in the case of hospital emergency evacuation decision-making and suggest for decision support system.[160,199] It seems that subway evacuation decision support system can also be taken into account for better and timely decision. In some studies included in the present systematic review also, decision-making for response operations and decision support and emergency notification systems were identified as factors affecting a timely evacuation response.[181,200-203]

In some studies of the current systematic review, researchers identified the management of evacuees exiting the station and management of buses when urban rail transportation operations are stopped to be necessary for the subway station emergency evacuation process; it would be possible to control the traffic of evacuees to confront exit blockage and threats related to crowd aggregation outside the stations if bus transportation outside the train is ready.[204-207] Based on the results of these studies, our findings conclude that the spectrum of definition of a safe emergency evacuation can be expanded from the time of the public announcement of emergency evacuation until the distribution and transfer of evacuees outside the subway station to the street.

In general, in places such as subway stations faced with crowd aggregation, there is the risk of secondary incidents such as crowd disaster following by emergency situation.[208,209] Therefore, in response to emergency situations, emergency management simultaneous with crowd management has special importance.[16,46,210] In an efficient management of emergencies and disasters, the activation of an incident command system (ICS) is an effective strategy for responding to emergency situation and disasters;[211] however, based on the present systematic review findings, lack of studies related to efficiency and importance of ICS in response of subway emergency evacuation is evident. Thus, in the field of ICS efficiency in subway incident management and emergency response, future studies can discuss more.

Reconstruction and maintenance of evacuation facilities

Other factors related to subway station management, which affect the management of safe evacuation during emergencies, include the reconstruction and maintenance of evacuation equipment and facilities, telecommunication equipment, and relief and rescue facilities in stations.[87] Consequently, it is important to perform reconstruction, maintenance, and updating programs for subway rail transportation system, in

order to ensure the timely functioning of equipment during emergencies. This is also in line with previous studies in injury prevention fields, which pronounced the importance of evacuation facility, of which mainly related to a system approach for injury and accident prevention.[212]

Conclusion

This systematic review showed that there is a lack of system approach in literatures. Furthermore, the number of studies on subway emergency evacuation with a qualitative and health-based approach is very low.

Most studies in the present systematic review focused on evacuation in the shortest possible time in order to mitigate injuries and causalities during emergencies and disasters. The dominant approach of studies to analyze the efficiency of emergency evacuation was quantitative approach; there is a lack of qualitative approach to effectiveness of subway emergency evacuation by focusing on minimizing injuries during evacuations. Therefore, it is essential to review safe evacuation indicators in future qualitative studies with focus on human health in emergencies.

As a result of systematic literature review of studies on system approach to safe emergency evacuation in subways, we found the considering optimal egress paths for emergency evacuation as the main theme of environmental factors. As well as, the mitigation of injuries and preparedness are initial proceeding for successful emergency evacuation as organizational management-related factors effect on safe emergency evacuation.

Based on the evidence of the present systematic review, environmental factors can affect efficiency of emergency evacuation through modifying safe egress time. On the other hand, preventive and preparedness measures are organizational management-related factors often taken to increase the ASET. The results of the present study also confirm organizational actions and environmental measures that can be taken to improve the safe egress time. Consequently, from the researcher's point of view, the timely decision-making for responding to emergency situations, such as decision-making for emergency evacuation public announcing and passenger's timely reactions to evacuation alarm and decision to start evacuation, can almost save the ASET before the accident turns into a crisis and can prevent injuries and causalities.

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Conflicts of interest

There are no conflicts of interest.

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Appendix 1a: Search syntax tables for systematic review on environmental and organizational management-related factors that affect the safe emergency evacuation in subway stations

1. Search syntax in SCOPUS for managerial factors affecting the safe emergency evacuation in subways

Search round	Syntax	Description	NNR	Records number
1	(ALL (Evacuation) OR ALL(“emergency evacuation”) OR ALL(“Pedestrian evacuation”) OR ALL(“Passenger flow”) OR ALL(“Passenger evacuation”) OR ALL(“Evacuation capability”) OR ALL(“Evacuation capacity”) OR ALL(“Evacuation plan”) OR ALL(“Evacuation strategy”) OR ALL(“Evacuation strategies”) OR ALL(“Evacuation route”) OR ALL(“Evacuation safety”) OR ALL(“Evacuation efficiency”) OR ALL(“Crowd evacuation”) OR ALL(“Evacuation performance”) OR ALL(“Evacuation times”) OR ALL(“Evacuation behavior”) OR ALL(“Evacuation parameter”) OR ALL(“Evacuation features”) OR ALL(“Evacuation analysis”) OR ALL(“Evacuation facilities”) OR ALL(“Evacuation possibilities”) OR ALL(“Possible evacuation”) OR ALL(“Evacuation situation”) OR ALL(“Evacuation techniques”) OR ALL(“Evacuation scenario”) OR ALL(“Staged evacuation”) OR ALL(“Evacuation models”) OR ALL(“Evacuation performance”) OR ALL(“evacuation time”) OR ALL(“evacuation process”) OR ALL(“safe evacuation”) OR ALL(“passenger evacuation”) OR ALL(“human evacuation”) OR ALL(“humans evacuation”) OR ALL(“personnel evacuation”) OR ALL(“passengers evacuation”) OR ALL(“evacuation centers”) OR ALL(“evacuation center”) OR ALL(“safety evacation”) OR ALL(“Fire evacuation”) OR ALL(“evacuation design”) OR ALL(“Safely evacuation”)) AND (ALL(“subway stations”) OR ALL(“rail roads”) OR ALL(“subway station”) OR ALL(“subway fire”) OR ALL (Metro) OR ALL(“Urban rail”) OR ALL(“Urban transit”) OR ALL(“Urban station”) OR ALL (Subway) OR ALL(“Subway accidents”) OR ALL(“Underground station”) OR ALL (“Subway fire”) OR ALL(“Railway stations”) OR ALL(“Underground stations”) OR ALL(“Crowded subway”) OR ALL(“Metro stations”) OR ALL(“Metro station”) OR ALL (Subway- mall) OR ALL (Underpass) OR ALL(“Subway lines”) OR ALL (Metropolitan) OR ALL(“Metropolitan area”) OR ALL(“Underground area”) OR ALL(“Rail transit”)) AND (ALL(“managerial factors”) OR ALL(“managerial requirements”) OR ALL(“adminastrative requirements”) OR ALL(“adminastrative factors”) OR ALL (managerial) OR ALL (adminastrative) OR ALL(“management factors”) OR ALL(“governance factors”) OR ALL(“critical governance factors”) OR ALL(“Safety management”)) AND (PUBYEAR <2019 AND PUBYEAR >1989) ALL (“Evacuation strategies”) OR ALL (“Evacuation route”) OR ALL (“Evacuation safety”) OR ALL (“Evacuation efficiency”) OR ALL (“Crowd evacuation”) OR ALL (“Evacuation performance”) OR ALL (“Evacuation times”) OR ALL (“Evacuation behavior”) OR ALL (“Evacuation parameter”) OR	Journals articles	~25	247
2	ALL (“Evacuation features”) OR ALL (“Evacuation analysis”) OR ALL (“Evacuation facilities”) OR ALL (“Evacuation possibilities”) OR ALL (“Possible evacuation”) OR ALL (“Evacuation situation”) OR ALL (“Evacuation techniques”) OR ALL (“Evacuation scenario”) OR ALL (“Staged evacuation”) OR ALL (“Evacuation models”) OR ALL (“Evacuation performance”) OR ALL (“evacuation time”) OR ALL (“evacuation process”) OR ALL (“safe evacuation”) OR ALL (“passenger evacuation”) OR ALL (“human evacuation”) OR ALL (“humans evacuation”) OR ALL (“personnel evacuation”) OR ALL (“passengers evacuation”) OR ALL (“evacuation centers”) OR ALL (“evacuation center”) OR ALL (“safety evacation”) OR ALL (“Fire evacuation”) OR ALL (“evacuation design”) OR ALL (“Safely evacuation”)) AND (TITLE-ABS (“subway stations”) OR ALL (“rail roads”) OR TITLE-ABS (“subway station”) OR TITLE-ABS (“subway fire”) OR TITLE-ABS (metro) OR ALL (“Urban rail”) OR ALL (“Urban transit”) OR ALL (“Urban station”) OR TITLE-ABS (subway) OR TITLE-ABS (“Subway accidents”) OR TITLE-ABS (“subway incidents”) OR TITLE-ABS (“subway events”) OR TITLE-ABS (“Underground station”) OR TITLE-ABS (“Subway fire”) OR ALL (“Railway stations”) OR ALL (“Underground stations”) OR ALL (“Crowded subway”) OR ALL (“Metro stations”) OR TITLE-ABS (“Metro station”) OR ALL (subway- AND mall) OR ALL (underpass) OR ALL (“Subway lines”) OR ALL (metropolitan) OR ALL (“Metropolitan area”) OR TITLE-ABS (“Underground area”) OR ALL (“Rail transit”)) AND (TITLE-ABS (“managerial factors”) OR ALL (“managerial requirements”) OR ALL (“adminastrative requirements”) OR TITLE-ABS (“adminastrative factors”) OR ALL (managerial) OR ALL (adminastrative) OR ALL (“management factors”) OR TITLE-ABS (“governance factors”) OR ALL (“critical governance factors”) OR ALL (“Safety management”)) AND (PUBYEAR <2019 AND PUBYEAR >1989)	Conferences papers/conferences proceedings	~16	117
	(ALL (Evacuation) OR TITLE-ABS(“emergency evacuation”) OR TITLE-ABS(“Pedestrian evacuation”) OR ALL(“Passenger flow”) OR TITLE-ABS(“Passenger evacuation”) OR ALL(“Evacuation capability”) OR ALL(“Evacuation capacity”) OR ALL(“Evacuation plan”) OR ALL(“Evacuation strategy”) OR ALL(“Evacuation strategies”) OR ALL(“Evacuation route”) OR ALL(“Evacuation safety”) OR ALL(“Evacuation efficiency”) OR ALL(“Crowd evacuation”) OR ALL(“Evacuation performance”) OR ALL(“Evacuation times”) OR ALL(“Evacuation behavior”) OR ALL(“Evacuation parameter”) OR ALL(“Evacuation features”) OR ALL(“Evacuation analysis”) OR ALL(“Evacuation facilities”) OR ALL(“Evacuation possibilities”) OR ALL(“Possible evacuation”) OR ALL(“Evacuation situation”) OR ALL(“Evacuation techniques”) OR ALL(“Evacuation scenario”) OR ALL(“Staged evacuation”) OR ALL(“Evacuation models”)	Journal article: 45	~13	83

Contd...

1. Contd...

Search round	Syntax	Description	NNR	Records number
	OR ALL("Evacuation performance") OR ALL("evacuation time") OR ALL("evacuation process") OR ALL("safe evacuation") OR ALL("passenger evacuation") OR ALL("human evacuation") OR ALL("humans evacuation") OR ALL("personnel evacuation") OR ALL("passengers evacuation") OR ALL("evacuation centers") OR ALL("evacuation center") OR ALL("safety evacation") OR ALL("Fire evacuation") OR ALL("evacuation design") OR ALL("Safely evacuation")) AND (TITLE-ABS("subway stations") OR ALL("rail roads") OR TITLE-ABS("subway station") OR TITLE-ABS("subway fire") OR TITLE-ABS (Metro) OR ALL("Urban rail") OR ALL("Urban transit") OR ALL("Urban station") OR TITLE-ABS (Subway) OR TITLE-ABS("Subway accidents") OR TITLE-ABS("subway incidents") OR TITLE-ABS("subway events") OR TITLE-ABS("Underground station") OR TITLE-ABS("Subway fire") OR ALL("Railway stations") OR ALL("Underground stations") OR ALL("Crowded subway") OR ALL("Metro stations") OR TITLE-ABS("Metro station") OR ALL (Subway- mall) OR ALL (Underpass) OR ALL("Subway lines") OR ALL (Metropolitan) OR ALL("Metropolitan area") OR TITLE-ABS("Underground area") OR ALL("Rail transit")) AND (TITLE-ABS("managerial factors") OR ALL("managerial requirements") OR ALL("adminastrative requirements") OR TITLE-ABS("adminastrative factors") OR TITLE-ABS (managerial) OR ALL (adminastrative) OR TITLE-ABS("management factors") OR TITLE-ABS("governance factors") OR ALL("critical governance factors") OR ALL("Safety management")) AND (PUBYEAR <2019 AND PUBYEAR >1989)	Conference paper: 19 Book: 8 Review: 7 Book chapter: 2 Conference review: 1 Short survey: 1		

2. Search syntax in Web of Science for managerial factors affecting the safe emergency evacuation in subways

Syntax number	Syntax	Description	Records Number
1	(TS=(Evacuation) OR TS=("emergency evacuation") OR TS=("Pedestrian evacuation") OR TS=("Passenger flow") OR TS=("Passenger evacuation") OR TS=("Evacuation capability") OR TS=("Evacuation capacity") OR TS=("Evacuation plan") OR TS=("Evacuation strategy") OR TS=("Evacuation strategies") OR TS=("Evacuation route") OR TS=("Evacuation safety") OR TS=("Evacuation efficiency") OR TS=("Crowd evacuation") OR TS=("Evacuation performance") OR TS=("Evacuation times") OR TS=("Evacuation behavior") OR TS=("Evacuation parameter") OR TS=("Evacuation features") OR TS=("Evacuation analysis") OR TS=("Evacuation facilities") OR TS=("Evacuation possibilities") OR TS=("Possible evacuation") OR TS=("Evacuation situation") OR TS=("Evacuation techniques") OR TS=("Evacuation scenario") OR TS=("Staged evacuation") OR TS=("Evacuation models") OR TS=("Evacuation performance") OR TS=("evacuation time") OR TS=("evacuation process") OR TS=("safe evacuation") OR TS=("passenger evacuation") OR TS=("human evacuation") OR TS=("humans evacuation") OR TS=("personnel evacuation") OR TS=("passengers evacuation") OR TS=("evacuation centers") OR TS=("evacuation center") OR TS=("safety evacation") OR TS=("Fire evacuation") OR TS=("evacuation design") OR TS=("Safely evacuation")) AND (TS=("subway stations") OR TS=("rail roads") OR TS=("subway station") OR TS=("subway fire") OR TS=(Metro) OR TS=("Urban rail") OR TS=("Urban transit") OR TS=("Urban station") OR TS=(Subway) OR TS=("Subway accidents") OR TS=("subway incidents") OR TS=("subway events") OR TS=("Underground station") OR TS=("Subway fire") OR TS=("Railway stations") OR TS=("Underground stations") OR TS=("Crowded subway") OR TS=("Metro stations") OR TS=("Metro station") OR TS=(Subway- mall) OR TS=(Underpass) OR TS=("Subway lines") OR TS=(Metropolitan) OR TS=("Metropolitan area") OR TS=("Underground area") OR TS=("Rail transit")) AND (TS=("managerial factors") OR TS=("managerial requirements") OR TS=("adminastrative requirements") OR TS=("adminastrative factors") OR TS=(managerial) OR TS=(adminastrative) OR TS=("management factors") OR TS=("governance factors") OR TS=("critical governance factors") OR TS=("Safety management")) AND PY=(1989-2019)		8

3. Search in PubMed for managerial factors affecting the safe emergency evacuation in subways

Syntax number	Syntax	Description	Records number
1	((Evacuation) OR (“emergency evacuation”) OR (“Pedestrian evacuation”) OR (“Passenger flow”) OR (“Passenger evacuation”) OR (“Evacuation capability”) OR (“Evacuation capacity”) OR (“Evacuation plan”) OR (“Evacuation strategy”) OR (“Evacuation strategies”) OR (“Evacuation route”) OR (“Evacuation safety”) OR (“Evacuation efficiency”) OR (“Crowd evacuation”) OR (“Evacuation performance”) OR (“Evacuation times”) OR (“Evacuation behavior”) OR (“Evacuation parameter”) OR (“Evacuation features”) OR (“Evacuation analysis”) OR (“Evacuation facilities”) OR (“Evacuation possibilities”) OR (“Possible evacuation”) OR (“Evacuation situation”) OR (“Evacuation techniques”) OR (“Evacuation scenario”) OR (“Staged evacuation”) OR (“Evacuation models”) OR (“Evacuation performance”) OR (“evacuation time”) OR (“evacuation process”) OR (“safe evacuation”) OR (“passenger evacuation”) OR (“human evacuation”) OR (“humans evacuation”) OR (“personnel evacuation”) OR (“passengers evacuation”) OR (“evacuation centers”) OR (“evacuation center”) OR (“safety evacation”) OR (“Fire evacuation”) OR (“evacuation design”) OR (“Safely evacuation”)) AND ((“subway stations”) OR (“rail roads”) OR (“subway station”) OR (“subway fire”) OR (Metro) OR (“Urban rail”) OR (“Urban transit”) OR (“Urban station”) OR (Subway) OR (“Subway accidents”) OR (“subway incidents”) OR (“subway events”) OR (“Underground station”) OR (“Subway fire”) OR (“Railway stations”) OR (“Underground stations”) OR (“Crowded subway”) OR (“Metro stations”) OR (“Metro station”) OR (Subway- mall) OR (Underpass) OR (“Subway lines”) OR (Metropolitan) OR (“Metropolitan area”) OR (“Underground area”) OR (“Rail transit”)) AND ((“managerial factors”) OR (“managerial requirements”) OR (“adminastrative requirements”) OR (“adminastrative factors”) OR (managerial) OR (adminastrative) OR (“management factors”) OR (“governance factors”) OR (“critical governance factors”) OR (“Safety management”)) AND 1990/01/01[PDAT] : 2019/01/20[PDAT]		858
2	((Evacuation[tiab]) OR (“emergency evacuation” [tiab]) OR (“Pedestrian evacuation” [tiab]) OR (“Passenger flow”) OR (“Passenger evacuation” [tiab]) OR (“Evacuation capability”) OR (“Evacuation capacity”) OR (“Evacuation plan” [tiab]) OR (“Evacuation strategy”) OR (“Evacuation strategies”) OR (“Evacuation route”) OR (“Evacuation safety”) OR (“Evacuation efficiency”) OR (“Crowd evacuation”) OR (“Evacuation performance”) OR (“Evacuation times”) OR (“Evacuation behavior”) OR (“Evacuation parameter”) OR (“Evacuation features”) OR (“Evacuation analysis”) OR (“Evacuation facilities”) OR (“Evacuation possibilities”) OR (“Possible evacuation”) OR (“Evacuation situation”) OR (“Evacuation techniques”) OR (“Evacuation scenario”) OR (“Staged evacuation”) OR (“Evacuation models”) OR (“Evacuation performance”) OR (“evacuation time”) OR (“evacuation process”) OR (“safe evacuation”) OR (“passenger evacuation”) OR (“human evacuation”) OR (“humans evacuation”) OR (“personnel evacuation”) OR (“passengers evacuation”) OR (“evacuation centers”) OR (“evacuation center”) OR (“safety evacation”) OR (“Fire evacuation”) OR (“evacuation design”) OR (“Safely evacuation”)) AND ((“subway stations” [tiab]) OR (“rail roads”) OR (“subway station” [tiab]) OR (“subway fire” [tiab]) OR (Metro) OR (“Urban rail”) OR (“Urban transit”) OR (“Urban station”) OR (Subway[tiab]) OR (“Subway accidents” [tiab]) OR (“subway incidents” [tiab]) OR (“subway events” [tiab]) OR (“Underground station” [tiab]) OR (“Subway fire” [tiab]) OR (“Railway stations”) OR (“Underground stations” [tiab]) OR (“Crowded subway”) OR (“Metro stations” [tiab]) OR (“Metro station” [tiab]) OR (Subway- mall) OR (Underpass) OR (“Subway lines”) OR (Metropolitan) OR (“Metropolitan area”) OR (“Underground area”) OR (“Rail transit”)) AND ((“managerial factors” [tiab]) OR (“managerial requirements”) OR (“adminastrative requirements”) OR (“adminastrative factors” [tiab]) OR (managerial[tiab]) OR (adminastrative) OR (“management factors” [tiab]) OR (“governance factors” [tiab]) OR (“critical governance factors” [tiab]) OR (“Safety management”)) AND 1990/01/01[PDAT] : 2019/01/20[PDAT]		132

4. Search syntax in ProQuest for managerial factors affecting the safe emergency evacuation in subways

Syntax number	Syntax	Description	Records Number
1	(ALL (Evacuation) OR ALL("emergency evacuation") OR ALL("Pedestrian evacuation") OR ALL("Passenger flow") OR ALL("Passenger evacuation") OR ALL("Evacuation capability") OR ALL("Evacuation capacity") OR ALL("Evacuation plan") OR ALL("Evacuation strategy") OR ALL("Evacuation strategies") OR ALL("Evacuation route") OR ALL("Evacuation safety") OR ALL("Evacuation efficiency") OR ALL("Crowd evacuation") OR ALL("Evacuation performance") OR ALL("Evacuation times") OR ALL("Evacuation behavior") OR ALL("Evacuation parameter") OR ALL("Evacuation features") OR ALL("Evacuation analysis") OR ALL("Evacuation facilities") OR ALL("Evacuation possibilities") OR ALL("Possible evacuation") OR ALL("Evacuation situation") OR ALL("Evacuation techniques") OR ALL("Evacuation scenario") OR ALL("Staged evacuation") OR ALL("Evacuation models") OR ALL("Evacuation performance") OR ALL("evacuation time") OR ALL("evacuation process") OR ALL("safe evacuation") OR ALL("passenger evacuation") OR ALL("human evacuation") OR ALL("humans evacuation") OR ALL("personnel evacuation") OR ALL("passengers evacuation") OR ALL("evacuation centers") OR ALL("evacuation center") OR ALL("safety evacation") OR ALL("Fire evacuation") OR ALL("evacuation design") OR ALL("Safely evacuation")) AND (ALL("subway stations") OR ALL("rail roads") OR ALL("subway station") OR ALL("subway fire") OR ALL (Metro) OR ALL("Urban rail") OR ALL("Urban transit") OR ALL("Urban station") OR ALL (Subway) OR ALL("Subway accidents") OR ALL("Underground station") OR ALL("Subway fire") OR ALL("Railway stations") OR ALL("Underground stations") OR ALL("Crowded subway") OR ALL("Metro stations") OR ALL("Metro station") OR ALL (Subway- mall) OR ALL (Underpass) OR ALL("Subway lines") OR ALL (Metropolitan) OR ALL("Metropolitan area") OR ALL("Underground area") OR ALL("Rail transit")) AND (ALL("managerial factors") OR ALL("managerial requirements") OR ALL("adminastrative requirements") OR ALL("adminastrative factors") OR ALL (managerial) OR ALL (adminastrative) OR ALL("management factors") OR ALL("governance factors") OR ALL("critical governance factors") OR ALL("Safety management")) AND YR (19900101-20190120)	Scholarly journals: 3 Dissertation and theses: 6 Feature: 3	9

Appendix 1b: Search syntax tables for systematic review on environmental factors affecting the safe emergency evacuation in subways

1. Search syntax in SCOPUS for environmental factors affecting the safe emergency evacuation in subways

Search round	Syntax	Description	NNR	Records number
1	(ALL (Evacuation) OR ALL("emergency evacuation") OR ALL("Pedestrian evacuation") OR ALL("Passenger flow") OR ALL("Passenger evacuation") OR ALL("Evacuation capability") OR ALL("Evacuation capacity") OR ALL("Evacuation plan") OR ALL("Evacuation strategy") OR ALL("Evacuation strategies") OR ALL("Evacuation route") OR ALL("Evacuation safety") OR ALL("Evacuation efficiency") OR ALL("Crowd evacuation") OR ALL("Evacuation performance") OR ALL("Evacuation times") OR ALL("Evacuation behavior") OR ALL("Evacuation parameter") OR ALL("Evacuation features") OR ALL("Evacuation analysis") OR ALL("Evacuation facilities") OR ALL("Evacuation possibilities") OR ALL("Possible evacuation") OR ALL("Evacuation situation") OR ALL("Evacuation techniques") OR ALL("Evacuation scenario") OR ALL("Staged evacuation") OR ALL("Evacuation models") OR ALL("Evacuation performance") OR ALL("evacuation time") OR ALL("evacuation process") OR ALL("safe evacuation") OR ALL("passenger evacuation") OR ALL("human evacuation") OR ALL("humans evacuation") OR ALL("personnel evacuation") OR ALL("passengers evacuation") OR ALL("evacuation centers") OR ALL("evacuation center") OR ALL("safety evacation") OR ALL("Fire evacuation") OR ALL("evacuation design") OR ALL("Safely evacuation")) AND (ALL("subway stations") OR ALL("rail roads") OR ALL("subway station") OR ALL("subway fire") OR ALL (Metro) OR ALL("Urban rail") OR ALL("Urban transit") OR ALL("Urban station") OR ALL (Subway) OR ALL("Subway accidents") OR ALL("Underground station") OR ALL("Subway fire") OR ALL("Railway stations") OR ALL("Underground stations") OR ALL("Crowded subway") OR ALL("Metro stations") OR ALL("Metro station") OR ALL (Subway- mall) OR ALL (Underpass) OR ALL("Subway lines") OR ALL (Metropolitan) OR ALL("Metropolitan area") OR ALL("Underground area") OR ALL("Rail transit")) AND (ALL("environmental factors") OR ALL("environmental requirements") OR ALL("environments requirements") OR ALL("environmental factor") OR ALL (environmental)) AND (PUBYEAR <2019 AND PUBYEAR >1989)	Journals articles	~25	1822

Contd...

1. Contd...

Search round	Syntax	Description	NNR	Records number
2	(ALL (evacuation) OR TITLE-ABS("emergency evacuation") OR TITLE-ABS("Pedestrian evacuation") OR ALL("Passenger flow") OR TITLE-ABS("Passenger evacuation") OR ALL("Evacuation capability") OR ALL("Evacuation capacity") OR ALL("Evacuation plan") OR ALL("Evacuation strategy") OR ALL("Evacuation strategies") OR ALL("Evacuation route") OR ALL("Evacuation safety") OR ALL("Evacuation efficiency") OR ALL("Crowd evacuation") OR ALL("Evacuation performance") OR ALL("Evacuation times") OR ALL("Evacuation behavior") OR ALL("Evacuation parameter") OR ALL("Evacuation features") OR ALL("Evacuation analysis") OR ALL("Evacuation facilities") OR ALL("Evacuation possibilities") OR ALL("Possible evacuation") OR ALL("Evacuation situation") OR ALL("Evacuation techniques") OR ALL("Evacuation scenario") OR ALL("Staged evacuation") OR ALL("Evacuation models") OR ALL("Evacuation performance") OR ALL("evacuation time") OR ALL("evacuation process") OR ALL("safe evacuation") OR ALL("passenger evacuation") OR ALL("human evacuation") OR ALL("humans evacuation") OR ALL("personnel evacuation") OR ALL("passengers evacuation") OR ALL("evacuation centers") OR ALL("evacuation center") OR ALL("safety evacation") OR ALL("Fire evacuation") OR ALL("evacuation design") OR ALL("Safely evacuation")) AND (TITLE-ABS("subway stations") OR ALL("rail roads") OR TITLE-ABS("subway station") OR TITLE-ABS("subway fire") OR TITLE-ABS (metro) OR ALL("Urban rail") OR ALL("Urban transit") OR ALL("Urban station") OR TITLE-ABS (subway) OR TITLE-ABS("Subway accidents") OR TITLE-ABS("subway incidents") OR TITLE-ABS("subway events") OR TITLE-ABS("Underground station") OR TITLE-ABS("Subway fire") OR ALL("Railway stations") OR ALL("Underground stations") OR ALL("Crowded subway") OR ALL("Metro stations") OR TITLE-ABS("Metro station") OR ALL (subway- AND mall) OR ALL (underpass) OR ALL("Subway lines") OR ALL (metropolitan) OR ALL("Metropolitan area") OR TITLE-ABS("Underground area") OR ALL("Rail transit")) AND (TITLE-ABS ("environmental factors") OR TITLE-ABS ("environmental requirements") OR TITLE-ABS ("environments requirements") OR TITLE-ABS ("environmental factor") OR TITLE-ABS (environmental)) AND (PUBYEAR<2019 AND PUBYEAR>1989)	Journal article: 138 Conference paper: 29 Book: 25 Review: 8 Book chapter: 9 Conference review: 6 Article in press: 2	~13	217

2. Search syntax in Web of Science for environmental factors affecting the safe emergency evacuation in subways

Syntax number	Syntax	Description	Records number
1	(TS=(Evacuation) OR TS=("emergency evacuation") OR TS=("Pedestrian evacuation") OR TS=("Passenger flow") OR TS=("Passenger evacuation") OR TS=("Evacuation capability") OR TS=("Evacuation capacity") OR TS=("Evacuation plan") OR TS=("Evacuation strategy") OR TS=("Evacuation strategies") OR TS=("Evacuation route") OR TS=("Evacuation safety") OR TS=("Evacuation efficiency") OR TS=("Crowd evacuation") OR TS=("Evacuation performance") OR TS=("Evacuation times") OR TS=("Evacuation behavior") OR TS=("Evacuation parameter") OR TS=("Evacuation features") OR TS=("Evacuation analysis") OR TS=("Evacuation facilities") OR TS=("Evacuation possibilities") OR TS=("Possible evacuation") OR TS=("Evacuation situation") OR TS=("Evacuation techniques") OR TS=("Evacuation scenario") OR TS=("Staged evacuation") OR TS=("Evacuation models") OR TS=("Evacuation performance") OR TS=("evacuation time") OR TS=("evacuation process") OR TS=("safe evacuation") OR TS=("passenger evacuation") OR TS=("human evacuation") OR TS=("humans evacuation") OR TS=("personnel evacuation") OR TS=("passengers evacuation") OR TS=("evacuation centers") OR TS=("evacuation center") OR TS=("safety evacation") OR TS=("Fire evacuation") OR TS=("evacuation design") OR TS=("Safely evacuation")) AND (TS=("subway stations") OR TS=("rail roads") OR TS=("subway station") OR TS=("subway fire") OR TS=(Metro) OR TS=("Urban rail") OR TS=("Urban transit") OR TS=("Urban station") OR TS=(Subway) OR TS=("Subway accidents") OR TS=("subway incidents") OR TS=("subway events") OR TS=("Underground station") OR TS=("Subway fire") OR TS=("Railway stations") OR TS=("Underground stations") OR TS=("Crowded subway") OR TS=("Metro stations") OR TS=("Metro station") OR TS=(Subway- mall) OR TS=(Underpass) OR TS=("Subway lines") OR TS=(Metropolitan) OR TS=("Metropolitan area") OR TS=("Underground area") OR TS=("Rail transit")) AND (TS=("environmental factors") OR TS=("environmental requirements") OR TS=("environments requirements") OR TS=("environmental factor") OR TS=(environmental)) AND PY=(1989-2019)		22

3. Search in PubMed for environmental factors affecting the safe emergency evacuation in subways

Syntax no	Syntax	Description	Records number
1	((Evacuation) OR (“emergency evacuation”) OR (“Pedestrian evacuation”) OR (“Passenger flow”) OR (“Passenger evacuation”) OR (“Evacuation capability”) OR (“Evacuation capacity”) OR (“Evacuation plan”) OR (“Evacuation strategy”) OR (“Evacuation strategies”) OR (“Evacuation route”) OR (“Evacuation safety”) OR (“Evacuation efficiency”) OR (“Crowd evacuation”) OR (“Evacuation performance”) OR (“Evacuation times”) OR (“Evacuation behavior”) OR (“Evacuation parameter”) OR (“Evacuation features”) OR (“Evacuation analysis”) OR (“Evacuation facilities”) OR (“Evacuation possibilities”) OR (“Possible evacuation”) OR (“Evacuation situation”) OR (“Evacuation techniques”) OR (“Evacuation scenario”) OR (“Staged evacuation”) OR (“Evacuation models”) OR (“Evacuation performance”) OR (“evacuation time”) OR (“evacuation process”) OR (“safe evacuation”) OR (“passenger evacuation”) OR (“human evacuation”) OR (“humans evacuation”) OR (“personnel evacuation”) OR (“passengers evacuation”) OR (“evacuation centers”) OR (“evacuation center”) OR (“safety evacation”) OR (“Fire evacuation”) OR (“evacuation design”) OR (“Safely evacuation”)) AND ((“subway stations”) OR (“rail roads”) OR (“subway station”) OR (“subway fire”) OR (Metro) OR (“Urban rail”) OR (“Urban transit”) OR (“Urban station”) OR (Subway) OR (“Subway accidents”) OR (“subway incidents”) OR (“subway events”) OR (“Underground station”) OR (“Subway fire”) OR (“Railway stations”) OR (“Underground stations”) OR (“Crowded subway”) OR (“Metro stations”) OR (“Metro station”) OR (Subway- mall) OR (Underpass) OR (“Subway lines”) OR (Metropolitan) OR (“Metropolitan area”) OR (“Underground area”) OR (“Rail transit”)) AND ((“environmental factors”) OR (“environmental requirements”) OR (“environments requirements”) OR (“environmental factor”) OR (environmental)) AND 1990/01/01[PDAT] : 2019/01/20[PDAT]		645
2	((Evacuation[tiab]) OR (“emergency evacuation” [tiab]) OR (“Pedestrian evacuation” [tiab]) OR (“Passenger flow”) OR (“Passenger evacuation” [tiab]) OR (“Evacuation capability”) OR (“Evacuation capacity”) OR (“Evacuation plan” [tiab]) OR (“Evacuation strategy”) OR (“Evacuation strategies”) OR (“Evacuation route”) OR (“Evacuation safety”) OR (“Evacuation efficiency”) OR (“Crowd evacuation”) OR (“Evacuation performance”) OR (“Evacuation times”) OR (“Evacuation behavior”) OR (“Evacuation parameter”) OR (“Evacuation features”) OR (“Evacuation analysis”) OR (“Evacuation facilities”) OR (“Evacuation possibilities”) OR (“Possible evacuation”) OR (“Evacuation situation”) OR (“Evacuation techniques”) OR (“Evacuation scenario”) OR (“Staged evacuation”) OR (“Evacuation models”) OR (“Evacuation performance”) OR (“evacuation time”) OR (“evacuation process”) OR (“safe evacuation”) OR (“passenger evacuation”) OR (“human evacuation”) OR (“humans evacuation”) OR (“personnel evacuation”) OR (“passengers evacuation”) OR (“evacuation centers”) OR (“evacuation center”) OR (“safety evacation”) OR (“Fire evacuation”) OR (“evacuation design”) OR (“Safely evacuation”)) AND ((“subway stations” [tiab]) OR (“rail roads”) OR (“subway station” [tiab]) OR (“subway fire” [tiab]) OR (Metro) OR (“Urban rail”) OR (“Urban transit”) OR (“Urban station”) OR (Subway[tiab]) OR (“Subway accidents” [tiab]) OR (“subway incidents” [tiab]) OR (“subway events” [tiab]) OR (“Underground station” [tiab]) OR (“Subway fire” [tiab]) OR (“Railway stations”) OR (“Underground stations” [tiab]) OR (“Crowded subway”) OR (“Metro stations” [tiab]) OR (“Metro station” [tiab]) OR (Subway- mall) OR (Underpass) OR (“Subway lines”) OR (Metropolitan) OR (“Metropolitan area”) OR (“Underground area”) OR (“Rail transit”)) AND ((“environmental factors” [tiab]) OR (“environmental requirements” [tiab]) OR (“environments requirements” [tiab]) OR (“environmental factor” [tiab]) OR (environmental[tiab])) AND 1990/01/01[PDAT] : 2019/01/20[PDAT]		126

4. Search syntax in ProQuest for environmental factors affecting the safe emergency evacuation in subways

Syntax number	Syntax	Description	Records number
1	(ALL (Evacuation) OR ALL("emergency evacuation") OR ALL("Pedestrian evacuation") OR ALL("Passenger flow") OR ALL("Passenger evacuation") OR ALL("Evacuation capability") OR ALL("Evacuation capacity") OR ALL("Evacuation plan") OR ALL("Evacuation strategy") OR ALL("Evacuation strategies") OR ALL("Evacuation route") OR ALL("Evacuation safety") OR ALL("Evacuation efficiency") OR ALL("Crowd evacuation") OR ALL("Evacuation performance") OR ALL("Evacuation times") OR ALL("Evacuation behavior") OR ALL("Evacuation parameter") OR ALL("Evacuation features") OR ALL("Evacuation analysis") OR ALL("Evacuation facilities") OR ALL("Evacuation possibilities") OR ALL("Possible evacuation") OR ALL("Evacuation situation") OR ALL("Evacuation techniques") OR ALL("Evacuation scenario") OR ALL("Staged evacuation") OR ALL("Evacuation models") OR ALL("Evacuation performance") OR ALL("evacuation time") OR ALL("evacuation process") OR ALL("safe evacuation") OR ALL("passenger evacuation") OR ALL("human evacuation") OR ALL("humans evacuation") OR ALL("personnel evacuation") OR ALL("passengers evacuation") OR ALL("evacuation centers") OR ALL("evacuation center") OR ALL("safety evacation") OR ALL("Fire evacuation") OR ALL("evacuation design") OR ALL("Safely evacuation")) AND (ALL("subway stations") OR ALL("rail roads") OR ALL("subway station") OR ALL("subway fire") OR ALL (Metro) OR ALL("Urban rail") OR ALL("Urban transit") OR ALL("Urban station") OR ALL (Subway) OR ALL("Subway accidents") OR ALL("Underground station") OR ALL("Subway fire") OR ALL("Railway stations") OR ALL("Underground stations") OR ALL("Crowded subway") OR ALL("Metro stations") OR ALL("Metro station") OR ALL (Subway- mall) OR ALL (Underpass) OR ALL("Subway lines") OR ALL (Metropolitan) OR ALL("Metropolitan area") OR ALL("Underground area") OR ALL("Rail transit")) AND (ALL ("environmental factors") OR ALL ("environmental requirements") OR ALL ("environments requirements") OR ALL ("environmental factor") OR ALL (environmental)) AND YR (19900101-20190120)	Scholarly journals: 11 Dissertation and theses: 28 Feature	39

Appendix 2: Data extraction form of systematic review on environmental and organizational management-related factors affecting the safe emergency evacuation from subway stations

A: Identification information
1. Study code
2. Study title
3. First author
4. Publication year
5. Country
6. Study design
B: Specific goals of systematic review
Factors affecting passenger's safe evacuation from subways, in normal conditions
Environmental factors affecting safe emergency evacuation from subway, in emergency conditions
Organizational and managerial factors affecting safe emergency evacuation from subway, in emergency conditions
Subways risk factors of emergency evacuation
Evacuees vulnerability in emergency evacuation

Appendix 3: Critical appraisal checklist of articles in systematic review of environmental and organizational management-related factors affecting the safe emergency evacuation from subway stations

Reviewer	Manuscript Code				
Author	Review date				
Journal	Publication date				
1. Screening question		**Yes**	**NC**	**No**	**NA**
1.1. Is study about subway emergency evacuation?					
1.2. Does study include safe evacuation parameters?					
2. Study design/type of study		**Yes**	**NC**	**No**	**NA**
2.1. Is it quantitative study design?		□	□	□	□
Simulation	□				
Cross-sectional	□				
Case–control	□				
Case report	□				
Cohort	□				
Experimental	□				
Quasi-experimental	□				
		Yes	**NC**	**No**	**NA**
2.2. Is it qualitative study design?		□	□	□	□
Content analysis	□				
Phenomenology	□				
Grounded theory	□				
Ethnology	□				
2.3. Is it mix method of quantitative and qualitative study?		□	□	□	□
3. Findings		**Yes**	**NC**	**NO**	**NA**
3.1. findings are presented in clear, intelligible manner		□	□	□	□
with sufficient detail for decision-making	□				
Well-presented aspects of a concept (emergency evacuation)	□				
Well-presented aspects of a concept (safety in evacuation)	□				
3.2. Are findings described well?		□	□	□	□
3.3. Are findings based on study question?		□	□	□	□
4. Strength of recommendations		**Yes**	**NC**	**NO**	**NA**
4.1. Is study consistent with evidence?		□	□	□	□
Based on empirical evidence	□				
Studies done within the underground, metro, subway stations	□				
Study presented a model	□				
Study presented a hypotheses	□				
Well description of findings	□				

NC: Not clear, NA: Not applicable