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The Impact of Architectural Organization on Emergency Evacuation Routes in Airport Terminals

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Abstract

Mega-scale airport terminals are complex public structures where multi-layered spatial organization, transfer-based circulation, and heterogeneous user profiles are intertwined. This study examines the position of the relationship between architectural organization, wayfinding in times of crisis, and disaster/emergency evacuation in these structures in the literature through a conceptual-bibliometric design. Two complementary Boolean strings, extended (n = 176) and focused (n = 76), were run on the Web of Science Core Collection (2019–2026); datasets were analyzed through VOSviewer at the scientific mapping level. Findings show that the field concentrates within engineering categories; architectural organization, spatial readability, and decision-point concepts do not form an independent thematic cluster. The three-level research gap identified (disciplinary visibility, thematic clustering, contextual intersection) documents the fragmented representation of architecture in this literature. The study's original conceptual contribution is the proposal of a dual-mode performance framework read through wayfinding, decision points, and visual access thresholds.

Keywords: mega-scale airport terminal; architectural organization; wayfinding in crisis; disaster and emergency evacuation; spatial legibility; bibliometric analysis.

Introduction

1.1 Background and Context

Mega-scale airport terminals constitute one of the most complex public building typologies of the contemporary built environment. These structures combine features such as multi-layered spatial organization, transfer-based circulation design, heterogeneous user profile, and openness to different emergency scenarios under high occupancy conditions (Adey, 2008; Hubregtse, 2016). The analysis developed by Jung and Shin (2016) on international hub airport typologies reveals that the terminal space should be read as an integrated area where modern public space and mobility infrastructure are intertwined. Multiple levels, branching corridor systems, security thresholds, transit areas, waiting areas, and gate connections transform the mega terminal space into a complex circulation system consisting of successive decision points. Therefore, movement within the terminal cannot be read solely as a physical displacement process; It should be considered as a dynamic wayfinding process in which the user perceives environmental cues, evaluates route options, and makes decisions based on spatial readability (Lynch, 1960; Weisman, 1981).

In mega airport terminals, the user profile is one of the key factors that increases this complexity. These structures often simultaneously accommodate passengers who are unfamiliar with the terminal beforehand, have different linguistic and cultural backgrounds, are under time pressure, are physically tired, or are constrained by luggage. Under these conditions, users make their spatial decisions not based on pre-existing structural knowledge, but on immediate environmental cues, directional elements, visual access, and the readability of the spatial layout. Arthur and Passini's (1992) wayfinding approach defines this process as a decision-making relationship between the user and the environment, beyond signage systems. The study by Hasanzade, van Oel, and Pazhouhanfar (2022), which examined passengers' preferences for architectural design features in airport terminals using a 3D visual-based experiment, and the analysis by Vieira, Silva, Alves, and Borille (2023), which systematically evaluated the quality assurance of pedestrian behavior simulation models applied to airport terminals, document the decisive role of terminal design on passenger experience and modeling in the current literature. Another element that makes the mega-terminal context critical is that these structures can be the scene of different types of disasters and emergencies. Terminal fires, attacks, explosions, security-related evacuations, and operational crises demonstrate that user movement in airport terminals can quickly shift from the normal flow to crisis conditions. Selected airport events, in this respect, make visible situations where spatial variables such as smoke dispersion, entrance thresholds, decision points, crowd orientation, evacuation organization, and visual accessibility become critical in the terminal space (Table 1). Such events show that emergency performance in mega-terminal design is not limited solely to technical capacity; This indicates that spatial readability, wayfinding continuity, location of decision points, and organization of user flows should be evaluated. The combined interpretation of these three

characteristics defines the specific research context that distinguishes mega airport terminals from other types of public structures. While wayfinding and evacuation problems can also arise in structures such as hotels, shopping malls, stadiums, or single-story transit stations, in mega terminals these problems are transformed into a more complex spatial structure involving international passenger movement, security thresholds, transfer flows, multiple decision points, and high-density circulation patterns. Therefore, intra-terminal passenger flow and critical decision points should be considered as a significant area of architectural organization for evaluating disaster and emergency evacuation. Figure 1 schematically illustrates the stages a user goes through from entrance to boarding gate in a typical international terminal and the wayfinding decision points encountered during this process.

Table 1: Selected Airport Emergency Incidents and Spatial Implications for Terminal Evacuation.

Year	Airport	Incident Type	Fatalities	Spatial Implications for Terminal Evacuation
1996	Düsseldorf Airport, Germany	Terminal fire	17	The incident constitutes a significant example in terms of smoke dispersion, loss of visibility, material performance, and the complexity of intra-terminal evacuation.
2013	Jomo Kenyatta International Airport, Kenya	Terminal fire	0	Terminal fires demonstrate the importance of smoke control, continuity of access, disruption of arrival/immigration areas, and evacuation organization.
2016	Brussels Airport, Belgium	Bomb attack	16	Dense waiting and decision-making areas, such as check-in and departure halls, highlight the importance of security thresholds, escape orientation, and crowd evacuation organization.
2016	Istanbul Atatürk Airport, Türkiye	Armed and bomb attack	45	The incident presents an emergency case in which terminal entrance thresholds, intensive user movement, decision points, and emergency wayfinding capacity become critical.
2017	Fort Lauderdale–Hollywood International Airport, USA	Armed attack	5	Panic-induced movement in arrival-zone spaces such as baggage claim reveals spontaneous evacuation behavior and user orientation toward safe areas.
2023	London Luton Airport, United Kingdom	Terminal car park fire	0	Fires originating in support areas close to the terminal demonstrate the relationship between access organization, operational continuity, smoke effects, and terminal-perimeter evacuation/transport management.

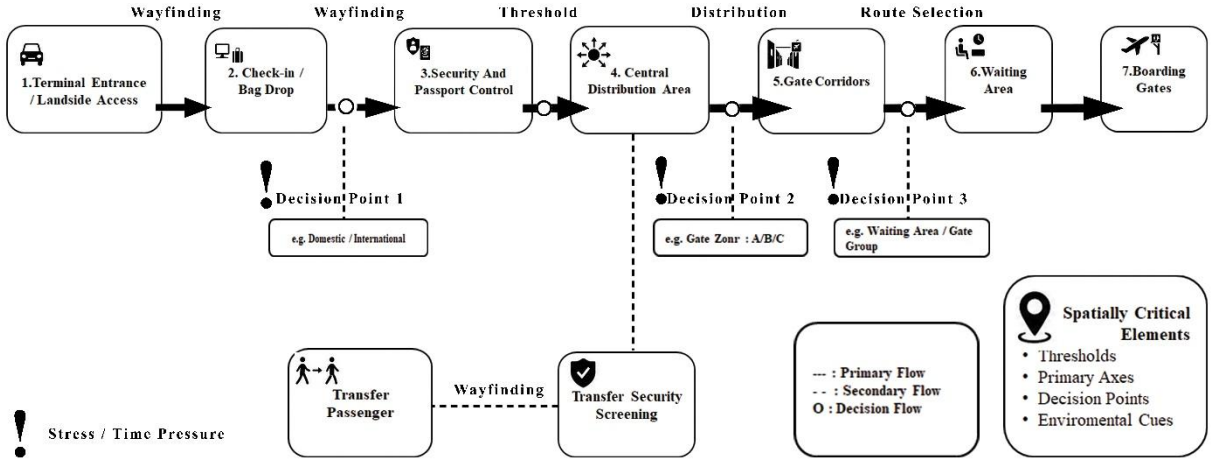

Figure 1. Mega Terminal Flow and Decision Points.

1.2 Problem Statement and Research Gap

The terminal flow summarized in Figure 1 shows that passenger movement in mega-scale airports progresses through successive thresholds, routing points, distribution areas, and route selections. Within this flow, check-in, security/passport threshold, central distribution area, gate corridors, and waiting areas should be read not only as circulation steps but also as critical nodes that determine the user's wayfinding, route selection, and spatial decision-making process. Therefore, mega-terminal evacuation is not merely a flow problem measured by exit capacity or movement time, but a multi-layered research area that should be considered in conjunction with the relationship between spatial organization, decision points, and user behavior.

The current evacuation literature has largely developed within the framework of fire safety engineering, human behavior, and crowd flow models (Kuligowski, 2013). The basic parameters of this approach include evacuation time, walking speed, flow density, queuing behavior, exit capacity, route distance, and exit selection. This operational framework has also matured strongly in recent years with digital modeling and simulation methods: Wahlqvist et al. (2021) developed a platform combining Unity-based agent modeling with fire spread simulation; Lovreglio, Dillies, Kuligowski, Rahouti, and Haghani (2022) adapted discrete choice modeling to building evacuation decision-making processes in an immersive virtual reality environment. The operational framework offers powerful tools for measuring and modeling evacuation performance; however, how architectural organization relates to behavioral and cognitive evacuation parameters in mega-scale airport terminals is more limitedly visible. The behavioral-cognitive evacuation literature has developed through variables such as pre-evacuation behavior, alarm interpretation, risk perception, social influence, decision-making under uncertainty, spatial information processing, and exit selection (Kuligowski, 2013). Decision-making processes under stress change with cognitive load, time pressure, and uncertainty; spatial information stands out as an important component influencing users' route selection and evacuation behavior (Starcke & Brand, 2012). The study by Bernardini, Lovreglio, Quagliarini, and D'Orazio (2023), which measured the effect of active and passive wayfinding systems on fire evacuation in a virtual reality environment, demonstrates that the intersection of wayfinding and evacuation behavior is on the current research agenda. The research gap here stems from the fact that these behavioral-cognitive variables are not sufficiently integrated into a holistic research framework at the mega-terminal scale, in conjunction with architectural organization variables such as circulation hierarchy, visual access, decision point organization, and spatial readability (Hillier & Hanson, 1984; Lynch, 1960; Weisman, 1981). The importance of this gap is closely related to the heterogeneous nature of the mega-airport user profile. Passengers who are unfamiliar with the terminal beforehand, have different linguistic and cultural backgrounds, are under time pressure, are physically tired, or are constrained by luggage often make their spatial decisions in crisis situations based on instantaneous environmental cues (Augé, 1995; Hubregtse, 2016). In this context, architectural organization; The organization of movement, wayfinding continuity, location of decision points, visual accessibility, and spatial readability can be considered as interfaces influencing evacuation behavior. This study bibliometrically examines the position of the relationship between architectural organization, wayfinding behavior, and disaster/emergency evacuation in mega-scale airport terminals in the literature. The main research gap of the study is the fragmented and limited visibility of the relationship between architectural organization and behavioral-cognitive evacuation dimensions in the context of mega-terminals. The study aims to make this correlation visible through Web of Science data and VOSviewer co-occurrence maps.

1.3 Aim and Research Questions

The main aim of this study is to systematically map how the relationship between architectural organization, wayfinding behavior, and disaster/emergency evacuation in mega-scale airport terminals is positioned in the literature. The study aims to examine the extent to which operational criteria, behavioral-cognitive variables, and architectural organization concepts are represented together in the evacuation literature within the context of mega-terminals. Accordingly, a two-layered conceptual-bibliometric research design has been adopted, and the study has been structured around the following three research questions:

RQ1. How are the publication trends and disciplinary distribution of the literature on disaster/emergency evacuation, wayfinding in crisis, and spatial organization shaped in the context of mega-scale airport terminals?

RQ2. To what extent do keyword co-occurrence networks make visible the conceptual relationships between architectural organization, spatial perception, visual access, decision points, and behavioral-cognitive evacuation variables?
RQ3. Bibliometric findings reveal which disciplinary, thematic, and methodological research gaps at the intersection of architectural circulation backbone, primary/secondary wayfinding strategies, spatial complexity, visual access, and evacuation behavior in the context of mega-terminals. These three research questions are addressed at the methodological level through a two-stage bibliometric search strategy; at the findings level through publication trends, WoS category distributions, and VOSviewer co-occurrence maps; and at the interpretive level through a three-layered research gap framework.

1.4 Importance and Structure of the Article

This article is a conceptual-bibliometric study that examines how the relationship between disaster/emergency evacuation, crisis navigation, and architectural organization in mega-scale airport terminals is positioned in the literature through comparative bibliometric analysis. The study makes visible the disciplinary and thematic distribution of the field through two sequential scanning strategies; based on the findings, it identifies research gaps that can be read from the perspective of the architectural discipline and responds to these gaps with a proposed conceptual framework. The increasing use of bibliometric analysis in the architectural literature (Donthu et al., 2021; Mohamed & van der Laag Yamu, 2024) strengthens the disciplinary legitimacy of this methodological approach. The contribution of the study is structured at four levels. The first contribution is the comparative mapping of the intersection of mega-terminal, disaster/emergency evacuation, crisis navigation, and architectural organization through two different scanning String from the Web of Science Core Collection. This approach allows for a more controlled reading of the field's bibliometric positioning by considering the intersection of focused research with an expanded literature view. The second contribution is the classification of disciplinary, thematic, and contextual research gaps through publication trends, WoS category distributions, and VOSviewer keyword co-occurrence maps. The third and original conceptual contribution is the proposal of a dual-mode performance framework that reads architectural organization in mega-scale airport terminals as an interface that produces simultaneous performance under normal use and crisis conditions. This framework is read through three spatial thresholds: orientation threshold, decision point threshold, and visual access threshold; it positions the operational performance paradigm and the spatial-cognitive performance paradigm as complementary, not opposing, levels. The fourth contribution is the spatial visualization of this conceptual framework through a representative terminal schematic and the concretization of the ground on which the discipline of architecture can contribute to evacuation research. The second part of the article describes the data source, Boolean search strings, filtering process, and VOSviewer analysis parameters. The third chapter presents publication and citation trends, Web of Science category distributions, keyword co-occurrence networks, and the three layers of the research gap. The fourth chapter discusses the findings within the context of architecture, wayfinding, and evacuation literature; a dual-mode performance framework is developed. The fifth chapter summarizes the main conclusions, limitations, and future research directions of the study.

2. Method

2.1 Study Design

This study examines the position of the relationship between architectural organization, wayfinding, and disaster/emergency evacuation in mega-scale airport terminals in the literature using a two-layered conceptual-bibliometric design (Donthu et al., 2021; Zupic & Čater, 2015). The first layer is based on bibliometric performance analysis, which evaluates publication year, research area, and disciplinary concentrations; the second layer is based on scientific mapping, which examines conceptual relationships, thematic clusters, and interdisciplinary connections through keyword co-occurrences (van Eck & Waltman, 2010). The combined use of performance analysis and scientific mapping within the same study is a recently adopted research strategy in the field of architecture: Mohamed and van der Laag Yamu (2024) demonstrated the applicability of this approach to architectural conceptual fields by mapping the space syntax literature from the Web of Science Core Collection in a two-layered manner, both through publication trends and disciplinary distribution, and through keyword co-occurrence networks. The present study adapts a similar structure to the intersection of architectural organization, wayfinding, and evacuation within the context of mega-terminals. This research design is based on the premise that disaster and emergency evacuation is mostly addressed in the literature from an operational and engineering perspective; while the design dimension related to architectural organization, decision points, spatial readability, and wayfinding behavior is represented in a more fragmented way. Therefore, the study aims to discuss evacuation performance in mega-scale airport terminals through an architectural reading by transforming bibliometric findings into a conceptual evaluation tool.

2.2 Data Source and Scope of Search

The bibliometric dataset was created from the Web of Science Core Collection. The search was conducted on May 1, 2026, to include SCI-EXPANDED, SSCI, A&HCI, and ESCI indexes and was limited to the period 2019–2026. This period was chosen to capture current literature trends in disaster/emergency evacuation, crisis navigation, spatial cognition, and user movement at the terminal scale. The reason for choosing Web of Science as the database is its controlled indexing structure in bibliometric analyses, the traceability of citation data, and the ability to compare interdisciplinary category distributions. Therefore, Scopus, Google Scholar, and architecture-focused databases were not included in this study. This limitation is also discussed in String 2.6. Only English-language publications of the Article and Review Article type were included in the study. The Web of Science categories are narrowed down to encompass the relationship of research to architecture, the built environment, engineering, psychology, and urban studies: Architecture, Construction & Building Technology, Civil Engineering, Experimental Psychology, Urban Studies, and Multidisciplinary Psychology. This category selection is based on the assumption that the field of architecture is not directly represented

within the Architecture category. Because studies on airport terminals, evacuation, passenger flow, and wayfinding are often indexed under the Construction & Building Technology, Civil Engineering, Urban Studies, or Psychology categories. Therefore, the number of publications in the Architecture category reflects the relative visibility of the field of architecture within the Web of Science classification system, not its absolute contribution.

2.3 Structuring Boolean Search Strings

The keyword strategy was structured around three conceptual axes: wayfinding and spatial cognition, disaster/emergency evacuation, and the built environment–terminal context. These axes were informed by the theoretical frameworks of Lynch (1960), Arthur and Passini (1992), Hillier and Hanson (1984), Weisman (1981), Helbing et al. (2000), and Kuligowski (2013). The terminology selection was grounded not only in theoretical literature but also in systematic review studies. The terms related to wayfinding correspond to the integrative review of indoor wayfinding by Jamshidi, Ensafi, and Pati (2020), while the evacuation-related terms are consistent with Haghani's (2020) synthesis of mathematical, architectural, and behavioral approaches to crowd evacuation. This correspondence indicates that the Boolean strings were not constructed arbitrarily, but were derived from both conceptual and methodological foundations in the literature. In both strings, the intersection between the three conceptual sets was established using the AND operator, while terminological variation within each set was represented through the OR operator. Multi-word expressions were searched within quotation marks to limit out-of-context matches and to increase the precision of the retrieved records.

String 2 — Extended Search: ("wayfinding" OR "navigation" OR "spatial cognition" OR "spatial behavior") AND ("evacuation" OR "emergency evacuation" OR "emergency") AND ("building" OR "environment" OR "public space" OR "transport hub" OR "terminal")

String 1 — Focused Airport-Terminal Search: ("airport terminal" OR "mega airport" OR "large-scale airport*" OR "international airport*" OR "hub airport*" OR "passenger terminal*" OR "air terminal*" OR "transit hub*" OR "transfer hub*") AND ("evacuation" OR "emergency evacuation" OR "fire evacuation" OR "pre-evacuation" OR "pre-movement" OR "egress" OR "emergency response" OR "disaster" OR "disaster response" OR "fire safety" OR "emergency management") AND ("wayfinding" OR "way-finding" OR "spatial cognition" OR "spatial behavior" OR "spatial configuration" OR "spatial legibility" OR "architectural organization" OR "decision-making" OR "decision point*" OR "panic" OR "risk perception" OR "human behavior" OR "behavioral response" OR "visual access" OR "isovist" OR "space syntax" OR "circulation")

String 2 provides an expanded bibliometric view of evacuation, emergency, and wayfinding research across the built environment, public space, transportation hub, and terminal contexts. String 1, on the other hand, identifies the more focused intersection of evacuation, crisis-time wayfinding, spatial cognition, behavioral response, and architectural organization within the specific context of airport terminals. The combined use of these two strings enables a comparative reading between the broader literature landscape and the more specific airport-terminal research intersection. The comparative structure, terminological scope, and numerical results of the two Boolean strings are presented in Table 2.

2.4 Filtering and Data Set Creation

Table 2: Comparative Structure, Terminological Scope, and Numerical Results of the Two Boolean Strings.

Dimension	String 2 — Extended Search	String 1 — Focused Search
Search Aim	To map the broader bibliometric landscape of evacuation, emergency, and wayfinding research in built environments.	To delineate the bibliometric intersection of airport-terminal, evacuation, and wayfinding research.
Database & Index Coverage	Web of Science Core Collection (SCI-E, SSCI, A&HCI, ESCI)	Web of Science Core Collection (SCI-E, SSCI, A&HCI, ESCI)
Building Type / Context Cluster	building; environment; public space; transport hub; terminal	airport terminal; mega airport; large-scale airport; international airport; hub airport; passenger terminal; air terminal; transit hub*; transfer hub
Evacuation / Disaster Cluster	evacuation; emergency evacuation; emergency	evacuation; emergency evacuation; fire evacuation; pre-evacuation; pre-movement; egress; emergency response; disaster; disaster response; fire safety; emergency management
Wayfinding / Behavior / Space Cluster	wayfinding; navigation; spatial cognition; spatial behavior	wayfinding; way-finding; spatial cognition; spatial behavior; spatial configuration; spatial legibility; architectural organization; decision-making; decision point*; panic; risk perception; human behavior; behavioral response; visual access; isovist; space syntax; circulation
Boolean Logic	Set A AND Set B AND Set C; OR within each set	Set A AND Set B AND Set C; OR within each set
Document Types	Article; Review Article	Article; Review Article
Language Filter	English	English
Search Field	TS = Topic (Title, Abstract, Author Keywords, KeyWords Plus)	TS = Topic (Title, Abstract, Author Keywords, KeyWords Plus)

Publication Year Range	2019–2026	2019–2026
Date of Last Search	1.05.2026	1.05.2026
Number of Raw Records	N = 1,704	N = 961
WoS Category Filter (applied)	Architecture; Construction & Building Technology; Engineering Civil; Psychology Experimental; Urban Studies; Psychology Multidisciplinary	Architecture; Construction & Building Technology; Engineering Civil; Psychology Experimental; Urban Studies; Psychology Multidisciplinary
WoS Category–Document Assignments (sum)	176 assignments	76 assignments
Architecture Category (unique documents)	8 documents	4 documents
Architecture vs. Two Dominant Categories	8 / 229 = 3.5% (28.6-fold gap)	4 / 102 = 3.9% (25.5-fold gap)
VOSviewer Unit of Analysis	All Keywords (Author Keywords + KeyWords Plus); full counting; min. co-occurrence = 1	All Keywords (Author Keywords + KeyWords Plus); full counting; min. co-occurrence = 1
Analytical Purpose	Main dataset for performance analysis; evaluation of publication trends and research area distribution	Focused intersection dataset; core dataset for keyword co-occurrence analysis and thematic mapping

Data sets were created using a multi-stage filtering process adapted from the PRISMA 2020 flow logic (Page et al., 2021). The process consists of identification, scanning/filtering, suitability assessment, inclusion, and data export stages. These stages are defined separately to increase the reproducibility of the study and to allow the reader to clearly follow how the raw record count was derived from the final analysis data set. The same filtering criteria were applied to both sets: year range 2019–2026; document type Article and Review Article; language English; WoS categories Architecture, Construction & Building Technology, Engineering Civil, Psychology Experimental, Urban Studies, and Psychology Multidisciplinary. In the suitability assessment stage, records that were clearly outside the scope of the research at the title, abstract, and keyword levels (off-terminal infrastructures, irrelevant building performance studies, and records that did not establish an evacuation-wayfinding relationship) were eliminated to prevent the creation of analytical noise in the data set. Filtering resulted in n = 176 included records from 1,704 raw records for String 2; and n = 76 included records from 961 raw records for String 1.

These two datasets form the two-level analysis logic of the study: String 2 represents the overarching view of the expanded literature area, while String 1 represents the focused intersection of the concepts of evacuation, wayfinding, behavior, and architectural organization in the context of an airport terminal. Thus, the bibliometric evaluation is not dependent on a single narrow query; the broad field view and the focused terminal context can be read comparatively. At this stage, a noteworthy finding is that the Architecture category remains at a low representation level in both String (String 2: 8 publications; String 1: 4 publications). This does not mean that architecture is completely excluded from the literature; it needs to be evaluated comparatively with related disciplines such as Construction & Building Technology, Civil Engineering, Urban Studies, and Experimental Psychology. Therefore, this number is not an absolute measure of the contribution of architecture, but rather its relative visibility within the WoS category system. Detailed analysis is covered in Section 3.

Included records were exported from Web of Science using the Full Record and Cited References option: Plain Text files were used for co-occurrence mapping with VOSviewer, and CSV files were used for WoS Analyze Results outputs. The overall process, consisting of data collection, scanning/filtering, suitability assessment, inclusion, export, and bibliometric visualization, is presented in Figure 2.

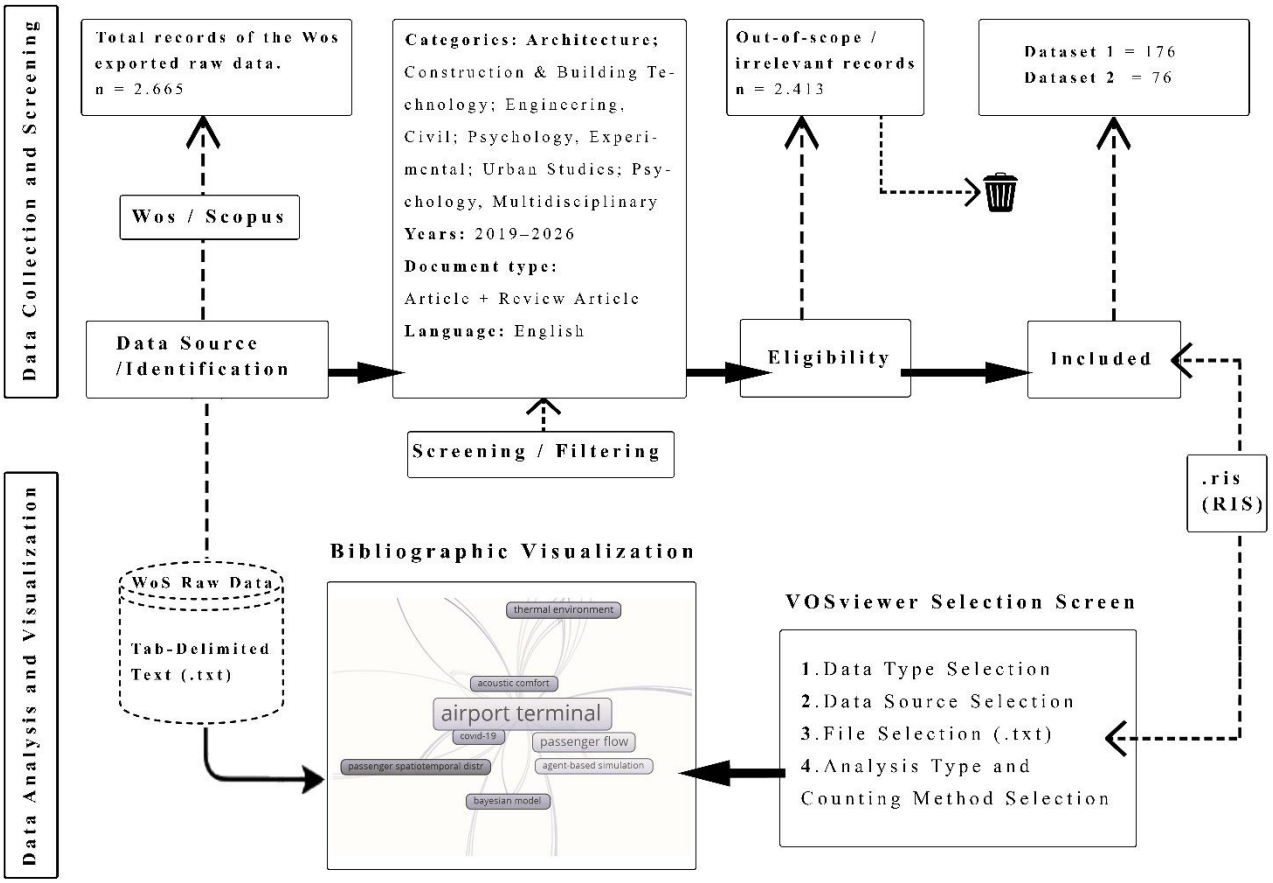

Figure 2. Bibliometric Analysis and Data Selection Process Flow Diagram. (Source: authors).

2.5 Bibliometric Analysis Material and Mapping Parameters

The analysis was conducted using Web of Science Analyze Results and VOSviewer 1.6.20. Web of Science Analyze Results was used to evaluate distribution by publication year, citation trends, and category-based disciplinary distributions. VOSviewer was used to create keyword co-occurrence networks, identify thematic clusters, and visualize inter-concept relationships (van Eck & Waltman, 2010).

In the VOSviewer analysis, All Keywords was selected as the unit. This selection allows for a broader reading of the conceptual network as it includes both author keywords and Keywords Plus terms. Full counting was used as the counting method. This choice was made to prevent the reduction of the visibility of concepts through weighting due to the relatively limited volume of the datasets and to avoid excluding low frequency but theoretically important terms from the analysis. The minimum co-occurrence threshold was set to 1. This threshold was chosen specifically because the String 1 dataset has a more limited volume with n = 76. Using a higher threshold would risk excluding low-frequency concepts critical to architecture and spatial cognition, such as architectural organization, spatial legibility, spatial configuration, decision point, visual access, and risk perception. Therefore, the low threshold was considered a conscious bibliometric decision prioritizing conceptual visibility over quantitative density. After generating co-occurrence networks, thematic clusters were interpreted and overlay visualizations were created using the average publication year parameter. This process was used to evaluate not only which clusters the concepts belonged to, but also which themes became visible earlier or later. Thus, the study was not limited to producing a static keyword map; it also included the temporal shift of thematic orientations in the analysis.

2.6 Reproducibility and Scope Limitations

To enhance the reproducibility of the study, the database, search date, year range, document type, language filter, Web of Science categories, Boolean strings, export format, software used, and VOSviewer parameters were explicitly reported. This information allows for the re-tracing of the research process under the same database and filtering conditions, and for comparison with future bibliometric updates.

The scope of the study was defined through three main limitations. First, the dataset was created solely from the Web of Science Core Collection. Web of Science offers a strong bibliometric resource in terms of its selective indexing structure and traceability of citation data; however, Scopus, Google Scholar, and other architecture-focused databases were not included in the scope of this study (Mongeon & Paul-Hus, 2016; Pranckutė, 2021).

Secondly, the search was conducted through the Topic area of Web of Science. This area includes title, abstract, author keywords, and Keywords Plus information. Therefore, the dataset was limited to publications that explicitly matched the selected keywords. The fact that concepts such as spatial readability, orientation, circulation design, and decision point are expressed with different terminologies in the architectural literature constitutes one of the main scope limitations of the keyword-based search approach. Thirdly, the Web of Science category system does not always classify architectural

contributions directly under the Architecture category. Studies with architectural content are also indexed in related fields such as Construction & Building Technology, Engineering Civil, Urban Studies, or Psychology Experimental. Therefore, the low number of publications in the Architecture category was not considered as a lack of contribution from architecture to the subject, but rather as its relative visibility within the Web of Science classification system. A two String search strategy was used to balance these scope limitations; String 2 represents the expanded literature view, while String figür 1 represents the focused intersection in the context of the airport terminal.

3. Results

This section presents a comparative analysis of the datasets obtained from a two-stage bibliometric search. The findings were evaluated using the extended dataset (String 2) and the focused dataset (String 1). The analysis was conducted at four levels: publication trends, Web of Science category distributions, keyword co-occurrence networks, temporal concentrations, and the layered structure of the research gap. Thus, the visibility of the relationship between architectural organization, wayfinding, and disaster/emergency evacuation in mega-scale airport terminals in the literature was read through bibliometric indicators.

3.1 Descriptive Findings: Publication Trends and Disciplinary Distribution

The publication distribution of both datasets over the years reveals the current development trajectory of the field in the period 2019–2026. In the String 2 expanded dataset, the number of publications was determined as 16 in 2019, 15 in 2020, 25 in 2021, 21 in 2022, 20 in 2023, 28 in 2024, 33 in 2025, and 18 in the first four months of 2026. This distribution shows a significant concentration of publications in the expanded literature field, especially during the 2024–2026 period. In the String 1 focused dataset, however, the annual number of publications shows a more limited volume. In this dataset, 7 publications were identified in 2019, 9 in 2020, 10 in 2021, 11 in 2022, 11 in 2023, 10 in 2024, 16 in 2025, and 2 in the first four months of 2026. Both datasets reached their highest publication volume in 2025. However, the lower publication volume of String 1 indicates that the intersection of architectural organization, wayfinding, and evacuation in the context of airport terminals is more limitedly represented in the literature. The publication and citation trends of String 2 and String 1 datasets over the years are presented comparatively in Figure 3.

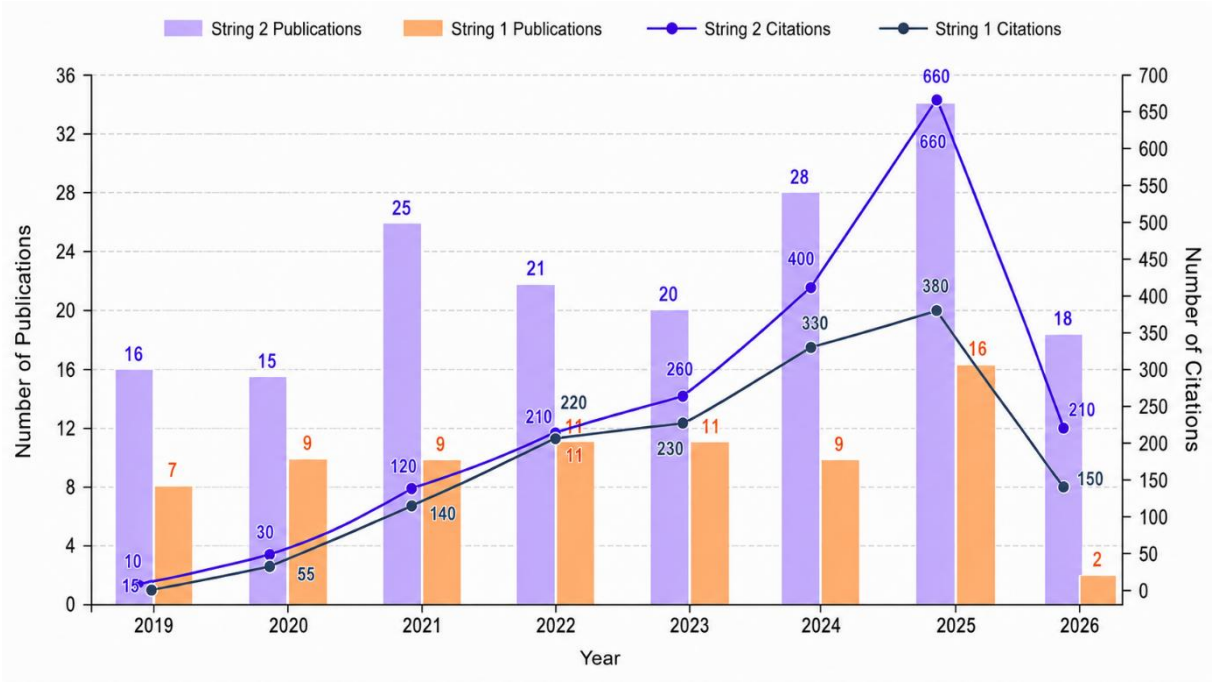

Figure 3. Annual Publication and Citation Trends of the String 2 and String 1 Datasets (2019–2026).

Table 3 presents a comparative disciplinary distribution of the two datasets according to Web of Science categories. The disciplinary distribution according to Web of Science categories shows that engineering and construction technologies are dominant in both datasets. In Dataset 2, the prominent categories are Engineering Civil, Construction & Building Technology, Transportation Science & Technology, Transportation, Engineering Environmental, Energy & Fuels, Urban Studies, Economics, Green & Sustainable Science & Technology, and Operations Research & Management Science. The Architecture category is represented by 8 publications in this dataset. A similar disciplinary concentration is observed in Dataset 1. In this dataset, Engineering Civil and Construction & Building Technology categories are dominant; Transportation Science & Technology, Engineering Marine, Engineering Ocean, Oceanography, and Urban Studies categories are represented at a secondary level. The Architecture category is represented by 4 publications in Dataset 1.

Table 3: Comparative Disciplinary Distribution of the Two Datasets According to Web of Science Categories.

WoS Category	String 2 (n=176)	String 1 (n=76)
Engineering Civil	139	62
Construction & Building Technology	90	40
Transportation Science & Technology	40	8
Transportation	28	—
Engineering Environmental	24	—
Energy & Fuels	16	—
Urban Studies	13	5
Engineering Marine	—	7
Engineering Ocean	—	6
Oceanography	—	6
Architecture	**8**	**4**
Sum of Category Assignments (Top-10 + Architecture)	358	138

This distribution indicates that the field of architecture is not directly uninvolved in the subject, but rather represents a low level of visibility within the Web of Science category system. In String 2, the Architecture category remains quite limited compared to the combined publication volume of the Engineering Civil and Construction & Building Technology categories. A similar situation is observed in String 1. This result reveals that the intersection of mega-terminal evacuation, wayfinding, and architectural organization is still predominantly addressed within the framework of engineering, building performance, and transportation studies; while architectural organization has gained weaker visibility as an independent research focus.

3.2 Thematic Clusters and Mismatch

Keyword co-occurrence analysis was performed separately for the two datasets and bibliometric maps were generated using the full counting method and minimum co-occurrence threshold one (1) parameter with VOSviewer 1.6.20 software. The generated keyword co-occurrence maps are presented in Figure 4a and Figure 4b. Thematic clusters for String 2 (n = 176): Eight thematic clusters were identified in the co-occurrence network. These clusters are respectively; emergency evacuation – building safety – architectural visual access; virtual reality – fire emergency – eye; building information modelling – agent-based modeling; wayfinding – area of interest; evacuation – built environment – disability – fire safety; indoor navigation – agent-based modeling – point cloud – navigation mesh; building information modeling – BIM – multi-user system – route planning – 3D city model; It is organized around the axes of public transportation – behavioral sciences – optimization – emergency management – access management. Underground space is observed as a bridge between clusters. Evacuation and wayfinding concepts are located at the center of the network; virtual reality and building information modeling form dense connection patterns with technological tool themes. In contrast, disciplinary architectural concepts such as architectural organization, spatial configuration, spatial legibility, and decision point do not form an independent cluster; they are located scattered within the existing network. Although the concept of architectural visual access is present on the map, its position within the network is dependent on the environmental and emergency evacuation cluster.Thematic clusters for String 1 (n = 76): Nine thematic clusters were identified in the co-occurrence network. These clusters are primarily organized around the themes of building performance (airport terminals – walking speed – thermal comfort – public building), thermal environment (elevated air velocity – thermal environment), airflow (air infiltration – large space), passenger movement (airport terminal – passenger flow – COVID-19 – agent-based simulation – acoustic comfort), demand modeling (demand response – clustering), spatiotemporal passenger distribution (passenger spatiotemporal distribution – air-conditioning system – health), Bayesian model, building material performance (aerogel-membrane – building performance), and structural safety (large-span buildings – structural safety – finite element model). In the map, the airport terminal concept is located at the center of the network and acts as the dominant hub node; secondary concepts connected to this concept are passenger flow, thermal comfort, agent-based simulation, walking speed, and building performance. In contrast, the concepts forming the conceptual backbone of the study's research question—specifically wayfinding, evacuation, emergency, spatial cognition, decision-making, architectural organization, spatial legibility, and risk perception—do not form a distinct cluster in Network String 1; most of these concepts are not visible in the network because they fall below the co-occurrence threshold.When comparing the two maps, a significant asymmetry is observed in the co-occurrence patterns. Network String 2 shows the concepts of evacuation, wayfinding, and virtual reality in a central position; while Network String 1 positions the airport terminal concept in a central position, but as a hub independent of the evacuation and wayfinding concepts. This pattern numerically documents that the concepts of wayfinding and evacuation, and architectural organization, do not coexist in the same co-occurrence core within the context of an airport terminal.

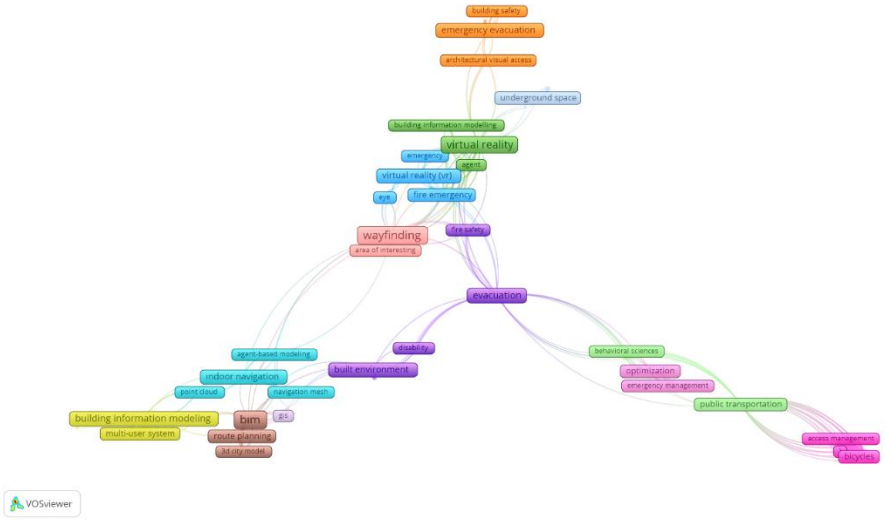

Figure 4a. String 2 VOSviewer Keyword Co-occurrence Map.

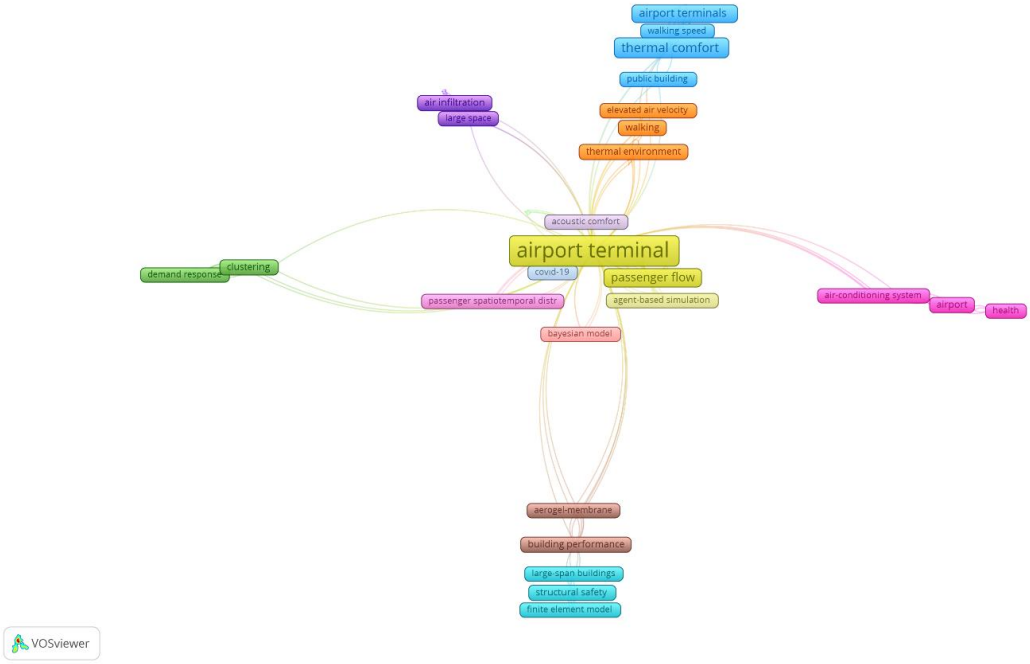

Figure 4b. String 1 VOSviewer Keyword Co-occurrence Map.

3.3 Temporal Shift / Overlay Findings

The application of the average publication year parameter to co-occurrence networks revealed the temporal evolution pattern of thematic clusters. In String 2, early concepts are mainly located around fire emergency, fire safety, emergency evacuation, and building information modeling; while in the middle period, wayfinding, indoor navigation, agent-based modeling, virtual reality, and emergency management concepts come to the fore. In the late period, architectural visual access, public transportation, optimization, behavioral sciences, access management, and point cloud concepts become visible.

In String 1, early concepts are mostly clustered around thermal comfort, building performance, structural safety, large-span buildings, and aerogel-membrane. In the middle period, agent-based simulation, passenger flow, walking speed, COVID-19, and passenger spatiotemporal distribution concepts gain visibility; while in the late period, demand response, clustering, Bayesian model, and health concepts come to the fore. When comparing the two datasets, it is observed that in String 2, the concepts of evacuation, wayfinding, and digital modeling are visible within the network in the early-to-mid period; while in String 1, the temporal concentration is more focused on themes such as passenger flow, building performance, comfort, health, and data analytics. This pattern shows that the two **Strings** produce different conceptual focuses not only in terms of terminological scope but also in terms of temporal orientations.

3.4 Three Layers of the Research Gap

Bibliometric findings point to a research gap pattern observable at three different analytical levels. These three layers are summarized in Table 4.

First layer — Disciplinary visibility gap. The Architecture category is represented by a low publication volume in both datasets. In String 2, the publication volume for Architecture (n = 8) is approximately 3.5% of that of the two dominant categories (Engineering Civil + Construction & Building Technology = 229 publications); this difference corresponds to

a volume asymmetry of 28.6 times. In String 1, the same ratio is observed as 3.9% against the two dominant categories (102 publications) (a 25.5-fold asymmetry). The position of the Architecture category in the top ten disciplinary rankings is at the bottom in both datasets. Second layer — Thematic clustering gap. VOSviewer co-occurrence maps revealed that disciplinary architectural concepts such as architectural organization, spatial configuration, spatial legibility, architectural layout, and decision point do not form an independent and distinct thematic cluster in any dataset. In the String 2 map, these concepts are scattered within the existing network; In the String 1 map it is not included in the visible network structure because it falls below the co-occurrence threshold. Although the concept of architectural visual access is observed in the second map, it does not form an independent set of architectural concepts; it is positioned in relation to the emergency evacuation set.

The third layer — Contextual intersection gap. Although the airport terminal is positioned as the central node the String 1 map the set of concepts directly connected to this node consists of building performance, thermal comfort, passenger flow, structural safety, and ventilation system themes. The concepts of evacuation, wayfinding, spatial readability, decision-making, and architectural organization are not observed in the same co-occurrence core as the airport terminal node. This pattern numerically documents that, in the context of airport terminals, the concepts of architectural organization do not form a common co-occurrence set with disaster/emergency evacuation and behavioral-cognitive dimensions in the literature. A holistic reading of the three layers reveals that the volume of publications identifiable through the Web of Science Core Collection at the bibliometric intersection corresponding to the study's research question—architectural organization, airport terminal context, and disaster/emergency evacuation—is limited, and that existing publications exhibit a scattered pattern at disciplinary, thematic, and contextual levels. This three-layered void structure forms the fundamental basis of the study's original contribution; the conceptual framework developed in the discussion section directly responds to this void structure.

Table 4: Bibliometric Evidence for the Three-Layered Research Gap.

Layer	Type of Research Gap	Bibliometric Indicator	Bibliometric Evidence
1	Disciplinary Visibility Gap	Relative position of the Architecture category compared to dominant disciplines	The Architecture category is represented by n = 8 in String 2 and n = 4 in String 1. The two dominant categories total 229 publications in String 2 (Engineering Civil + Construction & Building Technology) and 102 publications in String 1. Architecture corresponds to 3.5% of these dominant totals in String 2 and 3.9% in String 1, representing 28.6-fold and 25.5-fold volume gaps, respectively.
2	Thematic Clustering Gap	Whether architectural organization and spatial legibility concepts form an independent cluster in the VOSviewer network	Architectural organization, spatial configuration, spatial legibility, architectural layout, and decision point do not form an independent and distinct thematic cluster in either map. VOSviewer parameters: minimum co-occurrence = 1; full counting; All Keywords (Author Keywords + KeyWords Plus). String 2 yielded 8 thematic clusters and String 1 yielded 9 thematic clusters. These architectural concepts either remain scattered across existing clusters in String 2 or fall below the visibility threshold in String 1.
3	Contextual Intersection Gap	Whether wayfinding/evacuation concepts in the airport terminal context are located in the same co-occurrence core	In the airport-terminal-centered network of String 1, passenger flow, thermal comfort, agent-based simulation, building performance, and structural safety come to the fore, whereas evacuation and wayfinding do not become distinct within the same co-occurrence core. The concepts of evacuation, wayfinding, spatial legibility, decision-making, and architectural organization are not observed within the same co-occurrence core as the airport-terminal node.

4. Discussion

This section discusses the conceptual meanings that the bibliometric findings produce for the discipline of architecture. The results presented in Section 3 have shown that the concepts of disaster/emergency evacuation, wayfinding, and architectural organization in mega-scale airport terminals are not represented with equal intensity in the literature. Therefore, the discussion focuses not on repeating the publication numbers or category distributions, but on what these distributions signify in terms of architectural design, spatial readability, and decision-making processes in times of crisis. The discussion is structured at four levels. First, the interpretation of the bibliometric findings from the perspective of the field of architecture is presented. Secondly, the different analytical meanings of the concepts of disaster and emergency in the context of terminal evacuation are explained. Thirdly, the operational evacuation paradigm is compared with the spatial-cognitive performance paradigm. Finally, a dual-mode performance framework is proposed for mega-scale terminal typologies, considering architectural organization as an interface that produces simultaneous performance under normal use and crisis conditions.

4.1 Interpretation of Findings

The study's two-system scanning strategy allowed for the evaluation of the relationship between architectural organization, wayfinding, and disaster/emergency evacuation in mega-scale airport terminals at two different analytical levels. This structure simultaneously reduces two risks that might arise in single-system analyses—either over-broadening the field or over-narrowing the original question.

The disciplinary visibility, thematic clustering, and contextual intersection gaps defined in Section 3.4 demonstrate that architecture is not entirely excluded from this literature; however, design-oriented concepts such as architectural organization, spatial readability, decision points, and wayfinding are not systematically integrated into the disaster/emergency evacuation literature. As Adey (2008) points out, airports are complex spatial systems where movement, security, and emotion/control mechanisms are intertwined; however, the academic literature has not yet transformed this multi-layered nature into a research framework that combines architectural and engineering perspectives. The publication and citation trends presented in Figure 3 show that the field has reached a stage of maturity. However, this maturation is shaped not through the discipline of architecture, but through engineering categories such as Civil Engineering and Construction & Building Technology. This suggests that evacuation performance is mostly evaluated using quantitative parameters such as time, capacity, density, and flow; while qualitative dimensions of spatial organization, such as intuitive orientation, perceptual continuity, and decision point readability, are weakly represented. This trend points to a critical point supporting the main claim of the study: evacuation in airport terminals is not only an operational safety problem; it is also a spatial performance problem that must be addressed through the relationship between spatial readability, user behavior, and architectural organization. Lynch's (1960) concept of readability, Arthur and Passini's (1992) wayfinding framework, and Hillier and Hanson's (1984) spatial syntax theory provide a theoretical basis for this argument; however, bibliometric maps reveal that these three theoretical lines are not integrated into the airport evacuation literature. The scattered position of the architectural visual access concept, solely tied to the emergency evacuation cluster, and the fact that the concepts of architectural organization, spatial configuration, and decision point do not form independent clusters, documents this situation at the numerical level.

4.2 Comparison with Previous Studies: Conceptual Distinctions Between Disaster and Emergency

In comparing bibliometric findings with previous studies, the analytical distinction between the concepts of disaster and emergency provides an important ground for discussion. Although these two concepts are sometimes used interchangeably, they correspond to different scales, time pressures, levels of intervention, and decision-making processes in terms of architectural organization, wayfinding, and evacuation performance. This distinction is presented at the structural level in Table 5. In this study, disaster refers to crisis scenarios that produce large-scale, systemic effects and involve multiple uncertainties; while emergency refers to events that develop in a more limited area and can be directly managed through operational intervention mechanisms. This distinction explains why the thematic clusters concentrated around emergency evacuation in the String 2 network predominantly correspond to the emergency line: the literature has mostly developed around fire safety, crowd movement, operational evacuation, and simulation-based performance metrics. Multiple uncertainties specific to the scale of a disaster, spatial disorientation, and the intuitive guiding role of architectural organization during a crisis create a weaker thematic density. Previous studies have shown that user behavior differs in disaster and emergency conditions. Kuligowski (2013) emphasizes that evacuation behavior is not only physical movement but also a multi-layered process consisting of event perception, information interpretation, decision-making, and action. Helbing et al. (2000) provide an important basis in crowd movement and panic modeling; while Starcke and Brand (2012) reveal that decision-making under stress differs with cognitive load and time pressure. When these studies are considered together, it is seen that the evacuation process is not only a physical flow but also a perceptual-cognitive decision-making process. At this point, Augé's (1995) non-place concept adds a different dimension to the discussion. Airport terminals are transit spaces where the user experiences the structure through short transitions, without prior knowledge. Hubregtse (2016) shows that this transit nature requires that wayfinding be considered not only through signage systems but also as a dynamic composition of spatial organization and user movement. Xu, Bai, Shao, Hu, and Dong (2022), who conducted a comprehensive literature review on multimodal transportation centers, reinforce this argument by systematically demonstrating that passenger emergency behavior, flow, and spatial organization should be considered integrally.

Table 5: Conceptual Distinction between Disaster and Emergency in the Airport-Terminal Context.

Criteria	Disaster	Emergency	References
Nature of the Conceptual Reference	UNDRR, AFAD	AFAD	UNDRR (2017); AFAD
Nature of the Operational Reference	—	ICAO, FAA	ICAO Annex 14; FAA AEP
Nature of the Definition	An event that exceeds the coping capacity of society or the system and generates multidimensional and long-term impacts	Situations affecting the safety of the airport, aircraft, passengers, and personnel and requiring immediate response	ICAO Annex 14, Ch. 9; Doc 9137
Scale	Regional / National	Facility / Airport scale	UNDRR; ICAO
Level of Intervention	National–international coordination	Local / in-facility management	AFAD; ICAO
Temporal Dimension	Medium to long term	Sudden, short term	UNDRR; ICAO
Equivalent in the Airport Context	Events that disrupt the general functioning of the airport system and the region in which it is located	Events within the terminal requiring evacuation, wayfinding, and operational decision-making	ICAO Annex 14
Passenger–Terminal Relationship	Passenger safety and accessibility are addressed within the scope of post-disaster re-functioning and temporary use arrangements	Passenger safety, wayfinding, and controlled movement are part of emergency planning	ICAO Annex 9 – Facilitation
Types of Events Covered	Large-scale natural or human-induced events that seriously disrupt the functioning of the airport system (e.g., major earthquake, widespread infrastructure damage)	Aircraft accidents, terminal incidents, fire, explosion, situations requiring evacuation	ICAO Annex 14
Focus in Terms of Architectural Organization	Structural resilience, functional recovery	Evacuation routes, circulation scheme, decision points	ICAO; FAA

Hasanzade and van Oel (2022), on the other hand, empirically document the decisive role of terminal design on user perception by examining the relationship between passenger experience and architectural choices through 3D visualizations of 435 passengers. As a study that empirically tests the concepts of readability and wayfinding in the Türkiye context,Yavuz, Ataoğlu, and Acar (2020) analyzed Lynch's (1960) five spatial elements (path, edge, district, node, landmark) using the example of Trabzon city square, demonstrating that spatial readability significantly shapes user cognitive maps. Although this finding at the city scale cannot be directly transferred to the building scale, it reveals that the concept of readability is positioned as an empirical research variable in built environment research in Türkiye; it prepares the disciplinary ground for similar empirical studies that should be conducted for mega-scale airport terminals. This comparison reveals a pattern consistent with the bibliometric findings of the study: the literature has predominantly developed along emergency operational lines; architectural organization and spatial-cognitive dimensions at the disaster scale have remained under limited representation. This gap forms the theoretical justification for the dual-mode performance framework proposed in Section 4.3.

4.3 Conceptual Implications for the Discipline of Architecture: A Dual-Mode Performance Framework

The most critical implication of the bibliometric findings for the discipline of architecture is that evacuation performance in mega-scale airport terminals should be re-evaluated not only as an operational output but also as a dual-mode spatial performance. In this study, dual-mode performance is based on the assumption that every architectural organizational decision made in the terminal simultaneously produces two different performances in normal use and crisis conditions. In normal use, spatial decisions supporting functional orientation, user experience, and circulation continuity determine the performance of vital variables such as decision-making under stress, visual accessibility, and spatial readability in crisis conditions. This duality can be said to be embodied through three basic spatial thresholds: orientation threshold, decision point threshold, and visual access threshold. The orientation threshold is supported by information-based tools such as signage, digital displays, and symbol systems in normal use; while in crisis conditions, it becomes dependent on intuitive spatial cues that the user can quickly perceive under stress. The decision point threshold is a circulation component that regulates directional choice in normal use; In crisis situations, route selection, perception of exit, and response to crowd movement become a critical spatial node. While visual accessibility thresholds are normally related to spatial quality and ease of navigation, in a crisis they reduce disorientation and influence evacuation decisions.

Table 6. Comparison of Operational and Spatial-Cognitive Performance Paradigms through Architectural Organization.

Parameter Type	Operational Performance Paradigm	Spatial-Cognitive Performance Paradigm	Mediating Variable of Architectural Organization
Time	Evacuation time; RSET; movement time	Pre-evacuation time; decision-making time; delay in initiating movement	Decision-point organization; route continuity
Capacity and density	Flow density; outlet capacity; queuing	Crowd pressure perception; pause; crowd following behavior	Circulation hierarchy; bottleneck control
Movement and flow	Walking speed; flow pattern; circulation efficiency	Slowing down under stress; reversal; route-searching behavior	Main circulation spine; alternative route configuration
Decision-making	Outlet capacity; outlet distribution	Route choice under uncertainty; route preference; cognitive load	Decision-point design; perceptibility of outlets
Spatial perception	Line of sight; accessibility; legibility of routes	Spatial cognition; orientation continuity; visual access	Spatial legibility; visual corridors; isovist relations
Information processing	System-centered information: alarms, announcements, signage, digital wayfinding	User-centered information: environmental cues, risk perception, alarm interpretation	Environmental information presentation; functional zoning; reference points
User behavior	Standardized user flow; controlled movement; capacity-based distribution	Social influence; following behavior; panic tendency; cognitive load	Volumetric hierarchy; perceptual openness; guiding spatial configuration
Modeling approach	Flow dynamics; queuing theory; capacity- and time-based simulation	Behavioral patterns; agent-based simulation; cognitive decision models	Design-based simulation; spatial scenario generation
Unit of analysis	Total evacuation performance; system efficiency	Individual-cognitive performance; user–environment interaction	Spatial performance; user route; decision threshold

The distinction presented in Table 6 highlights the unique contribution of this study to the discipline of architecture. While the operational paradigm primarily addresses evacuation through measurable variables such as flow, duration, and capacity; the spatial-cognitive paradigm focuses on how the user perceives the space, how they interpret decision points, and which environmental cues they turn to under stress. These two paradigms are not alternatives but complementary; however, bibliometric findings show that the operational paradigm is more strongly represented in the existing literature, while spatial-cognitive parameters are addressed in a more scattered manner. This imbalance also aligns with Iftikhar, Shah, and Luximon's (2021) systematic examination of the need to evaluate wayfinding performance in complex structures not only with objective (mission duration, distance) but also with subjective (perception, experience) criteria.

The spatial equivalent of this framework is shown in Figure 5 through a representative mega-scale terminal typology. Figure 5 is not a technical plan analysis, simulation output, or field measurement of a specific airport; Operational flow is used as a conceptual spatialization of the relationship between spatial-cognitive readability and critical threshold zones. With this approach, the contribution of architectural discipline to evacuation research should be considered not only through circulation arrangement or exit placement, but also through the design of the perceptual and cognitive infrastructure that guides user behavior in times of crisis.

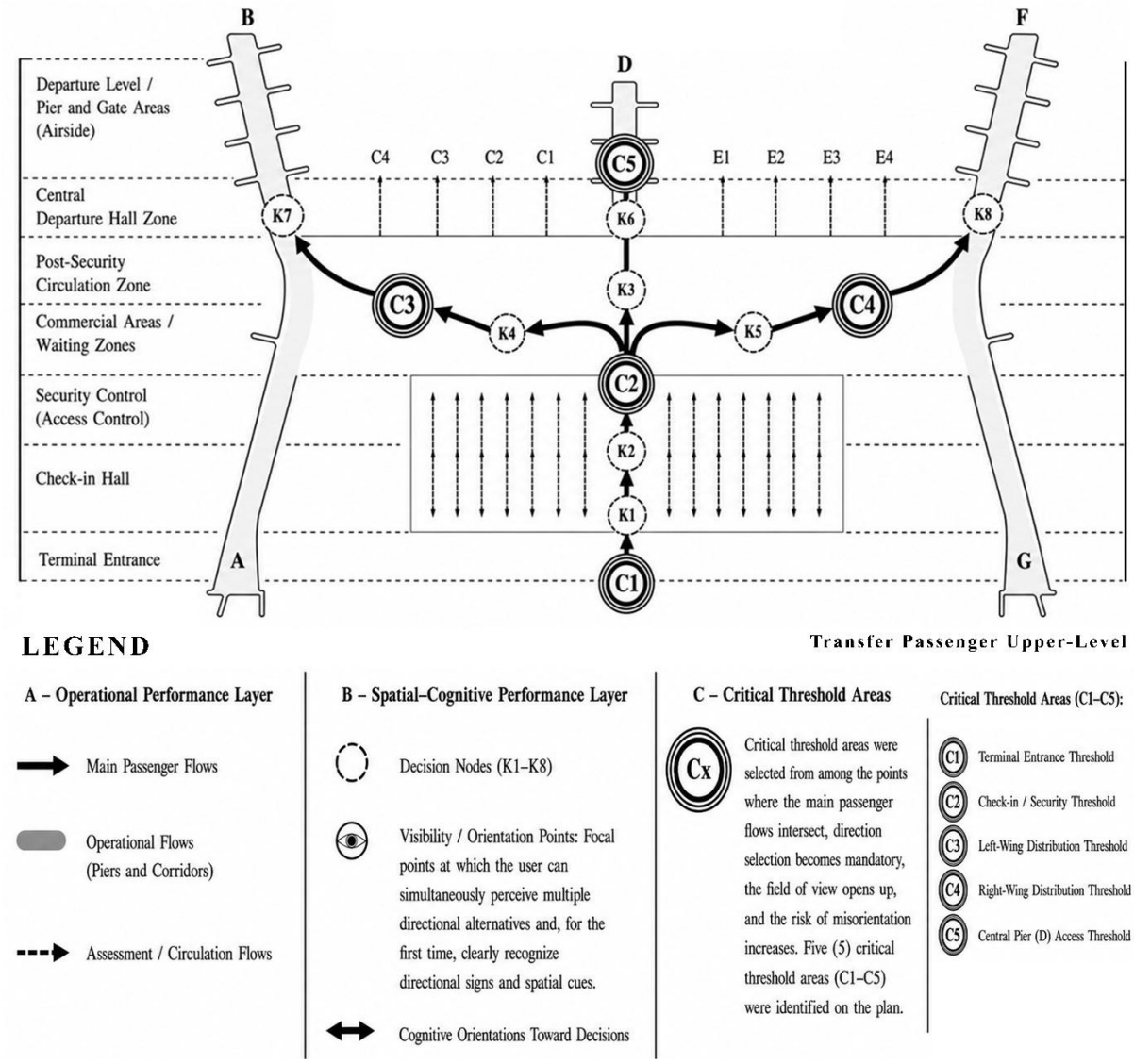

Figure 5. Spatial Reading of Operational and Spatial-Cognitive Performance Parameters in a Mega-Scale Terminal Typology.

4.4 Limitations and Future Research Directions

In addition to the scope limitations detailed in the Methods section (Chapter 2.6), three points of consideration should be highlighted in terms of interpreting the findings. First, the bibliometric analysis reveals the academic visibility in the field; this visibility does not directly represent all the accumulated knowledge or level of professional practice in architectural practice (Donthu et al., 2021). Second, Figure 5 is not a technical plan analysis, isovist or space syntax review, simulation output, or field measurement of a specific airport; it is a conceptual diagram showing the representative spatial counterpart of the dual-mode performance framework. Third, the developed conceptual framework is not a model that can be directly transferred to other mega-structure typologies (stadium, shopping mall, hospital complex); it is a ground for discussion that needs to be re-tested according to context. These limitations point to four future research directions. Firstly, empirically testing the dual-mode performance framework using agent-based simulation, virtual reality, and isovist-based spatial analysis methods is a critical step in transforming the concept into a research variable. Studies such as those by Yan, He, Basiri, Hancock, and Yeboah (2024), which evaluate evacuation performance under low visibility conditions, demonstrate that the visual access threshold within the framework can be empirically tested. Secondly, the impact of architectural organization on wayfinding behavior should be evaluated through heterogeneous user profiles, such as users unfamiliar with the structure, those who do not speak the language, those who are fatigued, or those carrying luggage, in mega-terminals. Lin, Cao, and Li's (2020) VR-based experimental study, which shows that the level of spatial information completion significantly shapes evacuation behavior in metro stations, provides a methodological basis for this approach. Thirdly, developing disaster scenario-based architectural organization strategies for mega-scale airports in the Turkish context presents a unique research agenda due to local disaster risk and operational scale. Fourthly, the adaptability of the

dual-mode performance framework to other complex public building typologies such as high-complexity transportation hubs, healthcare facilities, convention and sports complexes creates an orientation that will expand the disciplinary contribution potential of the conceptual framework. The study by Wang, Liang, Chen, and Wu (2022), which examines the effect of natural light on emergency evacuation route selection in underground spaces, provides an opportunity to test the validity of visual accessibility and spatial readability variables in different building typologies.

5. Conclusion

This study examined the position of the relationship between architectural organization, crisis navigation, and disaster/emergency evacuation in mega-scale airport terminals in the literature through a two-layered conceptual-bibliometric research design. Two complementary Boolean String extended searches (String 2; n = 176) and focused searches (String 1; n = 76) conducted on the Web of Science Core Collection between 2019 and 2026 allowed for the evaluation of both the general disciplinary view of the field and the bibliometric intersection corresponding to the original research question.

5.1 Synthesis of Key Findings

The bibliometric analysis reached three key findings. First, evacuation and related research areas in mega-scale airport terminals are predominantly concentrated in categories related to engineering and building technologies such as Engineering Civil, Construction & Building Technology, and Transportation Science & Technology; the Architecture category remains underrepresented in both datasets (String 2: 8 publications; String 1: 4 publications). Secondly, VOSviewer keyword co-occurrence maps show that concepts related to architectural organization, such as architectural organization, spatial configuration, spatial legibility, and decision point, do not form an independent thematic cluster. Thirdly, in the context of an airport terminal, the concepts of architectural organization do not integrate with disaster/emergency evacuation and behavioral-cognitive dimensions in the same co-occurrence core. These three findings make the research gap of the study visible in three layers: disciplinary visibility, thematic clustering, and contextual intersection.

5.2 Relationship with Research Questions

The study is structured around three research questions. Within the scope of RQ1, it has been shown that the literature on disaster/emergency evacuation and wayfinding has developed mainly through engineering-based categories; while the field of architecture is represented with a limited volume. Within the framework of RQ2, it has been determined that keyword co-occurrence networks do not position the concepts of architectural organization, spatial perception, visual accessibility, and decision points in the same core as behavioral-cognitive variables. Within the scope of RQ3, it has become visible that a three-layered research gap operates simultaneously at disciplinary, thematic, and contextual levels. A common feature of the study's answers to the research questions is that the discipline of architecture is not entirely excluded from this literature; however, it reveals that concepts such as architectural organization, spatial readability, decision points, and wayfinding in times of crisis have gained fragmented and limited visibility in the mega-terminal evacuation literature.

5.3 Conceptual Contribution and Positioning within Literature

The main conceptual contribution of this study is the dual-mode performance framework developed from bibliometric findings. This framework proposes that architectural organizational decisions in mega-scale airport terminals produce two simultaneous performance regimes that are not mutually exclusive, both in normal use and in crisis conditions. Dual-modality is interpreted through three spatial thresholds: the wayfinding threshold, the decision point threshold, and the visual access threshold. The literature contribution of this approach can be evaluated at three levels. Firstly, it proposes a conceptual bridge to the fragmented structure in the literature by positioning the operational performance paradigm and the spatial-cognitive performance paradigm as two complementary, rather than opposing, levels of evaluation. Secondly, it redefines architectural organization not only as a construct that regulates daily passenger flow, but also as a spatial interface that influences route selection, wayfinding, and evacuation behavior in crisis conditions. Thirdly, by reading Lynch's (1960) readability, Arthur and Passini's (1992) wayfinding, and Hillier and Hanson's (1984) spatial arrangement approaches in an integrated manner within the context of disaster/emergency evacuation, it demonstrates how architectural theory can conceptually contribute to this literature.

5.4 Practical Implications and Limitations

At the practical level, the study shows that evacuation performance in mega-airport design and evaluation processes should be considered not only in terms of time, capacity, and flow parameters, but also in conjunction with spatial readability, location of decision points, visual accessibility, and wayfinding continuity. This implication supports the systematic inclusion of spatial-cognitive parameters in architectural decision-making processes—from concept design to post-occupancy evaluation. The findings of the study should be read within certain limitations. Bibliometric analysis was conducted only through the Web of Science Core Collection; Scopus, Google Scholar, and architecture-focused databases were excluded. Keyword-based searching may have failed to include some studies using different terminology in the dataset. Furthermore, bibliometric analysis reveals academic visibility; it does not directly represent the entire body of knowledge in architectural practice. These limitations indicate that the findings should be evaluated at the level of bibliometric visibility and conceptual representation.

5.5 Future Research Directions

Four axes stand out for future research. First, empirically testing the dual-mode performance framework through agent-based simulation, virtual reality-based user experience studies, isovist analysis, and spatial complexity measurements. Second, examining the impact of architectural organization on wayfinding behavior in crisis situations through user profiles unfamiliar with the terminal, with diverse language and cultural backgrounds, fatigued, or constrained by baggage. Third, investigating the relationship between disaster and emergency scenarios and architectural organization strategies in mega-scale airports in the Turkish context, considering local disaster risk and operational scale. Fourth, evaluating the adaptability of the dual-mode performance framework to other complex public building typologies such as large transportation hubs, health campuses, convention centers, and sports complexes. The main conclusion reached by this study is that architectural organization can be read as a dual-mode performance tool operating in mega-scale airport terminals, both under normal use and crisis conditions; this reading positions the discipline of architecture as an actor offering a unique conceptual contribution to the disaster/emergency evacuation literature.

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Conflicts of Interest

The authors report no conflicts of interest.

Data Availability Statement

The bibliometric data analyzed in this study are derived from the Web of Science Core Collection. The Boolean search strings, filtering criteria, and VOSviewer analytical parameters are reported in full in Sections 2.2–2.5 of this paper, ensuring full reproducibility. The two analytical datasets (String 2, n = 176; String 1, n = 76) can be regenerated by executing the same search strings under the same year range (2019–2026), document type filters, and Web of Science category constraints reported in Table 2. Plain-text export files and VOSviewer co-occurrence map outputs are available from the corresponding author upon reasonable request.

Institutional Review Board Statement

Not applicable. This study is based on bibliometric analysis of publicly available academic publications indexed in the Web of Science Core Collection and does not involve human participants, animal subjects, identifiable personal data, or any other element requiring institutional ethical review.

CRediT Author Statement

Buse Yalpı: Conceptualisation; Methodology; Investigation; Data curation; Formal analysis; Visualisation; Writing – original draft.
Aslı Er Akan: Methodology; Supervision; Writing – review & editing; Validation.
All authors have read and approved the final manuscript.

Reference List

Adey, P. (2008). Airports, mobility and the calculative architecture of affective control. *Geoforum, 39*(1), 438–451. https://doi.org/10.1016/j.geoforum.2007.09.001

Arthur, P., & Passini, R. (1992). *Wayfinding: People, signs, and architecture*. McGraw-Hill Ryerson.

Augé, M. (1995). *Non-places: Introduction to an anthropology of supermodernity* (J. Howe, Trans.). Verso.

Bernardini, G., Lovreglio, R., Quagliarini, E., & D'Orazio, M. (2023). Can active and passive wayfinding systems support fire evacuation in buildings? Insights from a virtual reality-based experiment. *Journal of Building Engineering, 74*, 106778. https://doi.org/10.1016/j.jobe.2023.106778

Donthu, N., Kumar, S., Mukherjee, D., Pandey, N., & Lim, W. M. (2021). How to conduct a bibliometric analysis: An overview and guidelines. *Journal of Business Research, 133*, 285–296. https://doi.org/10.1016/j.jbusres.2021.04.070

Haghani, M. (2020). Optimising crowd evacuations: Mathematical, architectural and behavioural approaches. *Safety Science, 128*, 104745. https://doi.org/10.1016/j.ssci.2020.104745

Hasanzade, M. P., van Oel, C. J., & Pazhouhanfar, M. (2022). Passengers' preferences for architectural design characteristics in the design of airport terminals. *Architectural Engineering and Design Management, 19*(6), 586–601. https://doi.org/10.1080/17452007.2022.2104206

Helbing, D., Farkas, I., & Vicsek, T. (2000). Simulating dynamical features of escape panic. *Nature, 407*(6803), 487–490. https://doi.org/10.1038/35035023

Hillier, B., & Hanson, J. (1984). *The social logic of space*. Cambridge University Press.

Hubregtse, M. (2016). Passenger movement and air terminal design: Artworks, wayfinding, commerce, and kinaesthesia. *Interiors, 7*(2–3), 155–179. https://doi.org/10.1080/20419112.2016.1215678

Iftikhar, H., Shah, P., & Luximon, Y. (2021). Human wayfinding behaviour and metrics in complex environments: A systematic literature review. Architectural Science Review, 64(5), 452–463. https://doi.org/10.1080/00038628.2020.1777386

Jamshidi, S., Ensafi, M., & Pati, D. (2020). Wayfinding in interior environments: An integrative review. *Frontiers in Psychology, 11*, 549628. https://doi.org/10.3389/fpsyg.2020.549628

Jung, K., & Shin, S. (2016). Identification of urban-form characteristics impacting public space integration in international hub airports. *Sustainable Cities and Society, 28*, 144–154. https://doi.org/10.1016/j.scs.2016.06.024

Kuligowski, E. D. (2013). Predicting human behavior during fires. *Fire Technology, 49*(1), 101–120. https://doi.org/10.1007/s10694-011-0245-6

Lee, J. H., Ostwald, M. J., & Zhou, L. (2023). Socio-spatial experience in space syntax research: A PRISMA-compliant review. *Buildings, 13*(3), 644. https://doi.org/10.3390/buildings13030644

Lin, J., Cao, L., & Li, N. (2020). How the completeness of spatial knowledge influences the evacuation behavior of passengers in metro stations: A VR-based experimental study. *Automation in Construction, 113*, 103136. https://doi.org/10.1016/j.autcon.2020.103136

Lovreglio, R., Dillies, E., Kuligowski, E., Rahouti, A., & Haghani, M. (2022). Exit choice in built environment evacuation combining immersive virtual reality and discrete choice modelling. *Automation in Construction, 141*, 104452. https://doi.org/10.1016/j.autcon.2022.104452

Lynch, K. (1960). *The image of the city*. MIT Press.

Mohamed, A. A., & van der Laag Yamu, C. (2024). Space syntax has come of age: A bibliometric review from 1976 to 2023. *Journal of Planning Literature, 39*(2), 287–303. https://doi.org/10.1177/08854122231208018

Mongeon, P., & Paul-Hus, A. (2016). The journal coverage of Web of Science and Scopus: A comparative analysis. *Scientometrics, 106*(1), 213–228. https://doi.org/10.1007/s11192-015-1765-5

Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., Shamseer, L., Tetzlaff, J. M., Akl, E. A., Brennan, S. E., Chou, R., Glanville, J., Grimshaw, J. M., Hróbjartsson, A., Lalu, M. M., Li, T., Loder, E. W., Mayo-Wilson, E., McDonald, S., … Moher, D. (2021). The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. *BMJ, 372*, n71. https://doi.org/10.1136/bmj.n71

Pranckutė, R. (2021). Web of Science (WoS) and Scopus: The titans of bibliographic information in today's academic world. *Publications, 9*(1), 12. https://doi.org/10.3390/publications9010012

Starcke, K., & Brand, M. (2012). Decision making under stress: A selective review. *Neuroscience & Biobehavioral Reviews, 36*(4), 1228–1248. https://doi.org/10.1016/j.neubiorev.2012.02.003

van Eck, N. J., & Waltman, L. (2010). Software survey: VOSviewer, a computer program for bibliometric mapping. *Scientometrics, 84*(2), 523–538. https://doi.org/10.1007/s11192-009-0146-3

Vieira, D. J., Silva, E. J. da, Alves, C. J. P., & Borille, G. M. R. (2023). Assuring quality of pedestrian behavior results derived from simulation models applied to airport terminals. *Transportation Research Record, 2677*(11), 90–105. https://doi.org/10.1177/03611981221127017

Wahlqvist, J., Ronchi, E., Gwynne, S. M. V., Kinateder, M., Rein, G., Mitchell, H., Bénichou, N., Ma, C., Kimball, A., & Kuligowski, E. (2021). The simulation of wildland-urban interface fire evacuation: The WUI-NITY platform. *Safety Science, 136*, 105145. https://doi.org/10.1016/j.ssci.2020.105145

Wang, D., Liang, S., Chen, B., & Wu, C. (2022). Investigation on the impacts of natural lighting on occupants' wayfinding behavior during emergency evacuation in underground space. *Energy and Buildings, 255*, 111613. https://doi.org/10.1016/j.enbuild.2021.111613

Weisman, J. (1981). Evaluating architectural legibility: Way-finding in the built environment. *Environment and Behavior, 13*(2), 189–204. https://doi.org/10.1177/0013916581132004

Xu, J., Bai, S., Shao, Z., Hu, X., & Dong, M. (2022). Pedestrian flow simulation in emergency evacuation at multimodal transportation hubs: A comprehensive literature review. *Journal of Transportation Engineering, Part A: Systems*. https://doi.org/10.1061/(ASCE)TE.1943-5436.0000680

Yan, J., He, G., Basiri, A., Hancock, C., & Yeboah, S. K. (2024). The impact of postures and moving directions in fire evacuation in a low-visibility environment. *Sensors, 24*(5), 1378. https://doi.org/10.3390/s24051378

Yavuz, A., Ataoğlu, N. C., & Acar, H. (2020). The identification of the city on the legibility and wayfinding concepts: A case of Trabzon. *Journal of Contemporary Urban Affairs, 4*(2), 1–12. https://doi.org/10.25034/ijcua.2020.v4n2-1

Zupic, I., & Čater, T. (2015). Bibliometric methods in management and organization. *Organizational Research Methods, 18*(3), 429–472. https://doi.org/10.1177/1094428114562629