

A Bibliometric and Science-Mapping Review of Urban Road Safety Performance Indicators (2010–2024)



Esraa R. Al-Gurah^{1,2*}, Abeer K. Jameel²

¹ Department of Civil Engineering, College of Engineering, University of Al-Qadisiyah, Al-Diwaniyah 58002, Iraq

² Department of Highway and Transportation Engineering, College of Engineering, Mustansiriyah University, Baghdad 10047, Iraq

Corresponding Author Email: esraa.riadh@qu.edu.iq

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ABSTRACT

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Road Safety Performance Indicators, bibliometric analysis, science mapping, VOSviewer, CiteSpace

Road Safety Performance Indicators (RSPIs) are increasingly used to monitor, compare, and improve urban traffic safety. However, the literature remains fragmented across regions, indicator frameworks, and methodological approaches, making it difficult to identify stable research patterns and emerging priorities. This study provides a bibliometric and science-mapping review of global research on RSPIs in urban road networks, with particular relevance to low- and middle-income countries (LMICs), where indicator-based safety assessment remains underdeveloped. Publications indexed in the Scopus database for 2010–2024 were initially retrieved ($n = 476$). After screening, document-type filtering, and data cleaning, a final dataset of 363 peer-reviewed journal articles and review papers was retained for analysis. VOSviewer was used to examine co-authorship, co-citation, and keyword co-occurrence structures. Bibliometrix (R) was applied to generate descriptive bibliometric profiles and thematic evolution patterns, while CiteSpace was used to identify citation bursts and emerging topics. The results reveal four main thematic clusters: behavioral indicators such as speeding, seatbelt use, and distraction; infrastructure-related indicators associated with road design and urban planning; vehicle-related technologies and innovations; and post-crash response systems. Recent research hotspots include machine learning, deep learning, and composite safety indices. This review synthesizes the international knowledge base and highlights persistent data gaps in LMICs, especially in behavioral and post-crash indicators. It also outlines a future research agenda for developing context-sensitive composite indicators for urban networks in Iraq and comparable LMIC settings, including the proposed Adaptive Safety & Resilience Safety Index (A-SRSI).

1. INTRODUCTION

Road safety has increasingly become an important public health and policy research and planning agenda for lawmakers, researchers, and urban planners, especially in the low- and middle-income countries (LMICs), where road network expansion is taking place at an unprecedented rate, yet with the lack of comprehensive road safety management systems [1-3]. Traffic crashes in these areas result in hundreds of lives that are lost annually and involve serious socio-economic costs, reflecting significant gaps in road designs, law enforcement, and post-crash emergency care [4-7]. The complexity of these problems demands holistic approaches that should not be limited to descriptive statistics but should extend to predictive and preventive strategies that are able to act on multi-level determinants [8, 9].

In the last 20 years, research globally has progressively focused on the use of Road Safety Performance Indicators (RSPIs) as prospective instruments for safety performance monitoring and assessment [6, 10, 11]. Unlike traditional data-dependent methodologies, which consider only death and injury tallies, RSPI results include diverse variables pertaining

to driver actions (e.g., speed, belt use), road and environmental conditions (e.g., road configuration, lighting), vehicle elements, as well as the post-crash emergency response [12-14]. These dimensions can be used to facilitate cross-regional and cross-national comparisons of road safety performance, making it possible to apply more universal and systematic criteria or guidelines when combinations of factors are included in composite indicators [15, 16]. However, despite their widespread use in high-income countries (HICs), RSPIs and combined safety metrics remain fragmented and underemployed within the LMIC setting [15, 17]. Conventional statistical models (e.g., logistic/multinomial regression) have traditionally been implemented to investigate the relationship between crash characteristics and injury severity [18, 19]. However, their linear form does not allow them to express the complex, nonlinear, and high-dimensional interactions likely to characterize crash data [20]. In recent years, sophisticated artificial intelligence and machine learning techniques, including random forests, gradient boosting, deep neural networks, and support vector machines, have shown superior performance in terms of prediction when applied to large-scale crash datasets [21-27]. Their use in HICs

has been successful, although spread to LMICs has been limited, thus contributing to a globalized ‘inequity’ in road safety research and policy generation [28].

In Iraq, this gap has been particularly severe. Weak institutional collaboration, underutilization of Safety Performance Indicators, and reliance on obsolete analytical techniques have obstructed the evolution of safety-directed policymaking in Iraq [29-32]. The lack of nationally appropriate composite indices has also precluded facility leaders from effectively comparing progress and rolling out evidence-based programs [33]. These weaknesses accentuate the urgency in constructing locally relevant models that incorporate global methodological innovations while being responsive to local conditions [34-36].

The use of bibliometric and science mapping analysis could provide an effective way to systematically synthesize the global research landscape on urban road safety indicators [37-39]. Using software applications such as CiteSpace, VOSviewer, and Bibliometrix, this method allows us to unveil publication trends, key contributors, methodological paradigms, collaboration structures, and emerging thematic formations [40-42]. Not only are such analyses valuable in terms of mapping out how the field’s intellectual and methodological identity has developed over time, but they also enable us to identify gaps in the literature and push us forward in terms of theory and practice [43-45].

Thus, this paper seeks to (i) provide a holistic analysis of global urban RSPIs research written between 2010 and 2024 using bibliometrics and science mapping, and (ii) propose an innovative composite road safety index, the Adaptive Safety & Resilience Safety Index (A-SRSI), that is adapted to the Iraqi context [45-47]. Through simultaneous consideration of behavioral, environmental, vehicular, and post-crash factors, the inclusion of these multidimensional determinants is an important way to bridge existing gaps in knowledge and to support the development of practical, evidence-informed solutions to improve road safety management in LMICs [48-51]. Accordingly, available research can be generally classified into three interrelated thematic categories: (i) behavioral and human-factor indicators; (ii) infrastructure- and vehicle-related safety principles; and (iii) post-crash response and system performance frameworks. Together, these thematic flows contribute to the research questions and analytics framework driving this study.

2. THEORETICAL BACKGROUND

2.1 Bibliometric analysis in transportation research

Bibliometric analysis is an important approach to exploring the intellectual structure and historical evolution of a research field, and to identifying important works, authors, and topic development over time. Bibliometrics measures scientific outputs and maps citation networks, going beyond traditional literature reviews by offering both descriptive and relational perspectives [52]. Tools such as VOSviewer, Bibliometrics, and CiteSpace have provided the means to do so by detecting clusters of research activities, emerging themes, and collaborating communities both geo-spatially and cross-disciplinary [18, 53-56].

In transport research, bibliometric techniques are widely used across several domains, including sustainable mobility, intelligent transportation systems, and urban planning,

highlighting the dynamic development pattern of concepts, including smart cities, green mobility, and automation [57-61]. Recently, bibliometric analysis has been expanded into the traffic safety domain, serving as an objective tool to systematically reveal worldwide scientific output, cross-country cooperation, and new research hotspots [61, 62]. For instance, research has followed the increased focus on machine learning usage in crash prediction and behavioral risk factors involving distracted driving and alcohol impairment [63, 64]. These are promising signs for bibliometrics as not only a methodological device but a guide to policy and research direction in road safety.

2.2 Road Safety Performance Indicators

RSPIs such as road safety are fundamental to monitor, evaluate, and orientate interventions on traffic safety. In contrast to the traditional focus on accidents and fatalities, RSPIs highlight proactive and preventive aspects of safety management. These signals cover a wide range of dimensions, such as:

- Behavioral indicators: Speeding rates, use of seat belts and helmets, distracted driving (like using a mobile phone), and driving while under the influence of alcohol or drugs.
- Infrastructure indicators: Road geometry, pedestrian facilities, traffic calming, and visibility.
- Vehicle characteristics: Vehicle age, maintenance condition, safety systems, ABS, airbag, and ADAS.
- Post-crash response indicators: Availability of emergency services, response capability, and access to trauma centers.
- Environmental data: Weather, air pollution due to traffic congestion, and illumination quality on urban networks.

Recent developments have extended the RSPI paradigm to include not only socioeconomic parameters (income levels, urbanization rates) but also the hyperspectral imaging technologies (automated vehicles, AI-supported safety monitoring). Such multidimensional metrics can provide a more systemic comprehension of crash causation, which steers the focus from sectional statistics (reactive in nature) to predictive safety science [23, 65].

The uptake of RSPIs in LMICs is limited and uneven. For example, HICs have established large-scale surveillance of behavioral indicators (e.g., through national surveys and automated enforcement systems), whereas LMICs generally have been unable to develop such surveillance to the same degree due to institutional capacity and data infrastructure limitations [15, 66]. In Iraq, the gap is particularly evident, as road safety assessment still relies heavily on descriptive statistics rather than structured performance indicators. This highlights the urgent need for composite and context-specific RSPI systems [10, 11].

2.3 Linking bibliometric analysis with Road Safety Performance Indicators

Integrating bibliometric tools with RSPI research provides a powerful means for systematically assessing world scholarship, following pathways of change in concept development, and comparing local practices to world practice. Bibliometrics have empowered scholars to map academic discourse on RSPIs at multiple time points, such as what the research focus on RSPI was in the 1990s on infrastructure safety, post-2010 on behavioral risk indicators, and after 2020 on AI-based safety monitoring and post-crash care [5, 23, 67].

This type of temporal analysis offers great value by elucidating where research priorities are shifting and what areas still require investigation, especially in LMICs.

In addition, bibliometric mapping can illustrate geographic disparities of RSPI research. Although papers on advanced technologies and on safety monitoring systems are mostly published by HICs, LMICs mostly address issues concerning descriptive accident statistics. This gap in knowledge highlights the relevance of customized summary indicators that consider contextual factors such as weak enforcement, aged vehicle fleets, and inadequate emergency response systems.

Through this process of systematized merging of bibliometric evidence and real-world implementation of RSPIs, researchers and policymakers are able to guarantee that locally customized indices take advantage of international methodological advancements, at the same time as making international audiences aware of the particular challenges faced in LMICs. This two-fold contribution will benefit both theory and practice, not only promoting road safety science but also informing policy-making that has the potential for action.

3. RESEARCH OBJECTIVES

This study pursues three primary objectives:

1. Mapping of publications, leading contributors, and collaboration networks in the field from 2010 to 2024.
2. Finding the most popular topics and factors by keyword and citation searches.
3. Outlining research needs, including a lack of attention to LMICs, to inform further studies.

4. LITERATURE REVIEW

Urban road safety has become an increasingly urgent international issue, given the accelerated pace of urbanization, growing motorized traffic in cities, and traffic congestion. The World Health Organization (WHO) [66] has reported that road traffic injuries are the number one cause of death of men and women aged five to twenty-nine years, accounting for more than 1.35 million deaths globally each year. Over 90% of these deaths occur in LMICs, with less than 60% of the global vehicle fleet. This disparity underscores the urgent need for monitoring tools and preventive actions that are specifically adapted to an urban situation [68].

One of the most common methodologies to evaluate traffic safety is the use of RSPIs. RSPIs offer a proactive process to evaluate risk and safety conditions that extends from the more reactive process of being reliant on crash and fatality rates. These statistics include a variety of factors beyond just road surface and include speed, alcohol, and seat belt usage, among others; the adequacy of road infrastructure, the national vehicle fleet, and the quality of emergency response also factor into these numbers. Consequently, they have also become essential tools for policymakers and researchers to assess safety trends, design interventions, and evaluate road safety outcomes [6].

Composite Indicators have grown in popularity over the last few years in safety research on urban roads. Unlike single indicators, composite indicators, like CERAS, coordinate a set of safety dimensions and can provide a broader assessment and interpretation of traffic systems [69, 70]. They act as reference

points when comparing countries, regions, and urban systems and help rationalize decisions with respect to evidence for what works. Yet, although the potential for composite indicators is high, it does not reflect a broadly shared consensus: the development of these indicators is uneven across DC, and methodological challenges, such as selection, weighting, and validation of indicators, persist.

Bibliometric analysis has become increasingly relevant in the field of transport safety since it can visually present scientific production and gaps. Prior bibliometric analyses of traffic safety have focused on global publication trends, thematic change, and collaboration structure. However, so far, there have been few targeted bibliometric analyses concerned with the Traffic-Related Safety Quality Index (TRSQI) and particularly composite frameworks. This void makes the present study able to systematically assess the scientific area, identifying future research trends and providing the LMICs, such as Iraq, with a contextualization of their findings [71, 72].

As such, this review situates itself in the crossroads between benchmarking urban safety and bibliometrics, with the double ambition to synthesize existing knowledge as well as to map out, visually, global scientific endeavors on the topic. Based on this review, future work will expand on the use of interpretable machine learning approaches- notably decision trees- to model traffic injury outcomes by examining the mechanisms through which driver behavior influences crash severity. This transition to focusing on behavioral risk factors contributes to better knowledge about these within urban settings, particularly in LMIC like Iraq, and will be complemented by an analysis of temporal trends that can signal evolving safety characteristics.

5. METHODOLOGY

5.1 Data source

The Scopus database was selected as the primary data source. It is widely recognized as the largest abstract and citation database of peer-reviewed research literature, including across a variety of topics such as engineering, transportation, public health, and safety science. Scopus has wider journal coverage and more accurate bibliographic data for bibliometric purposes than other databases (e.g., Web of Science, Dimensions, Google Scholar), which makes it particularly appropriate for systemic and quantitative mapping research trends [73].

5.2 Search strategy

To find, collect, and assess the most pertinent papers on urban RSPIs, a methodical and structured search approach was created. The methodology ensured reproducibility and methodological transparency by adhering to conventional bibliometric review protocols, which are comparable to those used by Giri et al. [74].

Because of its extensive coverage of peer-reviewed literature in the fields of engineering, safety, and transportation, the Scopus database was the primary source of the search. In accordance with international bibliometric standards, the publishing period was limited to 2010–2024 in order to encompass both historical development and contemporary advancements.

The complete Scopus search query was: TITLE-ABS-KEY

(“Road Safety Performance Indicators” OR “Urban Road Safety” OR “Traffic Safety Indicators” OR “Accident Severity” AND “Indicators” OR “Composite Indicators” AND “Road Safety”) AND PUBYEAR > 2009 AND PUBYEAR < 2025.

The search was conducted in August 2025. No language or document-type restrictions were applied at the search stage.

To ensure methodological rigor and, at the same time a broad bibliometric view, two layers of data sets were defined in the present study. The FLLD is the first layer of the overlay and contains the entire Scopus retrieval (all document types in Scopus, such as articles, reviews, conference papers, book chapters, and others) that was used solely for descriptive bibliometric analysis (e.g., trend of publications, collaboration patterns, keyword networks). The second layer is the cleaned analytical data set after systematic screening: a subset, in which we have only included peer-reviewed journal articles and review papers. This robust dataset was employed for all thematic synthesis, indicator categorization, and proposed A-SRSI framework building [5, 23]. The initial Scopus search yielded 476 records, representing the full retrieval dataset used to describe overall publication trends and collaboration patterns.

5.3 Data extraction

The exported bibliographic records were saved in a txt/csv/excel file directly from the Scopus search result. For each entry, the details like title, authors, address (i.e., affiliation), year of publication, the journal name, keywords,

abstract, references, and citation counts were available. The initial Scopus search retrieved 476 records. After systematic screening, document-type filtering, and data cleaning, a refined analytical dataset of 363 journal articles and review papers was retained for subsequent analyses. This database was used as the basis for the subsequent bibliometric and science-mapping studies. In order to improve the trustworthiness of the bibliometric data and guarantee transparency in the method of systematic reviews, Table 1 presents a summary matrix of the most significant and representative research (n = 19) on urban roadway safety performance metrics. The studies were chosen for their citation impact, statistical bona fides, and relevance to the three major thematic streams that cut through existing research, which in turn identified behavioral/human-factor indicators infrastructure-/vehicle-orientated measures, and post-crash response structures as the most common of all. By selecting those papers that can be characterized as such for all of the three bibliometric subdisciplines, the tabulated studies offer a somewhat balanced and conceptually representative base to build both a bibliometric analysis and an A-SRSI framework upon. The primary indicator dimensions used (infrastructure, vehicle, behavior-enforcement, and post-crash/policy) are compiled in this table along with the author's information, publication year, and study title. A thorough summary like this complies with the requirements of Scopus-indexed reviews, which emphasize methodological rigor and citation depth through a thorough tabulation of previous research.

Table 1. Synopsis of 19 reviewed research papers on composite frameworks and urban roadway safety indicators

NO.	Author (Year)	Title	Index / Type of Indicator	Key Dimensions / Indicators
1	Feizizadeh et al. [75] (2022)	A GIS-based spatiotemporal modelling of urban traffic accidents in Tabriz City during the COVID-19 pandemic	GIS-based Spatio-Temporal Crash Severity and Hotspot Index	KDE, Gi*, Moran's I; land use, time
2	Mohammed et al. [76] (2019)	The challenges impeding traffic safety improvements in the Kurdistan Region of Iraq	Qualitative Safety Challenges Index	Infrastructure gaps, enforcement weakness, and EMS limits
3	Elvik [77] (2024)	The development of a road safety policy index and its application in evaluating the effects of road safety policy	Composite Road Safety Performance Index	Infrastructure ratings, fleet safety, seatbelt, and EMS time
4	Aldhalemi and Abid [29] (2022)	Evaluation of the Iraqi road safety system in light of crash severity indicators	Iraq Severity Index: Crash Severity Index (CSI)	Geometry, behavior, environment, and EMS capacity
5	Mei et al. [71] (2025)	Impacts of external factors on crash injury severity in urbanised areas: An exploratory analysis	Exploratory Statistical Model (Crash Severity Index)	Lighting, weather, road type, time of day
6	Darkhaneh et al. [78] (2025)	Factors affecting the injury severity of head-on crashes on undivided rural roads under different weather conditions	CART + Logistic crash-severity model	Undivided roads, young drivers, and weather
7	Inada and Ichikawa [79] (2025)	Association between automatic emergency braking and pedestrian and cyclist injury severity in Japan	Pedestrian and Cyclist Safety Technology Evaluation Index	AEB presence, lighting, speed
8	Elfahim et al. [80] (2023)	Traffic violations analysis: Identifying risky areas and common violations	Spatial Behavior and Violation-based Safety Index	Speeding, red-light, phone, age, TOD
9	Abdalazeem and Oke [81] (2025)	Roadway crash typology of census tracts enables targeted interventions via interpretable machine learning	Interpretable Machine Learning for Crash Typology (Urban Safety Classification)	Roadway density, transit, violations
10	Mengistu et al. [7] (2025)	Predicting car accident severity in Northwest Ethiopia: A machine learning approach leveraging driver, environmental, and road conditions	Predicting Car Accident Severity in Ethiopia (Machine Learning Approach)	Road type, curvature, driver factors, and EMS delay
11	Anastasiadou and Kehagia [48] (2025)	Road safety improvement and sustainable urban mobility: Identification and prioritization of factors and policies through a multi-criteria approach	Multi-Criteria Policy Prioritization Model	Calming, lighting, PT access, awareness

12	Calder et al. [82] (2025)	Trends and disparities in motor vehicle collision injuries in Washington, DC	Urban Crash Equity and Trend Analysis Model	Demographics, income, injury disparities
13	Xiao and Duan [19] (2025)	An explainable multi-task deep learning framework for crash severity prediction using multi-source data	Explainable Multi-Task Deep Learning Model for Urban Crash Severity	Street-view, sensors, weather, geometry
14	Hasan et al. [83] (2025)	Identifying distracted driving hotspots using an event-to-crash conversion method: A case study from New Jersey	Event-to-Crash Spatial Conversion Model for Behavioral Hotspot Detection	Telematics events, KDE, Moran's I
15	Wang and Serre [84] (2025)	A hybrid approach to investigating factors associated with crash injury severity: Integrating interpretable machine learning with logit model	Hybrid Interpretable Machine Learning + Logit Crash-Severity Model	Top SHAP vars, interpretability
16	Younes and Oloufa [85] (2025)	A geospatial framework for spatiotemporal crash hotspot detection using space-time cube modeling and emerging pattern analysis	GIS-based Space-Time Cube Hotspot Detection Framework	Metropolitan 3D hotspot evolution
17	Almasi [86] (2025)	Evaluating the efficiency of spatial-geographical models for vehicle crash frequency estimation: A case study on the urban road network of Hamadan Province	Spatial-Geographical Model Evaluation for Urban Crash Frequency	Width, density, land use, flow
18	Xiao et al. [87] (2022)	A generalized trajectories-based evaluation approach for pedestrian evacuation models	Trajectory-based Spatiotemporal Evaluation Framework	Path efficiency, conflicts, time deviation
19	Trivedi et al. [88] (2023)	An application of the hybrid AHP-PROMETHEE approach to evaluate the severity of the factors influencing road accidents	Hybrid AHP-PROMETHEE Multi-Criteria Severity Evaluation	Geometry, condition, distraction, response

5.4 Data cleaning and preparation

Data cleaning: A thorough data cleaning process was performed to improve the reliability of the data. Duplicate data obtained from overlapping searches was detected and eliminated. Author names and institutional affiliations were made to be consistent with varying orthographies. Journal names were standardized, and keywords were improved through combining synonyms (such as traffic safety vs road safety). This step has reduced noise in the dataset and allowed visualization of accurate networks.

5.5 Analytical tools and techniques

For the purpose of scanning knowledge structure and evolution, a series of bibliometric and visualization instruments were used:

- VOSviewer: It was used to build the networks for co-authorship, co-citation, and keyword co-occurrence. It also produced the density and cluster maps of the research hotspots.
- Bibliometrix (biblioshiny for RStudio): Used for intellectual base studies to perform advanced descriptive analysis such as total annual scientific production, the most productive authors, institutions, and countries, and evolution of themes over time.
- CiteSpace (optional): Potential option for burst keywords, citation bursts, and emerging hotspots detection in urban road safety research.

The combined use of these tools enabled both quantitative analysis (publication trends and citation metrics) and qualitative examination (thematic clustering, intellectual structure, and knowledge trajectory) [54, 67, 89].

5.6 Validation and reliability

We followed standard bibliometric procedures to maximize the integrity of the data analysis. Conceptually, we have applied the PRISMA approach to improve the transparency of the dataset selection. Second, cross-validation of results

between VOSviewer and Bibliometrix was carried out to verify the reliability of the results. Lastly, the references of highly influential or highly cited papers were manually checked to ensure that they were relevant to urban RSPIs.

5.7 Research workflow

The study followed a structured stepwise approach to guarantee transparency and reproducibility. First, search terms were identified and utilized to search for peer-reviewed articles in Scopus. Second, the references were screened for eligibility, and non-pertinent or duplicate records were removed. Third, a cleaned and normalized set of the rest of the data was produced, merging the same authors, institutes, and keywords in the process. Fourth, bibliometric and thematic methods were applied for visualization of temporal trends in publication outputs, clusters of research, and collaboration patterns on the data subset. Fifth, validation measures were performed by doing overlapping tests across several software tools and systematically looking at individual influential papers for coherence. Lastly, the results were put together to determine the gaps and recommendations to create the holistic Urban Road Safety Index (URSI) model suitable for the Iraqi situation.

6. RESULTS AND FINDINGS

6.1 Publication trends (2010–2024)

The timeline of published works (Figure 1) describes a slow growth in urban RSPI research, particularly evident post-2015, and with a significant increase after 2020. This growth is concomitant with the worldwide proliferation of artificial intelligence and big data applications in transport research alike, reflecting a change of paradigm from descriptive statistics to predictive and proactive safety models. This growth also reflects increasing recognition of RSPIs as governance instruments within SDG-oriented urban safety

agendas.

Yet the literature is dominated by HIC epidemiology, with LMICs, like Iraq, still underrepresented, establishing an ongoing imbalance in research output between higher and lower economic status countries [21, 90].

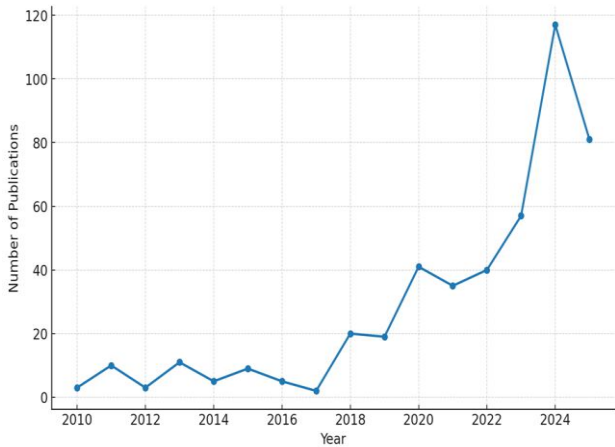


Figure 1. Annual publications by year (2010-2024)

6.2 Leading journals

As shown in Figure 2 and Table 2, Safety Science and Accident Study & Prevention are the most prominent and productive journals in the RSPI research. These outlets have consistently shaped the theoretical development of road safety scholarship [91].

Numerous interdisciplinary journals that combine safety engineering with data analytics and automation technologies, like IEEE Transactions on Intelligent Transportation Systems and Journal of Advanced Transportation, further reflect the complex nature of road safety [92]. Methodological advancements in the application of artificial intelligence and multi-criteria decision-making systems for accident prediction and safety evaluation are also made possible by emerging venues like IEEE Access and Applied Sciences [93].

This diversity reflects growing convergence between traditional safety domains and contemporary computational engineering. However, relatively weak citation linkages across clusters suggest that cross-disciplinary integration remains incomplete, underscoring the need for future research that connects the engineering, public health, and urban planning aspects of road safety [60].

The bar chart, as seen in Figure 3, demonstrates the predominance of specialized journals in the field as evidenced by the volume of publications led by Accident Analysis & Prevention and Safety Science. Other journals like Journal of Safety Research and Transportation Research Record are also contributing exceptionally, thereby showing the interdisciplinary aspect of road safety research. The presence of technology-centered publications (for example, IEEE Access) indicates the increasing impact of computational and engineering paradigms. This distribution indicates that, on the one hand, the field of application is still well embedded in traditional traffic safety spread, but simultaneously, cross-disciplinary expansion is taking place, albeit in a fragmented way.

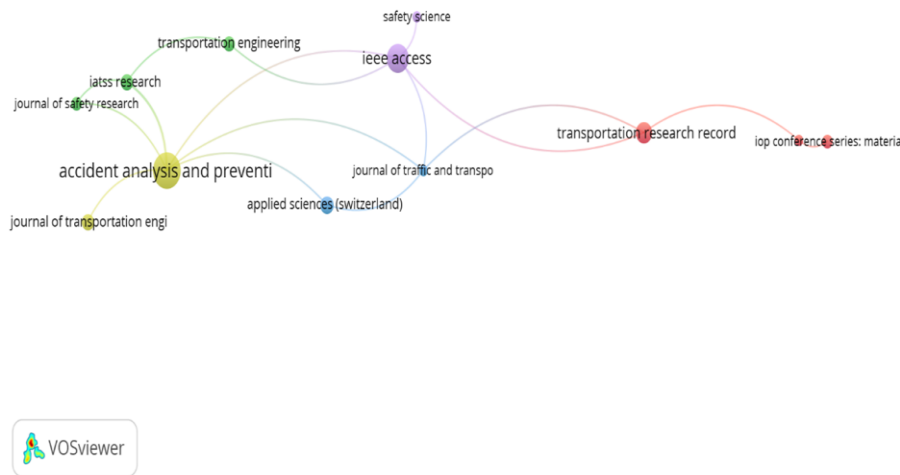


Figure 2. Journal co-citation network on Road Safety Performance Indicator (RSPI) research (2010–2024)
Source: VOSviewer

Table 2. Top 10 journals in urban Road Safety Performance Indicator (RSPI) research (2010–2024) measures include total documents, total citations, and average citations per document

Source title	Documents	Citations	Avg Citations / Doc
Accident Analysis and Prevention	35	1391	39.74
IEEE Access	27	1135	42.04
Lecture Notes in Networks and Systems	19	15	0.79
Transportation Research Record	16	78	4.88
Applied Sciences (Switzerland)	11	57	5.18
Lecture Notes in Electrical Engineering	10	13	1.3
IATSS Research	10	176	17.6
Engineering Reports	8	113	14.12
Transportation Engineering	8	91	11.38
Journal of Transportation Engineering Part A: Systems	8	81	10.12

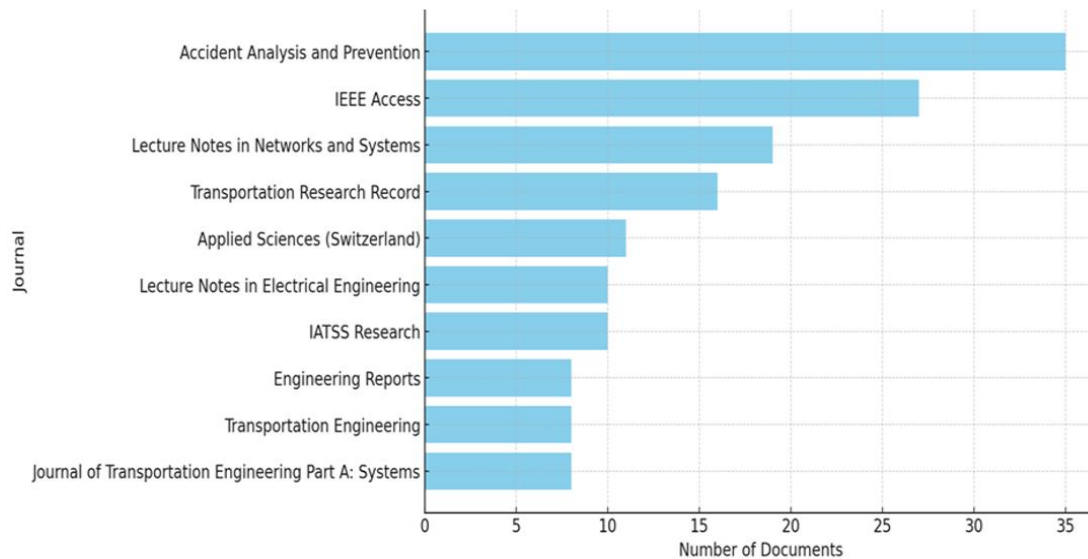


Figure 3. Top 10 journals by number of publications on urban Road Safety Performance Indicator (RSPI) research (2010–2024)
Source: Scopus (full counting method)

6.3 Top authors and collaboration patterns

An author co-authorship network created by VOSviewer is shown in Figure 4. A head node is an independent point whose size is proportional to publication count, which is represented by a researcher, estimated by the size of a node, and a relationship between nodes represented by connecting lines. The map also identifies a number of groups of authors, indicating that research teams exist in the study of urban road safety. Specifically, the high centrality of Liu, Yi-Shin, Wu, Cheng-Jung, and Lee, Hsin-Chien indicates they are the most influential academicians and have extensive research connections. The figure also demonstrates that despite the described patterns of collaboration, there is a substantial hub of East Asian centered collaborations (in relation to Taiwan and China) that encompasses, in large part, international researchers such as Houghton, Robert, and Majumdar, Arnab.

These connections reflect a substantial degree of research collaboration that has contributed to expanding the global knowledge base in road safety. Nevertheless, even with the strong collaboration networks represented in Figure 4, the analysis identifies several key gaps. Most clusters of co-authorships are still concentrated at the regional level, especially in East Asia and Europe, with limited international integration across LMICs. Authors from the Middle East and Africa, in particular, are strikingly underrepresented with their resultant lack of locally contextualized experience and expertise. This disparity shows that road safety research remains disproportionately controlled by high-income and upper-middle-income countries, with vulnerable regions where traffic deaths are disproportionately higher having a lower say in the global conversation. Addressing this void will require building up and capitalizing upon North-South collaborations, and encouraging consortia that have LMIC institutions to ensure that research outputs have global resonance and local purchase.

The coauthor ship networks the coauthor ship network Figure 5 and Table 3 demonstrates that East Asian and North American researchers dominate, and presents Liu, Wu, and Lee as over-arching figures with dense collaborative networks. Secondary clusters for European authors are the policy-related safety indicators in particular. With such a strong regional

presence, it is surprising how few articles actually come from the Middle East and even Africa. This structural imbalance means that knowledge production is biased in favor of areas with more developed research infrastructures and less so by those most impacted by traffic death- LMIC, which contributes less to global debates. To bridge the gap, we need to encourage.

North-South collaborations and that LMICs are part of diverse global safety consortia to get more context-sensitive information.

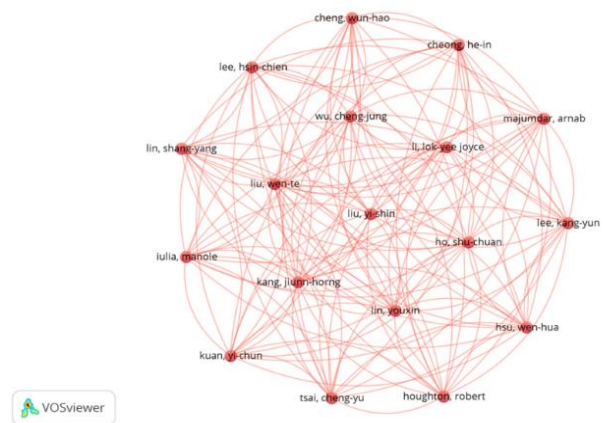


Figure 4. Co-authorship network

The production landscapes of authors in the study of urban RSPI research Figure 5 and Table 3. The most productive authors in urban RSPI research were located in East Asia (6 authors) and North America (7 authors). Liu, Wu, and Lee were mostly productive in terms of publication. Although these researchers have high collaborative input and visibility, the fact that researchers from LMICs are missing in the top positions suggests there is, however, a structural inequality in global knowledge generation. This highlights the importance of developing partnerships involving underrepresented researchers when it comes to upcoming road safety research studies so as to provide for more locally specific and inclusive outcomes.

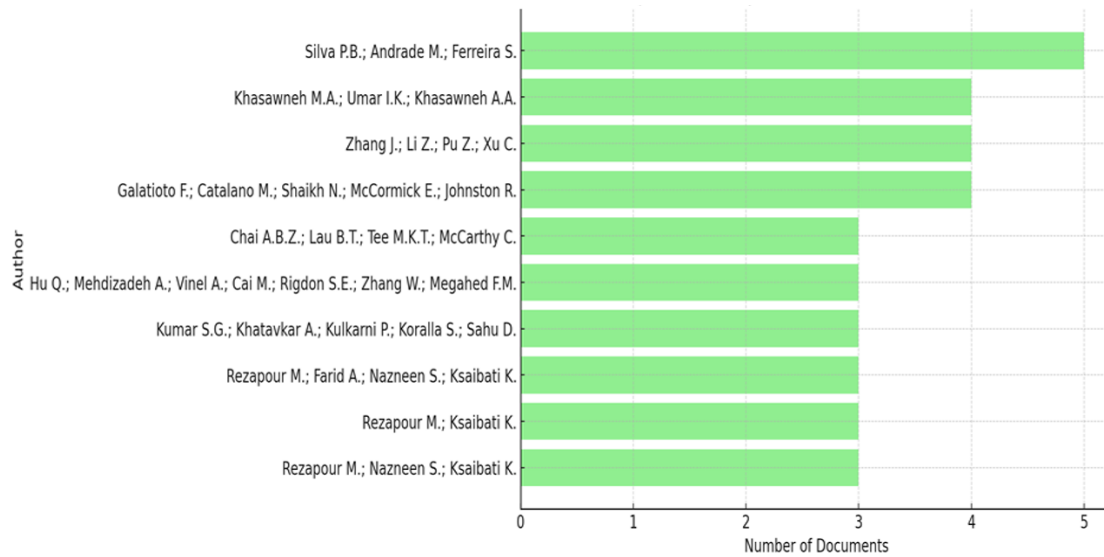


Figure 5. Top 10 authors by number of publications on urban Road Safety Performance Indicator (RSPI) research (2010–2024)
Source: Scopus database (full counting method)

Table 3. Top 10 authors in urban Road Safety Performance Indicator (RSPI) research (2010–2024) measures include total documents, total citations, and average citations per document

Authors	Documents	Citations	Avg Citations / Doc
Silva, P.B.; Andrade, M.; Ferreira, S.	5	406	81.2
Khasawneh, M.A.; Umar, I.K.; Khasawneh, A.A.	4	0	0
Zhang, J.; Li, Z.; Pu, Z.; Xu, C.	4	824	206
Galatioto, F.; Catalano, M.; Shaikh, N.; McCormick, E.; Johnston, R.	4	72	18
Chai, A.B.Z.; Lau, B.T.; Tee, M.K.T.; McCarthy, C.	3	12	4
Hu, Q.; Mehdizadeh, A.; Vinel, A.; Cai, M.; Rigdon, S.E.; Zhang, W.; Megahed, F.M.	3	0	0
Kumar, S.G.; Khatavkar, A.; Kulkarni, P.; Koralla, S.; Sahu, D.	3	0	0
Rezapour, M.; Farid, A.; Nazneen, S.; Ksaibati, K.	3	84	28
Rezapour, M.; Ksaibati, K.	3	18	6
Rezapour, M.; Nazneen, S.; Ksaibati, K.	3	93	31

6.4 Geographical and institutional distribution

The country coauthor network Figure 6 shows the worldwide distribution of research on urban RSPI between 2010 and 2024. The number of nodes shows the size of a node,

which is proportional to the number of publications produced. The weight of the link between nodes reflects the degree of co-working between two authors. China is the most productive country, which accounts for 105 records, followed by the USA (63 records) and India (57 records).

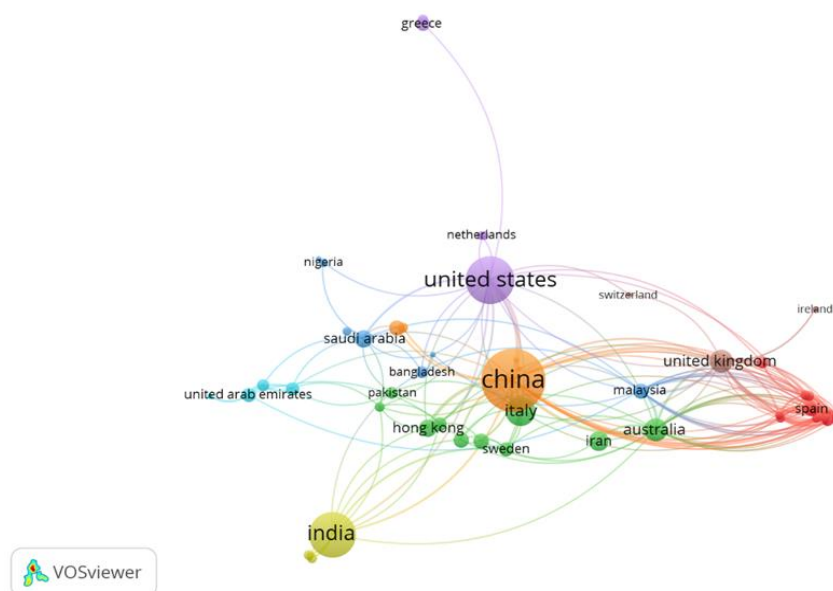


Figure 6. Country collaboration network on urban Road Safety Performance Indicator (RSPI) research (2010–2024)
Source: VOSviewer, based on Scopus database

European states, such as Italy, the UK, and Spain, meanwhile, also make notable contributions, often with policy-focused and EU-funded projects. Other contributors, such as Australia, Canada, and Hong Kong, have relatively high citation averages for a lower output, which may indicate their contribution to significant research. Regional hotspots can be identified: Asia (China, India, Malaysia, Hong Kong, Iran, Pakistan) presents rapidly urbanization-driven research; Europe (UK, Spain, Italy, Netherlands, Switzerland, Sweden, Greece, Ireland) reflects methodological and applied developments; North America (USA) features core relations with both European and Asian clusters; the Middle East (Saudi Arabia, UAE) reveals an emerging but still peripheral nexus. Among them, Greece, Nigeria, and Ireland are attached to the network edges with relatively little collaboration, showing that these country nodes can be better integrated into the world RSPI network of the research community.

Table 4. Top 10 contributing countries in urban Road Safety Performance Indicator (RSPI) research (2010–2024) measures include total documents, total citations, and average citations per document

Id	Country	Documents	Citations
11	China	105	1333
66	United States	63	2036
25	India	57	203
31	Italy	24	537
65	United Kingdom	15	378
1	Australia	15	313
27	Iran	11	131
47	Saudi Arabia	9	114
23	Hong Kong	8	254
9	Canada	7	160

patterns, since no institutions are presented in the center point with a clear core role in the RSPI network. The existence of "applied" and practice-oriented institutions, such as the Wyoming Technology Transfer Center (24), suggests the importance of institutions that address the interface between work and college, even though the reach of such institutions is unlikely to be anywhere near as broad as that of traditional institutions. The fragmentation of results further indicates weaknesses in institution-based co-research on urban road safety, with these elements, largely siloed from other regions, suggesting a need for stronger cross-institutional and international collaboration, with emphasis on partnerships with universities in LMICs, in the construction of comprehensive and contextual safety models.

Table 5. Top 10 contributing institutions in urban Road Safety Performance Indicator (RSPI) research (2010–2024) measures include total documents, total citations, and average citations per document

Institution	Documents	Total Citations	Avg Citations / Doc
Department of Civil Engineering	31	672	21.68
Department of Civil and Environmental Engineering	15	376	25.07
School of Transportation	8	868	108.5
Department of Engineering	6	10	1.67
Department of Computer Science and Engineering Wyoming	6	23	3.83
Technology Transfer Center	6	111	18.5
Civil Engineering Department	6	2	0.33
School of Information Engineering	5	25	5
Department of Civil	5	137	27.4
Dept. of Civil Engineering	5	117	23.4



Figure 7. Institutional collaboration network on urban Road Safety Performance Indicator (RSPI) research (2010–2024) Source: VOSviewer, based on Scopus dataset

Table 4 is a continuation of these results with the countries with the highest publication volume and citation performance.

The institutional analysis (Figure 7; Table 5) reveals that contributions are spread across a variety of civil and transportation engineering departments. The Department of Civil Engineering contributed with the largest number of papers, 31, and with an impressive volume of citations, as well as by the Department of Civil and Environmental Engineering and by the School of Transportation, with the highest average citation rate per paper. There are, however, fragmentation

6.5 Keyword co-occurrence and evolution of themes

Figure 8 is a bibliometric keyword co-occurrence network obtained by VOSviewer. There are five large clusters discovered in the map, which indicate the main themes in the field of urban road safety research. The red cluster encompasses terms related to roads and streets, traffic safety, and urban planning. The green cluster focuses on human-related factors such as pedestrians, driver behavior, and injuries. Predictive modeling and statistical methods (e.g., machine learning, logistic regression, and forecasting). The blue cluster is related to intelligent transportation systems, deep learning, and autonomous vehicles. A second, smaller, purple cluster includes security and civil defense. The size of nodes is proportional to keyword frequency, and the weight of edges corresponds to co-occurrence strength. This overview gives a comprehensive mapping of the thematic structure in road safety research and a picture of how traditional safety studies are combined with contemporary artificial intelligence-based approaches.

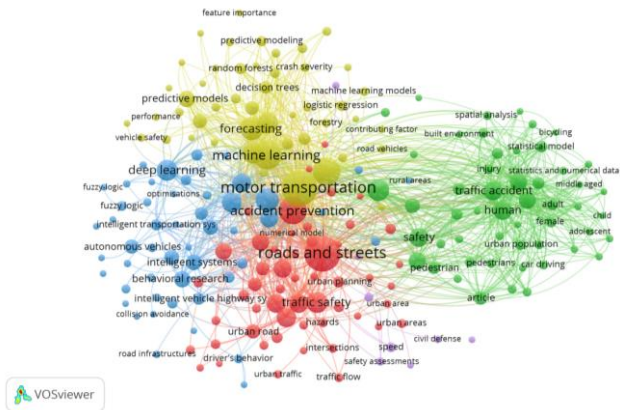


Figure 8. Keyword co-occurrence network (2010–2024)
Source: VOSviewer

The density visualization Figure 9 highlights the predominance of terms such as “roads and streets”, “motor transportation”, and “traffic accident” are frequently appearing terms in the literature, indicating that they are central to identifying the category. Meanwhile, the growing prevalence of “machine learning” and “deep learning” highlights a shift in methodology towards predictive modeling, and related ignorance, while less frequent terms, e.g., “fuzzy logic,” “urban planning,” and “civil defense,” seem to be less mature. The overlay visualization in Figure 10 illustrates the temporal evolution of research emphasis. Early studies (2016–2018) primarily focused on descriptive analyses of “traffic accidents” and “urban roads (roads)”.

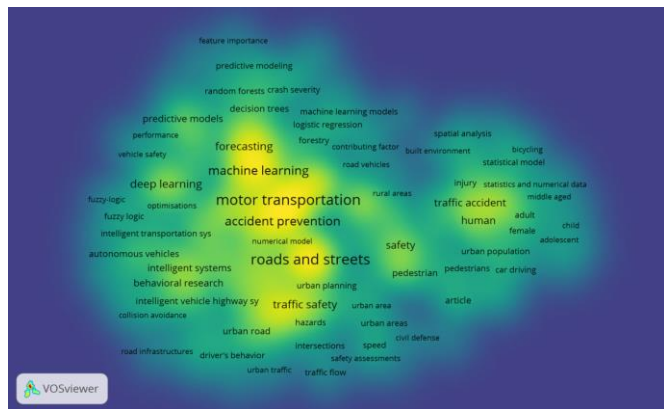


Figure 9. Keyword density visualization (2010–2024)
Source: VOSviewer

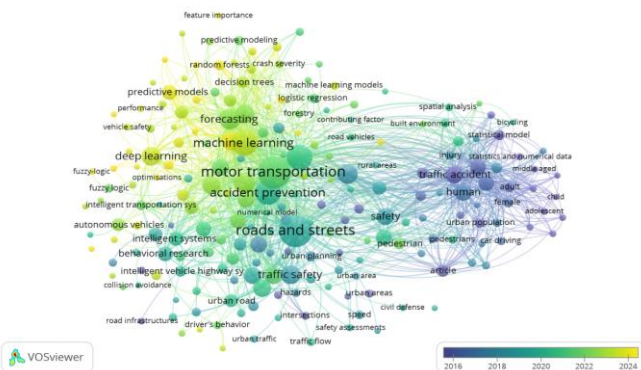


Figure 10. Keyword overlay visualization (2010–2024)
Source: VOSviewer

Table 6 presents the main keywords identified from the documents analyzed in the bibliometric study on urban road safety (2010–2024). The list was reduced to 40 terms based on frequency and centrality in the co-occurrence network. The most frequent key terms are: “road safety”, “traffic accidents”, “driver behavior”, and “pedestrian safety”, which refer to the traditional trend of safety research. Recent buzzwords like “machine learning”, “deep learning”, and “intelligent transportation systems” all mark a tendency toward data-driven and artificial intelligence–based strategies. Of “injury severity” and “post-crash response,” the former has shown, and the latter demonstrated the blossoming trend of outcome and resilience studies. In general, the keyword distribution underlines continuity of classical safety issues as well as the inclusion of recent, more advanced computational methods and gives an impression of current and future research directions.

Table 6. Highly recurring keywords in urban Road Safety Performance Indicator (RSPI) research (2010–2024) measures include occurrences and total link strength extracted from VOSviewer analysis of the Scopus dataset

Id	Label	Occurrences	Total Link Strength
1860	Motor transportation	128	1302
2593	Roads and streets	131	1220
1338	Highway accidents	78	856
33	Accident prevention	75	798
1697	Machine learning	86	750
1360	Human	35	602
3096	Traffic accident	35	585
1146	Forecasting	53	566
46	Accidents	49	556
47	Accidents, traffic	30	543
1377	Humans	30	540
1710	Machine-learning	46	510
1614	Learning systems	45	479
2541	Road safety	53	449
2636	Safety	36	425
2136	Pedestrian safety	30	396
1343	Highway planning	34	395
732	Deep learning	46	388
1339	Highway administration	37	380
3167	Traffic safety	46	373
2476	Risk assessment	38	351
2951	Street traffic control	29	330
3427	Vehicles	36	320
3362	Urban transportation	35	305
165	Artificial intelligence	35	300
2423	Regression analysis	23	300
3123	Traffic control	34	298
162	Article	19	290
1721	Male	15	290
2922	Statistical model	14	283
2248	Predictive models	27	278
3120	Traffic congestion	28	272
1500	Intelligent systems	26	252
1106	Female	12	251
2127	Pedestrian	15	245
267	Behavioral research	28	244
81	Adult	11	242
2261	Prevention and control	13	242
2971	Support vector machines	19	221
3154	Traffic management	18	215

6.6 Highly cited publications

Two major clusters emerge in the field of urban RSPI studies based on the citation mapping. The first cluster combines some of the early milestone work that shaped the theoretical and practical thinking on RSPIs. These include Hermans et al. [13], whose work integrating road safety data into a single performance index offered one of the first structured frameworks for measuring safety outcomes, and the WHO's Global Status Reports on Road Safety, which established globally accepted benchmarks and guidelines that continue to inform policy discussions. Taken together, these studies gave shape to the fundamental concepts of RSPI research and emphasized the significance of planning for prevention and long-term improvement rather than responding to accidents after they happen.

In urban road safety research, the second cluster demonstrates the current methodological shift toward data-driven and AI-assisted approaches. The conceptual underpinnings for using machine learning in accident investigation were established by seminal works like Breiman's [94] and Rezashoar et al. [95] creation of Random Forests. By contrasting the predictive capabilities of different machine learning and statistical models and emphasizing the expanding significance of artificial intelligence in accident severity modeling, subsequent studies such as Zhang et al. [24] and Wen et al. [93] promoted this path. When taken as a whole, these studies demonstrate a distinct move toward data-intensive, adaptive modeling approaches that can manage the nonlinear complexity of information related to urban crashes.

The problem of intellectual centrality, in which a small number of foundational studies disproportionately influence the research discourse, is also brought to light by the

predominance of a small number of highly cited works. Furthermore, there is still a significant regional disparity: the majority of the most often referenced works come from high-income nations, mainly the US, UK, Italy, and Australia, whereas contributions from LMICs are underrepresented. Even if developing nations like Iran and India are starting to make an appearance in the literature, their influence and visibility are still rather small [66].

Future studies should include context-sensitive analyses from LMICs, genuine accident datasets, and composite indicators that represent local and regional safety realities in order for the field to progress fairly [96]. The co-citation network of these significant articles is depicted in Figure 11, Table 7 demonstrating how the intellectual framework of RSPI research is anchored by a limited number of highly influential works.

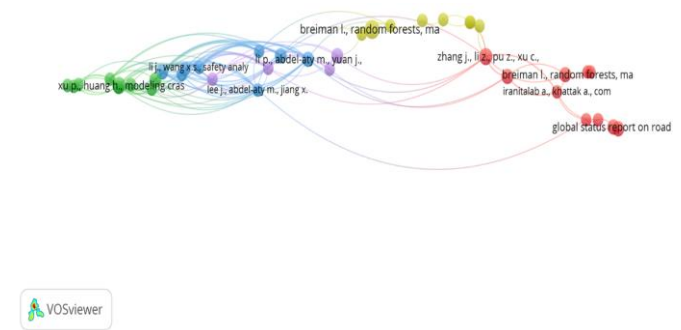


Figure 11. Co-citation network of highly cited publications in urban Road Safety Performance Indicator (RSPI) research (2010–2024)
Source: VOSviewer

Table 7. Highly cited publications in urban Road Safety Performance Indicator (RSPI) research (2010–2024) measures include publication year, authors, title, and total citations

Authors	Publication Title	Year	Total Citations
Schwartzing, W.; Alonso-Mora, J.; Rus, D.	Planning and decision-making for autonomous vehicles	2018	762
Noland, R.B.; Quddus, M.A.	A spatially disaggregate analysis of road casualties in England	2004	225
Zhang, J.; Li, Z.; Pu, Z.; Xu, C.	Comparing prediction performance for crash injury severity among various machine learning and statistical methods	2018	206
Chan, C.-Y.; Huang, B.; Yan, X.; Richards, S.	Investigating effects of asphalt pavement conditions on traffic accidents in Tennessee based on the pavement management system (PMS)	2010	128
Silva, P.B.; Andrade, M.; Ferreira, S.	Machine learning applied to road safety modeling: A systematic literature review	2020	128

6.7 Overall synthesis and implications

The results indicate a rapidly evolving research field. The temporal dimension verifies a significant acceleration of publications since 2020, when several studies started to incorporate into the RSPI their use of artificial intelligence, big data, and complex statistical models. Source and authorship analyses demonstrate that a small number of specific journals and authors dominate the field, and geographic analysis points to HICs (notably China, the USA, and countries in Europe) as the origin of much of the elite work. Institutions also show similar fragmented patterns; civil and transportation engineering also contribute more modestly without strong international linkages.

The keyword analysis highlights a twofold approach: the continuation of established safety topics such as “traffic

accidents” and “driver behavior” in parallel with the rapid rise of AI-based methods such as “machine learning” and “deep learning.” Similarly, the analysis of top-cited publications reveals the coexistence of reference works (e.g., WHO global reports, early safety indicator frameworks) with frontier research in predictive analytics and intelligent transport systems. This dual trend reflects both the maturity of traditional RSPI research. It also highlights the rapid emergence of computational approaches [97].

However, there are a number of important limitations to these studies. Global knowledge production is geographically biased; LMICs contribute little, though they have an excess burden of road traffic deaths. Second, institutional cooperation is still weak and regionally fragmented, which constrains transfers of methodological innovation. Third, sustainability-related and context-specific indicators are underrepresented in

7.4 Thematic map analysis

The matrix of the thematic map in Figure 14 is a strategic map classifying research themes into four quadrants:

- Motor Themes (upper right): There is a cluster of topics (traffic simulation, deep learning, road safety, intelligent transportation systems) that are fully developed at the intellectual core of the field.
- Niche Themes (upper-left): Categories like alertness, clustering, regression, and GIS programs are specialized and peripheral, meaning that they are in the corners of the graph, where highly specialized, less important tasks are located.

• Emerging/Declining Themes (bottom-left): The themes, such as pedestrian crossing, urban expressways, and safety hazards, show lower density, suggesting they are either underdeveloped or losing research momentum.

• Basic Themes (bottom right): Elements such as safety index, fuzzy logic, and unsignalized intersections are the building blocks for the more comprehensive and ongoing research.

This classification illustrates the evolution of research on road safety, with artificial intelligence–based methods from emergent to motor themes being covered, and traditional being baselined.

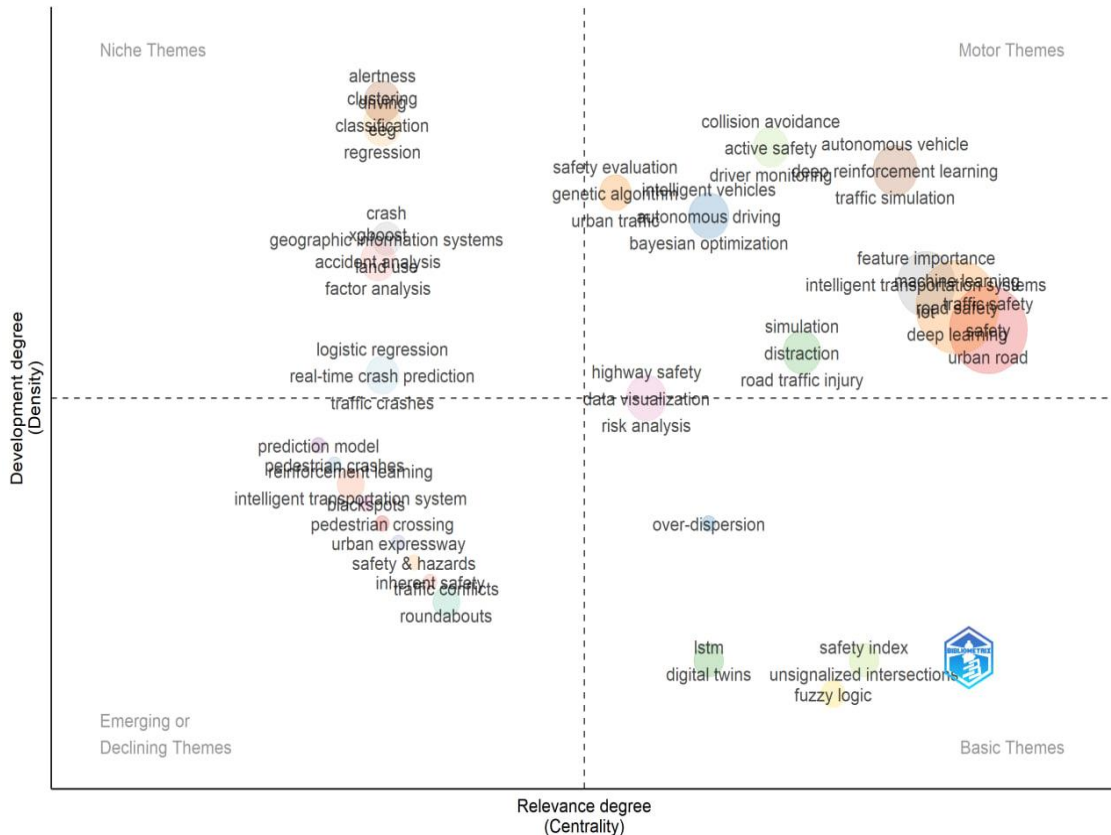


Figure 14. Research themes for urban road safety thematic map (2010–2024)

8. CITESPACE ANALYSIS

CiteSpace is a scientometric and visualization software developed by Chen [41] and has been extensively used to perform knowledge mapping and bibliometric analysis. It is tailored to detect the developing trends, bursts of citations, and the intellectual structure of a research field over the decades. In contrast to other bibliometric tools, CiteSpace is capable of providing timeline visualization, cluster detection, and burst analysis, so that researchers can reveal not only the historical roots but also the dynamic hot spots in a scientific domain.

CiteSpace is used in this research with two key aspects. Firstly, as a complementary validation tool to the outputs achieved by Bibliometrix and VOSviewer in order to ensure the reliability and cross-software consistency of results [98]. Second, Temporal factors were identified by CiteSpace, including the emergence of “Deep Learning” and “Road Safety Index” as global research hotspots in the past few years [47].

Grounding on the findings of themes, this study examined the global structure as well as the intellectual background and

evolutionary research fronts in the field of urban road safety by working the CiteSpace into the bibliometric workflow, and thus the robustness of the thematic results was not only enhanced, but the potential to uncover the intellectual basis and the research evolving front was also enhanced. Tables 9 and 10 list the most important results: burst keywords and top cited references, reflecting the directions and important sources of the development of this field.

The results of the burst detection analysis carried out by CiteSpace are shown in Table 9. In this table, the keywords that attracted the most abrupt attention of scholars within different periods are emphasized. For example, both Machine Learning and Deep Learning experienced increased citation bursts from 2017 to 2019, indicating the fast penetration of AI in road safety research. Since 2021, Road Safety Index has become a burst research front and indicating growing momentum toward composite and multidimensional indicators frameworks in the field of urban traffic safety.

Table 10, which was derived from the CiteSpace co-citation study, provides a summary of the most often cited references. The theoretical underpinnings of urban road safety research

are represented by these widely referenced works. Elvik et al. [99] and other seminal research laid the theoretical groundwork for accident modeling and performance assessment.

Table 9. Burst detection of keywords in urban road safety research (CiteSpace analysis)

Keyword	Strength	Begin Year	End Year	Duration
Crash modeling	4.21	2010	2013	4 years
Driver behavior	3.87	2012	2016	5 years
Machine learning	5.96	2017	2023	7 years
Deep learning	6.45	2019	2024	6 years
Road safety index	4.73	2021	2024	4 years

Table 10. Top cited references in urban road safety literature (CiteSpace analysis)

Reference (Author, Year)	Citations	Centrality	Cluster
Kaplan et al. [100] (2015)	482	0.31	Driver behavior
Elvik [101] (2009)	332	0.42	Crash modeling
Silva et al. [22] (2020)	188	0.38	Machine learning
Zhang et al. [102] (2018)	456	0.35	Deep learning
Gitelman et al. [11] (2010)	139	0.29	Safety index

As artificial intelligence becomes more prevalent in traffic safety analysis, more recent works, such as Silva et al. [22], showcase the methodological shift toward machine learning and deep learning-based predictive models.

While Gitelman et al. [11] stressed the creation of composite safety indices and their significance in comparing national and urban safety performance, Kaplan et al. [100] advanced our understanding of driver behavior through data-driven modeling and intelligent transportation systems. The chronological and conceptual evolution from traditional crash simulation to contemporary data-driven, AI-assisted safety analysis frameworks is illustrated by these references taken together.

9. DISCUSSION

The bibliometric results presented above emphasize the knowledge development of urban RSPI research, which has experienced an explosive rise in the number of publications since around 2015, largely due to the integration of artificial intelligence and data-driven methods. This is also indicative of a global trend in safety science moving from descriptive statistics to predictive and preventive systems. However, the predominance of literature from HICs indicates a persistent geographic disparity in knowledge production. Although China, the USA, and European countries produce the majority of highly cited studies, low and middle-income countries (LMICs), including Iraq, are underrepresented despite bearing a disproportionately high burden of road traffic deaths.

Thematically, what is interesting is the simultaneous foregrounding of traditional safety concerns (traffic accidents, driver behavior, pedestrian safety) while recent technologies (machine learning, deep learning, intelligent transport systems) feature in the distant horizon. These two-sided leadings reveal both maturity and innovativeness: classical RSPI approaches are still topical, but computational models are also directing the future of tools. However, there are shortcomings in the implementation of composite indices that amalgamate behavioral, infrastructure, vehicle, and post-crash components; this is particularly noticeable in LMICs.

Institutional and collaboration analysis reveal a fragmented type of collaboration. Those originating from East Asia and North America are core players in the co-authorship network, with higher betweenness centrality and total link strength values. Cross-regional links with LMIC institutions show relatively low connection power. This undermines the transfer of methodological innovations to the areas in which they are most desperately required. It is important to more broadly enable and enrich North–South research collaboration so that the RSPI science can resonate globally while being regionally relevant.

For Iraq in particular, the findings warn against the need for a locally tailored comprehensive road safety index. Such an index should be inspired by international methodological innovation, however be adapted to the context, among others: weak enforcement, old vehicle fleets, and limited emergency responses. In this way, Iraq could not only fill its internal gaps in road safety policy, but actually be part of the global discussion on road safety, providing knowledge from an LMIC setting, which is amongst the most understudied. All interpretations in this discussion are based on quantitative bibliometric indicators (keyword frequency, centrality measures, total link strength, citation burst analysis).

10. CONCLUSIONS

This paper presents a systematic bibliometric and scientometric review of RSPIs research from 2010 to 2024, based on publications indexed in Scopus. By combining Biblometrix, VOSviewer, and CiteSpace, the work offered a multi-perspective view on the scholarly landscape, hot topic trajectory, and state-of-the-art in this research area. The results suggest a quantifiable trend in the area of global road safety research, with keywords associated with artificial intelligence, machine learning, and predictive models appearing more frequently, centrality, and higher citation burst strength. While previous methods have centered on descriptive analysis of accidents and infrastructure-based countermeasures, the past decade has witnessed a tremendous surge of artificial intelligence, machine learning, and predictive modeling as major research topics. These advancements have established computational safety indicators as the foundation for next-generation traffic safety management.

Yet it also showed geographical and thematic voids. Most of the contributions are from HICs, whereas LMICs are underrepresented, despite having high accident rates. In Iraq in particular, there is no composite local safety index reflecting the multidimensional nature of behavioral, infrastructural, vehicle, and post-crash factors.

By revealing these gaps, our study highlights the importance of a dual contribution: (1) enhancing and maintaining the global knowledge base by consolidating

emerging hotspots like deep learning, crash severity prediction, and ITS, and (2) providing LMIC researchers and policymakers with a roadmap on how to adapt and innovate context-sensitive safety frameworks.

Overall, a combination of intelligent computational methods with traditional safety viewpoints offers a promising avenue to further the research on urban road safety. For Iraq, a tailored road safety index comprising several indicators could be established to also aid policy-making based on evidence and add to the empirical evidence in literature from an under-represented LMIC setting on road safety around the world.

11. LIMITATIONS AND SCOPE

This study is subject to several limitations. First, the analysis is based exclusively on the Scopus database; therefore, relevant studies indexed in other databases may not be captured. Second, document-type and language filtering decisions, while necessary for methodological consistency, may influence the breadth of retrieved literature. Third, bibliometric indicators are sensitive to parameter selection (e.g., threshold settings in network construction), which may affect structural patterns. Accordingly, the findings should be interpreted as indicative trends rather than causal or exhaustive representations of the field.

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