

Geometric Influence of Local Road on Safety: A Bibliometric Literatur Review

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ARTICLE INFO	ABSTRACT
Keywords: Road Geometric, Traffic Safety, Bibliometric, Local Road, VOSviewer	<i>Road geometry plays a pivotal role in shaping traffic safety outcomes, especially in developing regions experiencing rapid motorization. This study employs a bibliometric analysis to explore the trends, key themes, and research developments surrounding the influence of geometric road design on local road safety. Drawing data from the Scopus and Google Scholar databases via the Publish or Perish tool, the analysis is visualized using VOSviewer software to map keyword networks, author collaborations, and institutional linkages. The results reveal five dominant research clusters, ranging from road safety and driver behavior to technological approaches in traffic analysis. The overlay and density visualizations illustrate the evolution and concentration of thematic interests, with increasing attention given to geometric variables like curvature, alignment, and lane width in recent years. This research highlights significant gaps in contextual studies, especially in middle-income regions such as Indonesia, providing a foundation for future applied investigations in road safety engineering.</i>

1. Introduction

Road safety is one of the most crucial aspects in the planning and operation of a transportation network [1]. The high rate of traffic accidents in various countries, especially in regions with rapid vehicle growth, has sparked attention to factors that contribute to accident risk [2]. One of the main factors that often gets less attention is the geometric aspect of the road [3]. Road geometry, which includes elements such as horizontal curvature, vertical slope, lane width, road shoulder, and visibility, plays a significant role in determining the level of safety of road users [4]. An inappropriate geometric design can disrupt the flow of traffic, trigger risky maneuvers, and increase the likelihood of accidents. Evaluation and improvement of geometric elements is an important step to improve the overall quality of road safety [5].

Studies have shown that poor geometric design can lead to decreased vehicle performance, increased driver cognitive load, as well as decreased reaction time to potential hazards [6]. For example, sharp turns without adequate warning, steep inclines, or sudden narrowing of traffic lanes are examples of geometric conditions that contribute to a high risk of accidents [7]. Therefore, a deep understanding of the influence of road geometric elements such as curvature, slope, and lane width on safety is crucial [8]. This knowledge can be an important cornerstone in designing road infrastructure that is not only safe, but also sustainable for the long term [9]. Furthermore, the integration of safety data with geometric evaluations can help identify accident-prone points more accurately. This approach allows for evidence-based and more targeted design improvements in reducing traffic accident rates [10].

Traffic safety in Indonesia is still a serious challenge, reflected in the high number of accidents that occur every year on various types of roads, both in urban and rural areas [11]. One of the main causes of these accidents is often associated with the condition of road infrastructure that does not meet safety standards [12]. Among the various technical aspects, road geometry plays an important role in creating a safe driving environment [13].

Elements such as horizontal curvature, road slope, lane width, the presence of road shoulders, and available visibility are key factors that affect driver behavior and accident risk level [14]. The incompatibility of the geometric design with the characteristics of traffic and the surrounding environment can increase the potential for accidents [15]. Therefore, a deep understanding of the influence of each geometric element on safety is crucial in road planning and repair.

In Majalengka itself, there are still many poor geometric designs [16]. There are several roads that have sharp bending angles as well as sharp slopes and descents, all of which can be caused by a less careful calculation of the alignment [17]. The design of the road geometry will greatly affect the condition of the road itself, the geometry of the road itself functions at the time of determining the dimensions of the road and also the characteristics of traffic [18]. Therefore, a bad road can have an impact on poor geometry design, or even planning when the road is made. It can all affect a bad or uncomfortable road [19]. The incompatibility between geometric planning and field conditions can cause inconvenience and even safety risks for road users [20]. Therefore, a re-evaluation of geometric planning in areas such as Majalengka needs to be carried out as an effort to improve the quality and safety of road infrastructure in a sustainable manner.

As the number of studies on the relationship between road geometry and traffic safety increases, a systematic approach is needed to understand the direction and trends of the study [21]. Bibliometric methods were used in this study to analyze the literature related to the influence of geometric elements on local roads on safety [22]. This approach allows mapping the contributions of researchers, institutions, and countries in the field [23]. The results are expected to reveal the most dominant themes and potential for further development in future studies [24]. This analysis can also provide an overview of research gaps that have not been explored much, especially in the context of developing regions such as Indonesia [25]. Thus, the results of this bibliometric study can be the initial foothold in designing further research that is more contextual and applicative.

2. Literature Review

2.1 Highway

Roads are land transportation infrastructures designed to connect one region to another and facilitate the efficient movement of people, goods, and services [26]. Highways generally possess specific physical characteristics such as paved or concrete surfaces, clearly marked traffic lanes, and supporting facilities including signage, markings, and drainage systems. Functionally, highways play a crucial role in supporting economic growth, enabling community mobility, and enhancing accessibility between regions—both urban and rural. Highway classifications are typically based on their function and capacity, such as arterial roads, collector roads, local roads, and toll roads. Conversely, roads are also among the most vulnerable public spaces to accident risks, particularly when they are not designed or managed in accordance with safety principles. Therefore, the construction and maintenance of highways must adhere to strict technical standards and regulations to ensure the overall safety, comfort, and sustainability of the transportation system [27].

2.2 Road Geometry

The main elements of road geometry include horizontal curvature (bends), vertical alignment (inclines and declines), lane width, superelevation (transverse slope on curves), visibility, shoulders, and transition elements [28]. These components are interrelated and must be properly aligned to ensure vehicle stability and allow drivers to respond appropriately to road conditions. For instance, curves with a small radius and insufficient superelevation can cause vehicles to deviate from their path, particularly at high speeds or on slippery surfaces [29].

Sight distance is another critical aspect of road geometry, as it determines how far ahead a driver can see to identify potential hazards. Poor geometric design—such as sharp curves obscured by vegetation or hillcrests that block visibility—can reduce driver reaction time and increase the risk of collisions. Therefore, road designers must ensure that the minimum required visibility is maintained throughout the roadway, especially at locations with a high potential for accidents [30].

In conclusion, road geometry is a fundamental component of transportation infrastructure planning [31]. Designs that do not meet established standards or fail to account for local conditions can degrade road quality and contribute to elevated traffic accident rates. Thus, understanding and applying geometric design principles is essential for developing a safe and sustainable road network.

2.3 Road Safety

Road safety refers to the extent to which road users are protected from the risk of injury or death caused by traffic accidents. This concept encompasses not only the safety of motor vehicle drivers but also that of pedestrians, cyclists, and users of other modes of transport [32]. Road safety is influenced by various factors, including driver behavior, vehicle condition, traffic environment, and the design and physical condition of road infrastructure. A safe road is one that is planned and operated in a manner that minimizes human error and mitigates the consequences of accidents when they occur [33].

In transportation engineering, road safety is a central objective at every stage of planning, design, construction, and maintenance. Infrastructure elements such as street lighting, traffic signs and markings, drainage systems, and road geometry are all intended to enhance user safety [34]. Furthermore, systems-based strategies like the Safe System Approach advocate for road environments that can tolerate human error while still preventing severe outcomes through resilient and forgiving design.

The persistently high number of traffic accidents in Indonesia indicates that road safety remains a critical issue requiring coordinated, cross-sectoral efforts [35]. Improving safety cannot rely solely on law enforcement or public campaigns; it must also be supported by safety-focused infrastructure design, effective traffic management, and active public engagement. Road safety is not solely the government's responsibility—it is a collective obligation shared by all stakeholders [36].

3. Research Method

Based on this research, the method used is identifying studies, journals from networks, data, and developments with parameter standards, which can be according to the study subject matter, namely the resistance of metal substances to heat [37]. Bibliometrics is the analysis of published information (e.g., books, journal articles, datasets, blogs) and its related metadata (e.g., abstracts, keywords, citations) using statistics to describe or show relationships between published works [38], by collecting the scientific data used as the basis for this study were selected from the Elsevier Scopus database [39], then analyzing them using VOSviewer software to identify research trends, collaborations between authors and institutions, and dominant topics that are developing in the field, to provide an overall picture and future research directions. The research methods employed in this study include literature reviews and library searches using databases [40].

3.1 Data

Data sharing in the public domain has become the standard for proteomics researchers [41]. Data is a key component in bibliometric research that plays an important role in describing the development of research on transportation system capacity, especially on local road in medium-sized cities. Data collection in this study was conducted using reputable scientific databases such as Scopus and Web of Science. Through the selection of relevant and specific keywords, Documents are obtained as journal articles, books, datasets, reports, components, monographs, and references formatted in RIS data [42]. Then analyzed to identify research trends, collaboration between authors, and dominating topics in the field of geometric influence of local road.

Data processing involves systematic steps, from initial document selection to filtering based on publication year, document type, and topic suitability. The data, including research titles, authors,

publication years, and journal sources, is processed using VOSViewer software [43]. To visualize the network of collaborations, the interrelationships between keywords, and the distribution of research over time. This analysis provides a comprehensive picture of the dynamics of research focusing on geometric influence of local road in medium-sized cities.

The data analyzed also included information on the country of origin of the research, the institutions involved, and the journals that were the main source of publication from these results. It was found that the keyword "analysis" became the most frequent keyword from 1000 interrelated journals [44]. Thus, this study not only captures the technical aspects of geometric influence but also shows a map of collaborations and research centers that play a dominant role in the development of road geometric science. This allows researchers to identify research gaps and potential future collaborations.

Overall, the data collected and analyzed in this study showed that the impact of a researcher and the visibility of his or her institute are nearly always connected to the degree of strong research collaboration [45]. To understand the direction and development of local road geometric influence studies. The findings from the data are expected to contribute to the formulation of geometric influence that are more adaptive to the needs of medium-sized cities and support the development of a competitive and sustainable road system. The data will also serve as an important reference for future researchers in exploring aspects that have not yet been explored in depth.

The data used are selected journals from several journals available on Google Scholar with the keywords Geometry, Safety, Road, Traffic, Crash, Accident, Infrastructure, Mobility, Highway, Transportation, Vehicle, Alignment, Intersection, Pavement, Bibliometric Analysis, with a total of 1000 journals from the Publish or Perish filtering results.

3.2 Data Collection

Before choosing a data collection method, the type of data required for the research must be determined. This section aims to provide a summary of possible data types to go through the different data collection methods and sources of data based on these categories [46]. The data collection process began with determining appropriate and specific keywords, such as "Road," "Transportation," "Local Road," "Alignment," and "Geometric." These keywords were combined using Publish or Perish helps to collect similar journals around the world that have links to the research under review [47] to obtain more focused search results. In addition, inclusion and exclusion criteria were applied to filter out irrelevant documents, such as non-scientific publications, articles that did not address geometric influence, and documents that were outside the specified research timeframe. The next stage of data collection involves converting the database that appears from Publish or Perish can be converted into a mapping with the help of VosViewer software [48]. This process ensures that all the necessary information is available for further analysis, both in terms of visualizing the research network and identifying emerging topic trends.

Through a structured and rigorous data collection approach, the research was able to gather information that is representative of the growing body of knowledge on geometric influence at the local level. The data obtained not only mapped the extent to which this topic has been studied but also helped identify areas that remain underexplored. As such, data collection is an important foundation for producing accurate bibliometric analysis that will benefit the development of transportation systems in medium-sized cities.

3.3 Data Analysis

Analyze the data in this research using the bibliometric analysis method to examine a keyword [49]. Data collected from various scientific publications were processed and analyzed with the help of

VOSviewer software. This application can be used to retrieve and analyse [50]. This allows visualization of relationships between keywords, authors, institutions, and countries. The analysis reveals the evolution of research over time and the interdisciplinary nature of studies in this critical domain [51]. And aims to identify how far the research has progressed and how it relates to the various parties involved.

The analysis phase begins with mapping. A co-occurrence network of author keywords was built with VOSviewer for this study's keyword analysis [52]. This visualization shows the most dominant keywords and the relationship between one topic and another. In addition, a co-authorship analysis was conducted to evaluate the collaboration between authors and institutions involved in geometric influence research, thereby identifying centers of research excellence in this area.

The next analysis focuses on evaluating publication trends by year of publication, which gives an idea of the growth of research interest in local road capacity in medium-sized cities over time. In this way, it is possible to identify periods when the topic has experienced an increase in attention or even a decrease. In addition, journal sources were analyzed to determine which publications are the main and most prolific references in this field.

Results from the data. This analysis includes creating author, journal, and keyword rankings, and a visual network model of the relationships between articles in the data source [53]. Provides an in-depth understanding of scholarly developments and potential future research directions. This thorough analysis not only illustrates the current research landscape but also helps to identify open research gaps, which could be the focus of future studies. As such, the data analysis is an important part of strengthening the contribution of this research to the development of geometric influence, particularly regarding the alignment of local roads in medium-sized cities.

4. Result and Discussion

4.1. Network Visualization

The research was conducted using data collected and sorted using Publish and Perish based on keywords that represent the themes of this research. Then, the data is entered into VOSviewer to display the data obtained from publishing and publishing in the form of visualization of relationships, density, and year of publication. Data can also be processed into tables and graphs based on percentages and values that have been collected from international journals [54]. Keyword co-occurrence and clustering: VOSviewer was used to identify thematic clusters in urban transportation research. Two primary clusters emerged: one on sustainable urban mobility and another on motor transportation efficiency. These clusters correspond to red (sustainability, capacity, demand), green (bibliometric/system review), blue (simulation, autonomous vehicles), and additional smaller yellow and purple clusters on resilience, smart cities, and infrastructure [55].

The keyword network visualization illustrates the structure of thematic relationships in research related to the influence of local road geometry on traffic safety. This analysis was conducted using VOSviewer software, with the keyword approach taken from the metadata of scientific publications. Each node in the network represents one keyword, and the lines connecting the nodes indicate the frequency with which the word occurs in the same document. The different colors that appear mark clusters or groups of themes that are formed automatically based on thematic proximity.

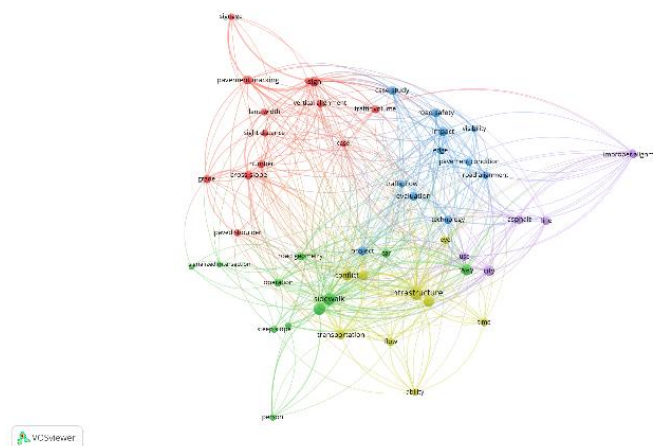


Figure 1 Network Visualization

Blue clusters are closely related to transportation models, simulation, and technologies such as autonomous vehicles. Meanwhile, the yellow and purple clusters represent more specific themes such as resilience, smart cities, and infrastructure. The keyword density level refers to how closely related the elements in the network are. In network analysis, density is calculated as the ratio between the actual number of connections and the number of possible connections in a network [56].

4.2. Density Visualization

The Density Visualization image is the result of a bibliometric analysis that illustrates the distribution of keywords in studies related to transportation system capacity. In the item density visualization, items are represented by their label. Each point in the item density visualization has a color that indicates the density of items at that point. By default, colors range from blue to green to yellow. The larger the number of items in the neighborhood of a point and the higher the weights of the neighboring items, the closer the color of the point is to yellow. The other way around, the smaller the number of items the closer the color of the point is to blue [57]. The colors in the visualization indicate the intensity or density of occurrence of certain keywords in the analyzed literature. The lighter the color displayed (towards yellow), the higher the frequency or significance of that keyword in the research network. Conversely, darker colors (blue to green) indicate keywords with lower frequency or relevance. visualization is Therefore, this affects the network size displayed in the visualization results, determining how large or small the number of entities seen is [58]. The visualization shows five main clusters that are interconnected, indicating that research in this field is broad and multidisciplinary. The red clusters dominate with a focus on keywords such as road safety, traffic accidents, and crash severity, indicating a major focus on the impact aspect of crashes. The green cluster is seen to center on technical terms such as horizontal alignment, lane width, curve radius, and intersection, indicating a direct link between road geometric elements and potential safety risks. Meanwhile, the blue and purple clusters contain terms such as GIS, machine learning, regression model and simulation, indicating an analytical approach and utilization of technology in road safety studies. The yellow cluster on the other hand depicts additional themes such as speed, driver behavior, and environment, which link road design to user behavior and external conditions.

The identified research theme trends from the documents were analyzed through overlay visualization. In this case, we use the color key to maximize the trend of the theme, providing a clearer understanding of the development of research topic [59]. Some of the keywords that appear dominant and appear in the highlighted yellow area are Road Geometry, Road Safety, Traffic Accident, and Rocal Roads. This indicates that these topics are the main focus in the analyzed publications. Around these

main keywords, there are also some frequently associated terms, such as “speed”, “crash rate”, “horizontal alignment”, and “safety performance”, indicating a strong link between road geometric elements (such as speed and curves) and crash potential.

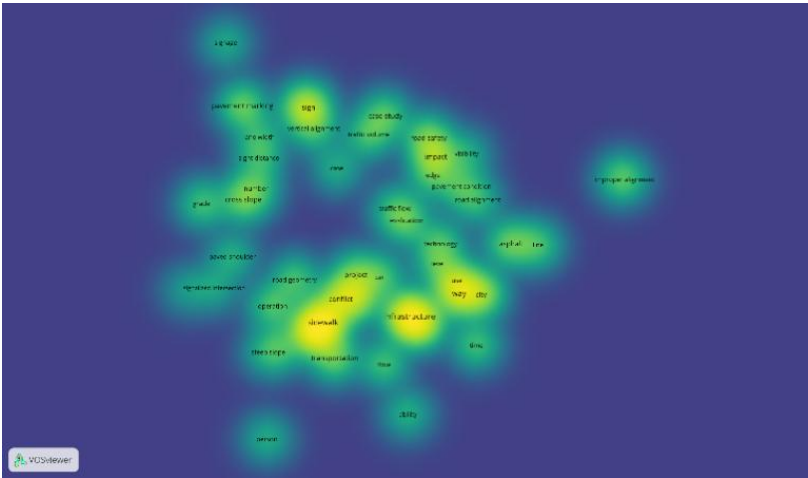


Figure 2 Density Visualization

4.3. Publications Development by Year

Trend mapping is done before clustering and mapping research. In addition, research is based on the year of publication of the article. The data obtained from overlay visualization can be used to assess the results of keyword analysis related to analysis research [60]. A visualization of the development of the number of publications per year related to the topic of the influence of road geometry on traffic safety. The visualization is arranged in the form of a radial (radar chart), which provides a comprehensive overview of publication trends from 2000 to 2024. The data used in this graph is the result of screening literature from the Scopus database, according to the inclusion criteria previously set.

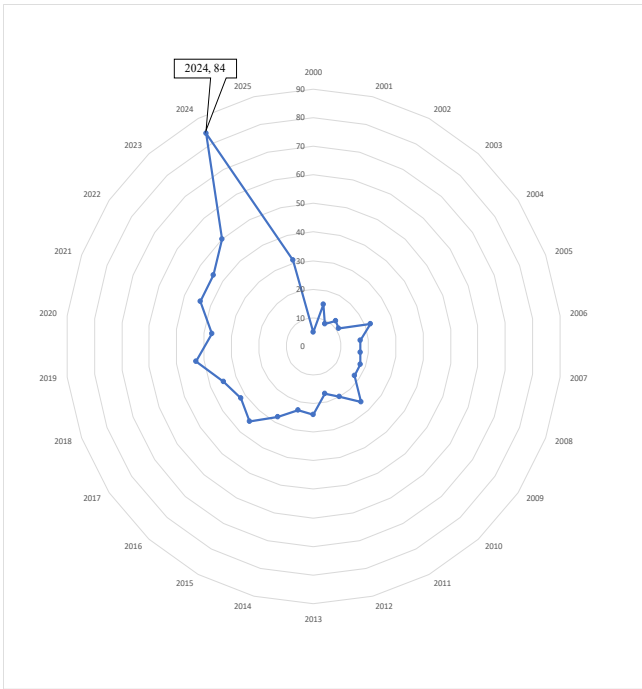


Figure 3 Annual Publication Trend

From the graph, it can be seen that the number of publications is relatively stable and low throughout the period 2000 to 2014, with an average of under 10 articles per year. This indicates that during this period, there was limited academic interest and attention to the issue of the relationship between local road geometric elements and safety. However, starting from 2015, there has been a gradual increase in the number of publications, especially since 2019, indicating a growing research interest in this theme. Highlighting the popularity of terms across different years but also using distinct colours to indicate the temporal evolution of each term. Within this visualization, the darker hues, tending towards purple, signify that the research on a specific term was predominantly conducted around the year 2018. Conversely, the lighter shades, verging towards yellow, represent terms that have emerged more recently in contemporary research [61].

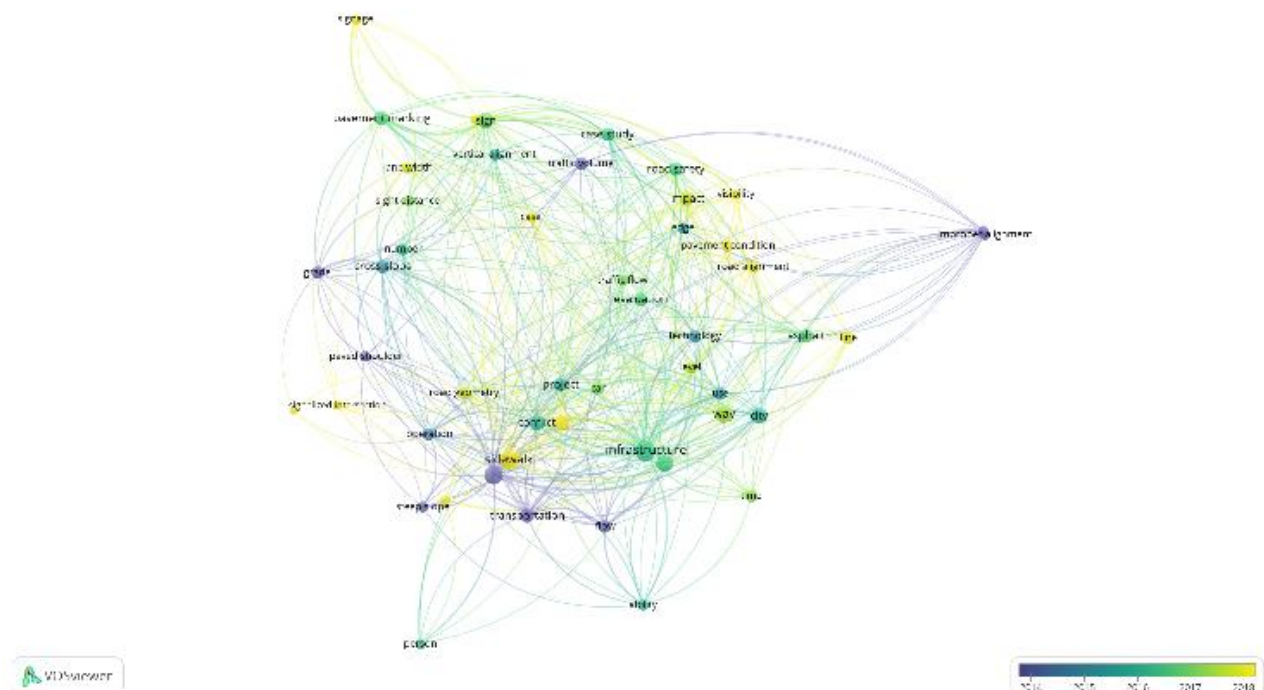


Figure 4 Overlay Visualization

Overlay visualization is used to illustrate the time dimension by using color gradients from blue to yellow [62]. From this visualization, it can be seen that there are several nodes that stand out with a large size, indicating that these entities have a high level of connectedness, both in terms of number of co-citations and collaborations. These nodes are at the center of the network, indicating their role as knowledge centers or core authors in the field of road geometry and traffic safety studies. The varying colors - such as purple, green, yellow and blue - indicate the differentiation of themes or sub-fields pursued by different groups of researchers.

This visualization will show the density between authors obtained from Publish or Perish software. From this data, we can see the relationship between the authors. The brightest colours in the image show the most contribution to the study [63]. The high density of the network indicates that there is a high level of collaboration or connectedness in the literature, especially among authors and studies that focus on technical aspects such as road alignment, design parameters, and traffic accident modeling. Oauthorsverlay visualization is used to identify temporal trends in scientific outputs by mapping average publication years of keywords or authors [64].

4.4. Research by Publisher

By using Publish or Perish database, we can obtain publication types as one of the information to use. The data collected from the publish or perish then will be exported to Microsoft Excel to be processed. The data then turned into a chart to explain the most popular types of publications to be used related to the topic [65] shows the distribution of literature sources used in this study based on the domain or publisher from which the article or document was accessed. This analysis provides an overview of the origins of the documents most frequently used in publications related to the influence of road geometry on traffic safety. Each bar represents the number of documents obtained from each publishing site or platform. In our bibliometric study of goods transportation, Elsevier journals dominate the field, followed closely by Springer publications, which collectively account for nearly 60 % of total publications in the domain [66].

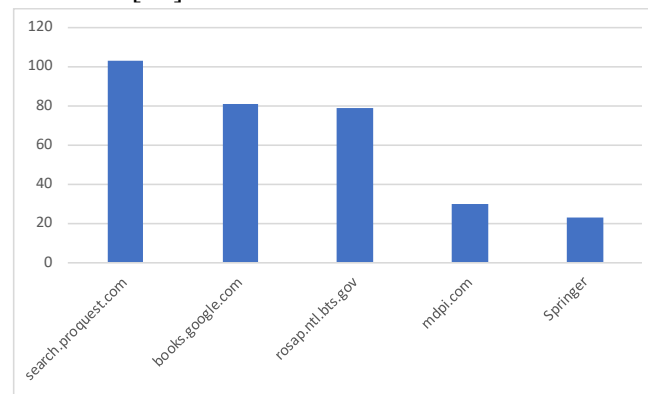


Figure 5 Study Publisher

Based on the database, ten publishers are related to keywords, especially related to civil engineering. Publish or Perish can also show which publishers have contributed the most to the author's keywords [67]. The visualization results show that search-proquest.com is the source that contributes the most documents, with more than 100 publications, followed by books.google.com and rosap.ntl.bts.gov, each with about 80 publications. These three dominate as the main sources of literature, indicating that in addition to scientific journals, technical reports, books and government repositories are also important references in this study. This is relevant to the technical and policy nature of the study topic, so the literature is not only sourced from commercial scientific publications, but also from institutional sources.

MDPI has become one of the largest open access publishers globally, known for its rapid peer-review system and multidisciplinary journals such as *Sustainability*, *Applied Sciences*, and *Energies* [68]. Meanwhile, scholarly publishers such as mdpi.com and Springer were also listed as sources of reference, albeit in relatively smaller numbers. This suggests that local road safety research is also published through formal academic channels, although not as frequently as report repositories or books. This finding reinforces that research in this area is interdisciplinary and not limited to one type of academic source, but includes a combination of academic studies and policy or technical reports.

4.5. Type of Search

Not only that, research on these topics also has references from various types of research. Not only through research articles, but research also takes references from other sources such as posted content, books, book chapters, reports, proceedings, datasets, and monographs. Various types of research that become references in making articles, will provide an understanding of the relevance, comparison, and continuation of the research to be made. Thus, the diverse use of references provides a solid basis and validity for the article [69]. The classification of document types used in this bibliometric study is based on media type or literature access format. This information is important to

understand the composition of literature sources referenced in research on the influence of road geometry on traffic safety. The categories analyzed include: journal article, PDF, book, citation, HTML, and TXT.

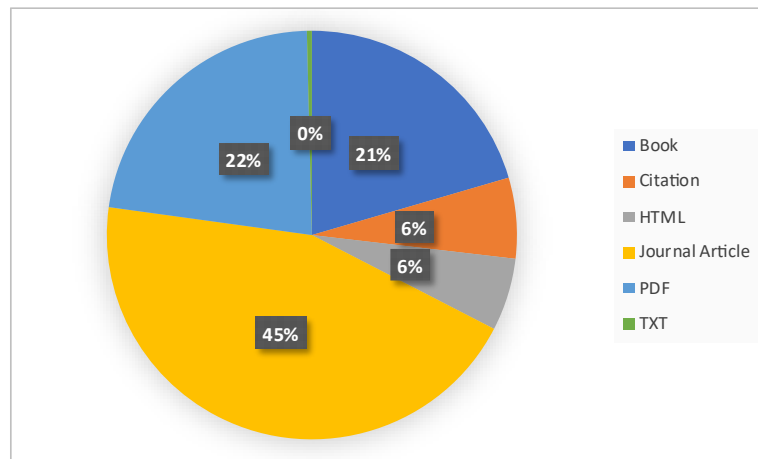


Figure 6 Study Type

Journal articles are the primary publishing type prevalent in unit hydrograph studies. Most studies on the unit hydrograph approach are usually presented as study case articles [70]. The visualization results show that journal articles dominate with a proportion of 45%, which reflects that most of the references in this study come from scientific sources that have gone through a peer review process. This type of document is generally used as the main reference because it provides relevant, up-to-date and methodologically verifiable information. This was followed by PDF documents at 22%, which include various forms of digital documents such as technical reports, institutional study results or scientific papers in open access format. Books accounted for 21%, demonstrating the importance of conceptual and theoretical literature in shaping the framework of research studies.

Other sources such as citation and HTML contributed 6% each, generally in the form of metadata or indirect access to the full content of the document. Meanwhile, the TXT format made no contribution (0%), indicating that unstructured documents were not used in this study. Overall, these findings show that the utilization of information sources in this study was diverse, but still placed journal articles and digital documents as the main sources that support the credibility and scientificity of the study.

5. Conclusion

The bibliometric review presented in this study confirms that the geometric configuration of local roads is an important factor influencing traffic safety. Through a comprehensive analysis of more than 1000 relevant publications, five main thematic groups were identified - emphasizing both technical and behavioral aspects of road design and use. Trend data shows a significant increase in research interest after 2015, underscoring the growing global concern for road safety and infrastructure planning. The visualization results from VOSviewer indicate strong interdisciplinary collaboration, although there is still a lack of localized empirical studies in developing regions such as Indonesia. Therefore, this research not only maps the current scientific discourse, but also encourages more in-depth investigations into the interaction between road design and crash risk. Future research should focus on integrating geometric assessments with real-world crash data to develop adaptive and sustainable road planning strategies that are aligned with local needs.

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