# A Review on Intersection Safety Studies with Bibliometric Methods

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**ABSTRACT**

**Considering the increase in intersection safety studies, the present study will review these studies using scientometric methods. To this aim, 744 articles related to intersection safety until April 1, 2021, were extracted from the Web of Science (WOS) research engine. In the current study, co-citation, co-author, and co-occurrence of words were presented with descriptive analysis methods using VOS viewer and Bibliometrix software, which provide a descriptive, social, and conceptual framework, respectively. Also, the growth and development of the publications, the most cited articles, the most influential authors, sources, institutions, and countries are analyzed. Results showed that according to the co-citation analysis, the conceptual structure of the intersection safety is divided into five main clusters: accident frequency, accident severity, safety performance measures, safety of vulnerable users, estimation of safety level, and intersection accident data analysis studies. Moreover, using conceptual analysis of keywords in intersection safety articles, topics related to cyclist safety, intelligent transportation systems, driver simulation, driver behavior, segment analysis, and road intersections were identified as high density and high centrality in studies. Topics such as empirical Bayes, resource allocation, vehicle communication, automated safety analysis, countermeasures, old drivers, and intersections without traffic lights were identified as basic and transversal themes.**

**KEYWORDS**

**Intersection safety, Bibliometrics, Review, Science mapping, Crash**

## Introduction

Intersections are among various parts of road networks, is one of Iran's riskiest and dangerous locations [1, 2]. According to 2008 Federal Highway Administration reports in the USA, 10,180 crashes occurred in intersections [3]. Therefore, the number of publications on intersection safety is increased annually for safety improvement. Generally, the number of scientific publications increases annually at the rate of 0.03 [4]. Due to the high number of intersection safety studies, there is a need to review and categorize the publications for identifying the recent and future research fronts,

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directions, and core cooperation scientific groups. One of the new and useful methods of reviewing the high volume of past literature is the bibliometrics review that analyzes the relationships between concepts and ideas in different scientific communities with quantitative and qualitative methods [5]. The Bibliometrics method was widely used in transport research, such as analysis of the studies related to autonomous vehicles [6], road safety [7], and motorcycle accidents[8]. With the development of intersection safety studies, this study aims to review the intersection safety studies with the bibliometrics through performance and science mapping analysis to identified research fronts, the most important scientific topics and documents, top authors journals, institutions, and countries.

### Data source and research process

The data were extracted from the core collection of Web of Science by. Table 1 group terms with the "AND" operator were used to search intersection safety-related documents. SCIE and SSCI citation indexes were selected in the document retrieval. A total of 861 articles were found in the first step, and by selecting the type of "Article" and "Review" documents, 744 articles left. It should be noted that in order to achieve logical and correct results, the data retrieval was done only in the titles of the documents.

**Table 1. Search terms for extracting intersection safety studies**

| Group | Search terms |
|---|---|
| Intersection | Intersection Or roundabout |
| Safety | Safety Or Accident Or crash Or collision Or Injury Or Fatal Or death Or casualty Or mortality Or Incident Or Hazard |

## METHODOLOGY

Bibliometrics is a quantitative and mathematical method to provide a big picture of research fronts and scientific groups in fields [5]. Our study conduct bibliometrics methods in four following steps:

- **Performance analysis**: in this section, the performance of scientific activists such as authors and publishers is compared by measuring productivity and producing indexes such as total publications, citation, and H-index.
- **Co-citation analysis**: co-citation analysis is used to clarify the intellectual structure with the science mapping approach. If cited in the third article, the two articles identified as a co-cited article that this relationship between documents can display in the co-cation network for categorizing the research fronts.
- **Co-author analysis:** This technique's main objective is to identify the core scientific authors groups by the total number of cooperation between authors with science mapping methods.
- **Thematic evolution:** the thematic evolution method is derived from co-words analysis, a keywords-based method that enabled the researcher to determine the research importance of themes or keywords. Two keywords are identified as co-word if used in an article that this relationship can display in the network by science mapping and categorize with centrality and development degrees.

The study used VOSviewer [9] for science mapping methods and bibiliometrix [5] for performance and thematic evolution analysis.

## Results

According to performance analysis, from 1965 to 2021, 744 articles were published in the intersection safety field that period of 2010 -2021, with an average publication of 47.45 per year is the most active period. *Accident Analysis And Prevention*, Abdel-Aty M, University of Central Florida, and United States with the high number of total publications identified as the most leading source, author, institution, and country. The article entitled "Comprehensive analysis of vehicle-pedestrian crashes at intersections in Florida" is the most cited paper with 288 total citations in intersection studies by Lee c et al [10]. Figure 1 presents the references co-citation network in the intersection safety analysis. Based on co-citation analysis of intersection safety references, research fronts were classified into 5 clusters as following: (1) **Crash frequency studies**: The most cited article of this cluster is published by Poch M et al that developed a negative binominal crash frequency by intersection crash data [11]; (2) **Crash severity studies**: The most popular article of this cluster publish by Abdel-Aty M et al that investigate the crash severity levels in signalized intersections[12]; (3) **Safety performance studies and analysis of intersection crash data**: the article of Mannering F et al is placed in the first rank of this cluster that presented the crash data analysis methodology [13]. (4) **Studies of intersection safety measures and performance indicators**: the paper of Persaud Bn et al identified as the most cited of this cluster[14]. This paper investigates the impact of intersection conversions to the roundabout on safety. (5) **Safety studies of vulnerable users at the intersection**: the article of Lee c et al that developed a comprehensive analysis on pedestrian-vehicle crashes in intersections is placed in the first rank of articles of this cluster.

Thematic analysis of authors' keywords was proposed in 2000-2010, 2010-2015, and 2015-2021. The period of 2015-2021 presented the most significant results on

thematic maps. In this period, "intelligent transportation system" and "bicycle safety" were the most developed themes with high centrality degrees. "Driver behavior", "automated safety analysis", "signalized intersection", and "resource allocation" have a high degree of centrality with low development degree that are the best cases for future studies.

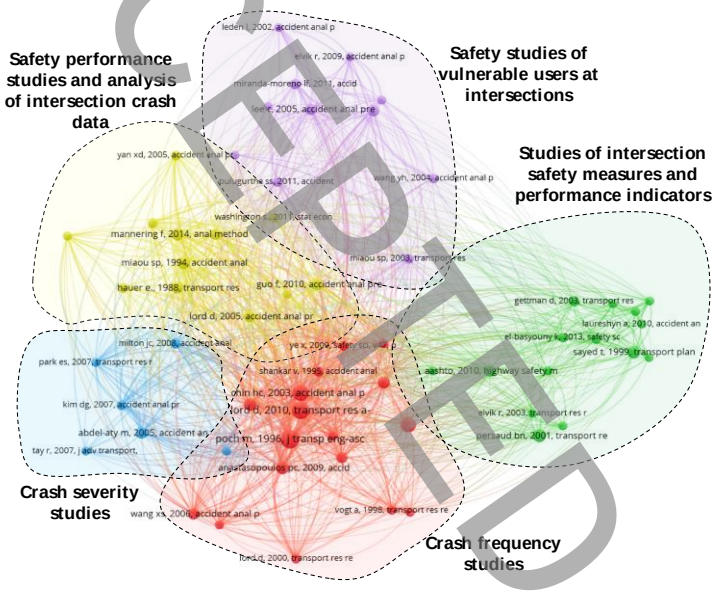


**Figure 1. Reference Co-citation network (Vosveiwer)**

## Conclusions

This study conducted the bibliometric analysis of 744 articles of intersection safety studies during the 1965-2021 period. The main research fronts of intersection studies are divided into five categories, including Crash frequency studies, crash severity studies, safety performance studies and analysis of intersection crash data, studies of intersection safety measures and performance indicators, safety studies of vulnerable users at the intersection. Themes such as "intelligent transportation system" and "bicycle safety" in intersection safety studies were identified as the most important research fronts.

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