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# Main guidelines in road safety audits: a literature review

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Road safety is a global issue, as each year more than 1.25 million people die in traffic accidents, and between 20 and 50 million suffer non-fatal injuries. Road Safety Audits (RSA) are implemented in different countries around the world. These audits involve a systematic process that includes an analysis to ensure that existing or future roads meet optimal safety criteria. In this context, the objective of this research is to identify the main guidelines applied in RSA through a literature review conducted using the PRISMA-ScR methodology. After grouping the guidelines, the ten most used worldwide are obtained, with four of them related to the human factor and six related to the road factor. The guidelines with the highest usage are those related to geometric design, signage, and safety devices. Finally, it is concluded that despite road accidents being an international issue faced by all countries, there is no clear or standardized methodology for the application of these audits. In other words, each country adopts its own method or checklist as a support tool for the team of auditors conducting RSA.

## KEYWORDS

RSA, road safety, roads, guidelines, road injures

## 1 Introduction

The deficiency in road safety is a socioeconomic problem with a global impact. It translates into numerous deaths, injuries, and high economic costs that affect both developed and developing countries. By 2022, road safety deficiency accounted for around 3% of the global Gross Domestic Product ([World Health Organization, 2022](#)) Road safety is a major concern for the United Nations, as several entities within the organization's system contribute to road safety, manifesting as one of the highest priority issues to be addressed through international policy, since every year more than 1.25 million people die in traffic accidents and between 20 and 50 million people suffer non-fatal injuries ([United Nations, 2021](#)). According to [Ahmed et al. \(2013\)](#), there are two types of approaches to counter road safety issues: the proactive approach and the reactive approach (see [Figure 1](#)). The approach analyzed in this research corresponds to proactive interventions through Road Safety Audits (RSA), which provide cost-effective and high-value corrective actions by promoting a safety culture. Furthermore, [Huvarinen et al. \(2017\)](#) state that audits can prevent around 27% of accidents, and the cost-benefit ratio of implementing RSA in various countries ranges from acceptable to excellent ([Garzón et al., 2017](#)).

RSA, which stands for Road Safety Audits, are formal examinations conducted by an independent team of experts. These examinations can be carried out in all stages of a project, ranging from the planning phase of a road to its operation ([Austroads, 2022](#)) Additionally, [Mayoral et al., \(2001\)](#) mention that RSA have proven to be an effective tool in reducing the severity of

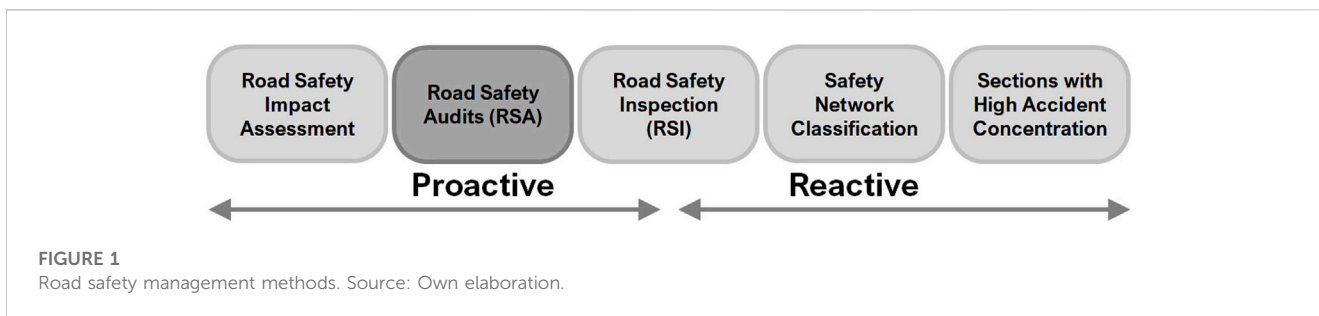


FIGURE 1 Road safety management methods. Source: Own elaboration.

TABLE 1 Definition of population, concept, and context.

Category	Include	Exclude
Population	Drivers, pedestrians, cyclists	-
Concept	Publications that address RSA and Road Safety	Publications that address RSI, accidents
Context	Developed countries, developing countries, and underdeveloped countries	-

Source: Own elaboration.

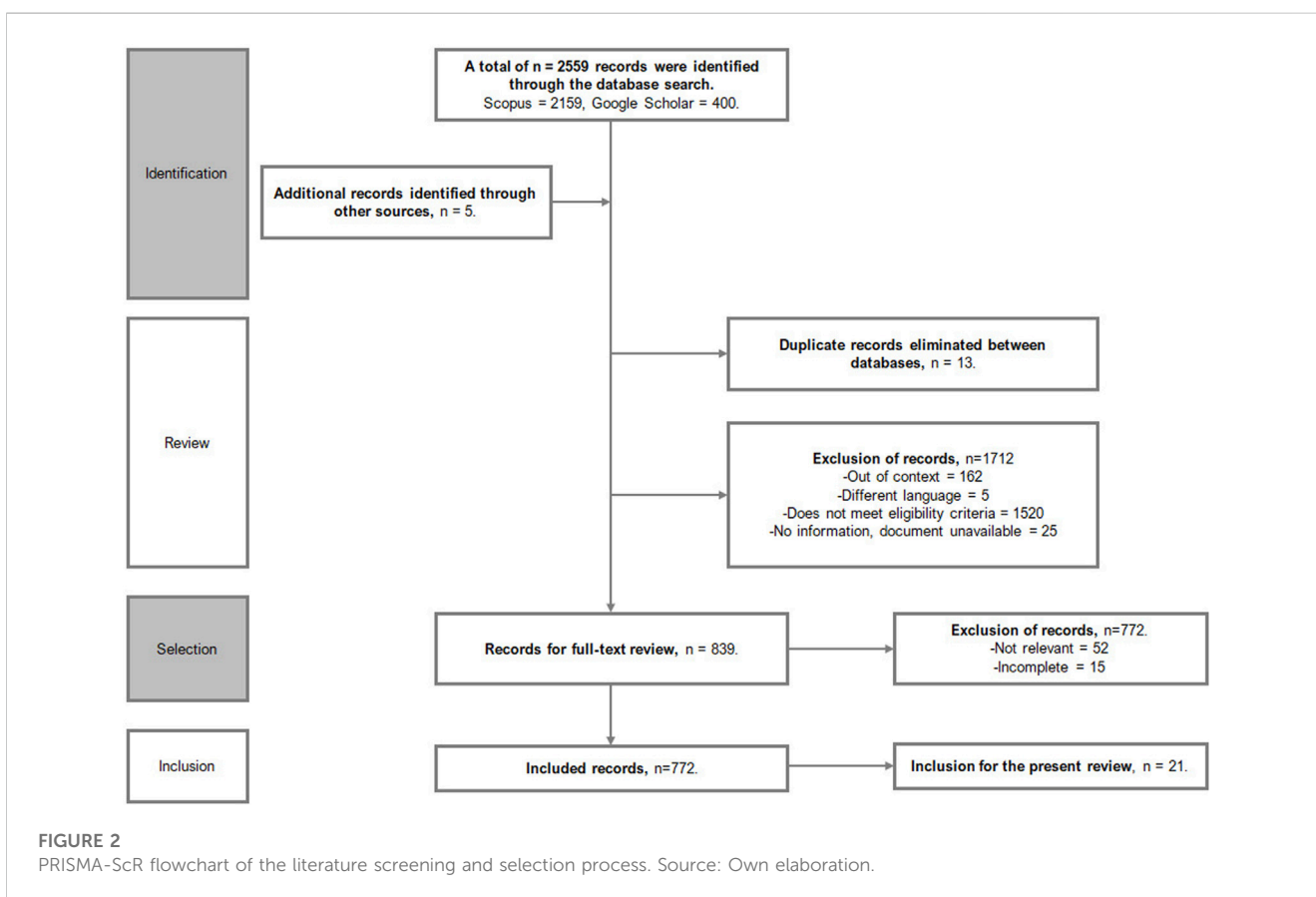
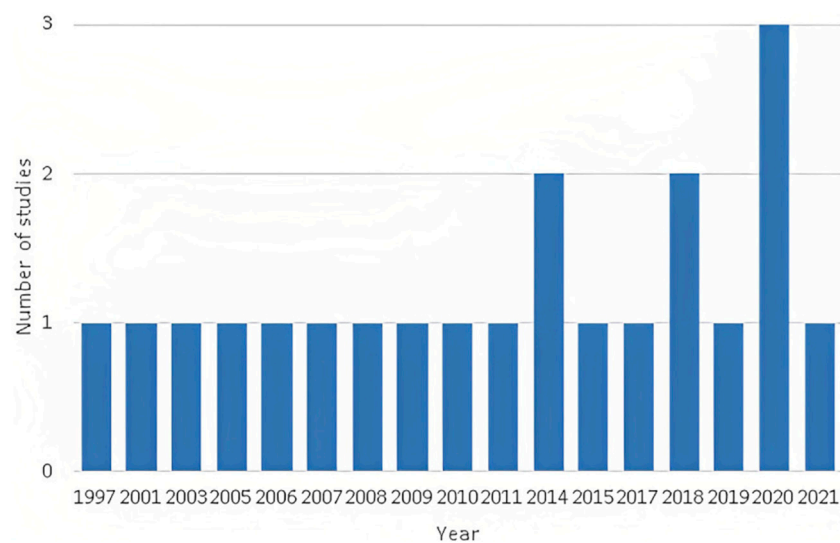


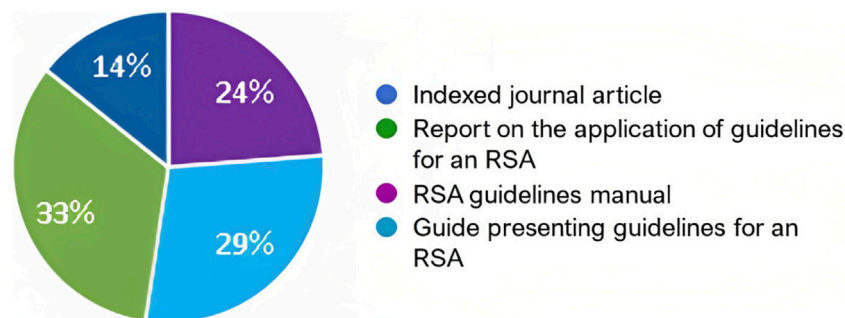
FIGURE 2 PRISMA-ScR flowchart of the literature screening and selection process. Source: Own elaboration.

accidents. In this regard, the outcome of an RSA is a report that identifies any road safety deficiencies, and the auditor must formulate recommendations aimed at eliminating or reducing these deficiencies. On the other hand, the Road Safety Inspection (RSI) is a formal examination of the road safety conditions of an existing road. It can only be conducted during the operational phase and is a more reactive

system that does not rely solely on accident statistics. However, like RSA, RSI are also carried out by an independent and qualified team (NCHRP, 2004). Ahmed et al., 2013 conducted a comparative review of RSA guidelines from different countries. The review process involved identifying and comparing four important parameters: auditor qualifications and equipment requirements, liability issues related to



**FIGURE 3**  
Studies published by year. Source: Own elaboration.



**FIGURE 4**  
Type of publication. Source: Own elaboration.

the subject matter, workflow diagrams for activities, and checklists. Similarly, in their review on road safety in India, [Rahooof and Kumar \(2017\)](#) focused on establishing the concept of RSA and its stages of application. On the other hand, [Al-Adhoobi et al. \(2017\)](#) examined the need to implement road safety audits and reviews, analyzing different international practices and conducting a critical evaluation. They also explored the role of road safety awareness and its impact. In general, it was observed that not all countries use the same parameters. While there are literature reviews that analyze RSA and compare methodologies, they often only scratch the surface. For instance, [Ahmed et al. \(2013\)](#) analyze the quantity of checklists but not the guidelines from seven countries. In this regard, the objective of this research is to provide a literature review that contributes to a rapid identification of RSA guidelines. This review focuses on analyzing RSA checklists from sixteen selected countries, representing different contexts (developed, underdeveloped, and developing), and highlighting the similarities or differences in the guidelines these checklists contain. The aim is to extract the converging points that can be interpreted as critical aspects for formulating a new RSA methodology proposal.

## 2 Materials and methods

A literature review was conducted following the methodology outlined in “The Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Reviews” (PRISMA-ScR) by [Peters \(2020\)](#). This methodology includes essential reporting elements to be considered in a scoping review. The reference management tool Rayyan ([Ouzzani et al., 2016](#)) was utilized to assist in the review of titles and abstracts. During this process, articles that did not meet the eligibility criteria or duplicates were excluded.

### 2.1 Research question and objective

What are the main guidelines used in the RSA within the national and international framework? To achieve the objective and address the research question posed, this review presents an explanatory framework and theoretical foundations of the benefits of RSA, as well as the impact and incidence of certain elements that

TABLE 2 List of reviewed documents.

Country	Guide, methodology, manual, and/or standard	Year
Latin America and the Caribbean	Technical Guide for the Application of Road Safety Audits in Latin America and the Caribbean (Pineda et al., 2018)	2018
Bangladesh	Guidelines for Road Safety Audit, Roads, and Highways Department (RHD, 2005)	2005
Bosnia and Herzegovina	Road Safety Audit and Road Safety Inspection on the TEM network—UNEC (Strnad, 2018)	2018
Cambodia	Safety Audit of Construction Drawing Design of the NR3 Highway Reconstruction and Expansion Project and Traffic Safety Developing Suggestion in Cambodia (Gong et al., 2020)	2020
Chile	Guide to Conducting a Road Safety Audit (Dourthé and Salamanca, 2003)	2003
Colombia	RSA Report: Base Guide for the Preparation of Road Safety Audit and Inspection Reports for Licensed Roads in Colombia (Román, 2020)	2020
	RSA Report: Road Safety Audit for Road Accesses and Interchanges in the Mobility Area of Bogota's Airport - El Dorado (Angulo and Giraldo, 2019)	2019
	RSA Report: Road Safety Audits. Example of Methodological Application (Garzón et al., 2017)	2017
Costa Rica	RSA Report: Development of Road Safety Audits and Evaluations in Costa Rica (Chaverri et al., 2014)	2014
Ecuador	RSA Report: Road Safety Audit of the First-Order Road Riobamba—Pallatanga, 2014 (Gómez and Gómez, 2014)	2014
United States	RSA report: FHWA Pedestrian Road Safety Audit Guidelines and Prompt Lists (Nabors et al., 2007)	2007
	FHWA Road Safety Audit Guidelines, US Department of Transportation (FHWA, 2006)	2006
France	Road Safety Audit Guidelines for Safety Checks of New Road Projects—PIARC (PIARC, 2011)	2011
India	Manual on Road Safety Audit, Indian Roads Congress (Indian-Roads-Congress, 2010)	2010
Indonesia	Safety audit of Becakayu toll road (Setyarini et al., 2020)	2020
Mexico	RSA Report: Road Safety Audits of Operational Highways (Mendoza et al., 2009)	2009
	Road Safety Audits. Procedures and Practices (Mayoral et al., 2001)	2001
Nepal	Road Safety Audit Manual, Department of Roads (Traffic Engineering and Safety Unit Design Branch, Department-of-Roads-Ministry-of-Works-and-Transport, 1997)	1997
United Kingdom	Guidelines for Road Safety Audit, Institution of Highways and Transportation (Carpenter, 2008)	2008
	Design manual for roads and bridges HD19/15 (Transport, Department for and Highways Agency of London, 2015)	2015
Russia	Road safety research in a safety audit (Mukhametshina and Zagidullin, 2021)	2021

Source: Own elaboration.

are evaluated, in relation to the evidence found in the selected publications.

## 2.2 Data sources and search strategy

To conduct this literature review, the Google Scholar and Scopus databases were used. The fields of science and engineering were selected based on their content coverage. It is worth mentioning that during the literature review, no document was found that compares the main guidelines used in RSA within the national and international framework. The search in the Google Scholar and Scopus databases was grouped into two blocks: 1) document classification: audits, guide, guidelines, methodology, report; 2) area of interest: roads, highways, safety, way, roadways. For the English language, 1) audit, guidelines and 2) road were used. Additionally, the terms were grouped to create the following search strings using Boolean operators (AND and OR), and eligibility and exclusion criteria were defined using search filters. Finally, a total of four generic

search strings were generated. 1. (audits or methodology or guide or guidelines or report) AND (safety or road safety or highway safety or roadway safety) 2. (audits or methodology or guide or guidelines or report) AND (highway or road or roadway or way or roadways) 3. (road safety audits or highway audits or road audits or roadway audits) 4. (road) AND (safety or safety audit or guidelines or guidelines for safety).

## 2.3 Eligibility and exclusion criteria

In this research, only indexed journals, peer-reviewed and indexed book chapters, experimental studies, reports, manuals, or guidelines that present the application of RSA guidelines are considered. These publications should be published and completed in English or Spanish. Subsequently, the publications from the first ten pages of Google Scholar, sorted by relevance, were selected. On the other hand, documents presented at conferences reporting accidents or only the application of RSI were excluded. This includes essays, popular science magazines, opinion articles,

**TABLE 3 Interventions and benefits of RSA.**

Country	Intervention	Outcome
New York, United States	RSAs low-cost safety enhancements and surface improvements	20%–40% reduction in crashes at more than 300 high-crash location
Arizona, United States	Findings from RSAs have been used to update DOT policies and standards	54% reduction in total crashes
		50% reduction in fatal/incapacitating injury crashes
Florida, United States	Improvements to design result in savings over the life of a project a RSA requirement for design permits	10.8% reduction in total crashes
		11% reduction in total crashes, two intersections
New Jersey, United States	The process was able to identify locations for quick, low-cost improvements that would lead to the highest reduction in severe crashes	25.6% reduction in total crashes
Tennessee, United States	RSAs are conducted in a more efficient and cost-effective manner	13.7% reduction in total crashes
		31.3% reduction in injury crashes
South Carolina, United States	Implementing RSA suggested improvements in four locations	Crashes decrease 12.5%
		15.8% decrease in crashes
		A reduction of 60% in fatalities
		23.4 percent reduction in crashes
Denmark	Treatments recommended by the ASF such as improved lighting, elimination of obstacles, implementation of safety devices, among others	Reduction in crashes from 5% to 40%
Germany	Implementing RSA	70% crash reduction in constructions of new roads
United Kingdom	Implementing RSA	1.25% reduction in fatalities
Ireland	Road Safety Strategy including implementation RSA on all national road schemes	Fatalities reduced by 48%; 38.8% reduce serious injuries

Source: Own elaboration with information from FHWA (2006), Road Safety Authority (2013), IDB (2018), and FHWA (2012).

**TABLE 4 RSA general process according to FHA.**

Category	Include
Step 1	Identify the project or roadway in service to be audited
Step 2	Select the RSA team
Step 3	Hold a pre-audit meeting to review project information
Step 4	Conduct field observations under various conditions
Step 5	Perform an audit analysis and prepare a report of findings
Step 6	Present the audit results to the project owner
Step 7	The project owner/design team prepares a formal response
Step 8	Incorporate the findings into the project as appropriate

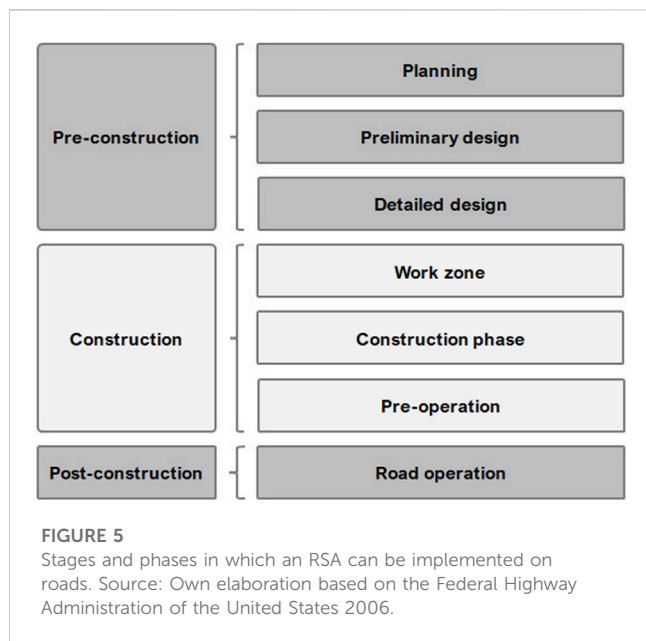
Source: Self-generated based on the Federal Highway Administration (FHA) of the United States, 2006.

apart from manuals presented at conferences. To select the studies for analysis, Table 1 presents the eligibility and exclusion criteria related to the population, concept, and context recommended by the JBI methodology framework for scoping reviews (Peters, 2020).

## 2.4 Article selection

The selection strategy is divided into four stages; the first stage consists of the “identification” of indexed journals, peer-reviewed

and indexed book chapters, individual case reports, experimental studies, reports, manuals, or guides that present the application of RSA guidelines published and completed in both English and Spanish languages, with an initial limited search in the Google Scholar and Scopus databases, identifying the established keywords in the titles and abstracts. In the second stage, called “review,” publications that appear in more than one database are eliminated to exclude duplicates, and then publications are selected through a title and abstract-based reading to meet the eligibility criteria using the Rayyan software tool for scope



review. In the third stage, called “selection,” publications are reviewed in full text to exclude those that did not meet the requirements. Finally, in the stage called “inclusion,” data from publications that met the eligibility criteria are analyzed and extracted.

In Figure 2, the search results are shown and report in a flowchart following the Preferred Reporting Items for Systematic Reviews and Meta-analyses for scoping review (PRISMA-ScR) extension. The extracted data includes specific details about the factors and relevant findings found in each publication that enable answering the research question. Additionally, it includes details about the context in which the research was conducted, the participants involved, and the study methods used. The relevant information is extracted from the full text of the selected articles using a customized Google Form. Please refer to Appendix A for further details.

## 2.5 Data extraction

After conducting a full-text reading of the selected publications, relevant information is extracted using a customized Google Form, as described in Appendix A. Subsequently, the extracted information is analyzed to provide answers to the research questions.

The collected information is organized into three categories:

- 1) “Publication characteristics,” aim to characterize the publication data, including:
  - Document type: Specify if it is an article, book, etc.
  - Publication title
  - Author(s) of the publication to identify the main researchers in this field.
  - Year of publication: It is expected to have recent and current publications.
  - Year of validity of the RSA guideline used.
  - Geographical location where RSA is applied: Refers to the case study mentioned in the publication.
- 2) “Study details” aims to obtain information about the case study, including:
  - Methods: Specify the methodology used to apply RSA.
  - Context: Define if the case study is located in a developed, developing, or underdeveloped country.
  - Participant or population: Refers to drivers, pedestrians, and cyclists. Data will be extracted for the literature review, including only publications that incorporate analysis of drivers.
  - Tools: Provide details about the technologies or software used, such as simulators, computer packages, etc.
- 3) “Study-related information” presents the variables considered in the case studies and proposed methodologies for conducting RSA, along with their descriptions, such as:
  - Human factor: Identify if this variable was used and which elements related to the human factor were analyzed.
  - Road factor or project: Provide details if this variable was used and which elements related to the road factor were analyzed.
  - Vehicle factor: Specify if this variable was used and which elements related to the vehicle factor were analyzed.

**TABLE 5** Grouping of the main guidelines used in an RSA.

G1—Guideline 1	Accident data
G2—Guideline 2	Reports from previous audits
G3—Guideline 3	User’s visual perception
G4—Guideline 4	Pedestrian and cyclist needs
G5—Guideline 5	Geometric design, including cross slopes, intersections (crossing form, position, angle, and visual distance), road layout, horizontal alignment, vertical alignment, volume data, speed data, shoulder width, road surface skid resistance, design plans, visibility distance, road type
G6—Guideline 6	Horizontal, vertical, and lighting signage
G7—Guideline 7	Safety devices, road furniture (fencing, delineators, cushions, barriers, speed bumps), rest areas, service areas
G8—Guideline 8	Additional works, such as work zones and accident management, drainage, bridges, alignment design, pillars, complementary buildings
G9—Guideline 9	Road operation: traffic lights, traffic management, road functional classification
G10—Guideline 10	Other external aspects (plants, vegetation, climate, natural features, visual distractions)

Source: Own elaboration.

TABLE 6 Main guidelines used in RSA.

Context	Country/Guide, methodology, manual, and/or standard	Human factor				Road factor					
		G1	G2	G3	G4	G5	G6	G7	G8	G9	G10
	United States										
	FHWA Road Safety Audit Guidelines, US Department of Transportation, 2006			✓	✓	✓	✓	✓		✓	✓
	RSA report: FHWA Pedestrian Road Safety Audit Guidelines and Prompt Lists, 2007			✓	✓	✓	✓	✓		✓	✓
	France										
Developed	Road Safety Audit Guidelines for Safety Checks of New Road Projects—PIARC, 2011	✓			✓	✓	✓		✓		✓
	United Kingdom										
	Guidelines for Road Safety Audit, Institution of Highways and Transportation, 1996			✓	✓	✓	✓	✓	✓		✓
	Design manual for roads and bridges HD19/15			✓	✓	✓	✓	✓	✓		✓
	Russia										
	Road safety research in a safety audit, 2021			✓		✓	✓			✓	✓
	Bosnia and Herzegovina										
	Road Safety Audit and Road Safety Inspection on the TEM network—UNEC, 2018		✓			✓	✓	✓		✓	
	Chile										
	Guide to Conducting a Road Safety Audit, 2003	✓				✓	✓	✓	✓	✓	✓
	Colombia										
	RSA Report: Base Guide for the Preparation of Road Safety Audit and Inspection										
	Reports for Licensed Roads in Colombia, 2003	✓			✓	✓					✓
	RSA Report: Road Safety Audit for Road Accesses and Interchanges in the Mobility										
	Area of Bogota’s Airport—El Dorado, 2019		✓	✓		✓	✓				
	RSA Report: Road Safety Audits. Example of Methodological Application, 2019		✓	✓		✓					
	Costa Rica										
	RSA Report: Development of Road Safety Audits and Evaluations in Costa Rica, nd	✓			✓	✓	✓	✓	✓		
Developing	Ecuador										
	RSA Report: Road Safety Audit of the First-Order Road Riobamba Pallatanga, 2014	✓		✓		✓	✓				✓
	India										
	Manual on Road Safety Audit, Indian Roads Congress, 2010					✓	✓				
	Indonesia										
	Safety audit of Bacakayu toll road, 2017	✓				✓	✓	✓	✓		
	Mexico										
	Road Safety Audits. Procedures and Practices, 2001	✓			✓	✓	✓	✓	✓	✓	
	RSA Report: Road Safety Audits of Operational Highways, 2008				✓	✓	✓		✓		
	Latin America and the Caribbean*										
	Technical Guide for the Application of Road Safety Audits in Latin America and the Caribbean, 2018			✓	✓	✓		✓			

(Continued on following page)

TABLE 6 (Continued) Main guidelines used in RSA.

Context	Country/Guide, methodology, manual, and/or standard	Human factor				Road factor					
		G1	G2	G3	G4	G5	G6	G7	G8	G9	G10
	Bangladesh										
	Guidelines for Road Safety Audit, Roads, and Highways Department, 2005	✓		✓		✓	✓				✓
Undevelopment	Cambodia										
	Safety Audit of Construction Drawing Design of the NR3 Highway Reconstruction and Expansion Project and Traffic Safety Developing Suggestion in Cambodia, 2020	✓				✓		✓			
	Nepal										
	Road Safety Audit Manual, Department of Roads, 1997					✓	✓	✓	✓	✓	

Source: Own elaboration. \* mean not all Latin American countries are in the Undevelopment context.

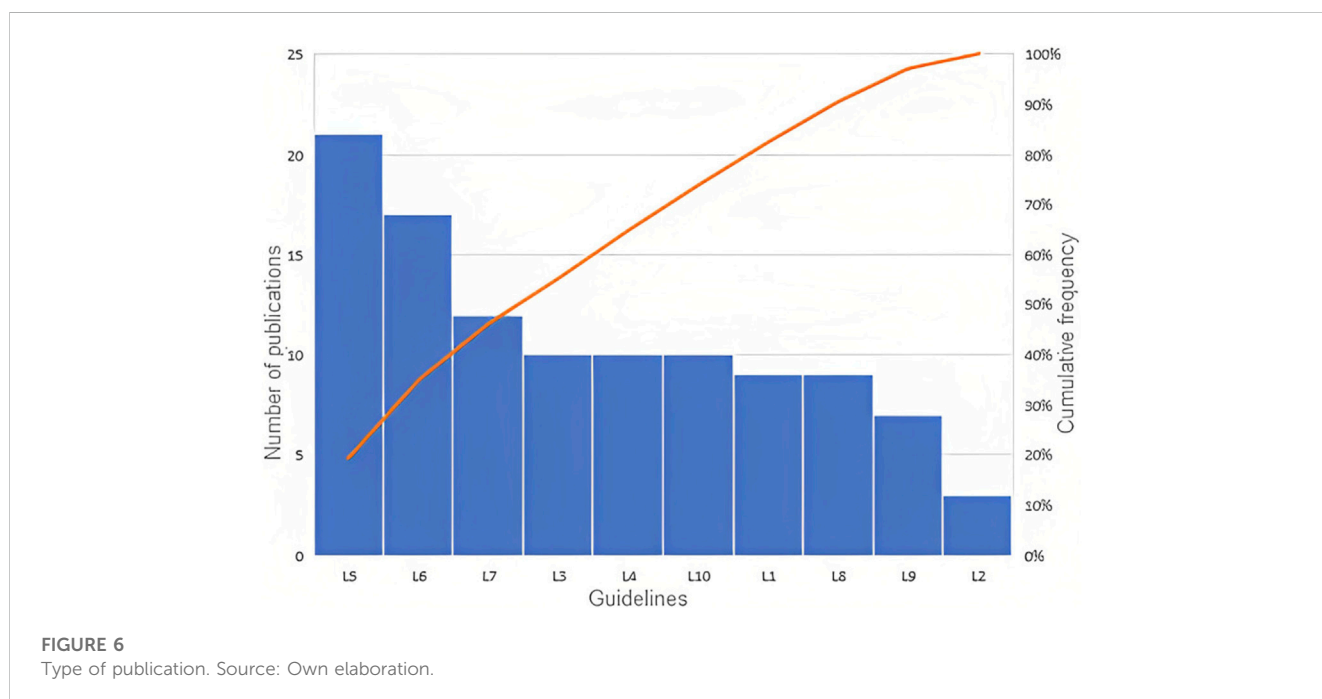


FIGURE 6 Type of publication. Source: Own elaboration.

### 3 Results and discussion

#### 3.1 Searches

A total of 2,564 publications were identified through searches in the mentioned databases, of which 13 were removed as duplicates. Therefore, the titles and abstracts of 2,551 publications were examined, of which 1,712 publications were excluded for the following reasons: out of context ( $n = 162$ ); written in a language other than the established eligibility criteria ( $n = 5$ ); not meeting the eligibility criteria ( $n = 1,520$ ); and lacking information or access to the document, marked as an error ( $n = 25$ ). The remaining 839 publications were selected for further evaluation, which involved a full-text review. A total of 67 publications were discarded as they were deemed irrelevant ( $n = 52$ ) or the full document was not available ( $n = 15$ ), leaving a total of 772 publications. Additionally, a final filtering was applied,

selecting a total of 21 publications that presented RSA manuals and case studies for this literature review.

#### 3.2 Characteristics of the studies

The selected studies for analysis ( $n = 21$ ) were classified by year of publication, type, and context. In this regard, Figure 3 shows that the studies, including audits, guidelines, frameworks, methodologies to achieve RSA, and their implementation, were from the year 2000 onwards. It is considered a recent review, with 52.38% of them representing studies from the last decade (11), and 47.62% (10) from previous years.

Regarding the type of document, Figure 4 shows that 24% (5) are RSA guideline manuals, 29% (6) of the studies correspond to guides presenting RSA guidelines, and 47% (10) are reports on the application of RSA guidelines and indexed journal articles.



### 3.3 Data standards

The importance of guidelines and methodologies in the field of road safety, as well as ASV standards, is recognized. Therefore, this research focuses on the analysis and identification of guidelines through 11 selected methodologies and guides, based on the availability of publications and cases reporting the application of RSA. These represent economies at different levels, classified according to their context. The scope review included parameters, methods, guidelines, factors, and benefits in the implementation of ASV. Therefore, data standards ensure that the information selected and interpreted by the methodology is correct.

#### 3.3.1 Context

A fundamental part of the analysis is to classify each publication according to its context, categorizing them into developed countries such as the United States, France, the United Kingdom, and Russia; developing countries such as Bosnia and Herzegovina, Chile, Colombia, Costa Rica, Ecuador, India, Indonesia, and Mexico; and underdeveloped countries such as Bangladesh, Cambodia, and Nepal. Additionally, the specific case of Latin America and the Caribbean is also considered, which comprises both underdeveloped and developing countries. In this regard, [Table 2](#) presents the list of study names and publication years for the reviewed studies.

It is important to mention that the [World Health Organization \(2022\)](#) states that deaths from road accidents mainly affect low- and middle-income countries, accounting for 90% of global fatalities. Therefore, if the number of deaths and injuries from road accidents is reduced, it would decrease the expenses associated with road accidents and could potentially improve the long-term economic level of these countries ([World Bank, 2023](#)).

To transfer the knowledge gained in developed countries to Low- and middle-income countries needs to be tested for cost and design effectiveness as well as the legal system for implementing road infrastructure. Many of the interventions are developed after considerable research and testing ([Gupta and Bandyopadhyay, 2020](#)).

According to [Ahmed et al. \(2013\)](#) no RSA guideline document can be considered the best, as they are prepared taking into account local conditions and requirements.

#### 3.3.2 Importance and benefits of RSA

According to the [World Health Organization \(2022\)](#) approximately 1.3 million people die in traffic collisions each year, which means more than two deaths every minute. Based on this, it can be argued that the implementation of an RSA is currently relevant, as it is expected to reduce the severity and number of accidents that occur through this means worldwide. Another benefit of implementing RSA is the reduction of expenses related to accidents, as safer roads are promoted with a lower likelihood of collisions, which in turn also reduces costs in the lifespan of the road and fosters a culture of road safety ([Morales et al., 2015](#)) According to the above, it reflects the need for and importance of implementing RSA.

In this regard, the United Nations in its Sustainable Development Goals (SDG) establishes Goal 11 “Sustainable Cities

and Communities,” which aims to provide access to safe, affordable, accessible, and sustainable transport systems for all, improving road safety.

On the other hand, the [FHWA \(2006\)](#) identifies several benefits of implementing RSA. These include addressing safety proactively, where road designs analyzed by RSA should result in fewer and less severe accidents. RSA also helps identify low-cost/high-value improvements, enhances consistency in safety considerations, and promotes a safety culture.

According to the Federal Highway Administration (FHWA), the reports generated in the RSA process are cost effective. However, it is important to mention that the majority of these reports refer to qualitative benefits. Because a cost-benefit ratio is not the motivating factor behind RSA implementation. In this sense, the benefits are substantial, such as the reduction of social costs, but largely immeasurable ([Federal Highway Administration, 2022](#)) However, it has been possible to find quantifiable benefits through experiences in various countries. [Table 3](#) presents the interventions related to RSA as well as their benefits in terms of road accidents.

According to the [Table 3](#), different developed countries are mentioned that have managed to reduce the number of accidents through the application of RSA and additional safety strategies. In this order of ideas, The World Health Organization (WHO) reports that there has also been more progress in reducing the number of road traffic deaths among middle- and high-income countries than low income countries. In fact it states that there has been no reduction in the number of road traffic deaths in any low-income country since 2013 ([WHO, 2018](#)).

#### 3.3.3 Road safety audit (RSA)

The use of an assessment guide or checklist can be highly useful for conducting RSA. The value of these lies primarily in providing indicators of the safety condition of a road and the elements that need to be reviewed ([Mayoral et al., 2001](#)).

Existing publications for each guideline or methodology have different forms or checklists, and sometimes only present flowcharts projecting the standard procedure to follow for conducting RSA. On the other hand, the RSA process requires field studies and road safety checklists that ensure the best performance.

It is important to understand that checklists are a means and not the end of RSA. Therefore, the auditor should decide what and how to use these instruments, which should not be included in the final report ([Dourthé and Salamanca, 2003](#)). The purpose of RSA checklists is to assist the audit team in identifying potential safety issues and ensuring that nothing important is overlooked. These checklists can also be used by road design engineers to proactively identify potential safety issues as they develop a road geometric design ([FHWA, 2006](#)).

During the development of an RSA, it is necessary to review and analyze the basic principles on which a road has been designed and constructed. The analyzed publications include some guidelines on the basic principles of road design and construction, as well as methodologies and recommendations related to road user safety. Some of these publications also provide a structure for the RSA report, including the name of the auditor, the audited section or road, and the recommendations issued.

The main findings from the comparison of the selected publications demonstrate that each country follows its own guidelines and procedures. However, the FHWA (ibid.) of the United States in 2006 defines a general process for ASV with eight steps. This process provides detailed guidance on each step to be followed and is tailored to the specific needs of each project (Table 4).

### 3.3.4 Application guidelines in RSA

RSA should be seen as a tool within an integrated range of instruments aimed at promoting the goals and objectives of a comprehensive road safety management program. In other words, it involves an analysis that incorporates a comprehensive approach to the various factors involved in a road project. Just like the Federal Highway Administration of the United States proposes in RSA, all types of vehicles and users (older drivers, pedestrians of different age groups including children and physically disabled individuals, cyclists, commercial, recreational, agricultural traffic, etc.) that could interact should be considered. Based on the above, to achieve a comprehensive analysis of these guidelines, three factors should be taken into account: human, vehicular, and road related. It is needed to understand what factors contribute to the high frequency of road injuries for guiding research and designing interventions (DeNicola et al., 2016).

The first factor is the “human” factor (drivers, passengers, pedestrians, cyclists, and motorcyclists), which should be integrated into the management system as the most important yet least reliable link. Humans can easily become distracted, get tired relatively quickly, and their behavior is influenced by many unpredictable factors. Roads and traffic management often take for granted and focus solely on how users adapt to the system and its conditions. The contribution of the human factor to the occurrence of an accident is very significant since accidents are largely attributed to the physical and psychological conditions of the user (Sakhapov et al., 2018). Traffic psychology is a fundamental discipline to understand. Researchers agree the human factor explains between 70% and 90% of accidents (Faus et al., 2023).

Another factor to consider is the “vehicular” factor, which involves identifying the differences in dimensions and operation among the types of vehicles used by users in the analyzed area. Motorized vehicles can be divided into two categories: heavy vehicles and light vehicles. Each of these types has differences in both the geometric design and operation of the road. Soria et al. (2018) establishes as a fundamental principle to consider all users of the road project in RSA.

Likewise, it is important to consider the “road-related” factor, in which there is a close relationship between the infrastructure and the user. The primary objective should be to make this relationship as favorable as possible so that humans make the fewest possible errors (Ibidem), and these errors do not lead to accidents or even fatalities. As mentioned before, the implementation of RSA can occur in any phase and/or stage of a road project. Generally, projects are developed in three stages, as indicated in Figure 5. The first stage, called pre-construction, encompasses preliminary works such as planning, preliminary design of the project, geometric studies, and everything necessary to establish the project’s schedule. The

second stage, construction, refers to all processes from land leveling, marking, and site clearance until the project is completed before the operation. Lastly, the post-construction stage is when the road is open to traffic and in operation by users.

Once the literature review has been conducted, it is possible to identify and group the most commonly used guidelines in an RSA, resulting in a list of the top 10 guidelines for human and road-related criteria (Table 5). Based on these previously obtained guidelines, Table 6 shows for each reviewed document, which guidelines are considered. Additionally, it is worth noting that four guidelines were obtained for the human factor and six for the road-related factor, based on the grouping of guidelines.

It is worth noting that the most frequently applied guidelines are G5, G6, and G7, representing 46.3% of the cumulative relative frequency and belonging to the road-related factor (Figure 6). This could indicate that, due to the frequency of application in the countries considered, these guidelines are the most relevant when formulating a guide, methodology, manual, or standard for RSA.

## 4 Discussion

This research presents a literature review aimed at describing and summarizing the main guidelines used in RSA in different countries. Consequently, a total of 21 documents were analyzed, and the guidelines that have the greatest impact are those related to geometric design (G5), which includes considerations such as cross slope, intersection design, roadway alignment, horizontal and vertical alignment, volume and speed data, shoulder design, road skid resistance, design plans, visibility distance, and road type. Additionally, the guidelines related to horizontal and vertical signage, lighting (G6), and the guidelines that encompass safety devices and road furniture (e.g., barriers, delineators, cushions, barriers, bumps), rest areas, and service areas (G7) also play a significant role. It is worth noting that these three guidelines belong to the road-related factor.

In Figure 4, it is shown that 47% of the identified articles have been published in indexed journals and reports on the application in case studies, while 53% are guidelines or manuals for RSA. On the other hand, Figure 4 shows that 70% of the analyzed studies were published in the last decade. In general, this literature review provides a comparison of the main RSA guidelines from selected countries in developed, underdeveloped, and developing regions. In most cases, developed countries implement checklists, while developing countries focus on both the road factor and the human factor. On the other hand, the selected underdeveloped countries have guidelines that are more focused on the road factor. The publications agree that checklists play a relevant role in conducting RSA, as they are an essential tool for the auditor and guide the proper execution of the RSA process. It is considered that in the future, RSA will be implemented more frequently and under an established set of guidelines that consider multiple factors. RSA will be seen as a process and tool within a road safety management system. On the other hand, a limitation of this study is that only articles in English and Spanish were selected. Another limitation is the access to various RSA manuals and guidelines from different countries, as most of them are presented as case studies and reports

without specifying the specific instruments used for conducting RSA.

## 5 Conclusion

By conducting this research, it was possible to develop a qualitative synthesis of the guidelines used in RSA in different countries around the world. It is worth noting that RSA is a proactive method carried out by an independent team of experts at different stages of a road project, and its main objective is to identify potential causes of traffic accidents.

This lack of a universally standardized approach highlights the need for further collaboration and knowledge sharing among countries to develop a more unified and comprehensive methodology for RSA. Such an approach would facilitate better understanding, comparison, and implementation of RSA practices worldwide. The results of the literature review provide valuable insights and practical application for researchers and implementers in this field. Furthermore, it emphasizes that RSA guidelines should not only focus on the road factor but also include aspects of all factors involved. This way, users who are not necessarily road safety auditors can provide useful and up-to-date feedback on road safety issues from their perspective.

It is worth mentioning that, in the comparison of the publications, no guideline was established that involves the vehicle. However, it is an aspect that should be linked to the project design, considering the geometric and operational considerations of the different types of vehicles that travel on the road.

Therefore, research on this topic continues to be relevant to the scientific community, as it promotes further investigations that contribute to improving road safety and, thus, safeguarding human lives.

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JC: Investigation, Methodology, Project administration, Supervision, Validation, Writing–original draft, Writing–review and editing. IN: Investigation, Methodology, Writing–original draft, Writing–review and editing. LG: Investigation, Methodology, Project administration, Supervision, Validation, Writing–original draft, Writing–review and editing. MM: Investigation, Methodology, Project administration, Supervision, Validation, Writing–original draft, Writing–review and editing.

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## Appendix A

Below is presented the Google Form created for data extraction.  
The form can be found in the following link: <https://docs.google.com/forms/d/e/1FAIpQLSfMg497eQ-fCcCpzBhIfwhAlgQHASLTBQ6Lu49p768HN85YyA/viewform?usp=sharing>.

[com/forms/d/e/1FAIpQLSfMg497eQ-fCcCpzBhIfwhAlgQHASLTBQ6Lu49p768HN85YyA/viewform?usp=sharing](https://docs.google.com/forms/d/e/1FAIpQLSfMg497eQ-fCcCpzBhIfwhAlgQHASLTBQ6Lu49p768HN85YyA/viewform?usp=sharing).