

Article

A Cross-Comparative Analysis of Transportation Safety Research

Monika Blišťanová ¹, Peter Koščák ¹, Michaela Tirpáková ^{1,*} and Magdaléna Ondicová ²

¹ Faculty of Aeronautics, Technical University of Kosice, 04001 Kosice, Slovakia; monika.blistanova@tuke.sk (M.B.); peter.koscak@tuke.sk (P.K.)

² Faculty of Criminology, Academy of the Police Force in Bratislava, 83517 Raca, Slovakia; magdalena.ondicova@akademiapz.sk

* Correspondence: michaela.tirpakova@tuke.sk

Abstract: This article aims to identify the main trends of safety research in relation to different transportation modes (aviation, rail, road, and ship) based on the chosen methods, emphasizing the same and different features in the research topics. In the context of the main goal, quantitative content analysis was chosen, which identified the trends and domains of safety research, and text-mining software Leximancer was used for processing concept maps and reports showing semantic structures. The article found that the dominant topics in all modes of transportation are safety issues, mostly related to incidents/accidents. All modes of transportation have similarities in research (e.g., management, safety, and legislation are discussed), but differences regarding the specific operation prevail. The article emphasizes what trends in safety research dominate and how they differ. It has also been proven that, even though it is safety research, security issues can also appear because the two concepts form an indivisible complex in many ways.

Keywords: safety; safety research; content analysis; Leximancer



Citation: Blišťanová, M.; Koščák, P.; Tirpáková, M.; Ondicová, M. A Cross-Comparative Analysis of Transportation Safety Research. *Sustainability* **2023**, *15*, 7609. <https://doi.org/10.3390/su15097609>

Academic Editors: Jie Li, Jie Xue, Dengsheng Wu and Xiaolong Zheng

Received: 22 March 2023

Revised: 25 April 2023

Accepted: 4 May 2023

Published: 5 May 2023



Copyright: © 2023 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

1. Introduction

Transportation currently plays an essential role in many areas of human life. Mobility generally helps people by providing access to employment, goods, and services [1]. The level of population mobility is increasing yearly, which means that the importance of transportation systems is also growing [2]. In recent years, many accidents have led to a considerable increase in the interest in solving safety issues based on procedures of identification and the control of risks, as well as the development and expansion of safety management systems (SMSs) in the area of transportation [3]. Therefore, safety is a core concept in the transportation sector in policy and regulation, with established institutional management strategies, collaborations, and practices associated with preventing incidents and accidents [4].

Generally, it is possible to distinguish between three basic modes of transportation: land (road, rail, and pipelines), water (shipping), and air [5]. Several authors [6–8] have investigated the determinants of transportation (different transportation modes). They have concluded that there are similarities between individual types but also significant differences which, in their essence, affect not only operation but also safety. One of the most apparent similarities is that every mode of transportation is designed to carry passengers, freight, or both. Differences can be observed mainly in the degree of freedom (in how many directions a vehicle can move), the unit of transportation (single, multi, or continuous), dependability, flexibility, adaptability, speed, or safety. The current trend in the transportation field is to achieve available, sustainable, intelligent transportation [9,10], since it has been proven that transportation has a significant impact on environmental, social, and economic sustainability. Indicators are proposed for measuring sustainability [11,12] and should be compiled to describe a situation or a time trend about a particular concern [13].

Although there are a wide variety of potential indicators, safety is part of the proposal for the social sustainability of transportation. Safety has been at the forefront of transportation planning for over a decade [14] and will continue to play an essential role. Plus, it is directly related to risk, and risk is associated with accidents. The analysis of accident causes has a long history [15] and has helped to introduce measures to increase safety. However, serious accidents and incidents with catastrophic potential keep recurring in all modes of transportation [16]. The probability of an accident in transportation can measure safety or risk [17]. The risk issue remains the focus of researchers and decision-makers, and is often evaluated [18]. Several studies focusing on specific risk groups have been published, for example, the transportation of dangerous substances [19–21], operational risks [22], and collision risks [23–25], but also cyber risks [26] and the vulnerability of transportation systems [27]. Currently, there is extensive safety research in terms of transportation, which is focused on several areas. These are primarily specific issues related to operations, human factors, or human errors, which are the most common sources of accidents. However, other topics related to autonomy or other modern conveniences are gradually coming to the forefront of technological progress. Safety research also directly connects to the issues of models of human behavior or planning [28]. In addition, it is necessary to emphasize that due to its nature, the transportation industry often combines safety and security issues as one integrated complex. Therefore, safety and security co-analysis (SSCA) is often used in practice and research, as was proposed by a previous study [29,30].

While safety is essential in many human activities, it has a preeminent role in transportation. Throughout history, all forms of transportation have carried some degree of danger, which is unlikely to change [31]. Back in 1997, Stoop and Thissen published a study focused on research on the field of transportation safety. The main point was the broad analysis of safety studies in transportation for the previous period, and, in the end, the authors described future challenges. The authors stated, among other things, that future research would focus on developing conceptual frameworks to describe system complexity, quantify system safety performance indicators, and redesign transportation safety research to be multidisciplinary [13]. This is precisely the aim of this study, to identify the trends or the present main domains in the research on the selected four modes of transportation (aviation, railway, road, and ship) with a focus on their differences and overlaps by examining selected safety articles via a quantitative study using bibliometric analysis.

2. Materials and Methods

The article's main aim was to identify trends or topics in research on the selected four modes of transportation (aviation, railway, road, and ship). The emphasis was placed on their differences or similarities via the quantitative examination of selected pieces of safety research.

Considering the fundamental aim of the study, content analysis was used. This type of analysis assesses words, phrases, or in-text relationships [32] and helps to examine document trends and domains [33]. There are two approaches to implementing content analysis: qualitative and quantitative [34]. Qualitative research is performed to study and understand phenomena in their natural contexts, whereas quantitative research focuses on explaining and/or predicting events by analyzing data using statistical methods [35]. In quantitative research, content analysts evaluate texts for predefined terms or phrases and use inferential statistics to conclude their presence. Quantitative content analysis provides a rigorous method for examining a broad range of topics that impact the field and is useful for academic disciplines and industry [36]. Content analysis is advantageous for the study of various types of documents in multiple fields such as psychology [37,38], tourism [39], business [40], and many more.

In this particular case, content analysis [41] was used to identify the trends or domains in safety research for selected modes of transportation (aviation, railway, road, and ship) and we used the text-mining software Leximancer, which uses word frequency and co-occurrence data to identify families (groups and clusters) of terms that tend to be used

together in the text to produce a set of concept maps and reports showing semantic structures [42]. Comprehensibly, from the first figure (Figure 1), the first step of the analysis was defining the main scope, which in this case was defining the “search formula” and the number of articles for particular research areas. To sum up, 50 articles were analyzed for each area, giving a total of 200 articles for all 4 modes of transportation.

The data source was the SSCI and SCI-E database in the Web of Science Core Collection. The search formula was set to “safety” in aviation/railway/road/ship from 2000 to 2022. The search language was “English”, and the document types were “Articles” and “Proceeding Papers”. Sorting by “relevance” was used. In addition to the named criteria, a minimum number of citations of 15 was added because, usually, the number of citations is assumed to reflect the impact of the research or its quality. Before the selection, the keywords in the abstract were checked in the articles. From each area, 500 articles were thoroughly reviewed, and 50 were selected that met all of the established criteria.

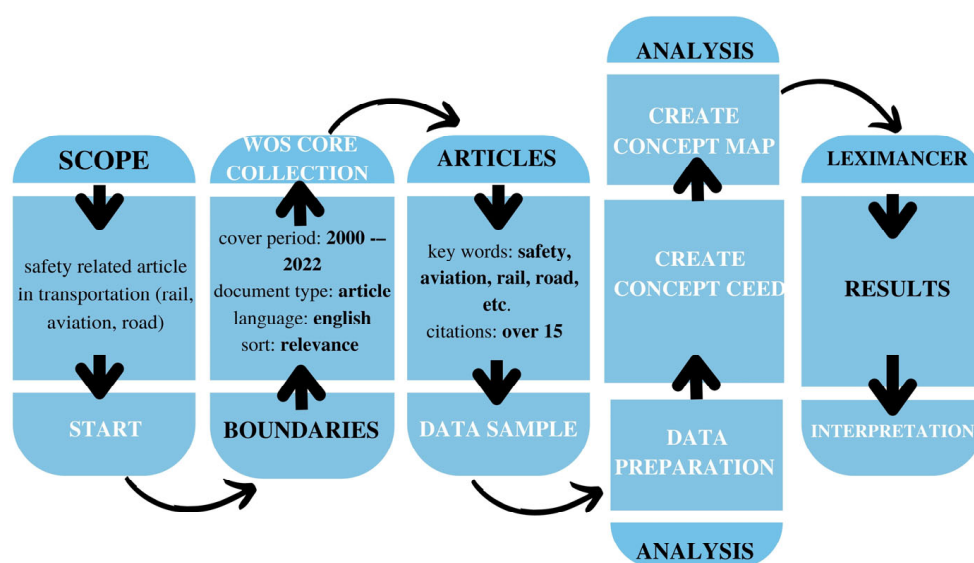


Figure 1. Graphic representation of the research methodology, step by step.

In the Leximancer software, concept seeds were first prepared, and subsequently, outputs were generated in the form of lists of themes and concept maps.

The results were evaluated for each studied area separately, and then attention was focused on common issues across the themes and subthemes. A concept map was also created from the complete set of 200 articles for the transportation field.

In connection with the research objectives, the following hypotheses were established:

H1: In safety research, for all modes of transportation, up to 70% of the same topics will prevail.

H2: In safety research, for all modes of transportation, up to 70% of the exact keywords will prevail.

H3: Safety research is currently multidisciplinary.

Data Source

The articles were selected based on the criteria mentioned earlier. It was necessary to go through more than 500 articles to compile a research set of 50 articles for the given area that met the criteria. The research mainly dealt with rail transportation at the beginning of the monitored period, and research on other modes of transportation was only used in later years. The most used studies were from 2015 and 2019, but it must be noted again that the number of citations was also an important criterion (Figure 2).

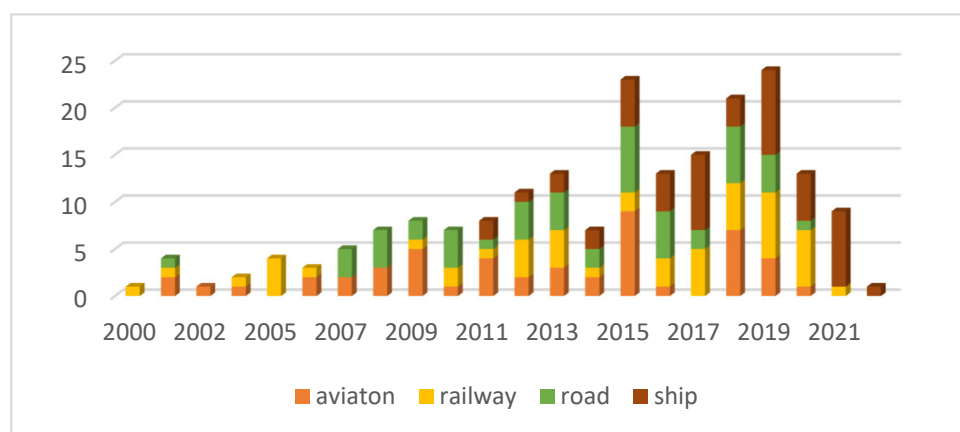


Figure 2. Display of research in selected modes of transportation in the time frame (2000–2022).

The resulting selection contained articles from 58 different journals and 9 conference proceedings. Most articles were from the Safety Science journal (55), and the second most frequent journal was Accident Analysis and Prevention, with 26 articles. The number of journals that were represented for particular areas is shown in Table 1.

Table 1. Frequency of journals utilized in research: a tabular overview.

Research Area	No. of Journals	Frequency
Aviation	24	Safety Science (38%), Journal of Transportation Management (10%)
Rail	25	Safety Science (32%), Reliability Engineering and System Safety (12%)
Road	17	Accident Analysis and Prevention (44%), Safety Science (10%)
Ship	15	Safety Science (30%), Reliability Engineering and System Safety (20%), Ocean Engineering (16%)
Total	67	Safety Science (28%), Accident Analysis and Prevention (13%), Reliability Engineering and System Safety (9%)

Articles from authors from 38 countries were represented in the resulting file. If the authors formed a collective composed of authors from several countries, the article of each represented country was counted. Table 2 shows that authors from 18 countries were represented for aviation, authors from 20 countries were represented for rail, authors from 27 countries were represented for road, and authors from 20 countries were represented for ship. The most numerous represented countries were different for each field.

Table 2. Frequency of countries appearing in research: a tabular overview.

Research Area	No. of Countries	Frequency
Aviation	18	USA (28%), Taiwan (14%), Australia (11%), China (7%)
Rail	20	China (22%), UK (19%), USA (8%), Italy (8%)
Road	27	Australia (14%), Sweden (9%), Spain (8%), Norway (8%), Italy (8%)
Ship	20	China (26%), Finland (17%), the Netherlands (10%), Poland (10%), UK (8%)
Total	39	China (16%), USA (9%), UK (9%), Australia (7%), Finland (7%)

3. Results

3.1. Safety in Aviation

Safety in air transportation is closely observed and considered to be one of the aviation industry's top priorities. The reason is evident as air accidents claim many lives and thus affect many people. Plus, it is historically proven that aviation disasters are inevitable and have enormous impacts [43]. Safety in aviation is regulated by Annex 19, which introduced the requirement to actively implement safety management systems to manage safety risks in air operations, air traffic services, aerodromes, and maintenance. Despite the industry's rigorous safety standards and regulations, aviation accidents occasionally occur, leading to loss of life, injury, and property damage. From this point of view, it is therefore essential to know what the research deals with and what safety issues it solves. In a thorough analysis of studies in the field of air transportation, three main dominant research themes were identified: safety, flight, and incidents. The themes and concepts are listed in the following table (Table 3).

Table 3. Safety in aviation—research hits and concepts.

Theme	Hits	Concepts
Safety	5896	Flight, aircraft, pilots, air, time, control, traffic, airport, crew, operations, icing, conditions, landing, weather, FAA, ATC, engine, runway, fuel, surface, area
Flight	3680	Aircraft, pilots, time, control, performance, crew, airport, icing, conditions, landing, failure, weather, ATC, engine, runway, fuel, surface, repair
Incidents	895	Issues, FAA, investigation

It is clear from the table that safety research dominates (5896 hits) and deals primarily with flight, aircraft, human factors, air traffic control (ATC), technical issues, or even weather or fuel. The flight itself is another important topic of research in air transportation. It is apparent that the themes of safety and flight complement one another and cooperate, since many keywords are similar or even the same. The last dominant theme is aviation incidents, which occur more often, unlike aviation accidents. The research mainly deals with issues that cause incidents and incident investigations. Plus, research also includes the Federal Aviation Administration (FAA), which can be attributed to the application of procedures in the event of an incident.

Figure 3 shows a concept map that includes three main clusters: red—safety, green—flight, and blue—incidents. Since the article mainly focuses on safety and safety-related examination, the emphasis was put on the main related concepts. Safety focuses on several topics, from legislative requirements and regulations to systems and human errors. The most common connection is safety education, followed by culture, cabin, regulations, behavior, management, aviation, airline, industry, and knowledge.

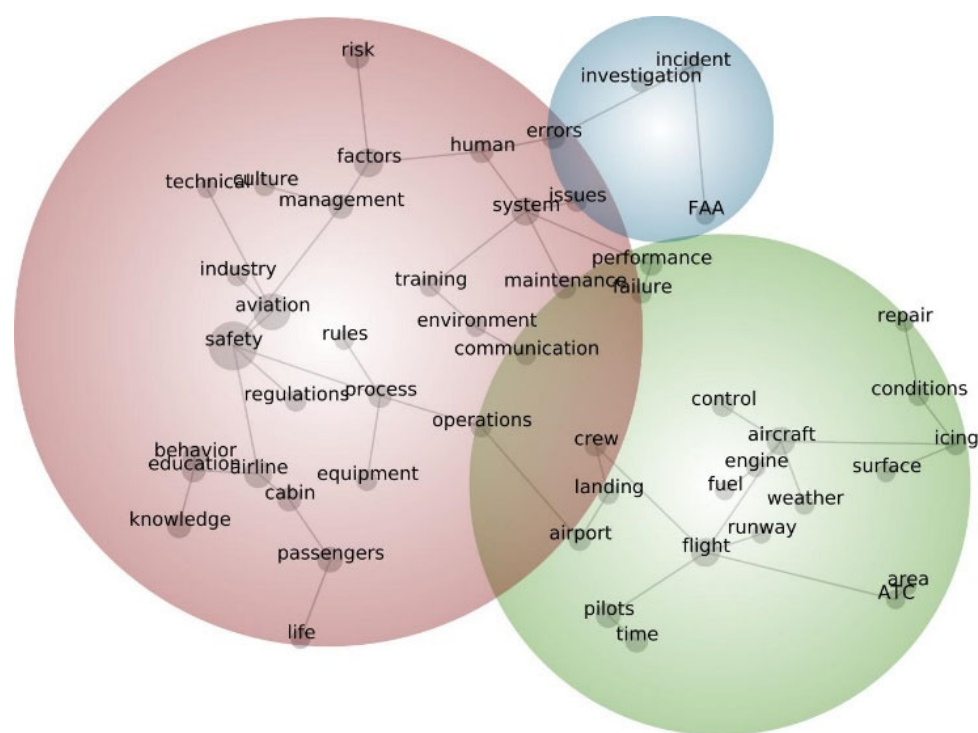


Figure 3. Concept map (aviation) with clusters: red—safety, green—flight, blue—incidents.

3.2. Safety in Rail Transportation

Rail transportation is generally considered to be a safe mode of transportation, but safety measures are still necessary to prevent accidents and ensure passengers' and employees' safety. Similar to other transportation modes, rail safety is an essential issue for governments and regulatory bodies worldwide [44]. Legislation and regulations are in place to ensure that railways operate safely and prevent accidents, while each country has its own measures and safety requirements. Various factors, including human error, equipment failure, infrastructure problems, and weather conditions, can cause rail accidents. The impact can be significant on both human life and the national economy. At this point, compared to air transportation, there is more extensive research into rail transportation (which may be partly because rail transportation was used much earlier than air transportation). From the point of view of safety, the three main topics of safety, accident, and track dominate in railway transportation (Table 4).

Table 4. Safety in rail transportation—research hits and concepts.

Theme	Hits	Concepts
Safety	5303	Railway, system, risk, management, operation, performance, control, equipment, process, training, construction, climate, support, rules, procedures
Accidents	4045	Train, factors, human, error, traffic, network, failure, crossings, behavior, fatalities
Track	2976	Rail, maintenance, conditions, time, station, infrastructure, speed, line, passenger, derailment, signal, function, area, detection

Safety also dominates in the case of railway transportation (5303 hits), while it mainly deals with system, management, operation, performance, control, rules, procedures, and so on. It can be noted that, based on these results, safety in rail transportation is mainly addressed at the level of legislation, rules, and management, which actively implement

it. Another important research topic in rail transportation is accidents. Still, unlike air transportation, which deals with more frequent incidents at the level of investigations and issues, rail transportation deals with other difficulties. The accident topic is mainly associated with the train as the primary vehicle, factors that cause accidents, errors, behavior (of employees) in operation, and fatalities. The last topic is “track”, which can be debatable based on the keywords of concepts because it deals with various inquiries, e.g., maintenance, time, stations, infrastructure, passengers, or even signals and functions.

Figure 4 shows a concept map that includes three main clusters: red—safety, green—accident, and blue—track. Similarly to air transportation, safety research dominates in rail transportation, emphasizing management, systems, and rules. The intersection of all three themes includes system, control, railway, operation, signal, failure, infrastructure, and equipment.

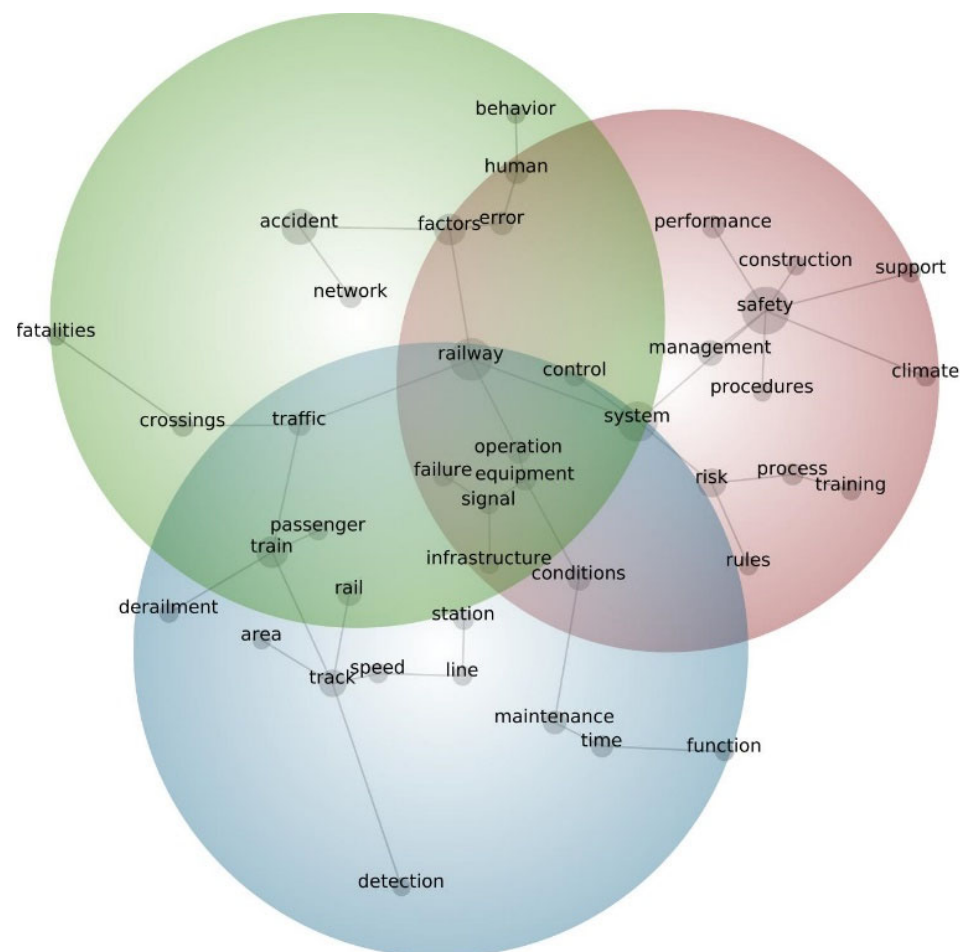


Figure 4. Concept map (rails) with clusters: red—safety, green—accident, and blue—track.

3.3. Safety in Road Transportation

Road transportation is a widely used mode of transportation, but in its nature it can pose significant safety risks (Table 5). Unlike other modes of transportation, it is primarily used for personal transportation and does not necessarily include mass transportation. Road transportation is available to almost everyone; therefore, it is considered to be the most accessible, flexible, reliable, and relatively cheap type of transportation compared to other modes. Nevertheless, it also has challenges, mainly related to safety and the environment [45]. Safety issues in road transportation are connected to drivers' behavior, which is a leading cause of road accidents; poorly designed or maintained road infrastructure; adverse weather conditions; pedestrian and cyclist safety; and many more. Road transportation

safety legislation is intended to ensure road users' safety and prevent accidents and injuries. However, the problem may be that many drivers do not follow these rules. This is the leading cause of road transportation's most significant safety issues. Unlike air and rail transportation, the effects of road accidents may not be so fatal. Still, according to the World Health Organization (WHO), approximately 1.35 million people die each year due to road traffic accidents worldwide. This means that, on average, approximately 3700 people die on the world's roads daily. Additionally, road traffic accidents are a leading cause of death for people aged 5–29.

Table 5. Safety in road transportation—research hits and concepts.

Theme	Hits	Concepts
Road	5403	Safety, system, transportation, factors, measures, performance, indicators, policy, components, control, management, strategies, infrastructure, process
Accidents	3399	Traffic, vehicle, crashes, injury, time, urban, fatalities, public, bus, car, travel, environment, people, probability, school, pedestrian, crossing
Driving	2588	Risk, behavior, effects, speed, area, conditions, young

The research situation regarding road transportation differs from the previous two modes of transportation. In contrast to safety, the topic of road dominates here (5403 hits), which has merits since road traffic represents the main safety issue. Other keywords include factors, measures, systems, indicators, policies, strategies, management, and components. So, it is evident that the majority of research is trying to find a way to prevent accidents and ensure road safety via practical measures and management implications. The next dominant theme is accidents, which, as already mentioned above, have value due to their prevalence and impact. The research mainly deals with crashes, injuries, fatalities, people, probability, schools, pedestrians, crossing, public transportation, and buses. The last topic to be mentioned is driving. As mentioned earlier, drivers' behavior on the roads is one of the leading causes of accidents that occur daily. Therefore, the research focuses mainly on risks, behavior, effects, speed, and even young drivers. The following figure (Figure 5) shows a concept map that includes three main clusters: red—road, green—accidents, and blue—driving. In safety research, road transportation seems to focus on specific problems and accidents that must be prevented. Since road transportation is typical in that each driver is responsible for their own actions, there are no regulations or particular procedures for adjusting safety-related issues. In the intersection of all three themes are vehicle, infrastructure, factors, and environment.

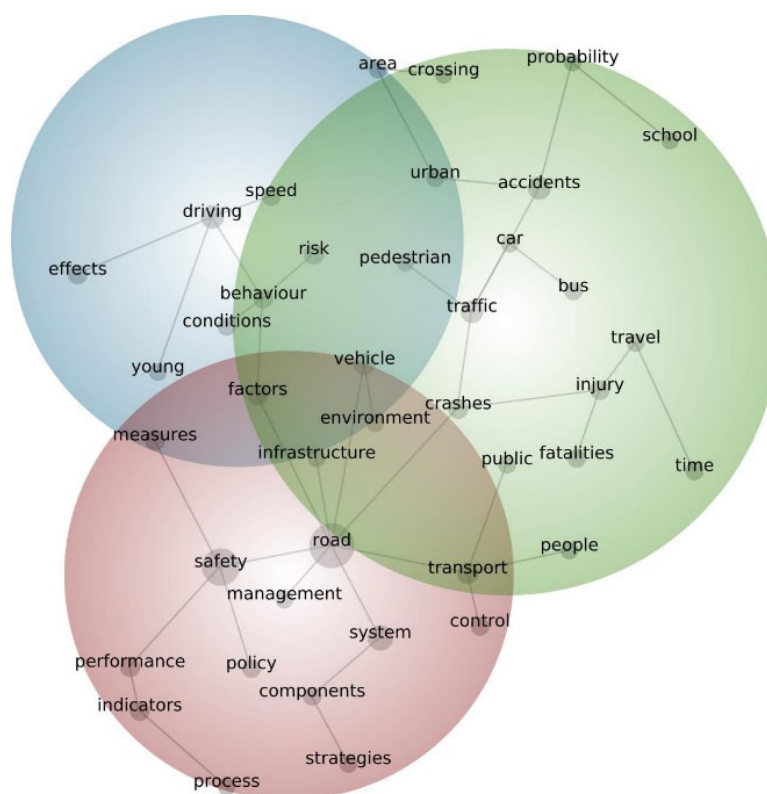


Figure 5. Concept map (road) with clusters: red—road, green—accidents, and blue—driving.

3.4. Safety in Ship Transportation

Ship transportation is a mode of transportation that involves the movement of goods, people, or even animals by sea or inland waterways using ships or vessels. Ship transportation, like any mode of transportation, poses various safety concerns that need to be addressed to prevent accidents and protect human life and the environment. Even though it is a very specific type of transportation, there is still an assumption (confirmed by historical events) that there are also various situations that can disrupt overall safety. Key safety concerns are mainly linked to collisions between ships or between ships and other objects, such as rocks, fires and explosions on ships, human errors, adverse weather conditions, such as high winds, heavy seas, and storms, and cargo safety [46]. In this type of transportation, cargo is mainly transported, and so the impacts do not have to have fatal consequences for human life, even if this is not a condition. Most often, however, there is extensive damage to the environment and economic impacts. Ship transportation is subject to various international and national regulations to ensure the safety of ships and their crews, protect the marine environment, and promote fair and efficient shipping practices (Table 6).

Table 6. Safety in ship transportation—research hits and concepts.

Theme	Hits	Concepts
Ship	6321	Conditions, operations, ice, traffic, speed, time, navigation, distance, area, sea, port, domain, conflict, AIS, water, channel, stability
Safety	4541	Risk, factors, collision, system, maritime, environment, assessment, process, management, design, framework, performance, industry
Accident	2966	Human, autonomous, control, shipping, cargo, error, oil, crew, damage, failure, passenger, IMO

In the case of ship transportation, the research is most often focused on the ship, which is based on the fact that the ship is the primary means of transportation. The keywords are conditions, operations, ice, traffic, speed, time, navigation, distance, area, sea, port, and others, and so they comprise operations at sea and consider their various aspects. The second most common topic is safety by default, and the research focuses on risks, factors affecting safety, safety assessment, frameworks, performance, or even ship design and operation management. The last dominating topic is accidents, in which attention is paid to the human factor, the autonomy of operation, shipping, cargo, errors, crew, damage, and the like. The following figure (Figure 6) shows a concept map that includes three main clusters: red—ship, green—safety, and blue—accidents. All three themes intersect with port, operation, design, autonomous, environment, and safety.

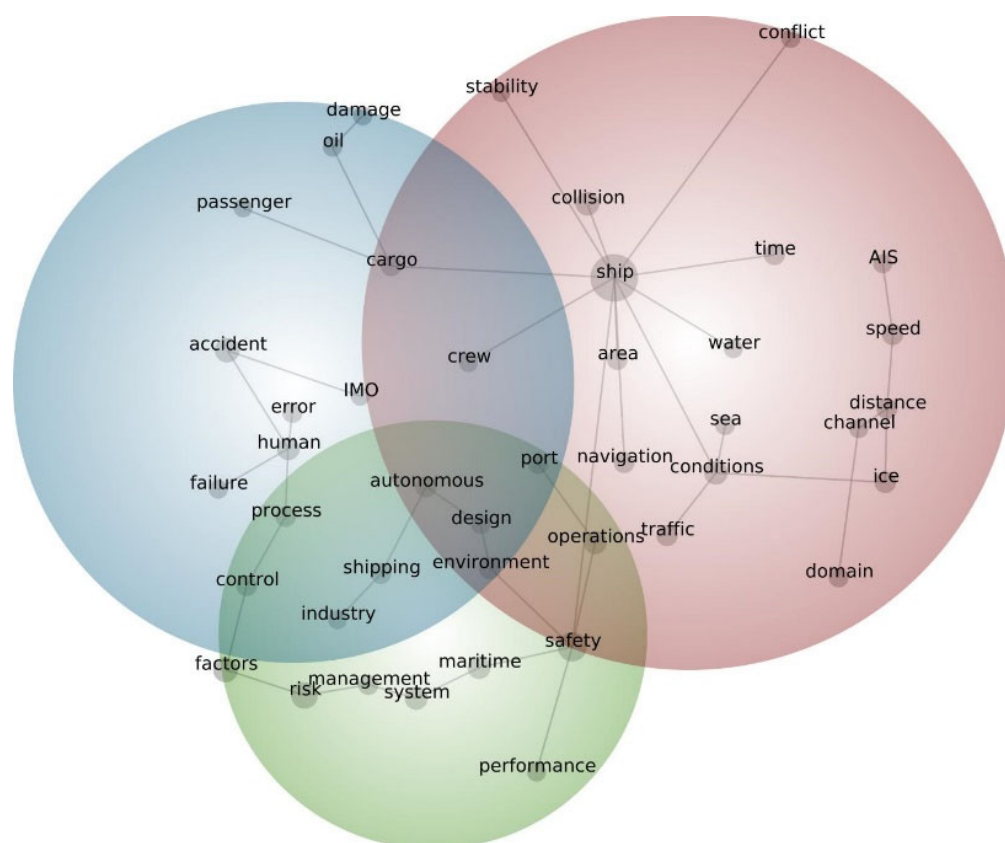


Figure 6. Concept map (ship) with clusters: red—ship, green—safety, and blue—accidents.

4. Discussion

The article aimed to identify trends or the present main domains in research on the selected four modes of transportation (aviation, railway, road, and ship). The focus was placed on their differences and overlaps by examining selected safety articles using a quantitative bibliometric analysis study. For this goal, a methodology was chosen in which content analysis and Leximancer software were applied. The results showed that safety research focusing on air, rail, road, and ship transportation has much in common regarding the main topics or themes. It has been proven that these topics are multidisciplinary and, in their essence, answer current questions, technological progress, or legislation. At the same time, safety is discussed here in various domains that respond to the nature of a particular mode of transportation. On the other hand, some highly expected topics did not appear in the analysis results, e.g., autonomous vehicles [47]. This may be due to the limiting factor that can be considered to be the number of citations. Since there is an assumption that citations increase over time, this condition may have limited the results. The most frequent issues out of all 200 articles were safety and incident/accident, while

the 3rd topic almost always related to a specific flight, track, or ship, e.g., operation. This result is not surprising since safety is intended to protect against events such as incidents, accidents, or other situations impacting human lives, property, or the environment [48]. However, the exception was road transportation, which had different themes which can partly be attributed to the diverse nature of transportation, as it usually involves personal rather than mass transportation. On the other hand, the content of the main topics changed, which precisely determined the differences in individual modes of transportation [49]. The following table (Table 7) lists all of the keywords related to research on the selected type of transportation. Some features are common (bold), while others represent differences. Among the terms that appear in all modes of transportation are management and performance. Among the terms that appear in all modes of transportation are management and performance since transportation system complexity requires effective management and adequate performance measured via key performance indicators [50]. Hypotheses were established in the article, which referred to the predicted outcomes of the prevalent topics and keywords. It was shown that the topics in all of the modes of transportation were almost similar (H1), but the keywords differed significantly (H2). In addition, current research has been shown to be multidisciplinary (H3), as it deals with many topics that complement each other and are not isolated. It is necessary to emphasize that, in our opinion, only multidisciplinary research brings about the required results for safety.

Table 7. Keywords related to research in a specific mode of transportation—common (bold) and different.

Aviation	Railway	Road	Ship
management	management	management	management
performance	performance	performance	performance
culture	system	system	system
equipment	equipment	environment	environment
rules	control	strategies	control
operation	operation	infrastructure	distance
industry	construction	components	industry
aviation	railway	road	maritime
airline	signal	transport	shipping
education	training	policy	design
cabin	support	indicators	crew
regulations	procedures	measures	navigation
behavior	conditions	young	autonomous
knowledge	climate	process	ice
passengers	risk	public	port

5. Conclusions

The quantitative analysis carried out in the article brought about several findings mainly related to topics represented in the framework of safety research in in terms of transportation. The main findings are related to the fact that the journal *Safety Science* dominates publications on almost all modes of transportation, and the analyzed studies came from authors from 38 countries (mainly China and the USA). Safety and incidents/accidents were the predominant research topics in all modes of transportation, but despite the prevailing themes, the concepts differed. In general, an accident includes a severe injury or illness, while an incident consists of property damage, an unexpected hazard, or a minor injury; this also applies in the case of transportation. The last finding was evident, and all kinds of transportation have similarities in the research into them (e.g., management, safety, and legislation are discussed), but differences regarding the specific operation prevail. A limitation of this study can be considered to be the fact that, in principle, the study was aimed at a quantitative evaluation of the existing research. At the same time, no emphasis was placed on the content of these studies. In addition, due to the number of citations, many studies did not have to include current topics, which was confirmed, and several

current issues were not even displayed in the result. The last limitation is that during the pandemic, safety research deviated significantly and focused mainly on measures related to COVID-19.

In summary, it is necessary to pinpoint that security issues also appeared even though the research was primarily concerned with safety. This results from the fact that transportation is generally very sensitive to various risks, where it is not possible to separate safety and security. Therefore, as was mentioned earlier, safety and security co-analysis (SSCA) is often used in risk assessment, which is inevitable to consider. However, there is also an assumption that precisely because this article is dedicated to safety, prevailing security topics, for instance, cybersecurity or intentional activities resulting in crime, did not appear. Plus, as predicted in 1997, the research is multidisciplinary, dealing with complex frameworks and systems, including safety and security topics. It is interesting, however, that many keywords and topics that are different in individual modes of transportation significantly refer to, for example, legislation, the framework, or the characteristics of the operation in question. Air transportation is mainly dominated by a positive safety culture implemented across aviation, education, and behavior. Railway transportation has its research situated in constructions and procedures, which are necessary to ensure the safe transportation of passengers. Road transportation as a specific type and its research covering passenger and mass transportation stands out mainly in terms of the infrastructure and components. It also deals with young drivers and their behavior. Shipping research directly refers to shipping and autonomous transportation. In conclusion, it is still possible to consider that some topics did not appear, even though they were expected to; for instance, an interesting parallel may be that autonomous transportation refers only to ships, although currently, research is increasingly focused on autonomous flying vehicles. It is possible to assume that future trends in safety research will concern new technologies being developed and probably also safety challenges related to, for example, the current tense situation in the world. In addition, it is possible to expect a greater emphasis on the autonomy of means of transportation and the safety issues that this trend will bring. Finally, as mentioned in the introduction, sustainability is one of the leading indicators and pillars of transportation, not only at present but also will be in the future, and safety is one of its main parts. This is also why it is necessary to pay close attention to safety research and topics that directly reflect current trends in transportation.

To sum up, it is possible to evaluate that hypothesis H1 is true because the research proved that the main topics in the research were almost identical for all modes of transportation; hypothesis H2 was not confirmed because the keywords differed significantly, which highlights the differences in the selected modes of transportation, and hypothesis H3 was approved. After all, the research was multidisciplinary and dealt with several topics that complemented each other. The multidisciplinary nature of safety research in terms of transportation has been demonstrated by the variety of topics which, in their essence, deal with various issues from management (safety requirements imposed on operators, drivers, etc.), to legislation (safety rules, regulations, laws), to the human factor (human factor errors, behavior models), technologies used (supporting safety, autonomy), or safe maintenance. From the point of view of safety, this multidisciplinary nature is vital because safety affects all topics, and natural importance is placed on it.

Author Contributions: Conceptualization, M.B. and P.K.; methodology, M.B.; software, M.B.; validation, M.T., M.O. and P.K.; formal analysis, M.B.; investigation, P.K. and M.O.; resources, M.T.; data curation, M.B.; writing—original draft preparation, M.B. and M.T.; writing—review and editing, M.B. and P.K.; visualization, M.B. and M.T.; supervision, M.B.; funding acquisition, M.B. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by the financial support from project ITMS code 313011T567 and ITMS code 313011AUP1.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: Not applicable.

Acknowledgments: This article is part of the project New possibilities and Approaches of Optimization within Logistic Processes in the field of Transportation and Transportation Systems, ITMS code 313011T567, and was also supported by the project Mobile Monitoring System for the Protection of Isolated and Vulnerable Population Groups against Spread of Viral Diseases, ITMS code 313011AUP1, co-funded by the European Regional Development Fund under the Operational Programme Integrated Infrastructure.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Illahi, U.; Mir, M.S. Assessment of transport sustainability using a hybrid approach: A comparison of four metropolitan cities of India. *Case Stud. Transp. Policy* **2021**, *9*, 703–714. [CrossRef]
2. Bolobonov, D.; Frolov, A.; Borremans, A.; Schuur, P. Managing public transport safety using digital technologies. *Transp. Res. Procedia* **2021**, *54*, 862–870. [CrossRef]
3. Jharko, E.; Sakrutina, E. Towards the problem of creating a safety management system in the transportation area. *IFAC-PapersOnLine* **2017**, *50*, 15610–15615. [CrossRef]
4. Blokland, P.J.; Reniers, G.L. The Concepts of Risk, Safety, and Security: A Fundamental Exploration and Understanding of Similarities and Differences. In *The Coupling of Safety and Security: Exploring Interrelations in Theory and Practice*; University of Toulouse: Toulouse, France, 2020; pp. 9–16.
5. Rodrigue, J.-P.; Comtois, C.; Slack, B. Transportation modes, modal competition and modal shift. In *The Geography of Transport Systems*; Taylor & Francis Group: London, UK, 2016. Available online: <https://transportgeography.org/> (accessed on 23 February 2023).
6. Commings, N.; Nolan, A. The determinants of mode of transport to work in the Greater Dublin Area. *Transp. Policy* **2011**, *18*, 259–268. [CrossRef]
7. Javaid, A.; Creutzinger, F.; Bambers, S. Determinants of low-carbon transport mode adoption: Systematic review of reviews. *Environ. Res. Lett.* **2020**, *15*, 103002. [CrossRef]
8. Elvik, R.; Bjørnskau, T. How accurately does the public perceive differences in transport risks?: An exploratory analysis of scales representing perceived risk. *Accid. Anal. Prev.* **2020**, *37*, 1005–1011. [CrossRef]
9. Zheng, J.; Garrick, N.W.; Atkinson-Palombo, C.; McCahill, C.; Marshall, W. Guidelines on developing performance metrics for evaluating transportation sustainability. *Res. Transp. Bus. Manag.* **2013**, *7*, 4–13. [CrossRef]
10. Toth-Szabo, Z.; Várhelyi, A. Indicator framework for measuring sustainability of transport in the city. *Procedia-Soc. Behav. Sci.* **2012**, *48*, 2035–2047. [CrossRef]
11. Friman, M.; Lättman, K.; Olsson, L.E. Public transport quality, safety, and perceived accessibility. *Sustainability* **2020**, *12*, 3563. [CrossRef]
12. Wang, C.; Quddus, M.A.; Ison, S.G. The effect of traffic and road characteristics on road safety: A review and future research direction. *Saf. Sci.* **2013**, *57*, 264–275. [CrossRef]
13. Stoop, J.A.; Thissen, W.A. Transport safety: Trends and challenges from a systems perspective. *Saf. Sci.* **1997**, *26*, 107–120. [CrossRef]
14. Blokus-Roszkowska, A.; Montewka, J.; Smolarek, J. Modelling the accident probability in large-scale, maritime transportation system. *J. Pol. Saf. Reliab. Assoc.* **2012**, *3*, 237–244.
15. Shyur, H.-J. A quantitative model for aviation safety risk assessment. *Comput. Ind. Eng.* **2008**, *54*, 34–44. [CrossRef]
16. Leitner, B. A general model for railway systems risk assessment with the use of railway accident scenarios analysis. *Procedia Eng.* **2017**, *187*, 150–159. [CrossRef]
17. Lee, W.-K. Risk assessment modeling in aviation safety management. *J. Air Transp. Manag.* **2006**, *12*, 267–273. [CrossRef]
18. Jafarian, E.; Rezvani, M. Application of fuzzy fault tree analysis for evaluation of railway safety risks: An evaluation of root causes for passenger train derailment. *Proc. Inst. Mech. Eng. Part F J. Rail Rapid Transit* **2012**, *226*, 14–25. [CrossRef]
19. Erkut, E.; Ingolfsson, A. Transport risk models for hazardous materials: Revisited. *Oper. Res. Lett.* **2005**, *33*, 81–89. [CrossRef]
20. Marcotte, P.; Mercier, A.; Savard, G.; Verter, V. Toll policies for mitigating hazardous materials transport risk. *Transp. Sci.* **2009**, *43*, 228–243. [CrossRef]
21. Dong, S.; Zhou, J.; Ma, C. Design of a network optimization platform for the multivehicle transportation of hazardous materials. *Int. J. Environ. Res. Public Health* **2020**, *17*, 1104. [CrossRef]
22. Tubis, A.; Werbińska-Wojciechowska, S. Operational risk assessment in road passenger transport companies performing at Polish market. In *Article Prepared for Conference European Safety and Reliability ESREL*; Wrocław University of Technology: Wrocław, Poland, 2017; pp. 18–22.
23. Galagedera, S.; Pasindu, H.; Adikariwattage, V. Evaluation of operational risk factors at runway high speed exits. *Transp. Res. Procedia* **2020**, *48*, 32–46. [CrossRef]
24. Liu, X. Analysis of collision risk for freight trains in the United States. *Transp. Res. Rec.* **2016**, *2546*, 121–128. [CrossRef]

25. Langard, B.; Morel, G.; Chauvin, C. Collision risk management in passenger transportation: A study of the conditions for success in a safe shipping company. *Psychol. Française* **2015**, *60*, 111–127. [\[CrossRef\]](#)
26. Tonn, G.; Kesan, J.P.; Zhang, L.; Czajkowski, J. Cyber risk and insurance for transportation infrastructure. *Transp. Policy* **2019**, *79*, 103–114. [\[CrossRef\]](#)
27. Ezell, B.C.; Michael Robinson, R.; Foytik, P.; Jordan, C.; Flanagan, D. Cyber risk to transportation, industrial control systems, and traffic signal controllers. *Environ. Syst. Decis.* **2013**, *33*, 508–516. [\[CrossRef\]](#)
28. Papadimitriou, E.; Schneider, C.; Tello, J.A.; Damen, W.; Vrouwenraets, M.L.; Ten Broeke, A. Transport safety and human factors in the era of automation: What can transport modes learn from each other? *Accid. Anal. Prev.* **2020**, *144*, 105656. [\[CrossRef\]](#) [\[PubMed\]](#)
29. Fan, S.; Yang, Z. Safety and security co-analysis in transport systems: Current state and regulatory development. *Transp. Res. Part A* **2022**, *166*, 369–388. [\[CrossRef\]](#)
30. Mattsson, L.-G.; Jenelius, E. Vulnerability and resilience of transport systems—A discussion of recent research. *Transp. Res. Part A Policy Pract.* **2015**, *81*, 16–34. [\[CrossRef\]](#)
31. Evans, L. Transportation Safety. *Int. Ser. Oper. Res. Manag. Sci.* **1999**, *23*, 63–108.
32. Boettger, R.K.; Palmer, L.A. Quantitative content analysis: Its use in technical communication. *IEEE Trans. Prof. Commun.* **2010**, *53*, 346–357. [\[CrossRef\]](#)
33. Stemler, S. An overview of content analysis. *Pract. Assess. Res. Eval.* **2000**, *7*, 17.
34. Kohlbacher, F. The use of qualitative content analysis in case study research. In *Forum Qualitative Sozialforschung/Forum: Qualitative Social Research*; Institut für Klinische Psychologie und Gemeindeforschung: Berlin, Germany, 2006; pp. 1–30.
35. Kyngäs, H. Qualitative research and content analysis. In *The Application of Content Analysis in Nursing Science Research*; Springer: Cham, Switzerland, 2020; pp. 3–11.
36. Cretchley, J.; Rooney, D.; Gallois, C. Mapping a 40-year history with Leximancer: Themes and concepts in the Journal of Cross-Cultural Psychology. *J. Cross-Cult. Psychol.* **2010**, *41*, 318–328. [\[CrossRef\]](#)
37. Dang, Q.T.; Rammal, H.G.; Michailova, S. Expatriates' families: A systematic literature review and research agenda. *Hum. Resour. Manag. Rev.* **2022**, *32*, 100877. [\[CrossRef\]](#)
38. Xu, J.; Chung, K.-H.M.; Zhang, X.; Tavitiyaman, P. Fostering Work-integrated Learning in Hospitality and Tourism: An Integration of Leximancer and Students' Self-reflective Statement Approaches. *J. China Tour. Res.* **2022**, *18*, 1330–1354. [\[CrossRef\]](#)
39. Young, L.; Wilkinson, I.; Smith, A. A Scientometric Analysis of Publications in the Journal of Business-to-Business Marketing 1993–2014. *J. Bus. Bus. Mark.* **2015**, *22*, 111–123. [\[CrossRef\]](#)
40. Liesch, P.W.; Håkanson, L.; McGaughey, S.L.; Middleton, S.; Cretchley, J. The evolution of the international business field: A scientometric investigation of articles published in its premier journal. *Scientometrics* **2011**, *88*, 17–42. [\[CrossRef\]](#)
41. White, M.D.; Marsh, E.E. Content analysis: A flexible methodology. *Libr. Trends* **2006**, *55*, 22–45. [\[CrossRef\]](#)
42. Aksnes, D.W.; Langfeldt, L.; Wouters, P. Citations, citation indicators, and research quality: An overview of basic concepts and theories. *Sage Open* **2019**, *9*, 2158244019829575. [\[CrossRef\]](#)
43. Chance, M.D.; Ferris, S.P. The effect of aviation disasters on the air transport industry. *J. Transp. Econ. Policy* **1987**, *21*, 151–165.
44. Dostál, I.; Adamec, V. Transport and its Role in the Society. *Trans. Transp. Sci.* **2011**, *4*, 43. [\[CrossRef\]](#)
45. Wegman, F. The future of road safety: A worldwide perspective. *IATSS Res.* **2017**, *40*, 66–71. [\[CrossRef\]](#)
46. Hetherington, C.; Flin, R.; Mearns, K. Safety in shipping: The human element. *J. Saf. Res.* **2006**, *37*, 401–411. [\[CrossRef\]](#) [\[PubMed\]](#)
47. Mallozzi, P.; Pelliccione, P.; Knauss, A.; Berger, C.; Mohammadiha, N. Autonomous vehicles: State of the art, future trends, and challenges. In *Automotive Systems and Software Engineering: State of the Art and Future Trends*; Springer: Berlin/Heidelberg, Germany, 2019; pp. 347–367.
48. Leveson, N.G. Applying systems thinking to analyze and learn from events. *Saf. Sci.* **2011**, *49*, 55–64. [\[CrossRef\]](#)
49. Lucas, K. Transport and social exclusion: Where are we now? *Transp. Policy* **2012**, *20*, 105–113. [\[CrossRef\]](#)
50. Rodrigue, J.P. *The Geography of Transport Systems*; Routledge: New York, NY, USA, 2020; pp. 151–206.

Disclaimer/Publisher's Note: The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of MDPI and/or the editor(s). MDPI and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.