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Railway safety analysis: trends and challenges

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Rail transport has been changing the mobility of people. The Railway's development has pointed the focus on the safety management of trains and infrastructure, particularly related to passengers. This paper focuses on the methods adopted to guarantee high safety in railways; for this reason, it was interesting to present a literature analysis about this topic. The authors short-listed 48 articles for in-depth analysis. Bibliometric research and a thorough literature assessment were conducted to evaluate the safety management in the Railway area. Today, the attention of experts and railway managers is very high on high-speed railways because of their high-risk levels.
For this reason, many advanced technologies have been developing all over the World, thanks to the new artificial intelligence tools and machine learning, to guarantee a constantly high degree of safety. Especially the stations and specifically, the platform zones, are crucial hotspots for railway accidents, particularly suicide events. Some prevention techniques showed an increment in safety quality and made Railway the safest transport infrastructure. So, a resilient model applied to safety railways could improve even more substantial safety degree.

Keywords: Safety, Railway, Station, Train, Literature review, Accidents.

1. Introduction

Railways are the principal mode of transport worldwide for short, medium and long-distance.
Over the years, scientific studies have focused on the research of methods to raise the speed and the safety of trains. This paper aims to highlight the many problems that affect the railway network, a problem to which the World's attention is extremely close.
Today many critical events affect railway safety: collisions caused by the level of intersection between railroad tracks and roadways, accidents brought on by inadequate infrastructure, and railway structures (Cortis, 2021) such as railroad switch problems (Bădău, 2022) or general management troubles, human errors, and accidental events like people overwhelm or suicides. It is also important to analyse the safety degree of train station weaknesses, such as the noise that excessively impacts daily life (Yildirim, 2021), and new ways to react to critical safety situations (Han, 2020).

Hence, the control of railway traffic is a crucial aspect of railway safety: nowadays, new methods for risk analysis about the localisation of trains are being developed to guarantee the performance requirements of Reliability, Availability, Maintainability, and Safety (RAMS): relevant are the new technologies regarding the Global Navigation Satellite System (GNSS) (Debiao, 2020) and the development and assessment of a high-speed rail communication system, particularly for the Long-Term Evolution railway system (Wen, 2020; Ahmad, 2020).
The incredible rise of the expansion of high-speed rail, lower tracking intervals, a more complex operating environment, and shorter departure times are all results of larger train fleet sizes and shorter departure times. (Shangguan, 2022; Lin, 2021) So it is crucial to improve the general level of safety in the railway setting.
Train operation and the issue of train combinations on station platforms are two of the fundamental scheduling issues for railway safety: this aspect increases the

complexity of train traffic problems, particularly in high-speed stations. This aspect is critical for ensuring the safety of users, which number is increasing with an exponential law (Wijayanto, 2022).
It is demonstrated that the decomposition processes of trains and stations can improve, for example, the occupancy balance of platform tracks and, consequently the safety of the total system (Xu, 2022). However, the consequence of an incident between a person and a train always has terrible consequences: suicide by train is a common case worldwide: victims place their bodies across the railroad tracks, leap in front of a moving train, or stand in front of it in order to be hit by it. (Woolery, 2021; Sahu, 2021; Preuss, 2020).

Train drivers may experience significant psychological repercussions as a result of general railway accidents and suicides, so it is also essential to introduce support protocols (Bardon, 2021).
Transport demand for railroad transportation is increasing rapidly, both for passengers and goods, so accidental events that affect the interruption of the service cause relevant economic damages and, obviously, disservices to users (Zhang, 2020).
Moreover, recent studies have shown how perceived safety has an important gap with actual safety and this aspect can affect travel behaviour before and during the journey: it is demonstrated how some factors, such as security personnel in stations or a better level of maintenance, can improve the safety (Coppola, 2021).
This paper aims to value the state of the art of railway safety: focusing on actual technologies to guarantee platform safety in stations is the first point of analysis. These places, in fact, are hotspot ones for personnel and travellers' safety: the section of the platform closest to the tracks where people are in danger of losing their physical integrity as a result of a train going through, arriving at, or departing the station (Schneider, 2021).
The remainder of this paper is organised as follows: in Section 2 "Research Questions"; in Section 3, "Review Protocol"; in Section 4 ", Current Safety Management"; in Section 5 ", Station Safety"; in Section 6 "Platform Accidents And Suicides Case – Global Situation"; in Section 7 "Conclusion".
Three research questions are proposed from analysing the articles researched in the bibliography and selecting the most relevant keywords.

The following research questions were used to guide the review:

RQ1. What are the hotspots of safety on the railroad?

RQ2. What are the current trends in the field of platform safety?

RQ3. What are new directions in research and applications for the prevention of platform accidents?

The writers conducted a methodical examination of the literature and adhered to a review process of previously published papers and reviews.

2. Methodology

Relevant articles were found and chosen using the Scopus database. A bibliometric analysis of the pertinent contributions of the authors, institutes, nations, and journals was also conducted.

The study started with the research objectives, in which the research objectives have been framed.
The first stage of review, which involved using the Scopus database's database selection, keyword, inclusion-exclusion criteria, etc., is also included in the second phase. The second review stage, which involved a deep screening, came after the first review stage as the next action. Finally, review, bibliometric, and network analysis are part of the third review stage.

3. Review Protocol

Accurate drafting of literature analysis is based on compliance with a rigorous standardised work protocol developed by a group of experts in 2005 and known by the acronym of PRISMA (Preferred Reporting Items for Systematic reviews and Me-ta-Analyses) Statement (Gurevitch, 2018). About a decade after the latest version, the PRISMA statement's major update was produced.

3.1 Databases, keywords, inclusion criteria

Information collection developed in this paper was carried out through a systematic review of the literature, allowing an exhaustive knowledge of state of the art relating to the subject matter. The first step was to identify a clear and effective studies localisation, selection, and inclusion strategy. Next, studies research relevant to the railway safety topic was carried out by placing specific queries on the Scopus database (http://www.scopus.com). Queries consist of entering specific keywords in the search engine: "Safety," "Railway," "Station," "High-speed Train," "Suicide Railway".

Queries chosen for the acquisition of the working database are listed below in chronological order:

- **Query 1**: "Safety", "Railway" and "Stations" in tiles-abstracts-keywords. This search returns 1406 documents. The publication window was restricted to the years 2020 through 2022. Additionally, only the English language was used in the studies. Finally, only scientific reviews and articles are considered (f.e. conference papers were excluded). The result is 151 documents as a result of these restrictions.
- **Query 2**: "Suicide" and "Railway" in tiles-abstracts-keywords. This search returns 318 documents. The publication window was restricted to the years 2020 through 2022. Additionally, only the English language was used in the studies. Finally, only scientific reviews and articles are considered (f.e. conference papers were excluded). The result is 40 documents as a result of these restrictions.

- **Query 3**: “High-speed trains" and "Safety", and "Station" in titles-abstracts-keywords. This search returns 443 documents. The publication window was restricted to the years 2020 through 2022. Additionally, only the English language was used in the studies. Finally, only scientific reviews and articles are considered (f.e. conference papers were excluded). The result is 57 documents as a result of these restrictions.
- **Query 4**: “Safety” and “Train” in titles-abstracts-keywords. This search returns 5710 documents. The publication window was restricted to the years 2020 through 2022. Additionally, only the English language was used in the studies. Finally, only scientific reviews and articles are taken into consideration (f.e. conference papers were excluded). The result is 137 documents as a result of these restrictions.

The result was to obtain 385 papers, reduced to a final database of 48 papers due to the exclusion of duplicates and eliminating all anonymous articles and all articles classified as "journal papers”. A further selection was made by discarding all the articles that did not specifically concern the subject matter with a screening.

In order to help the writers convey their complete work, from the title to the conclusions, efficiently and transparently, Figure 1 outlines the screening, selection, and inclusion procedure for articles.

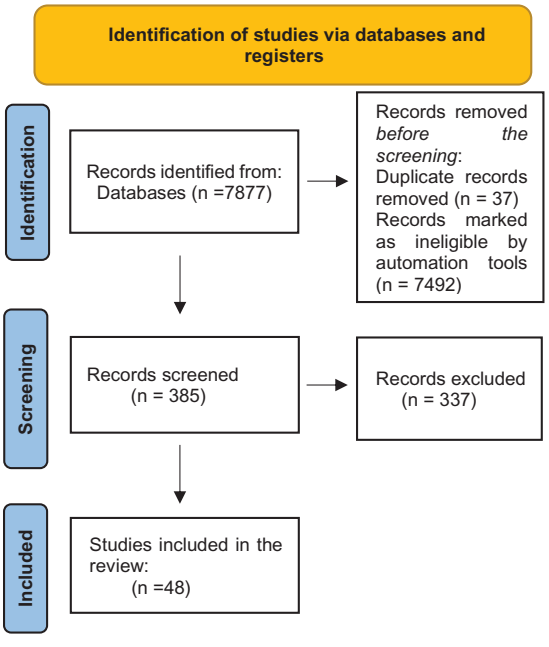

Fig. 1 - PRISMA 2020 flow diagram for new systematic reviews which included searches of databases and registers only

3.2. Classification

All 48 papers of the database, obtained previously, have been classified into two types:

i. **Article papers** (45), i.e., original research is reported in articles referred to as empirical or primary sources. An introduction, sections describing the procedures, and sections summarising the findings will normally be present.
ii. 2. **Review papers** (3): i.e., papers synthesise or analyse research that has already been undertaken in primary sources and are sometimes referred to as literature reviews or secondary sources. They often provide an overview of the state of the research on a certain subject.

3.3 Keywords analysis

This paragraph analyses all the various keywords obtained from the creation of the database. The results obtained correspond to those expected; the keywords most present, “Railway”, ”Railroad”, ”Railroad transportation” and “Safety”, are those used to research various queries. A possible observation is that some keywords, such as “Suicide” and “Human” are also very frequent.

The reason is simple, and the "Railway" and "Safety" themes have the main link with human and accidental aspects.

Looking at Figure 2 it is possible to note the relevance of keywords.

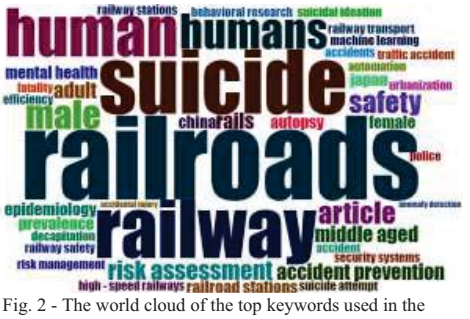

Fig. 2 - The world cloud of the top keywords used in the selected articles on the fields of railway safety

3.4 Authorship and collaboration

The total number of authors who worked on publishing the papers collected in the database is 185.

4. Current Safety Management

In the years, many scientific studies focused on the research of methods to raise the speed and the safety of trains. However, when a train derails, it can primarily result in financial losses in the form of crushed infrastructure or rolling stock, as well as more serious casualties and operational disruptions, all of which significantly negatively affect the railway industry's ability to develop sustainably.

Given the dynamic operational contexts, risk response is certainly highlighted as one of the most important aspects of the risk management process.
Since train and railways safety are complex, safety management is undoubtedly a critical issue to investigate.
Over 83% of all severe accidents on European railroads are due to obstructions on the track, and over 99% of all fatalities in rail transportation are attributable to such accidents. Each year, similar accidents on EU railroads result in the deaths of over 1,000 individuals (Rosić S., 2022).
Numerous research are analysing novel accident risk response techniques that can give railway safety managers and engineers a reliable and useful tool to select the optimum risk response strategy. (Zhang, 2020; Liu, 2020; Zhang, 2020; Catelani, 2021).
The high-speed railway system must get special attention since the safety of those facilities directly impacts the high-speed railway system's operational integrity: personnel, equipment, environment, and organisation management work together to control and achieve specific operation safety purposes.
Nowadays, automation is the new trend in railways development to increase its quality while maintaining a very high level of safety, mainly after electrification and the introduction of high-speed trains: is the base of the third revolution in the development of railway traffic. (Ramirez, 2022)
For this reason, artificial intelligence is a key tool for implementing safety automation instruments: autonomously operated trains, with the obstacle detection system, can increase the existing level of safety with the elimination of human errors and the recognition of obstacles in difficult conditions; and it can significantly increase transportation efficiency and decrease railway headway. (Chen, 2021).
Another recurrent problem is the lack of communication between trains. There is no direct information transfer between trains since each one uses the Global System for Mobile Communications-Railway (GSM-R) to interact with a Radio Blocking Center (RBC) and get Movement Authority (MA) to ensure its safe operation. (Wu, 2022). Many accidents occurred in the last years due to lack of communication, so experts are investigating new ways of communication-based artificial intelligence that can prevent railways disasters with the help of GPS and radar analysis. An example is the Centralised Traffic Control (CTC) system: an automated command system for remotely controlling railway operations that combines computer technology, network communication technology, and current control technology. (Zhang, 2022).
Machine Learning (ML) is now presented. ML is implemented to analyse accidents and enhance safety systems. Due to its capacity to draw relevant information from big data sets, it is a method for learning information through self-learning approaches that has been applied in every industry. For instance, the UK sector in charge of the trains has plans to digitise the sector.
Thus, the safety of stations and technology can be used to recognise any deficiency in those stations.
A viable way to overcome uncertainty is machine learning (ML) methodology, which can learn from past data., as demonstrated in some simulations in the literature (Alawad, 2020). An application of ML is the implementation of an intelligent monitoring system for the platform security gate. This intelligent system adopts wireless communications to implement a self-automated organisation to manage the platform gates and improve safety (Li, 2022).
In China, where there is the largest high-speed railway network (more than 40.000 km), the attention to railway safety is very close, as demonstrated by the number of articles regarding this aspect in the literature. In particular, China and Japan, as leading countries in Railway Technology in the World, have done a lot of work in accident prevention and safety (as shown in fig. 4 for China and in fig. 5 for Japan). Selecting the time interval of the reviewed articles between 2020 and 2022 showed that China in a short time had a significant improvement on rail accident safety and prevention. The comparison was made with Japan as its safety standards are the benchmark for the Asian continent. Data for Europe and the United States were omitted as they were comparable with japanese ones.

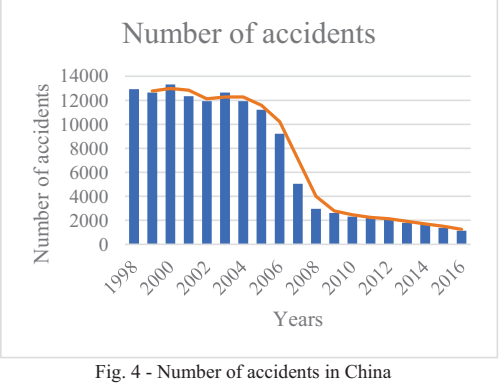

Fig. 4 - Number of accidents in China

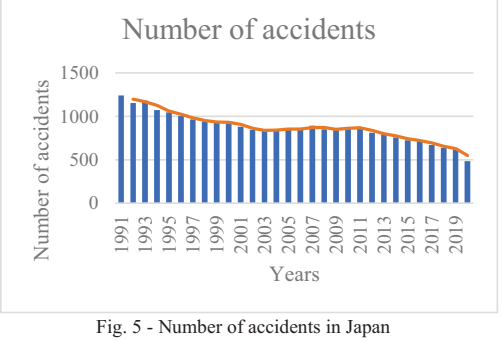

Fig. 5 - Number of accidents in Japan

The cases of accidents are various, but a preponderant part is made of train derailments, train conflicts, fatal accidents, and level-crossing accidents. In particular,

incidents brought on by other railroad employees result in the most fatalities in China. (Cao, 2022).
In India, there is a critical situation; in particular, a study of 2020 highlights how the movements of the fatalities across Railway line is one of the main causes of railway accidents: standing on the track, roof top travelling, and getting into running train are some examples (Kowsil, 2020).

5. Discussion Safety Station

Cities all across the World have benefited greatly from investments in stations in terms of the economy and environment. To raise the overall standard of safety stations, Italy has specifically advocated a strategic programme for improving current infrastructure and renovating outdated stations across the national territory. (Coppola, 2022).
With the global high-speed network rail expansion, the high-speed railway passenger station is a very important hotspot for safety. The high-speed railway passenger station is an evolution of the standard railway passenger station: It is evolving into a brand-new class of urban transportation hub. Consequently, the high-speed railway passenger station adopts a significant amount of new technologies and apparatus, which introduces new characteristics to transportation organisation, passenger service, and station management, such as multipart building structure, numerous internal apparatus, compact layout, wide traffic radiation, large passenger flow, and more concealed complex points.

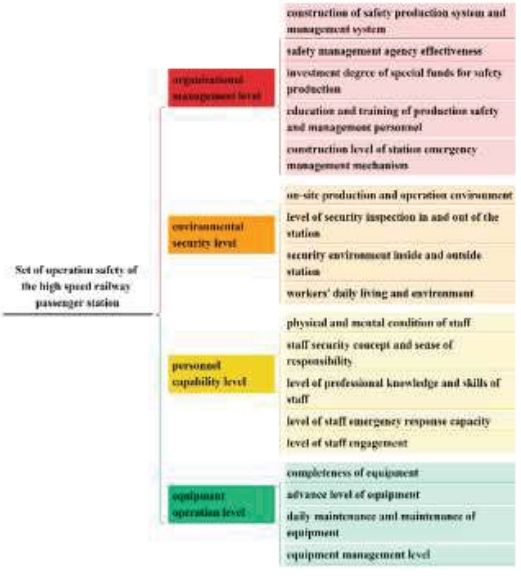

Fig. 6 - Set of operation safety of the high-speed railway passenger station

Figure 6 is reported a set of operation safety of the high-speed railway passenger station base on the study (Wang, 2020): in the diagram (created with the mind mapping software XMind), it is possible to note the higher level of importance of safety in the station management and how the relative security aspects are subdivided.
Moreover, it is important to highlight the travellers' choice of the main critical issues: an Italian study shows how road crossings are crucial aspects of railway safety. (Coppola, 2020)
An essential component of the transportation infrastructure is the level crossing. Here, the two types of traffic-regulated and unregulated-interact. Vehicles in the controlled rail traffic cross those in the unregulated road traffic. A rather small area is covered by this practise. However, the integrated processes are focused on long distances and medium speeds.
Additionally, it's important to consider the scene identification issue at level crossings, as seen from the train driver's perspective.

6. Platform accidents and suicides cases – the global situation

The platform is the most critical point in the complex system of the railway passenger station. The accidents that occur in the platform area have the worst consequences, both for people's life and the railway network. In particular, the aspect of suicides is the most relevant problem, and this paper aims to focus on this viewpoint. Many people tend to commit suicide on train tracks because they perceive instantaneous and certain death, plus it's seen as a good way to die. (Duddin, 2021).
A study in Japan illustrates the hotspots where accidents events take place: of 50 suicides, 48.0% occurred in front of benches or waiting rooms, 26.0% occurred at the front end of the platform, 24.0% occurred at the entrance to the platform, and 22.0% occurred at a blind spot for the train driver (Sueki, 2022).
In Uk, indeed, every year, around 6000 suicides are recorded (Katsampa, 2022).
The first way to control and prevent these fatal accidents is modern Rail Network Surveillance; a case study on implementing an automatic sensor that can evaluate possible accidents has reported very good results (Zhang, 2022).
Numerous studies today show how bystanders might be crucial in situations involving alleged suicide attempts on railroad networks. Such incidents can occur at times or places where only onlookers can respond by taking immediate action or sounding the alarm.
In Australia, a survey shows that over the period 2011-2019, the number of deaths by rail suicide decreased by 73% (Ngo, 2021).
The train crossing level, as already said, represents a critical place for railway safety; a survey on the prevention of railway suicides in Australia through level crossing removal has shown a direct impact in decreasing the number of fatal accidents (Clapperton, 2022).
So the planning for major infrastructure projects over old lines can give a relevant upgrading of railway safety.

Also, in Japan, and in particular in Tokyo train station, the use of blue lights is decreasing the number of fatal accidents.
Nearly 3,000 suicides on trains occurred each year in Europe between 2012 and 2016, accounting for 73% of all fatalities on European railroads. (European Union Agency for Railways, 2018). Furthermore, as the population grows, the need for mobility is increasing and the strategies for reducing environmental impact (such as CO2 emissions) entail increasing rail transport volumes: for this reason, more railway suicides can be expected, and the attention on safety goals is very close. These arguments have led to the EU RESTRAIL project, which illustrates new tools for reducing suicides. Some examples of measures focused on suicide prevention are the installation of mid-platform fencing, gatekeeper training for front-line staff, anti-trespass grids, and the installation of forward-facing closed-circuit cameras on train CCTV.
The safety recommendations illustrated in the European project can be divided into three phases:

- *1st phase*: immediate safety actions on site and reporting the circumstances;
- *2nd phase*: on-site management of an incident and provision of support responding bodies;
- *3rd phase*: restoration of routine operation.

(Restrail, 2022)

A statistical survey in the Netherlands has revealed a discrepancy between expected and observed numbers of railway suicides since 2012 (Van Houwelingen, 2021). This divergence directly affects the implementation of safety features and encourages investments in railway safety systems in preventive measures.
In Denmark, a study illustrates critical places for suicides in stations, and the consecutive installation of signs, physical barriers, and motion-sensitive lights has brought in the next 14 months no suicides death cases (Erlangsen, 2021).
In Sweden, research concerns the restriction of access to suicide methods in the form of different physical barriers. In particular, the use of mid-track fencing between the high-speed and commuter train tracks was analysed. During the period of the study 2002-2021, the results on the line outside Stockholm demonstrated that suicides at highspeed tracks occurring at stations were the major cause of death on the investigated railway line. It is relevant that an easy to install and cheap mid-track fencing can largely decrease the number of suicides on a train line (Fredin-Knutzén, 2022).
Another proposal to improve station safety can be the installation of full-height platform screen doors, above all in stations with high-speed trains passing by.
In Finland, an important study has analysed all known measures for preventing railway suicides: some top safety measures adopted are the training of railway personnel, camera surveillance (a method already seen in other parts of the World), and detection systems like radar and movement sensors. The study's results effectively improve the railway system's safe functioning, reducing delays in train traffic and work-related stress and trauma to railway staff. (Silla, 2022).
The research propositions can be included in this study's conclusion to guide future research on railway safety, including the key points of this work.

RS1: An increment of users in public transport requires an higher attention to railway safety;
RS2: Suicides are a common type of accident in Railway: the prevention and the techniques adopted in the World;
RS3: How a resilient model of railway safety can improve the general level of safety in stations and in the entire railway system.

Future concrete work illustrating the use of novel safety methods in intelligent railway systems, where information regarding the techniques or epistemologies employed by safety experts can be considered for analysis, is anticipated. The researchers can also use the research proposals for additional analysis.

7. Conclusions

The increase in the use of public transport globally has increasingly raised concerns about the safety importance in railways. Therefore, there is an urgent need to implement new safety ways to help people and, in general, societies be more confident in the railway system, which manages sustainable and circular economies. This can be partially achieved by implementing new safety systems that can reduce the risk level in railways and avoid economic and life losses.
A literature review of railway safety shows the actual methods adopted worldwide: the articles found in the literature show how the importance of safety is extremely high in China, the state with the longest high-speed Railway, and in Europe, which states are analysing many critical aspects of railway safety.
This study highlighted how the futuristic tools of artificial intelligence and machine learning could help the improvement of safety levels. For this reason, the collaboration between humans and robots is fundamental, and understanding how to improve this link is a key aspect of future research for railway safety.
This article focused attention on safety in the platforms zone of stations. The platform, in fact, is a crucial hotspot for railway accidents that involve people: in particular, the study examined the case of train suicides. Suicides are very recurrent accidents on Railway. Many methods to reduce the number of these tragic events are analysed in this study, in particular, European Union invested in the project RESTRAIL, which principal aim is the prevention of suicides in the European Railway.
Adopting new safety measures can aid in the collaboration of government leaders, service providers, and users to improve the transportation sector more broadly and develop safe, smart communities.
Additionally, a resilient model might be constructed to comprehend safety issues better, as indicated in the fatal incidents, which can be used to increase data collection on safety deficiencies and strengths for changes.

References

Ahmad, I., & Chang, K. (2020). Mission-critical user priority-based cooperative resource allocation schemes for multi-layer next-generation public safety networks. Physical communication, 38 doi:10.1016/j.phycom.2019.100926

Alawad, H., Kaewunruen, S., & An, M. (2020). A deep learning approach towards railway safety risk assessment. IEEE Access, 8, 102811-102832. doi:10.1109/ACCESS.2020.2997946

Alawad, H., Kaewunruen, S., & An, M. (2020). Learning from accidents: Machine learning for safety at railway stations. IEEE Access, 8, 633-648. doi:10.1109/ACCESS.2019.2962072

Bădău, F. (2022). railway interlockings – a review of the current state of railway safety technology in europe. [centralizări feroviare: o recenzie a stării tehnologiei de siguranță feroviară din prezent în europa] Promet - Traffic - Traffico, 34(3), 443-454. doi:10.7307/PTT.V34I3.3992

Bardon, C., Dargis, L., & Mishara, B. (2021). Evaluation of the implementation of a Railway critical incident management and support protocol to help train drivers cope with accidents and suicides. Journal of Occupational and Environmental Medicine, 63(8), E495-E504. doi:10.1097/JOM.0000000000002262

Cao, Y., An, Y., Su, S., Xie, G., & Sun, Y. (2022). A statistical study of railway safety in china and japan 1990–2020. Accident Analysis and Prevention, 175 doi:10.1016/j.aap.2022.106764

Catelani, M., Ciani, L., Galar, D., Guidi, G., Matucci, S., & Patrizi, G. (2021). FMECA assessment for railway safety- critical systems investigating a new risk threshold method. IEEE Access, 9, 86243-86253. doi:10.1109/ACCESS.2021.3088948

Chen, W., Yang, J., Khasawneh, M. T., Fu, J., & Sun, B. (2021). Rules of incidental operation risk propagation in metro networks under fully automatic operations mode. PLoS ONE, 16(12) doi:10.1371/journal.pone.0261436

Clapperton, A., Dwyer, J., Spittal, M. J., Roberts, L., & Pirkis, J. (2022). Preventing Railway suicides through level crossing removal: A multiple-arm pre-post study design in victoria, australia. Social Psychiatry and Psychiatric Epidemiology, doi:10.1007/s00127-022-02340-9

Coppola, P., Dell'Olio, L., & Silvestri, F. (2021). Random-parameters behavioral models to investigate determinants of perceived safety in railway stations. Journal of Advanced Transportation, 2021 doi:10.1155/2021/5530591

Coppola, P., Deponte, D., Vacca, A., Messa, F., & Silvestri, F. (2022). Multi-dimensional cost-effectiveness analysis for prioritising railway station investments: A general framework with an application to the italian case study. Sustainability (Switzerland), 14(9) doi:10.3390/su14094906

Coppola, P., & Silvestri, F. (2020). Assessing travelers' safety and security perception in railway stations. Case Studies on Transport Policy, 8(4), 1127-1136. doi:10.1016/j.cstp.2020.05.006

Cortis, D., & Malavasi, G. (2021). Evaluation of the robustness of a railway measurement system by means of "design of computer experiments" techniques. [Valutazione della robustezza di un sistema di misura ferroviario mediante tecniche di "progettazione al calcolatore degli esperimenti"] Ingegneria Ferroviaria, 76(3), 181-197. Retrieved from www.scopus.com

Debiao, L., Dezhang, T., & Dirk, S. (2020). Hazard rate estimation for GNSS-based train localisation using model-based approach. Chinese Journal of Electronics, 29(1), 49-56. doi:10.1049/cje.2019.09.006

Duddin, K. S. E., & Raynes, B. (2021). Why choose the Railway?: An exploratory analysis of suicide notes from a sample of those who died by suicide on the Railway. Crisis, doi:10.1027/0227-5910/a000807

Erlangsen, A., La Cour, N., Larsen, C., Karlsen, S. S., Witting, S., Ranning, A., . . . Nordentoft, M. (2021). Efforts to prevent railway suicides in denmark: A pilot study. Crisis, doi:10.1027/0227-5910/a000827

Fredin-Knutzén, J., Hadlaczky, G., Andersson, A. -., & Sokolowski, M. (2022). A pilot study evaluating the effectiveness of preventing railway suicides by mid-track fencing, which restrict easy access to high-speed train tracks. Journal of Safety Research, doi:10.1016/j.jsr.2022.08.019

Gurevitch , J., Koricheva , J., Nakagawa, S., Stewart, G. Meta - analisi e scienza della sintesi della ricerca. Natura 2018 555(7695), 175-182. doi : 10.1038/natura25753

Gurevitch , J., Koricheva , J., Nakagawa, S., Stewart, G. Meta - analisi e scienza della sintesi della ricerca. Natura 2018 555(7695), 175-182. doi : 10.1038/natura25753

Han, L., Wu, H., & Chen, X. (2020). Wireless network architecture for evacuated tube transportation system. China Communications, 17(10), 206-217. doi:10.23919/JCC.2020.10.015

Katsampa, D., MacKenzie, J. -., Crivatu, I., & Marzano, L. (2022). Intervening to prevent suicide at railway locations: Findings from a qualitative study with front-line staff and rail commuters. BJPsych Open, 8(2) doi:10.1192/bjo.2022.27

Kowsil, G. L., Nagaraju, K. V., & Surendar, J. (2020). Analytical study of railway accidental deaths. Indian Journal of Forensic Medicine and Toxicology, 14(3), 1882-1887. Retrieved from www.scopus.com

Li, C., Niu, H., Shabaz, M., & Kajal, K. (2022). Design and implementation of intelligent monitoring system for platform security gate based on wireless communication technology using ML. International Journal of System Assurance Engineering and Management, 13, 298-304. doi:10.1007/s13198-021-01402-6

Lin, F., Wu, P., & Xu, Y. (2021). Investigation of factors influencing the construction safety of high-speed railway stations based on DEMATEL and ISM. Advances in Civil Engineering, 2021 doi:10.1155/2021/9954018

Liu, P., Xie, M., Bian, J., Li, H., & Song, L. (2020). A hybrid pso–svm model based on safety risk prediction for the design process in metro station construction. International Journal of Environmental Research and Public Health, 17(5) doi:10.3390/ijerph17051714

Makara-Studzinska, M., Czabański, A., Gronowska, K., Leszek, J., Mikhaylenko, E. V., Avila-Rodriguez, M. F., . . . Aliev, G. (2021). Statistical review of the suicide attempts rates committed on polish railway tracks between the years 2013-2016. Central Nervous System Agents in Medicinal Chemistry, 21(2), 85-92. doi:10.2174/1871524921666210204220621

Młyńczak, J., Folęga, P., & Celiński, I. (2021). Specifics of the traffic scene identification problem observed at level crossings, analysed from the train driver's perspective. Archives of Transport, 58(2), 81-97. doi:10.5604/01.3001.0014.8799

Ngo, N. V., Gregor, S. D., Beavan, G., & Riley, B. (2021). The role of bystanders in the prevention of railway suicides in new south wales, australia. Crisis, doi:10.1027/0227-5910/a000804

Preuss, V., Vennemann, B., & Klintschar, M. (2020). Just another railway fatality. International Journal of Legal Medicine, 134(5), 1785-1790. doi:10.1007/s00414-020-02247-7

Ramirez, R. C., Adin, N., Goya, J., Alvarado, U., Brazalez, A., & Mendizabal, J. (2022). Freight train in the age of self-driving vehicles. A taxonomy review. IEEE Access, 10, 9750-9762. doi:10.1109/ACCESS.2022.3144602

RESTRAIL (Reduction of Suicides and Trespasses on RAILway property, (2022) UIC Communications department, http://www.restrail.eu consulted on 07/12/2022

Rosić, S., Stamenković, D., Banić, M., Simonović, M., Ristić-Durrant, D., & Ulianov, C. (2022). Analysis of the safety level of obstacle detection in autonomous railway vehicles. Acta Polytechnica Hungarica, 19(3), 187-205.
Retrieved from www.scopus.com

Sahu, G., Mishra, A., Panda, A., & Hansda, M. K. (2021). pattern of fatalities during the covid 19 pandemic lockdown period: anautopsy based study. Journal of Forensic Medicine and Toxicology, 38(1), 92-97. doi:10.5958/0974-4568.2021.00018.1

Schneider, A., Krueger, E., Vollenwyder, B., Thurau, J., & Elfering, A. (2021). Understanding the relations between crowd density, safety perception and risk-taking behavior on train station platforms: A case study from switzerland. Transportation Research Interdisciplinary Perspectives, 10 doi:10.1016/j.trip.2021.100390

Shangguan, W., Luo, R., Song, H., & Sun, J. (2022). High-speed train platoon dynamic interval optimisation based on resilience adjustment strategy. IEEE Transactions on Intelligent Transportation Systems, 23(5), 4402-4414. doi:10.1109/TITS.2020.3044442

Silla, A. (2022). Identifying measures with the highest potential to reduce suicides on finnish railways. Applied Ergonomics, 102 doi:10.1016/j.apergo.2022.103748

Sueki, H. (2022). Characteristics of train stations where railway suicides have occurred and locations within the stations. Crisis, 43(1), 53-58. doi:10.1027/0227-5910/a000761

Van Houwelingen, C. A. J., Di Bucchianico, A., Beersma, D. G. M., & Kerkhof, A. J. F. M. (2021). Railway suicide in the netherlands lower than expected: Are preventive measures effective? Crisis, doi:10.1027/0227-5910/a000792

Wang, L., Jin, C., & Xu, C. (2020). An evaluative study of the operational safety of high-speed railway stations based on IEM-fuzzy comprehensive assessment theory. Journal of Information Processing Systems, 16(5), 1064-1073. doi:10.3745/JIPS.04.0188

Wen, Z. R., He, R. S., Ai, B., Zhang, B., Yang, M., Wang, W., Zhang, H. X. (2020). Measurement and modeling of LTE-railway channels in high-speed railway environment. Radio Science, 55(4) doi:10.1029/2019RS007050

Wijayanto, Y., Fauzi, A., Rustiadi, E., & Syartinili. (2022). A system dynamics model of urban railway demand prediction for safety and security improvement: Lessons learned from indonesian railway network. International Journal of Safety and Security Engineering, 12(2), 145-157. doi:10.18280/ijsse.120202

Woolery, S., & Prahlow, J. A. (2021). Train-related suicidal decapitation. Forensic Science, Medicine, and Pathology, 17(4), 730-733. doi:10.1007/s12024-021-00396-8

Wu, W., Song, H., Zhang, Z., Zhang, S., Trinckauf, J., & Dong, H. (2022). A bayesian game-based train protection method using train-to-train communication. IEEE Intelligent Transportation Systems Magazine, 14(4), 202-213. doi:10.1109/MITS.2021.3075840

Xu, J., Wang, Z., Yao, S., & Xue, J. (2022). Train operations organisation in High-Speed railway station considering variable configuration. Sustainability (Switzerland), 14(4) doi:10.3390/su14042365

Yildirim, Y., & Allen, D. J. (2021). Station facilities and noise assessment: A multilevel analysis on light rail train stations. Noise Control Engineering Journal, 69(4), 364-372. doi:10.3397/1/376933

Zhang, H., Qi, C., & Ma, M. (2022). Improved employee safety behavior risk assessment of the train operation department based on grids. Processes, 10(6) doi:10.3390/pr10061162

Zhang, H., & Sun, Q. (2020). An integrated MCDM approach to train derailment risk response strategy selection. Symmetry, 12(1) doi:10.3390/sym12010047

Zhang, Q., Zhuang, Y., Wei, Y., Jiang, H., & Yang, H. (2020). Railway safety risk assessment and control optimisation method based on FTA-FPN: A case study of chinese high-speed railway station. Journal of Advanced Transportation, 2020 doi:10.1155/2020/3158468

Zhang, T., Aftab, W., Mihaylova, L., Langran-Wheeler, C., Rigby, S., Fletcher, D., . . . Bosworth, G. (2022). Recent advances in video analytics for rail network surveillance for security, trespass and suicide Prevention—A survey. Sensors, 22(12) doi:10.3390/s22124324

Zhang, T., Li, X., Wu, D., Wang, H., Liu, J., & Zhang, D. (2022). Evaluating the safety control scheme of railway centralised traffic control (CTC) system with coloured petri nets. Sustainability (Switzerland), 14(18) doi:10.3390/su141811669

Zhang, Y., Zhong, Q., Yin, Y., Yan, X., & Peng, Q. (2020). A fast approach for reoptimization of railway train platforming in case of train delays. Journal of Advanced Transportation, 2020 doi:10.1155/2020/5609524