RETROSPECTIVE ANALYSIS OF DEATHS DUE TO RAILWAY ACCIDENTS – AN AUTOPSY BASED STUDY

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ABSTRACT:

Railway accidents are a significant cause of unnatural deaths, with fatal consequences often involving severe injuries and hemorrhage. This retrospective autopsy-based study was conducted at Government Medical College, Thiruvallur, analyzing railway accident fatalities over a period of 1 year from June 2021 to May 2022. A total number of 63 cases were examined using forensic autopsy records, police inquest reports, and hospital documentation. The study aimed to analyze the demographic profile, causes, and injury patterns associated with railway fatalities. The analysis of railway accident victims (N=63) reveals that males (88.9%) were significantly more affected than females (11.1%), with the highest incidence in the age group of 41-50 years. Accidents occurred most frequently on Mondays (20.6%) and Fridays (19.0%), with the lowest incidence on Saturdays (6.3%). Seasonally, the highest cases were recorded in summer and winter (36.5% each), while the rainy season accounted for 27.0% of cases. Head injuries were the most common cause of death (47.6%), followed by lower extremities (20.3%), and multiple body injuries (15.9%). Skull fractures (90.5%) and amputations (60.3%) were the most severe injuries. Over half of the victims (57.1%) were declared dead on arrival, while 42.9% died instantly on the spot. The leading cause of accidents was crossing the track to catch a train (39.7%), followed by being hit by a running train (33.3%) and committing suicide (19.0%). Overall, accidental deaths (79.4%) were more common than suicides (20.6%), emphasizing the need for enhanced railway safety measures. These findings highlight the urgent need for improved railway safety measures, including the placement of barriers, warning systems, and public awareness campaigns. The high prevalence of undetermined deaths also underscores the need for enhanced forensic investigations. Addressing these issues through policy interventions and infrastructure improvements could significantly reduce railway-related fatalities.

1. Introduction

Railway accidents remain a significant public health concern globally, with various studies highlighting the prevalence and nature of injuries sustained during these incidents. In South India, a study indicated that railway-related deaths accounted for 18% of total autopsies, a figure that aligns with findings from other regions, such as Kerala, which also reported substantial proportions of railway fatalities among autopsy cases (SS, 2024). This underscores the necessity of conducting comprehensive autopsy studies to elucidate the circumstances surrounding these deaths and to inform preventive measures.

Demographic factors play a pivotal role in understanding railway fatalities. Research has shown that both the young and old age groups are disproportionately affected by railway accidents, with specific determinants varying across these demographics (Chatterjee et al., 2022). The analysis of age-related risk factors can provide insights into the vulnerabilities of different populations, which is essential for tailoring safety interventions. Furthermore, studies from Turkey and various Asian countries, including India and Sri Lanka, corroborate the high incidence of railway-related deaths, emphasizing the need for targeted research in these regions to address the underlying causes of such fatalities (TUNÇEZ et al., 2023).

Autopsy findings are instrumental in distinguishing between ante-mortem and post-mortem injuries, particularly in cases involving railway accidents. The forensic examination must be meticulous, as the nature of injuries can significantly influence the determination of the manner of death (Jibril, 2021). For instance, in Mangalore, a retrospective analysis highlighted the importance of careful autopsy procedures to ascertain whether injuries were sustained prior to or during the railway incident. This distinction is vital for legal and medical investigations, as it can affect liability and the understanding of accident dynamics.

The causes of railway accidents are multifaceted, often involving a combination of human error, equipment failure, and environmental factors. A significant proportion of railway accidents are attributed to human errors, which can stem from increased workload and fatigue among railway personnel (Joy, 2024). Studies have indicated that nearly half of railway accidents result from decreased alertness or distraction, which underscore the critical need for improved safety protocols and training for railway staff (Fan et al., 2022). Additionally, the identification of systemic issues, such as unsafe behaviors and organizational factors, is essential for developing comprehensive safety strategies (Bhuiyan et al., 2023). In the context of forensic autopsies related to railway accidents, the

analysis of injury patterns is crucial. Research has shown that head trauma is a leading cause of death in traffic accidents, including those involving trains (Eslamdost et al., 2020). This finding is consistent across various studies, highlighting the need for enhanced protective measures for vulnerable populations, particularly pedestrians and cyclists near railway crossings. Furthermore, the distinction between accidental deaths and suicides in railway incidents is significant, as studies have indicated varying trends in different regions. For example, while accidents were more prevalent in Jaffna, a contrasting trend was observed in New York, where suicides outnumbered accidents (Mayorathan, 2023).

The role of environmental factors, such as the design and safety of railway infrastructure, cannot be overlooked. Studies have demonstrated that inadequate safety measures at level crossings contribute significantly to the incidence of railway accidents (Wisultschew et al., 2021). The implementation of advanced warning systems and improved infrastructure design is essential for mitigating risks at these critical points. Moreover, integrating technology, such as 3D-LIDAR for object detection at crossings, represents a promising avenue for enhancing railway safety (Wisultschew et al., 2021).

In addition to infrastructural considerations, psychological factors also play a role in railway safety. Research has indicated that mental health issues, including depression and substance abuse, can increase the likelihood of suicidal railway accidents (Balt, 2024). Understanding the psychosocial dimensions of railway fatalities is crucial for developing comprehensive prevention strategies that address both the physical and mental health needs of at-risk populations.

The analysis of railway accident data through various computational models has proven effective in identifying risk factors and predicting accident occurrences. For instance, Bayesian network analysis has been utilized to assess the relationships between different risk factors and their contributions to railway accidents (Shi, 2024). Such data-driven approaches can inform policy decisions and safety interventions, ultimately reducing the incidence of railway-related fatalities.

2. Materials and Methods

Study Design and Setting

This retrospective autopsy-based study was conducted at Government Medical College, Thiruvallur, focusing on railway accident fatalities over a period of 1 year from June 2021 to May 2022. The study was approved by the Institutional Ethics Committee (IEC), Government Medical College, Thiruvallur, under IEC No. 5/2022. The study utilized forensic autopsy records, police inquest reports, and hospital documentation to analyze the cases.

Study Population and Sample Size

A total number of 63 cases of railway accident-related deaths were analysed. These cases were selected based on medico-legal autopsy reports and police records.

Inclusion and Exclusion Criteria

Cases were included if they involved railway accident-related deaths with sufficient medico-legal and circumstantial data. Cases with incomplete records or deaths occurring in railway premises unrelated to railway accidents were excluded from the study.

Parameters Analysed

The study analyzed multiple parameters to establish forensic patterns and medico-legal findings related to railway accident fatalities. Demographic details, including age and gender, were examined to determine the most affected population groups. The areas of injury were categorized based on the body regions involved, including the head, chest, abdomen, and pelvis, lower extremities, and cases where injuries were widespread across the body. Major injuries were systematically classified, with particular focus on head injuries such as skull fractures (vault, base, or both), intracranial haemorrhages (extradural, subdural, subarachnoid, and intracerebral), and brain contusions or lacerations. Other severe injuries included decapitations, transection of the trunk, rib fractures, fractures of the clavicle or sternum, lung lacerations, rupture of major organs such as the Heart, Liver, and Spleen, intestinal perforations, pelvic fractures, and amputations of the upper or lower limbs. Cases involving severe body trauma with complete transection of the body were also documented.

The cause of death was determined based on the post-mortem findings and classified into haemorrhage and shock, effects of head injury, instantaneous death, and secondary causes. The cause of accident was analyzed using circumstantial evidence and categorized into different scenarios, including crossing railway tracks to catch a train, falling from a running train, slipping on the platform while disembarking, jumping in front of a train, lying on the railway track, being hit by a train, and cases where the cause remained unknown. The manner of death was established based on the forensic examination and classified as suicidal, accidental, homicidal, or undetermined. The study aimed to identify patterns in injury distribution, the mechanism of fatalities, and the possible medico-legal implications to aid in forensic investigations and railway safety improvements.

Data Collection and Analysis

Data were collected from the autopsy reports, inquest findings, and toxicology reports. The cases were then tabulated and statistically analyzed to identify injury patterns and their correlation with railway

accidents. Descriptive statistical methods were used to interpret the frequency and distribution of injuries and their medico-legal implications.

3. Results

Age and Sex of the Victims of Railway Accidents

Table 1 presents the distribution of railway accident victims by age group and gender. Among the 63 victims, 88.9% were male, and 11.1% were female. The highest proportion of male victims (28.6%) was in the age group of 41-50 years, followed by the age group of 21-30 years (19.0%). Female victims were fewer in number, with the highest occurrence in the age group of 41-50 years and 51-60 years (3.2% each). There were no victims in the age group of 0-10 years.

Day-wise Variation in Railway Accidents

Table 2 shows the distribution of railway accidents across different days of the week. Monday had the highest number of accidents (20.6%), followed by Friday (19.0%). Saturday recorded the lowest number of incidents (6.3%). The distribution suggests a relatively even spread of accidents throughout the week, with slight peaks at the beginning and end of the workweek.

Seasonal Variation in Railway Accidents

Table 3 depicts the seasonal distribution of railway accidents. The highest number of accidents occurred during summer (March - June) and winter (November - February), each accounting for 36.5% of cases. The rainy season (July - October) had slightly fewer accidents (27.0%). This indicates that extreme weather conditions in summer and winter might contribute to a higher number of railway accidents.

Major Areas Injured in Railway Accidents

Table 4 highlights the most commonly affected regions of the body in railway accidents. Head injuries were the most frequent (47.6%), followed by lower extremity injuries (20.3%). Injuries affecting the entire body accounted for 15.9% of cases. Chest, Abdomen, and Pelvic injuries were less common, occurring in 9.5% and 6.3% of cases, respectively. The high prevalence of head injuries suggests a significant impact force in railway accidents.

Major Injuries in Railway Accidents

Table 5 provides insights into the types of injuries sustained in railway accidents. Skull fractures were the most prevalent injury, affecting 90.5% of victims. Amputation of extremities occurred in 60.3% of

cases. Fractures of ribs (28.6%) and pelvis (20.6%) were also notable. Other severe injuries included intracranial hemorrhage (25.4%), laceration of the lungs (12.7%), and transection of the spine (14.3%). The data highlights the severe and often fatal nature of railway accident injuries.

Period of Survival in Railway Accidents

Table 6 categorizes the period of survival among railway accident victims. More than half of the victims (57.1%) were declared dead on arrival, while 42.9% died instantly at the accident site. These figures indicate the severe impact of railway accidents, leading to rapid fatality in most cases.

Causes of Railway Accidents

Table 7 details the primary causes of railway accidents. The most common reason was crossing the track near the platform to catch a train (39.7%), followed by being hit by a train (33.3%). Suicidal acts such as jumping in front of a train accounted for 19.0% of cases. Other causes included falling from a running train (1.6%) and slipping on the platform (1.6%). The high percentage of track-crossing accidents highlights a major safety concern.

Manner of Death in Railway Accidents

Table 8 classifies railway accident fatalities based on their manner of death. A significant majority (79.4%) of deaths were accidental, while 20.6% were attributed to suicide. This suggests that railway accidents are predominantly unintentional, but suicide by train remains a concerning issue.

Table 1: Age and Sex of the Victims of Railway Accidents. N=63

Age Group	Male (No.)	Male (%)	Female (No.)	Female (%)
0-10	0	0.0	0	0.0
11-20	3	4.8	0	0.0
21-30	12	19.0	0	0.0
31-40	7	11.1	1	1.6
41-50	18	28.6	2	3.2
51-60	7	11.1	2	3.2
61-70	7	11.1	1	1.6
71-80	2	3.2	1	1.6
Total	**56**	**88.9**	**7**	**11.1**

Figure: 1 Distribution of Age and Sex of the Victims of Railway Accidents.

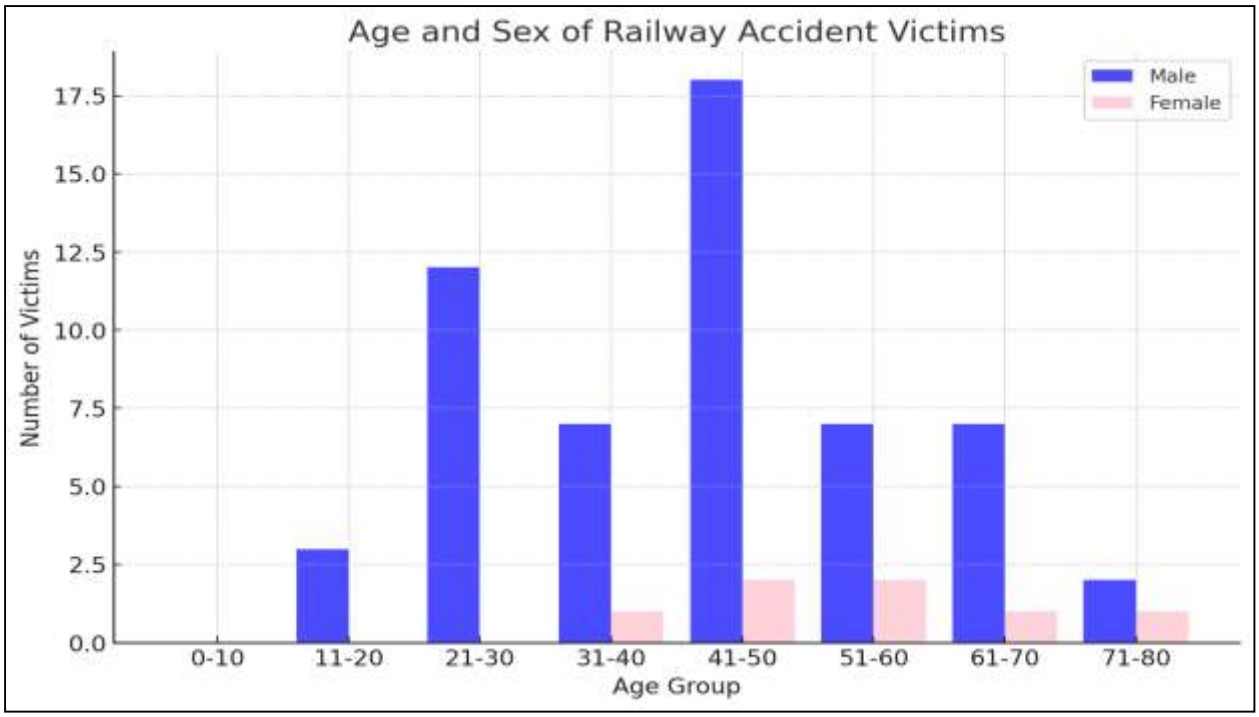

Table 2: Day-wise Variation in Railway Accidents. N=63

S. No	Day	No. of Cases	%
1	Monday	13	20.6
2	Tuesday	9	14.3
3	Wednesday	9	14.3
4	Thursday	9	14.3
5	Friday	12	19.0
6	Saturday	4	6.3
7	Sunday	7	11.1
Total		**63**	**100.0**

Table 3: Seasonal Variation in Railway Accidents. N=63

S. No	Season	No. of Cases	%
1	Summer (March - June)	23	36.5
2	Rainy (July - October)	17	27.0
3	Winter (November - February)	23	36.5
Total		**63**	**100.0**

Table 4: Major Areas Injured in Railway Accidents. N=63

S. No	Area Injured	No. of Cases	%
1	Head	30	47.6
2	Chest	6	9.5
3	Abdomen and Pelvis	4	6.3
4	Lower Extremity	13	20.3
5	All Over the Body	10	15.9
Total		**63**	**100.0**

Table 5: Major Injuries in Railway Accidents. N=63

S. No	Injury	No. of Cases	%
1	Fracture of Skull Bones	57	90.5
2	Intracranial Hemorrhage	16	25.4
3	Contusion / Laceration of Brain	5	7.9
4	Decapitation	10	15.9
5	Transaction of Spine	9	14.3

6	Fracture of Ribs	18	28.6
7	Fracture of Clavicle/Sternum	14	22.2
8	Laceration of Lungs	8	12.7
9	Transaction of Body	10	15.9
10	Rupture of Liver	6	9.5
11	Rupture of Spleen	1	1.6
12	Intestinal Perforation	3	4.8
13	Fracture of Pelvis	13	20.6
14	Amputation of Extremities	38	60.3

Table 6: Period of Survival in Railway Accidents. N=63

S. No	Period of Survival	No. of Cases	%
1	Death on Arrival	36	57.1
2	Instantaneous Death	27	42.9
Total		**63**	**100.0**

Table 7: Causes of Railway Accidents. N=63

S. No	Cause of Accident	No. of Cases	%
1	Crossing the track near the platform to catch the train	25	39.7
2	Fall/slip on the platform while getting off a train	1	1.6
3	Fall from a running train	1	1.6
4	Jump in front of the train	12	19.0
5	Lying on the railway track	1	1.6
6	Hit by the train	21	33.3
7	Unknown	2	3.2
Total		**63**	**100.0**

Table 8: Manner of Death. N=63

S. No	Manner of Death	No. of Cases	%
1	Suicidal	13	20.6
2	Accidental	50	79.4
Total		**63**	**100.0**

4. Discussion

The analysis of railway accident victims reveals significant demographic and temporal patterns that warrant a thorough discussion in the context of existing literature on railway safety and accident causation. The findings indicate a pronounced gender disparity among the victims, with males constituting a significant majority of the total, a trend that aligns with previous studies highlighting the predominance of male victims in railway accidents (Bagaria et al., 2020). This gender imbalance may be attributed to various sociocultural factors, including occupational roles and risk-taking behaviors, which have been documented in other transportation-related studies (Bagaria et al., 2020; Cao, 2023).

Furthermore, the age group most affected, specifically those aged 41-50 years, suggests a need for targeted safety interventions aimed at middle-aged individuals, who may be more likely to engage in risky behaviors such as crossing tracks to catch trains (Bagaria et al., 2020; Cao, 2023).

The temporal distribution of accidents, with peaks on Mondays and Fridays, aligns with findings from other research indicating that human factors, including fatigue and distraction, significantly contribute to accidents during these days (Fan et al., 2022). The lower incidence on Saturdays may reflect reduced railway operations or leisure travel patterns, which could be further explored in future studies. Seasonal variations, particularly the higher incidence of accidents during summer and winter, suggest that environmental factors, such as weather conditions and visibility, play a crucial role in accident occurrences (Lim, 2023). This is consistent with literature that emphasizes the impact of adverse weather on railway safety, particularly during heavy rain or snow (Lim, 2023).

In terms of injury patterns, head injuries were the most prevalent, followed by injuries to the lower extremities and multiple body injuries. This distribution underscores the need for improved protective measures for railway users, particularly in preventing head injuries, which have been identified as a

leading cause of fatalities in transportation accidents (Sehlikoğlu, 2024). The severity of injuries, with skull fractures and amputations being the most severe among the other injuries, highlights the critical need for enhanced safety protocols and emergency response strategies to mitigate the impact of such injuries (Sehlikoğlu, 2024). The high percentage of victims declared dead on arrival further emphasizes the urgency of addressing these safety concerns, as timely medical intervention could potentially reduce mortality rates (Sehlikoğlu, 2024).

The leading causes of accidents, particularly crossing tracks to catch a train and being hit by a train, reflect a significant behavioral component that has been documented in other studies (Guo et al., 2022). The prevalence of suicide as a cause also points to the need for mental health interventions and support systems for individuals at risk. The overall finding that accidental deaths far outnumber suicides reinforces the necessity for comprehensive safety measures that address both behavioral and infrastructural factors contributing to railway accidents (Guo et al., 2022).

In light of these findings, it is imperative to consider the broader implications for railway safety management. Enhanced safety measures, including better signage, increased surveillance at crossings, and public awareness campaigns, could significantly reduce the incidence of accidents. Furthermore, the integration of advanced technologies, such as artificial intelligence and machine learning, could aid in predicting and preventing accidents by analyzing patterns in historical data (Bešinović et al., 2022; Alawad et al., 2020). The literature suggests that a multifaceted approach, incorporating both human factors and technological advancements, is essential for improving railway safety outcomes (Cao, 2023; Bešinović et al., 2022; Alawad et al., 2020).

4. Conclusion

This retrospective analysis highlights that railway accidents predominantly affect middle-aged males, with peak incidents on Mondays, and Fridays, and extreme weather conditions. Head injuries and skull fractures are the most severe among the injuries, often leading to instant death or death on arrival. Unsafe track crossings, train hits, and suicides are the primary causes, highlighting the need for better safety measures like footbridges, automated alerts, and public awareness campaigns. Future research should explore behavioral risk factors, the effectiveness of safety interventions, and policy improvements to reduce fatalities and enhance railway safety.

6.Suggestions:

In view of a large number of railway accidents involving with just a small sample size it is very important that we should bring in certain changes in the aspects of railway safety.

- First and foremost is the use of foot over bridges/ under bridges to cross the railway track,
- Strictly prohibiting walking across the railway track.
- Use of barricades to stop people from crossing the track.
- Imposing heavy fines for the violators.
- Posting RPF personnel in all trains to stop college and school students from performing stunts in the moving train.
- To increase the frequency of trains from suburban & rural areas to the city in a view to reduce accidents that occur due to overcrowding.
- Using barricades or fences around the railway track to avoid suicide.
- Appropriate education to the public regarding railway traffic rules is a must.

REFERENCES

1. Alawad, H., Kaewunruen, S., & An, M. (2020). Learning from accidents: Machine learning for safety at railway stations. *IEEE Access, 8*, 633–648. https://doi.org/10.1109/access.2019.2962072
2. Balt, E. (2024). Sociodemographic and psychosocial risk factors of railway suicide: A mixed-methods study combining data of all suicide decedents in the Netherlands with data from a psychosocial autopsy study. *BMC Public Health, 24(1)*. https://doi.org/10.1186/s12889-024-18120-w
3. Bagaria, D., Banerjee, N., Gupta, A., Kumar, S., Mishra, B., Choudhary, N., … & Pandey, R. (2020). Train-associated injuries pose a significant burden on trauma care systems of emerging economies. *World Journal of Surgery, 44(9)*, 2993–2999. https://doi.org/10.1007/s00268-020-05563-6
4. Bešinović, N., Donato, L., Flammini, F., Goverde, R., Lin, Z., Liu, R., … & Tang, T. (2022). Artificial intelligence in railway transport: Taxonomy, regulations, and applications. *IEEE*

Transactions on Intelligent Transportation Systems, 23(9), 14011–14024. https://doi.org/10.1109/tits.2021.3131637

5. Bhuiyan, M., Ibtihal, S., & Nokshi, K. (2023). Involvement of human and organizational factors in railway accidents: Application of the human factors analysis and classification system and Bayesian network. *Transportation Research Record: Journal of the Transportation Research Board, 2677(8),* 496-508. https://doi.org/10.1177/03611981231156932
6. Blagojević, A., Kasalica, S., Stević, Ž., Tričković, G., & Pavelkić, V. (2021). Evaluation of safety degree at railway crossings in order to achieve sustainable traffic management: A novel integrated fuzzy MCDM model. *Sustainability, 13(2),* 832. https://doi.org/10.3390/su13020832
7. Cao, Y. (2023). Disaster risk assessment for railways: Challenges and a sustainable promising solution based on BIM+GIS. *Sustainability, 15(24),* 16697. https://doi.org/10.3390/su152416697
8. Chatterjee, A., Das, R., Mukherjee, A., & Das, S. (2022). A cross-sectional study on the determinants of railway fatalities in different age groups. *International Journal of Research in Medical Sciences, 11(1),* 80. https://doi.org/10.18203/2320-6012.ijrms20223296
9. Eslamdost, M., Rezaee, A., & Alizadeh, S. (2020). Investigating the causes of death in the injured of traffic accidents referred to Vali-Asr Hospital in Arak, based on oral autopsy and forensic autopsy. *Journal of Arak University of Medical Sciences, 23(3),* 338-347. https://doi.org/10.32598/jams.23.3.5986.1
10. Fan, C., Huang, S., Lin, S., Xu, D., Peng, Y., & Yi, S. (2022). Types, risk factors, consequences, and detection methods of train driver fatigue and distraction. *Computational Intelligence and Neuroscience, 2022,* 1-10. https://doi.org/10.1155/2022/8328077
11. Guo, Z., Chen, Z., Zhang, J., Guo, Q., He, C., & Zhao, Y. (2022). Characteristics of train–pedestrian collisions in Southwest China, 2011–2020. *International Journal of Environmental Research and Public Health, 19(10),* 6104. https://doi.org/10.3390/ijerph19106104
12. Houwelingen, C., Bucchianico, A., Beersma, D., & Kerkhof, A. (2022). Railway suicide in the Netherlands lower than expected. *Crisis, 43(5),* 368-374. https://doi.org/10.1027/0227-5910/a000792
13. Hromádka, V., Korytářová, J., Vítková, E., Seelmann, H., & Funk, T. (2020). New aspects of socioeconomic assessment of the railway infrastructure project life cycle. *Applied Sciences, 10(20),* 7355. https://doi.org/10.3390/app10207355

14. Jibril, I. (2021). Autopsy death profile due to railway injury in Mangalore, a coastal city of South Karnataka - A retrospective analysis. *Indian Journal of Forensic Medicine & Toxicology, 15(2)*, 2551-2557. https://doi.org/10.37506/ijfmt.v15i2.14757
15. Joy, P. (2024). Experience of personnel involved in dead body management at an apex institute in the aftermath of Odisha triple train collision. *PLOS One, 19(12)*, e0312595. https://doi.org/10.1371/journal.pone.0312595
16. Li, H., Zhong, Y., & Fan, C. (2020). Reducing the social risks of transnational railway construction: A discussion on the formation mechanism of host country people's coping behaviors. *Engineering, Construction & Architectural Management, 28(6)*, 1657-1682. https://doi.org/10.1108/ecam-04-2020-0232
17. Li, Q., Zhang, Z., & Peng, F. (2021). Causality-network-based critical hazard identification for railway accident prevention: Complex network-based model development and comparison. *Entropy, 23(7)*, 864. https://doi.org/10.3390/e23070864
18. Lim, K. (2023). Financial loss assessment for weather-induced railway accidents based on a deep learning technique using weather indicators. *Applied Sciences, 13(18)*, 10418. https://doi.org/10.3390/app131810418
19. Liu, J. (2023). Research on safety supervision and management system of China railway based on association rule and DEMATEL. *PLOS One, 18(12)*, e0295755. https://doi.org/10.1371/journal.pone.0295755
20. Mayorathan, U. (2023). Deaths due to locomotive injuries in Jaffna District - Eight-year retrospective study: Are we prepared to change our attitude? *Jaffna Medical Journal, 35(1)*, 15-19. https://doi.org/10.4038/jmj.v35i1.179
21. Sehlikoğlu, K. (2024). Investigation of fatal traumatic head injuries. *Turkish Journal of Trauma and Emergency Surgery*, 160-166. https://doi.org/10.14744/tjtes.2024.32463
22. Shi, L. (2024). Data-driven Bayesian network analysis of railway accident risk. *IEEE Access, 12*, 38631-38645. https://doi.org/10.1109/access.2024.3376590
23. SS, S. (2024). Retrospective study on railway-related deaths in South India. *Ain Shams Journal of Forensic Medicine and Clinical Toxicology, 0(0)*, 1-6. https://doi.org/10.21608/ajfm.2024.251960.1119
24. Tunçez, F., Uyan, A., Ersen, G., Tokdemir, M., & Karadeniz, Z. (2023). Evaluation of deaths related to railway accidents in İzmir, Türkiye: Retrospective original research. *Turkiye Klinikleri Journal of Forensic Medicine and Forensic Sciences, 20(1)*, 33-39. https://doi.org/10.5336/forensic.2022-94413

25. Wang, P., Wei, Q., Guo-fan, Z., Wang, J., & Yin, Y. (2022). Safety risk identification method for railway construction in complex and dangerous areas. *Sustainability, 14(21),* 13698. https://doi.org/10.3390/su142113698
26. Wisultschew, C., Mujica, G., Lanza-Gutiérrez, J., & Portilla, J. (2021). 3D-LiDAR based object detection and tracking on the edge of IoT for railway level crossing. *IEEE Access, 9*, 35718-35729. https://doi.org/10.1109/access.2021.3062220