A STUDY OF HUMAN ERROR FACTORS ON TRANSPORTATION ACCIDENTS IN CONTAINER TERMINALS IN SRI LANKA

ELLEPOLA S.A.* AND SRIDARRAN P.
University of Moratuwa, Sri Lanka
*Correspondence E-mail: sasirashanika@gmail.com

Abstract. Transportation accidents at container terminals often result from human error, a complex and multifaceted issue with significant implications for safety, productivity, and economic efficiency. This study investigates the human error factors influencing transportation-related incidents in Sri Lankan container terminals. Using a mixed-methods case study approach that combines documentation analysis with expert interviews, the study identifies key error-inducing conditions and underlying causes. Findings highlight a lack of training, communication breakdowns, poor supervision, and infrastructural inadequacies as primary contributors to accidents. Recommendations are made for improving training protocols, communication channels, and safety oversight. This research provides insights for policymakers and terminal operators to develop targeted interventions to mitigate human error and enhance operational safety.

Keywords. Human Error, Transportation Accidents, Container Terminals, Sri Lanka, Risk Factors

1. Introduction

Container terminals play a critical role in global logistics and trade, with operational safety being a key concern due to the high-risk nature of terminal activities. Human error is widely acknowledged as a major contributing factor to transportation accidents in these environments. While international studies have examined human error in port operations, there is limited research focusing on the Sri Lankan context, where unique infrastructural, regulatory, and operational challenges exist.

In Sri Lanka, the rapid growth of port activities has intensified safety concerns, particularly at busy container terminals such as Colombo Port. However, despite rising accident rates, there has been a lack of systematic investigation into the human factors contributing to these incidents. This study aims to fill that gap by examining the specific conditions and behaviors that lead to human error in Sri Lanka's container terminals.

1.1 RESEARCH QUESTIONS:

1. What are the primary human error factors contributing to transportation accidents in Sri Lankan container terminals?
2. How can these factors be mitigated through policy and operational interventions?

The study contributes to the literature by contextualizing human error within the Sri Lankan terminal environment and offering actionable recommendations for enhancing safety management practices.Prior studies on human error in transportation and logistics emphasize organizational, psychological, and environmental factors.(WEBER, 1983), for example, illustrates how latent failures and active errors interact to produce accidents. In port operations, factors such as inadequate training, miscommunication, fatigue, and poor supervision have been linked to accidents (Hetherington et al., 2006) However, few studies specifically address these issues in South Asian or Sri Lankan ports. A regional analysis by Perera and Fernando (2018) highlighted infrastructural constraints and limited safety oversight as key challenges in South Asia. This study extends that work by focusing specifically on container terminals in Sri Lanka, using a mixed-methods approach to examine human error in detail.

https://doi.org/10.31705/ICFMF2025.28

2. Methods Employed

A single case study method was chosen, following (Noor, 2008), who argues that investigations should be guided by replication rather than sampling rationale. Among the three operational terminals at the Port of Colombo, one container terminal was selected based on accessibility, efficient data collection, and its high handling capacity of 2 million TEUs annually. The unit of analysis in this study focuses on work-related transportation accidents, particularly those related to health and safety. A survey strategy was used to collect data on worker behaviors, perceptions, and experiences (Gomm, 2008),The study conducted semi-structured interviews with key personnel, including the Health, Safety, and Environment Manager, Operations Manager, and Safety Officer, chosen for their industry expertise.
Data collection included both primary and secondary sources. Secondary data was gathered from literature reviews and the Accident Investigation Report (AIR) database at the selected terminal. Primary data was collected through expert interviews, using open-ended and standardized questions to support the findings from quantitative analysis.

2.1 PRIMARY DATA FINDINGS

Transportation accidents in container terminals are largely influenced by human errors, inadequate safety measures, and insufficient training programs. One of the most frequent mistakes made by drivers is misjudging the turning radius of their vehicles, which often results in collisions with obstacles, containers, and terminal infrastructure such as crane ladders, curbs, and signboards. This issue is particularly common among drivers operating prime movers, which require wider turns. Many drivers fail to anticipate this, leading to either excessively sharp or overly wide turns that increase the risk of accidents. The primary causes of these errors include a lack of understanding of vehicle dimensions and improper steering techniques, highlighting gaps in practical training and experience.

Despite having safety protocols and training programs in place, the current measures appear to be theoretically driven rather than hands-on. The organisation conducts safety inductions, leaflet campaigns for external drivers, and defensive driving training. However, while these initiatives help in raising awareness, they do not fully prepare drivers for real-life emergency situations. Theoretical knowledge is necessary but insufficient when practical skills and on-the-job training are not emphasized. Another significant issue is that safety training programs do not evolve with operational changes. Equipment, vehicles, and traffic conditions change over time, yet training materials are not frequently updated to reflect these changes. This lack of periodic training refreshers results in drivers using outdated techniques that may no longer be effective in preventing accidents. Additionally, existing safety measures focus heavily on routine checks and hazard identification rather than on accident prevention strategies. This reactive approach means that while hazards are identified, proactive interventions to mitigate risks are often delayed or overlooked.

A specific accident case highlights the consequences of human error and the importance of strict safety enforcement. In one incident, an internal truck collided with another internal truck at 9:15 a.m. due to unsafe manoeuvring. The driver lost control of the vehicle, resulting in a serious accident where one driver lost two teeth due to the impact. Notably, neither driver was wearing a seatbelt, which could have mitigated the severity of the injuries. This accident prompted the organisation to strictly enforce seatbelt usage and introduce a colour-coded system that allows safety personnel to easily identify drivers who are not wearing seatbelts. Additionally, as an engineering control, the speed limit for all vehicles was reduced to 25 km/h, aiming to minimise the impact of collisions and improve overall traffic safety within the terminal.

Data analysis reveals clear patterns in accident occurrences across different vehicle types, time periods, and terminal locations. Internal trucks have consistently recorded the highest number of accidents, with a notable spike in 2023. The increase in inter-terminal truck incidents over the years also indicates a rising safety concern. Cab-related incidents peaked in 2022, marking the highest level in the last five years. These findings suggest that drivers operating internal and inter-terminal trucks require additional safety training and supervision to reduce accident risks. Accident timing analysis indicates that incidents are most frequent during the busy morning hours, with an unusual spike in early morning and midday in 2022. This suggests that fatigue, high traffic density, and environmental factors contribute to accident risks. Additionally, location-wise data shows that most accidents occur at the Wharf and Back Reach, with higher accident rates near the Gate House. This suggests that traffic congestion, poor visibility, and infrastructure design may be contributing to accident-prone zones within the terminal.

To address these challenges, several safety enhancements and interventions must be implemented. First, hands-on training should be prioritised to ensure drivers gain practical experience in manoeuvring their vehicles safely. The introduction of simulated accident scenarios would help drivers develop better emergency response skills. Second, stricter compliance with seatbelt usage must be enforced through regular monitoring of the newly introduced colour-coded system. Third, traffic management strategies need improvement, including better signage, improved lighting, and controlled traffic flow at accident-prone areas such as the Wharf, Back Reach, and Gate House. Additionally, fatigue management programs should be introduced to address accident spikes during early morning and midday by adjusting work schedules and enforcing rest breaks for drivers. Finally, safety training updates must be conducted periodically to ensure drivers are well-equipped with the latest safety knowledge and best practices.

Lastly, the findings indicate that human error, insufficient practical training, and weak enforcement of safety measures are major contributors to transportation accidents in container terminals. The lack of awareness about vehicle dimensions, improper turning techniques, and inadequate safety training significantly increase the risk of accidents. Accidents are most common during peak hours and at high-traffic locations, such as the Wharf and Back Reach, highlighting the need for enhanced visibility, better traffic management, and stricter enforcement of safety protocols. Addressing these issues through proactive training, improved accident prevention strategies, and stronger compliance measures is crucial for reducing accident rates and improving overall safety standards in container terminal operations.

2.2 SECONDARY DATA FINDINGS

Findings from secondary data reveal Equipment Wise Accidents as shown in Figure 1. The data indicates that Internal Trucks consistently account for the highest number of accidents across all years, with a noticeable increase in 2021, 2022, and 2023. This suggests that internal truck operations pose a significant safety risk and require targeted interventions. Additionally, Cab-related accidents peaked in 2022, marking the highest level in five years, before slightly declining in 2023. The sharp rise in Own Inter-Terminal Truck incidents in 2023 is a major concern, highlighting the need for enhanced safety protocols and stricter enforcement measures in inter-terminal operations.

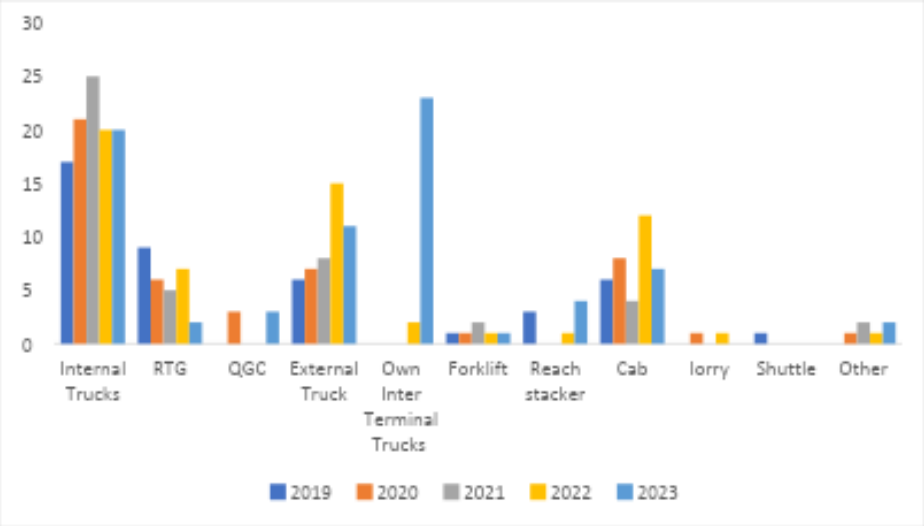

Figure 1: Equipment-Wise Accidents

The analysis also shows that External Trucks have experienced a steady increase in accidents, indicating growing operational risks that need better monitoring and training interventions. On the other hand, accident rates for RTG (Rubber-Tyred Gantry Cranes) (Ding et al., 2021) indicates that Forklifts, and Reach Stackers remain relatively low, suggesting that existing safety measures for these equipment types may be more effective. Equipment categories such as Lorry, Shuttle, and QGC (Quay Gantry Crane) (Premathilaka, 2018) have consistently recorded minimal accidents, indicating lower operational risk.

These findings highlight critical safety challenges within the terminal, particularly for Internal Trucks, Inter-Terminal Trucks, and Cab operations. Addressing these issues through enhanced training, stricter traffic management, improved speed control, and better compliance with safety regulations will be essential in reducing accident rates and improving overall transportation safety in the terminal.

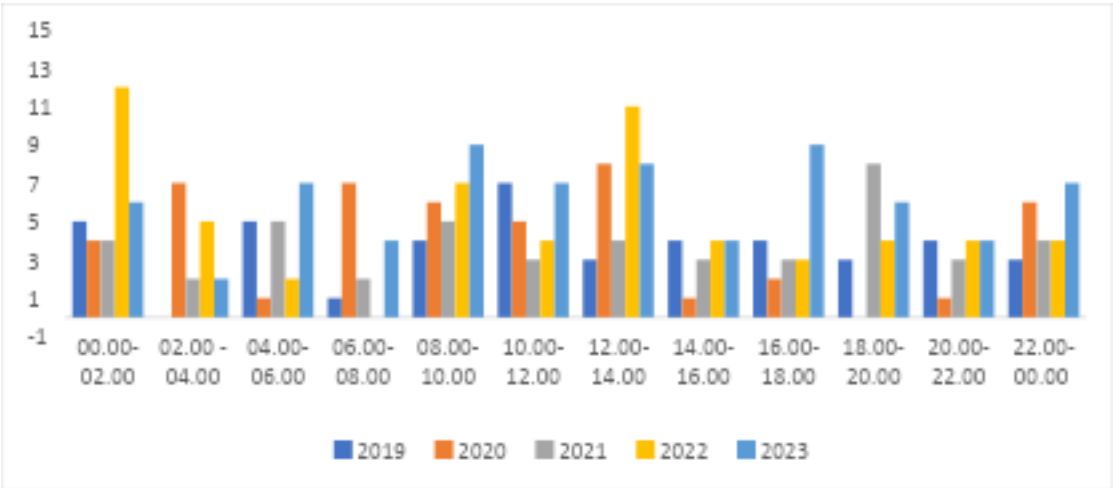

Figure 2: Accident times

Figure 2 illustrates the distribution of accident occurrences over time from 2019 to 2023, identifying peak accident hours and key contributing factors such as traffic density, fatigue, and environmental conditions. The data highlights a notable spike in accidents between 12:00 – 02:00 AM in 2022, likely due to driver fatigue and reduced alertness during night shifts. Another peak between 12:00 – 14:00 in 2022 may be attributed to post-lunch fatigue or increased

operational activity. Across all years, the highest accident frequencies occur between 10:00 AM – 14:00 PM, suggesting that high traffic density, workload pressure, and operational intensity contribute to accident risks. While accident rates decline after 16:00, a spike between 18:00 – 20:00 in 2021 suggests visibility challenges or shift transitions as potential factors.

The accident pattern in 2022 shows extreme variations, whereas 2023 records a generally higher accident count, indicating increased traffic density or systemic safety issues. Years 2019–2021 display a more even distribution with fewer peaks. To mitigate these risks, fatigue management programs, optimized traffic flow, improved visibility with better lighting and signage, and strict speed enforcement are crucial. Better scheduling, enhanced training, and compliance monitoring will help reduce accidents and improve overall safety in Sri Lankan container terminals.

Figure 3 shows the distribution of accidents by location from 2019 to 2023, identifying high-risk zones. The Wharf consistently records the highest number of accidents, peaking in 2023, likely due to heavy traffic and operational complexities. Outside the Terminal and Diesel Point also show significant spikes in 2023, suggesting issues with traffic management and fueling operations. Several turning points, such as 1/2AB, 3/4AB, and 2/3CD, exhibit moderate but consistent accident rates, indicating navigation difficulties and blind spots.

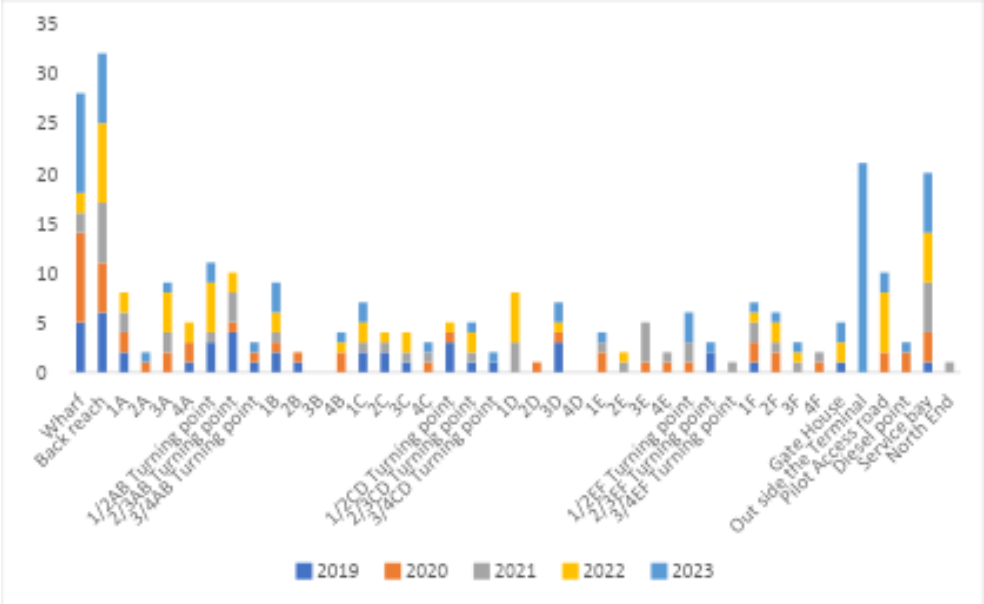

Figure 3: Accidents by location

The increase in accidents at 4F in recent years suggests a growing safety concern. These findings indicate that traffic congestion, operational hazards, and procedural gaps contribute to accident risks. Enhanced traffic regulations, better driver training, improved signage, and stricter enforcement of safety protocols are crucial to mitigating these risks. Addressing these high-risk areas will significantly improve overall terminal safety and operational efficiency.

3. Conclusion

In summary, this study underscores the significant role that human factors and organizational weaknesses play in transportation accidents at Sri Lankan container terminals. To create a safer and more efficient work environment, terminal operators must go beyond surface-level interventions and tackle the root causes—ranging from inadequate training and poor communication to lack of accountability and motivation.

For industry practitioners, the findings point to the urgent need for practical, hands-on training programs that simulate real-world conditions, particularly for internal truck drivers, where accident rates are highest. Strengthening safety enforcement, improving shift scheduling to address fatigue, and introducing structured recognition and feedback systems can motivate employees and encourage safer behaviors. Critical high-risk zones such as the Wharf, Back Reach, and Gate House also require targeted infrastructure improvements and better traffic flow management. For policymakers**,** the study highlights the necessity of regulatory oversight to ensure consistent safety standards across terminals. This includes mandating minimum training requirements, enforcing clear disciplinary procedures, and incentivizing terminals to adopt proactive safety cultures.

4. Recommendations

To address the critical issue of transportation accidents in Sri Lankan container terminals, this study recommends a multi-pronged approach that acknowledges both the human and systemic dimensions of safety. First**,** terminal operators must prioritize comprehensive training programs that go beyond theoretical instruction. Simulated, hands-on learning environments—especially tailored for internal truck drivers—can help staff respond more effectively to real-world scenarios and reduce the frequency of human errors. Second, organizational practices need a closer examination. Poor communication, inconsistent shift scheduling, and unclear accountability contribute to both mental fatigue and lapses in safety. Introducing structured feedback systems, clear communication channels, and performance-based recognition can foster a more safety-conscious and motivated workforce.

Furthermore, high-risk zones such as the Wharf, Back Reach, and Gate House demand immediate infrastructural attention. Improvements in traffic design, signage, and lighting can significantly reduce the risk of collisions and near-miss incidents in these congested areas. From a policy standpoint, there is a clear need for stronger regulatory frameworks that enforce uniform safety standards across terminals. Authorities should establish baseline requirements for driver training, implement transparent disciplinary procedures, and provide incentives for terminals that demonstrate measurable safety improvements. Ultimately, fostering a culture that values safety as much as operational efficiency requires collaboration between terminal management, frontline workers, and policymakers. By aligning human-centered strategies with infrastructure and policy reforms, Sri Lanka’s container terminals can move toward a safer, more resilient future.

4.1 LIMITATIONS

While this study offers valuable insights into the role of human error in transportation accidents at Sri Lankan container terminals, there are a few limitations to acknowledge. First, the research focused on a single terminal, which may limit how broadly the findings can be applied across other terminals with different operational setups or safety cultures. The insights from interviews, though rich in detail, were gathered from a relatively small group of individuals, which might not fully represent the experiences and views of all employees. Additionally, the study relied on existing accident records, which may not capture every incident accurately—especially minor or unreported ones that could still offer important clues about safety risks.

4.2 FUTURE RESEARCH

Going forward, researchers could expand the scope by studying multiple container terminals to compare practices and identify common patterns or unique challenges. It would also be valuable to explore employee experiences in more depth, perhaps through anonymous surveys or focus groups, to get a broader understanding of day-to-day safety issues. Long-term studies that track the effects of specific safety interventions—such as new training programs or communication

strategies—could help determine what works best in reducing accidents. Finally, future research might also look at how technology, like real-time tracking or automated safety alerts, can support safer operations and reduce the chances of human error.

5. References

Ding, Y., Yang, Y., Heilig, L., Lalla-Ruiz, E., & Voss, S. (2021). Deployment and retrofit strategy for rubber-tyred gantry cranes considering carbon emissions. *Computers and Industrial Engineering*, *161*(April), 107645. https://doi.org/10.1016/j.cie.2021.107645

Gomm, R. (2008). Social Research Methodology. *Social Research Methodology*. https://doi.org/10.1007/978-0-230-22911-2

Hetherington, C., Flin, R., & Mearns, K. (2006). Safety in shipping: The human element. *Journal of Safety Research*, *37*(4), 401–411. https://doi.org/10.1016/j.jsr.2006.04.007

Noor, K. (2008). Case Study : A Strategic Research Methodology Khairul Baharein Mohd Noor. *American Journal of Applied Sciences*, *5*(11), 1602–1604.

Perera, L., & Fernando, M. (2018). *Infrastructure Challenges in East and South Asia*

Premathilaka, W. H. V. (2018). *Determining the factors affecting the turnaround time of container vessels: a case study on Port of Colombo container vessels: a case study on Port of Colombo*. 77. https://commons.wmu.se/all_dissertations/600

WEBER, L. (1983). European Organization for the Safety of Air Navigation (Eurocontrol). *Regional Cooperation, Organizations and Problems*, *13*, 191–194. https://doi.org/10.1016/b978-0-444-86237-2.50059-7