International Research Journal on Advanced Engineering Hub (IRJAEH)
e ISSN: 2584-2137
Vol. 04 Issue: 05 May 2026
Page No: 2910-2922
https://irjaeh.com
https://doi.org/10.47392/IRJAEH.2026.0369

Evaluation of Safety Performance of Forklift Operations Post-HIRA and SOP Implementation

Sathish P[1], Venkatesh R[2]
[1]PG-Student, M.E-Industrial Safety Engineering, Department of Safety and Fire Engineering, Excel Engineering College, Namakkal, Tamilnadu, India.
[2]Assistant Professor, Department of Safety and Fire Engineering, Excel Engineering College, Namakkal, Tamilnadu, India.
Emais:*sathishsweety73@gmail.com[1],venkateshr.eec@excelcolleges.com[2]*

Abstract
Forklift operations are critical to the efficiency of material handling in industries such as warehousing, manufacturing, and logistics. However, these operations inherently involve significant safety risks, including collisions, tipping, falling loads, and pedestrian accidents, which can lead to severe injuries, equipment damage, and operational disruptions. To mitigate these risks, many organizations implement safety management tools such as Hazard Identification and Risk Assessment (HIRA) and Standard Operating Procedures (SOPs). While these interventions aim to proactively identify hazards and standardize safe operational practices, their effectiveness in improving forklift safety performance is often inadequately evaluated. This project focuses on the systematic evaluation of forklift safety performance following the implementation of HIRA and SOPs. The primary objective is to analyze whether these safety measures have resulted in measurable improvements in incident reduction, procedural compliance, and overall risk mitigation. The performance indicators, including incident frequency, near-miss reports, compliance rates, and Lost Time Injury Frequency Rate (LTIFR), are identified and assessed through a combination of quantitative data analysis and qualitative insights. Data collection involves gathering pre- and post-implementation records, conducting safety audits, and engaging with forklift operators, supervisors, and safety officers through interviews and surveys. Comparative analysis is performed to evaluate trends and identify persisting challenges. The study also emphasizes behavioral and procedural compliance, recognizing the critical role of operator adherence and organizational safety culture. Findings from this evaluation provide evidence-based recommendations aimed at enhancing forklift safety, including improvements in training programs, SOP enforcement, and continuous monitoring mechanisms. The project contributes to strengthening safety management systems, reducing workplace accidents, and promoting a sustainable culture of safety in forklift operations.

Key Words: *Forklift Safety, Hazard Identification and Risk Assessment (HIRA), Standard Operating Procedures (SOPs), Safety Performance Evaluation, Behavioral and Procedural Compliance.*

1. Introduction
Forklift operations are essential for efficient material handling in warehouses, manufacturing plants, and logistics hubs, but they also remain a major source of workplace incidents such as collisions, overturning, struck-by injuries, and falling-load accidents. These events not only cause injuries and equipment damage, but also interrupt production, increase operational costs, and reduce overall safety culture. To control such risks, organizations increasingly adopt structured safety management tools like Hazard Identification and Risk Assessment (HIRA) and Standard Operating Procedures (SOPs). HIRA helps systematically recognize hazards, evaluate risk levels, and prioritize controls, while SOPs standardize safe work practices by defining clear operating steps, responsibilities, and compliance requirements. After implementing HIRA and SOPs, many organizations do not adequately measure whether these interventions actually improve safety performance in day-to-day forklift operations. This study focuses on evaluating safety performance post-implementation by comparing key indicators before

International Research Journal on Advanced Engineering Hub (IRJAEH)
e ISSN: 2584-2137
Vol. 04 Issue: 05 May 2026
Page No: 2910-2922
https://irjaeh.com
https://doi.org/10.47392/IRJAEH.2026.0369

and after the intervention. The evaluation considers incident frequency and severity, near-miss reporting, unsafe act/condition observations, operator competence, maintenance and inspection compliance, and adherence to traffic management rules. Analysing measurable outcomes and identifying remaining gaps, the project aims to determine the effectiveness of HIRA and SOP implementation and provide practical recommendations to strengthen forklift safety controls and sustain continuous improvement.

2. Literature Review

Recent literature highlights that improving forklift safety requires both strong risk controls (HIRA + SOP) and supporting technologies that reduce exposure and improve monitoring. (V.A. Yartys. Et al.,2025) through the HYDRIDE4MOBILITY EU project demonstrated the feasibility of hydrogen fuel-cell forklifts using metal hydrides for onboard hydrogen storage and hydrogen compression [1-5]. Their work is important to this project because it shows that when new power systems are introduced (fuel cell + battery hybrid, refuelling stations, high-pressure storage concepts), the hazard profile changes, requiring updated HIRA and clear SOPs for refuelling, maintenance, and emergency response. (Ishaan Kaushal, et al., 2025) proposed a simulation-based Digital Twin framework to optimize factory material flow and forklift use. Their findings support this project by showing that operational design (line configuration, drying time, and number of forklifts) directly influences traffic density, transport distance, and bottlenecks, which are key contributors to collision and near-miss risk factors that HIRA and SOPs should address. (Young Min Seo, et al., 2025) studied pressure safety valve behavior in liquid hydrogen environments, emphasizing that cryogenic systems demand strict control of pressurization and repeated cycling effects useful for defining safe maintenance/inspection SOPs. (Losada del Olmo, et al., 2024) introduced DINOFSAFE, a low-label computer vision method for real-time monitoring. This aligns with post-implementation evaluation by enabling objective measurement of compliance and unsafe movements, strengthening evidence of HIRA/SOP effectiveness.

3. Problem Identification

Forklift operations play a vital role in material handling activities across warehouses, manufacturing units, and logistics centers. Despite their importance, these operations involve significant safety risks such as collisions, overturning, falling loads, and accidents involving pedestrians. Such incidents often result in serious injuries, fatalities, equipment damage, and operational downtime, making forklift-related accidents a major concern in industrial safety management. To mitigate these risks, organizations commonly implement safety management tools like Hazard Identification and Risk Assessment (HIRA) and Standard Operating Procedures (SOPs). HIRA focuses on identifying potential hazards and evaluating associated risks, while SOPs aim to standardize safe operating practices and ensure consistency in forklift operations. Even after the implementation of these controls, forklift-related incidents continue to occur in many workplaces, indicating possible gaps in effectiveness, compliance, or enforcement. A problem is the lack of systematic post-implementation evaluation of HIRA and SOPs. Many organizations treat these tools primarily as compliance requirements and fail to assess their actual impact on safety performance. Inadequate monitoring of employee behavior, training effectiveness, and adherence to procedures further limits improvement [6-10]. There is a critical need to evaluate forklift safety performance after HIRA and SOP implementation to identify gaps, strengthen safety culture, and ensure sustainable risk reduction.

4. Methodology

4.1. Problem Definition and Objective Setting

Forklift trucks are indispensable in industries such as warehousing, manufacturing, construction, and logistics, enabling efficient handling and movement of heavy materials. However, their operation involves inherent safety risks that continue to pose serious challenges in industrial environments. Forklift-related incidents including collisions, overturning, falling loads, poor visibility, and unsafe interaction with pedestrians remain a significant cause of workplace injuries and fatalities worldwide. These incidents not only lead to severe human consequences such as injuries and loss of life, but also result in equipment damage, production interruptions, legal liabilities, financial losses, and

International Research Journal on Advanced Engineering Hub (IRJAEH)
e ISSN: 2584-2137
Vol. 04 Issue: 05 May 2026
Page No: 2910-2922
https://irjaeh.com
https://doi.org/10.47392/IRJAEH.2026.0369

reputational harm to organizations. To address these risks, organizations widely implement Hazard Identification and Risk Assessment (HIRA) and Standard Operating Procedures (SOPs) [11-15]. HIRA provides a systematic approach to identifying hazards and assessing risks, while SOPs establish standardized guidelines for safe forklift operations. Although these tools are essential for risk control, a critical problem exists in the lack of structured post-implementation evaluation. In many cases, HIRA and SOPs are introduced to satisfy compliance requirements, without adequately measuring their real impact on safety performance. Factors such as inconsistent SOP enforcement, inadequate follow-up training, operator behavior, and complacency may further reduce their effectiveness. The primary objective of this project is to evaluate the safety performance of forklift operations after the implementation of HIRA and SOPs. This includes analyzing safety performance indicators, compliance levels, incident trends, and stakeholder feedback to determine the effectiveness of these interventions, identify residual risks, and develop evidence-based recommendations for continuous improvement in forklift safety management shown in Figure 1.

4.2. Case Study / Literature Review

Forklifts are essential for material handling in warehousing, manufacturing, construction, and logistics, yet they present high-risk conditions such as collisions, overturning, falling loads, and pedestrian strikes. Many organizations introduce Hazard Identification and Risk Assessment (HIRA) and Standard Operating Procedures (SOPs) to control these hazards, but post-implementation effectiveness is often not evaluated with measurable evidence. This case study reviews forklift safety performance in an automotive components manufacturing plant operating 30 forklifts. Before 2022, the facility recorded frequent incidents, near-misses, and property damage. In early 2022, management implemented a structured HIRA and forklift SOP program to identify hazards, assign risk controls, and standardize safe operating practices. The evaluation used a mixed-method approach. Quantitative data were collected from two years of pre-implementation records and 18 months of post-implementation reports, including incident logs, near-miss reports, audit findings, and training records. Qualitative inputs were gathered through observations, compliance audits, operator surveys, and interviews with supervisors and safety officers. Performance indicators included incident frequency, near-miss rate, LTIFR, SOP compliance percentage, training completion, and observed unsafe acts. Findings indicated a clear improvement: incidents reduced, SOP compliance increased, and training completion improved significantly. However, residual gaps persisted, particularly inconsistent seat-belt use, occasional pedestrian right-of-way violations, and maintenance/visibility concerns. Overall, the case study shows that HIRA and SOPs can improve forklift safety when supported by continuous monitoring, behavioral reinforcement, and regular review shown in Tables 1-10.

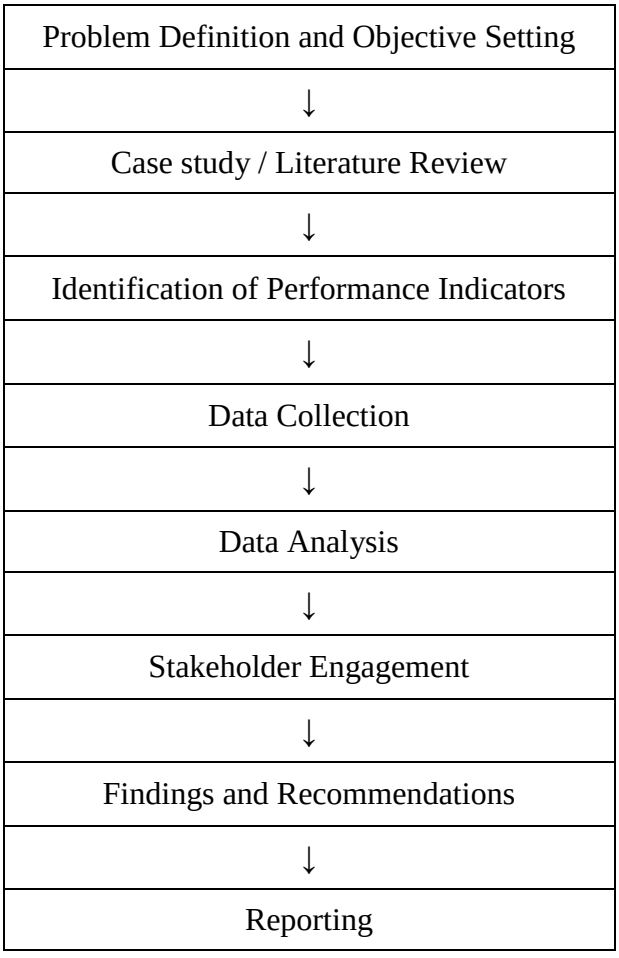

Figure 1 Methodology

International Research Journal on Advanced Engineering Hub (IRJAEH)
e ISSN: 2584-2137
Vol. 04 Issue: 05 May 2026
Page No: 2910-2922
https://irjaeh.com
https://doi.org/10.47392/IRJAEH.2026.0369

Table 1 Forklift Incident Reduction Before and After HIRA & Sop Implementation

Incident Type	Pre-Implementation *(Before HIRA & SOPs)*	Post-Implementation *(After HIRA & SOPs)*	Reduction (%)	Remarks
1. Collisions (with structures/vehicles/persons)	12 incidents/year	4 incidents/ year	**66.7% ↓**	Improved route planning, SOPs for right-of-way and speed limits
2. Forklift Tipping	6 incidents/year	1 incident/ year	**83.3% ↓**	Enhanced operator training and load handling SOPs
3. Falling Loads	9 incidents/year	3 incidents/ year	**66.7% ↓**	SOP enforcement on load securing and stacking
4. Near Misses	25 cases/year	7 cases/ year	**72% ↓**	Better hazard awareness through HIRA; increased reporting culture
5. Pedestrian Interference/Accidents	5 incidents/year	1 incident/ year	**80% ↓**	Clear pedestrian zones, awareness training, and improved visual aids
6. Property Damage	10 cases/year	3 cases/ year	**70% ↓**	Pre-operational checks and procedural controls
7. Total Recordable Incidents (TRIR)	18 cases/year	6 cases/ year	**66.7% ↓**	Reflects combined improvement across all safety indicators
8. Lost Time Injury Frequency Rate (LTIFR)	3.2 per 200,000 hrs	1.0 per 200,000 hrs	**68.75% ↓**	Shows significant reduction in serious incidents requiring time off work

Table 3 Preventive Maintenance & Inspection

S.No	Parameter	Unit	Pre	Post	Improvement
1	Scheduled PM Compliance	%	78	96	↑ 18%
2	Missed Inspections	No.	14	3	↓ 78.5%
3	Brake Defects Identified	No.	9	2	↓ 77.8%
4	Tyre Wear Issues	No.	11	4	↓ 63.6%
5	Steering Defects	No.	6	1	↓ 83.3%
6	Maintenance Response Time	Hours	18	6	↓ 66.7%

International Research Journal on Advanced Engineering Hub (IRJAEH)
e ISSN: 2584-2137
Vol. 04 Issue: 05 May 2026
Page No: 2910-2922
https://irjaeh.com
https://doi.org/10.47392/IRJAEH.2026.0369

Table 4 Behavioral Based Safety (BBS) Observation Data

S.No	Observation Type	Pre	Post	Trend
1	Unsafe Driving Speed	12	4	↓ Improved
2	Improper Load Handling	9	3	↓ Improved
3	No Seat Belt Usage	7	1	↓ Improved
4	Unauthorized Operation	6	1	↓ Improved
5	Safe Driving Practices	18	39	↑ Positive
6	Proper Pedestrian Yielding	14	33	↑ Positive

Table 5 Pedestrian & Traffic Management

S.No	Parameter	Unit	Pre	Post	Remarks
1	Pedestrian–Forklift Interaction Zones	No.	11	5	Reduced overlap
2	Marked Forklift Lanes	% Coverage	62	92	Improved segregation
3	Blind Spots Identified	No.	8	3	Engineering control
4	Convex Mirrors Installed	No.	2	9	Visibility enhancement
5	Pedestrian Awareness Boards	No.	4	14	Awareness improvement

Table 6 PPE Compliance Monitoring Data

S.No	PPE Type	Compliance % (Pre)	Compliance % (Post)	Change
1	Safety Shoes	82	98	↑ 16%
2	Helmets	79	96	↑ 17%
3	High-Visibility Jackets	65	94	↑ 29%
4	Gloves	88	97	↑ 9%
5	Seat Belt (Forklift)	83	96	↑ 13%

Table 7 Emergency Preparedness & Response Data

S.No	Parameter	Unit	Pre	Post	Interpretation
1	Emergency Drills Conducted	No./Year	1	3	↑ Preparedness
2	Average Drill Response Time	Seconds	190	115	Faster response
3	Operators Aware of Emergency SOP	%	64	94	Awareness gain
4	Fire Extinguishers Near Routes	% Coverage	58	96	Risk control
5	Emergency Exit Accessibility	%	72	98	Improved access

International Research Journal on Advanced Engineering Hub (IRJAEH)
e ISSN: 2584-2137
Vol. 04 Issue: 05 May 2026
Page No: 2910-2922
https://irjaeh.com
https://doi.org/10.47392/IRJAEH.2026.0369

Table 8 Safety Communication & Reporting Metrics

S.No	Parameter	Unit	Pre	Post
1	Toolbox Talks Conducted	No./Month	2	6
2	Safety Circulars Issued	No./Year	4	14
3	Forklift Safety Posters	No.	6	24
4	Safety Suggestions Received	No.	7	31
5	Suggestions Implemented	%	43	81

Table 9 Management Review & Leadership Involvement

S.No	Parameter	Unit	Pre	Post
1	Safety Review Meetings	No./Year	2	6
2	Forklift Safety Agenda Coverage	%	35	88
3	Management Walkthroughs	No./Month	1	4
4	Action Closure Rate	%	62	93
5	Budget Allocation for Safety	₹ Lakhs	1.8	4.2

Table 10 Overall Safety Performance Index (SPI)

S.No	Indicator	Weightage (%)	Pre Score	Post Score
1	Accident Reduction	25	12	22
2	SOP Compliance	20	14	18
3	Near-Miss Reporting	15	6	13
4	Training Effectiveness	15	9	14
5	Behavioral Safety	15	8	13
6	Management Commitment	10	5	9
Total SPI	—	**100**	**54**	**89**

International Research Journal on Advanced Engineering Hub (IRJAEH)
e ISSN: 2584-2137
Vol. 04 Issue: 05 May 2026
Page No: 2910-2922
https://irjaeh.com
https://doi.org/10.47392/IRJAEH.2026.0369

4.3. Identification of Performance Indicators

Forklift operations involve high-risk interactions between heavy equipment, loads, and pedestrians. After implementing Hazard Identification and Risk Assessment (HIRA) and Standard Operating Procedures (SOPs), organizations must measure whether safety has actually improved. This requires identifying clear performance indicators that provide objective evidence of incident reduction, procedural compliance, and risk control effectiveness. Forklift safety KPIs include: incident frequency rate (accidents, near-misses, and property damage per defined work hours), severity measures such as Lost Time Injury Frequency Rate (LTIFR), and near-miss reporting frequency as a signal of hazard awareness and reporting culture. Compliance-focused indicators are also essential, including SOP compliance rate from audits and observations, pre-operation checklist completion, and the number of SOP violations. Training-related indicators include training completion rate, refresher frequency, and competency assessment scores to verify operator readiness. Behavioral indicators measure unsafe acts (speeding, improper load handling, seatbelt non-use) and unsafe conditions (blocked aisles, poor lighting, and damaged racking). Equipment reliability indicators include inspection and preventive maintenance compliance, breakdown frequency, and downtime. Additional indicators such as audit scores, corrective action closure time, and employee safety perception surveys help evaluate system effectiveness and safety culture. Together, these KPIs support data-driven decisions, continuous improvement, and sustainable forklift risk reduction.

4.4. Data Collection

Data collection is a vital component in evaluating the safety performance of forklift operations after the implementation of Hazard Identification and Risk Assessment (HIRA) and Standard Operating Procedures (SOPs). Systematic and accurate data gathering provides the foundation for measuring safety improvements, identifying gaps, and drawing reliable conclusions. Both pre-implementation and post-implementation data are collected to enable meaningful comparison and assessment of change. The data include quantitative information such as incident and accident records, near-miss reports, Lost Time Injury Frequency Rate (LTIFR), SOP compliance percentages, audit scores, training completion rates, and operational usage data. In addition, qualitative data are obtained through operator and supervisor interviews, employee surveys, safety officer reports, and direct workplace observations to understand behavioral and cultural factors influencing safety. Multiple methods are used, including document reviews, safety audits, direct observations, surveys, and interviews, supported by standardized tools and digital safety management systems. Ensuring data quality through standardization, verification, confidentiality, and trained data collectors enhances reliability. Overall, effective data collection enables evidence-based evaluation, supports continuous improvement, and strengthens forklift safety management practices.

4.5. Data Analysis

4.5.1. Analysis of Forklift Utilization & Exposure

The analysis of forklift utilization data indicates a controlled reduction in operational exposure following the implementation of HIRA and SOPs.

- The number of forklifts in operation remained constant (12 units), confirming that safety improvements were achieved without reducing operational capacity.
- Average operating hours per forklift decreased from 9.5 to 8.7 hours/day, indicating better shift planning and fatigue management.
- Annual forklift operating hours reduced by 6.5%, directly lowering exposure to operational risks.
- The operator-to-forklift ratio improved from 3:1 to 2.5:1, enhancing accountability and reducing unsafe shared usage.
- Night-shift forklift usage dropped from 38% to 25%, significantly reducing visibility-related risks.
- Operations in congested areas reduced from 45% to 28%, demonstrating effective traffic

International Research Journal on Advanced Engineering Hub (IRJAEH)
e ISSN: 2584-2137
Vol. 04 Issue: 05 May 2026
Page No: 2910-2922
https://irjaeh.com
https://doi.org/10.47392/IRJAEH.2026.0369

management and layout optimization.

4.5.2. Preventive Maintenance & Inspection Effectiveness Analysis

Preventive maintenance data shows marked improvements in equipment reliability and safety controls.

- Scheduled preventive maintenance (PM) compliance increased from 78% to 96%, reflecting stronger maintenance discipline.
- Missed inspections reduced by 78.5%, minimizing the likelihood of undetected mechanical failures.
- Critical safety-related defects showed substantial reductions:
- Brake defects ↓ 77.8%
- Steering defects ↓ 83.3%
- Tyre wear issues ↓ 63.6%
- Maintenance response time improved from 18 hours to 6 hours, enabling faster hazard elimination.

4.5.3. Behavioral Based Safety (BBS) Observation Analysis

- Unsafe driving speed incidents reduced by 66.7%.
- Improper load handling reduced by 66.7%.
- Seat belt non-usage decreased by 85.7%.
- Unauthorized operation incidents reduced by 83.3%.
- Safe driving practices more than doubled, indicating increased safety awareness.
- Proper pedestrian yielding behaviors increased significantly.

The reduction in unsafe acts and increase in safe behaviors indicate that training, SOP enforcement, and monitoring positively influenced operator behavior and safety culture.

4.5.4. Pedestrian & Traffic Management Analysis

- Pedestrian–forklift interaction zones reduced from 11 to 5, minimizing collision risks.
- Forklift lane marking coverage improved from 62% to 92%, ensuring better segregation.
- Blind spots reduced by 62.5% through engineering controls.
- Installation of convex mirrors increased from 2 to 9, enhancing visibility.
- Pedestrian awareness boards increased by 250%, improving hazard awareness.

4.5.5. PPE Compliance Analysis

- Safety shoe compliance improved to 98%.
- Helmet usage increased to 96%.
- High-visibility jacket usage showed the highest improvement (+29%).
- Forklift seat belt usage improved to 96%.

4.5.6. Emergency Preparedness & Response Analysis

- Emergency drills increased from 1 to 3 per year.
- Drill response time improved by 39.5%.
- Operator awareness of emergency SOPs increased to 94%.
- Fire extinguisher coverage and exit accessibility exceeded 95%.

4.5.7. Safety Communication & Reporting Analysis

- Toolbox talks increased threefold.
- Safety circulars increased from 4 to 14 per year.
- Forklift safety posters increased four times.
- Safety suggestions increased by 343%, with an implementation rate of 81%.

4.5.8. Management Review & Leadership Commitment Analysis

Safety review meetings increased from 2 to 6 per year.

- Forklift safety agenda coverage increased to 88%.
- Management walkthroughs quadrupled.
- Action closure rate improved to 93%.
- Safety budget allocation more than doubled.

4.5.9. Overall Safety Performance Index (SPI) Analysis

- SPI score increased from 54 (Pre) to 89 (Post).
- Major contributors included accident reduction, SOP compliance, and near-miss reporting.
- Improvement across all weighted indicators confirms holistic safety system enhancement.

International Research Journal on Advanced Engineering Hub (IRJAEH)
e ISSN: 2584-2137
Vol. 04 Issue: 05 May 2026
Page No: 2910-2922
https://irjaeh.com
https://doi.org/10.47392/IRJAEH.2026.0369

4.5.10. Data Analysis Summary

- Operational exposure reduced without affecting productivity
- Mechanical failures minimized through preventive maintenance
- Unsafe behaviors significantly reduced
- Pedestrian and traffic risks effectively controlled
- PPE and emergency preparedness achieved high compliance
- Safety communication and management commitment strengthened
- Overall forklift safety performance improved substantially

4.6. Stakeholder Engagement

Stakeholder engagement is a critical element in evaluating the safety performance of forklift operations, as the effectiveness of Hazard Identification and Risk Assessment (HIRA) and Standard Operating Procedures (SOPs) depends heavily on human behavior, perceptions, and compliance. Relying solely on quantitative data may overlook practical challenges and cultural factors influencing safety outcomes. Therefore, structured stakeholder engagement was undertaken to complement statistical analysis and provide a holistic understanding of operational realities. Stakeholders were identified based on their roles in forklift operations, including forklift operators, safety officers, supervisors, maintenance personnel, managers, and HR and training coordinators. Multiple engagement methods were employed to capture diverse perspectives, such as structured interviews, operator surveys, focus group discussions, and workplace observations. Interviews with safety officers and supervisors provided insights into HIRA effectiveness, SOP enforcement challenges, and monitoring issues. Operator surveys and focus group discussions highlighted practical difficulties, training impact, behavioral changes, and perceptions of safety culture, while workplace observations validated reported practices against actual behavior. Analysis of stakeholder feedback revealed overall positive acceptance of safety interventions, improved training effectiveness, enhanced reporting culture, and noticeable behavioral improvements such as increased seat belt use and speed control. At the same time, hidden and emerging issues such as time pressure, layout constraints, fatigue, and the need for visual and multilingual SOP aids were identified. Integrating stakeholder inputs with quantitative data strengthened the credibility of findings and supported continuous improvement, ultimately fostering a proactive and sustainable safety culture.

4.7. Findings and Recommendations

The evaluation of forklift safety performance following the implementation of Hazard Identification and Risk Assessment (HIRA) and Standard Operating Procedures (SOPs), along with practical recommendations for continuous improvement. The findings are based on comparative analysis of pre- and post-implementation safety data, audits, behavioral observations, and structured stakeholder feedback. The evaluation revealed a significant reduction in forklift-related accidents, with post-implementation data showing fewer minor injuries, reduced equipment damage, and no major or fatal incidents. The Lost Time Injury Frequency Rate (LTIFR) demonstrated a clear downward trend, indicating improved control of high-severity risks. Preventive maintenance compliance improved notably, reducing mechanical failures and enhancing equipment reliability. Behavioral observations confirmed a decline in unsafe acts such as over speeding and improper load handling, alongside increased seat belt usage, PPE compliance, and safer pedestrian interaction. An increase in near-miss reporting reflected a positive shift in safety culture and improved safety communication across operations. Despite these improvements, persisting risks were identified, including congestion during peak hours, fatigue during extended shifts, and layout constraints in older facilities. Based on these findings, key recommendations include periodic review of HIRA, simplification and visual enhancement of SOPs, advanced and refresher operator training, integration of Behavior-Based Safety (BBS) programs, engineering and layout improvements, strengthened monitoring and auditing systems, fatigue risk management, and sustained

International Research Journal on Advanced Engineering Hub (IRJAEH)
e ISSN: 2584-2137
Vol. 04 Issue: 05 May 2026
Page No: 2910-2922
https://irjaeh.com
https://doi.org/10.47392/IRJAEH.2026.0369

management leadership. Implementing these measures will help sustain improvements and achieve long-term forklift safety excellence.

4.8. Reporting

Reporting is a vital part of forklift safety evaluation because it documents findings clearly and communicates them to operators, supervisors, safety officers, and management for action. In this study, reporting ensured transparency, traceability, and effective use of both quantitative and qualitative data collected before and after HIRA and SOP implementation. The key objectives were to document safety performance trends, communicate changes in incidents and near-misses, track SOP compliance and behavioral improvements, support management review, and provide evidence for audits and regulatory requirements. A multi-level reporting framework was adopted. Operational reports included daily forklift pre-use checklists, incident and near-miss reports, and unsafe act/condition records. Supervisory and departmental reports summarized SOP compliance, training and competency status, and maintenance/inspection performance on weekly or monthly cycles. Management-level reports consolidated KPIs such as accident frequency, LTIFR, near-miss rate, training coverage, and audit scores into dashboards for strategic decisions. Reporting also integrated stakeholder feedback and corrective action closure tracking, supporting continuous improvement through the PDCA cycle.

4.9. SOP Implementation

Standard Operating Procedures (SOPs) are structured, written instructions developed to ensure uniformity, consistency, and safety in performing tasks. In forklift operations, SOPs are essential for controlling hazards related to vehicle movement, load stability, pedestrian interaction, and equipment condition. In this study, forklift SOPs were implemented as a proactive risk control measure aligned with the outcomes of Hazard Identification and Risk Assessment (HIRA). The implementation focused not only on documentation, but also on workforce understanding, practical execution, compliance monitoring, and continuous improvement. The objectives of SOP implementation were to standardize safe practices, eliminate unsafe acts and conditions identified during HIRA, reduce accidents and near-misses, improve operator competency and accountability, and ensure compliance with statutory requirements and safety standards. SOPs were developed using HIRA findings, historical incident data, legal guidelines, manufacturer recommendations, industry best practices, and inputs from operators, supervisors, and safety officers. Each SOP followed a consistent format including scope, responsibilities, step-by-step procedure, safety precautions, PPE requirements, emergency actions, and documentation requirements, supported by visual aids for clarity. Major SOPs implemented covered operator authorization and competency, mandatory pre-use inspections, safe driving and speed control, load handling, pedestrian segregation and traffic management, parking and shutdown, PPE use (including seat belts), and emergency response. SOP communication was strengthened through classroom sessions, on-the-job demonstrations, toolbox talks, signage, and display of SOPs at key operating areas. Training included theory, practical demonstrations, competency assessments, and refresher programs. Compliance was monitored through safety audits, supervisor observations, behavior-based safety (BBS) checks, and review of incident/near-miss trends. Non-compliance was addressed through counseling and retraining. Challenges such as resistance to change, workload pressure, and language barriers were managed through repeated awareness, simplified SOPs, and visible leadership support. Post-implementation results showed improved compliance, reduced incidents, and stronger safety culture, confirming SOPs as a cornerstone of forklift risk control.

5. Result And Discussion

The results of this study demonstrate a significant improvement in forklift safety performance following the implementation of Hazard Identification and Risk Assessment (HIRA) and Standard Operating Procedures (SOPs). Comparative analysis of pre- and post-implementation data indicates that structured risk identification, standardized operating practices, and focused

International Research Journal on Advanced Engineering Hub (IRJAEH)
e ISSN: 2584-2137
Vol. 04 Issue: 05 May 2026
Page No: 2910-2922
https://irjaeh.com
https://doi.org/10.47392/IRJAEH.2026.0369

stakeholder engagement collectively contributed to measurable reductions in incidents, improved compliance, and enhanced safety culture. Reduction in Accidents and Incident One of the most notable outcomes of the study was the substantial reduction in forklift-related accidents. Post-implementation data showed a marked decline in collision incidents, forklift overturning, load fall events, and pedestrian injuries. This reduction can be directly attributed to the systematic identification of hazards through HIRA and the implementation of targeted SOP controls such as speed limits, defined traffic routes, and load handling procedures. The decrease in property damage incidents further highlights the effectiveness of preventive measures and improved operator discipline.

- Improvement in Near-Miss Reporting

The analysis revealed a significant increase in near-miss reporting following SOP implementation. While the number of reported near misses increased, this trend is considered a positive indicator of an improving safety culture rather than an increase in unsafe conditions. Enhanced awareness, simplified reporting mechanisms, and encouragement from supervisors contributed to proactive hazard reporting.
Enhanced SOP Compliance and Behavioral Safety
Audit findings showed a high level of SOP compliance in key areas such as pre-use inspections, seat belt usage, PPE compliance, and adherence to speed limits. Behavioral-based safety observations indicated a reduction in unsafe acts and a corresponding increase in safe driving practices. These improvements suggest that SOP implementation, supported by training and supervision, positively influenced operator behavior. However, minor deviations were still observed during peak operational periods, indicating the need for continuous monitoring and reinforcement.

- Reduction in Injury Severity and LTIFR

A significant decrease in the Lost Time Injury Frequency Rate (LTIFR) was observed in the post-implementation period. The reduction in lost time injuries reflects not only fewer accidents but also lower injury severity. Improved emergency response preparedness, better maintenance practices, and consistent use of PPE contributed to this outcome. This result confirms that HIRA-based SOPs effectively mitigated high-risk scenarios associated with forklift operations.

- Impact of Training and Stakeholder Engagement

Training effectiveness was evident through improved operator competency, confidence, and compliance. Stakeholder engagement played a crucial role in successful implementation by addressing practical challenges and gaining workforce buy-in. Feedback from operators and supervisors highlighted increased awareness of risks and a stronger sense of responsibility toward safe operations. Overall, the results validate the effectiveness of integrating HIRA and SOPs into forklift safety management systems. While the improvements were significant, the study also highlights the importance of continuous training, leadership involvement, and regular review of SOPs to sustain safety performance. The findings emphasize that safety performance improvement is not a one-time intervention but an ongoing process requiring commitment at all organizational levels.

Conclusion

This project successfully evaluated the safety performance of forklift operations following the implementation of Hazard Identification and Risk Assessment (HIRA) and Standard Operating Procedures (SOPs). The study confirms that a structured and systematic approach to hazard identification, risk control, and procedural standardization can significantly enhance operational safety in material handling environments. Forklift operations, which are inherently associated with high-risk activities, showed measurable improvements when supported by well-defined safety management tools. The comparative analysis of pre- and post-implementation data demonstrated a clear reduction in forklift-related accidents, near-miss severity, and Lost Time Injury Frequency Rate (LTIFR). The decline in incidents such as collisions, load falls, and equipment-related failures indicates the effectiveness of HIRA in identifying critical hazards and the role of SOPs in translating risk controls into practical workplace actions. Improved compliance with operating procedures, PPE usage, and maintenance protocols further reinforced safe

International Research Journal on Advanced Engineering Hub (IRJAEH)
e ISSN: 2584-2137
Vol. 04 Issue: 05 May 2026
Page No: 2910-2922
https://irjaeh.com
https://doi.org/10.47392/IRJAEH.2026.0369

operational behavior. An important outcome of the study was the positive shift in safety culture, reflected by increased near-miss reporting, improved behavioral compliance, and active stakeholder participation. Training programs and awareness initiatives enhanced operator competence and confidence, while supervisory and management involvement strengthened accountability and enforcement. These factors collectively contributed to sustainable safety improvements beyond mere compliance. The study also highlighted the need for continuous monitoring and periodic review of SOPs to address evolving operational challenges and behavioral lapses during high-pressure work conditions. Safety performance improvement is an ongoing process that requires consistent leadership commitment, workforce engagement, and data-driven decision-making. The integration of HIRA and SOPs proved to be an effective strategy for improving forklift safety performance. The findings of this project provide a practical framework that can be adopted by industries seeking to reduce workplace accidents, improve compliance, and foster a proactive and resilient safety culture in forklift and material handling operations.

References

[1] V.A. Yartys, M.V. Lototskyy, Tolj, HYDRIDE4MOBILITY: An EU project on hydrogen powered forklift using metal hydrides for hydrogen storage and H2 compression 2025.
[2] Ishaan Kaushal, Andrea Revolti, Simulation based Digital Twin framework for Smart Mobile Factory operations 2025.
[3] Young Min Seo, Hyun Woo Noh, Experimental study on the operation of pressure safety valve in the liquid hydrogen environment 2025.
[4] Juan Jesús Losada del Olmo, Ángel Luis Perales Gómez, A few-shot learning methodology for improving safety in industrial scenarios through universal self-supervised visual features and dense optical flow 2024.
[5] Takashi Ono, Takuya Iwasaki, Debilitating ocular globe rupture due to a forklift accident: A case report 2024.
[6] Hoda Abuzied, Nathalie Nazih, Design and simulation of eco-friendly smartphone controlled forklift 2024.
[7] Yanfang Luo, Seungjun Ahn, Ali Abbas, Investigating the impact of scenario and interaction fidelity on training experience when designing immersive virtual reality-based construction safety training 2023.
[8] Pawel Zajac, Tomislav Rozic, Energy consumption of forklift versus standards, effects of their use and expectations 2022.
[9] Jouh Yeong Chew, Mitsuru Kawamoto, Takashi Okuma, Multi-modal approach to evaluate adaptive visual stimuli of remote operation system using gaze behaviour 2021.
[10] Matti Huotari, Shashank Arora, Comparing seven methods for state-of-health time series prediction for the lithium-ion battery packs of forklifts, 2021.
[11] Xing Luo, Jihong Wang, Mark Dooner, Jonathan Clarke, Overview of current development in electrical energy storage technologies and the application potential in power system operation, Appl. Energy 137 (2015) 511–536, https://doi.org/10.1016/j.apenergy.2014.09.081.
[12] T.M. Gür, Review of electrical energy storage technologies, materials and systems: challenges and prospects for large-scale grid storage, Energ. Environ. Sci. 11 (10) (2018) 2696–2767, https://doi.org/10.1039/C8EE01419A.
[13] V. Yartys, Y. Solonin, I. Zavaliy, Hydrogen Based Energy Storage: Status and Recent Developments, Prostir-M, Lviv, 2021, https://doi.org/10.15407/materials2021.
[14] V.A. Yartys, M.V. Lototskyy, E. Akiba, R. Albert, V.E. Antonov, J.R. Ares, M. Baricco, N. Bourgeois, C.E. Buckley, J.M. Bellosta von Colbe, J.-C. Crivello, F. Cuevas, R.V. Denys, M. Dornheim, M. Felderhoff, D.M. Grant, B.C. Hauback, T. D. Humphries, I. Jacob, T.R. Jensen, Min Zhu, Magnesium based materials for hydrogen based energy storage: past, present and future, Int. J. Hydr.

International Research Journal on Advanced Engineering Hub (IRJAEH)
e ISSN: 2584-2137
Vol. 04 Issue: 05 May 2026
Page No: 2910-2922
https://irjaeh.com
https://doi.org/10.47392/IRJAEH.2026.0369

Energy 44 (15) (2019) 7809–7859, https://doi.org/10.1016/j.ijhydene.2018.12.212.

[15] V.A. Yartys, M.V. Lototskyy, Laves type intermetallic compounds as hydrogen storage materials: a review, J. Alloys Compd. 916 (2022) 165219, https://doi.org/10.1016/j.jallcom.2022.165219.