

Effectiveness of EHS Safety Training Programs in Reducing Workplace Accidents in Pharmaceutical Manufacturing

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Abstract — *Pharmaceutical manufacturing environments involve complex processes, hazardous materials, and strict regulatory requirements that make employee safety a critical organizational priority. Despite significant investment in Environmental, Health, and Safety (EHS) training programs, workplace incidents and unsafe behaviors continue to occur, raising concerns about training effectiveness. This design project evaluates the effectiveness of EHS safety training programs in reducing workplace accidents and unsafe behaviors within a pharmaceutical manufacturing environment. A non-experimental, descriptive, and longitudinal research design was applied using historical EHS data collected between 2022 and 2024, including incident reports, near-miss records, behavioral safety observations, and compliance indicators. The project execution and analysis were conducted during the academic period from November 2025 through mid-February 2026. Results indicate that EHS training positively influences safety performance, particularly in behavior-based outcomes such as procedural compliance, personal protective equipment adherence, and hazard awareness. Findings emphasize the importance of job-specific training, hands-on reinforcement, and continuous evaluation to sustain safe work practices.*

Key Terms — *Environmental, Health, and Safety (EHS); Pharmaceutical Manufacturing; Safety Training; Workplace Accidents.*

PROBLEM STATEMENT

Pharmaceutical manufacturing environments operate under strict regulatory frameworks and complex operational conditions that expose employees to chemical, biological, mechanical, and

ergonomic hazards. To mitigate these risks, organizations invest heavily in Environmental, Health, and Safety (EHS) training programs designed to promote hazard awareness, procedural compliance, and safe work behaviors. Despite these efforts, workplace incidents, near misses, and unsafe behaviors continue to occur, raising concerns regarding the true effectiveness of safety training initiatives. Regulatory agencies such as the Occupational Safety and Health Administration (OSHA) require organizations to implement structured training programs addressing hazard communication, personal protective equipment (PPE), emergency response, and safe task execution [1]. In pharmaceutical manufacturing, these requirements are further reinforced by Good Manufacturing Practices (GMP) and internal corporate safety standards. While compliance with training completion is typically achieved, inconsistencies in employee behavior during routine operations and unexpected events suggest a gap between training delivery and training effectiveness. Operational observations indicate that employees may successfully complete mandatory training modules yet demonstrate hesitation, procedural deviations, or reliance on peer guidance when faced with real-world safety scenarios. Additionally, recurring near misses and minor safety incidents, although often classified as low severity, may signal underlying weaknesses in training retention, behavioral reinforcement, or alignment between training content and job-specific hazards. If not addressed, these deficiencies may contribute to more serious accidents, regulatory scrutiny, or operational disruptions. Therefore, a systematic evaluation of EHS safety training effectiveness is necessary to determine whether existing programs meaningfully reduce workplace accidents and unsafe behaviors

within pharmaceutical manufacturing environments. Understanding the relationship between training completion, behavioral performance, and safety outcomes is essential for strengthening safety culture and supporting proactive risk management strategies.

RESEARCH DESCRIPTION

This design project examines the effectiveness of Environmental, Health, and Safety (EHS) training programs in reducing workplace accidents and unsafe behaviors within pharmaceutical manufacturing environments. The study focuses on evaluating whether structured safety training contributes to measurable improvements in employee behavior, procedural compliance, and overall safety performance.

The research utilizes a non-experimental, descriptive, and longitudinal approach based on the analysis of historical EHS data collected between 2022 and 2024. Data sources include injury and illness reports, near-miss and unsafe condition records, behavioral safety observations, personal protective equipment (PPE) compliance findings, and training completion records. By analyzing trends across multiple years, the study assesses changes in safety performance before and after the completion and reinforcement of key EHS training modules.

Pharmaceutical manufacturing operations present unique safety challenges due to chemical exposure risks, sterile processing requirements, biological hazards, and complex automated systems. Minor deviations from established procedures—such as improper chemical handling, incorrect gowning practices, or incomplete equipment shutdown—may escalate into significant safety or quality events. As a result, this project emphasizes the importance of evaluating training effectiveness beyond completion metrics, focusing instead on behavioral performance and real-world application.

In addition, the study considers the influence of training modality and reinforcement practices on knowledge retention and behavioral consistency. Instructor-led sessions, hands-on training, and

emergency drills are examined as critical components supporting employee confidence and preparedness during routine operations and unexpected events. The findings of this project aim to provide practical insight into how EHS training programs can be optimized to support sustained safety performance in regulated manufacturing environments.

RESEARCH TIMELINE

The research activities for this design project were conducted during the academic period from November 2025 through mid-February 2026. This timeline reflects a structured and sequential development of the project, beginning with topic definition and proposal refinement, followed by the development of the problem statement, research objectives, and literature review.

During the initial phase, existing literature related to Environmental, Health, and Safety (EHS) training effectiveness, workplace safety, and behavioral compliance within regulated manufacturing environments was reviewed to establish the theoretical foundation of the study. Concurrently, the research design and methodology were defined to ensure alignment with the project objectives and data availability.

Subsequent phases focused on the analysis of historical EHS data collected between 2022 and 2024, including incident reports, near-miss records, and behavioral safety observations. This analysis was conducted without direct operational intervention, consistent with the non-experimental and longitudinal nature of the study. Additional time was allocated for the interpretation of results, integration of findings with existing literature, and development of the discussion and conclusions.

The final phase of the project emphasized content refinement, formatting adjustments, and incorporation of feedback to ensure academic rigor and compliance with graduate-level publication standards. This structured timeline supported effective project management while allowing sufficient time for analysis, revision, and final submission.

RESEARCH CONTRIBUTIONS

This design project provides meaningful contributions at the practical, organizational, and academic levels by evaluating the effectiveness of Environmental, Health, and Safety (EHS) training programs within pharmaceutical manufacturing environments. From a practical perspective, the study offers insight into how safety training influences both incident-based and behavior-based safety outcomes. By integrating traditional lagging indicators, such as injury and near-miss reports, with leading indicators, including procedural compliance and personal protective equipment (PPE) adherence, the project demonstrates the value of a comprehensive approach to evaluating training effectiveness beyond injury rates alone.

At the organizational level, the findings support improved alignment between EHS training content and job-specific hazards commonly encountered in regulated manufacturing operations. The results emphasize the importance of targeted, role-specific training, hands-on reinforcement, and continuous evaluation to strengthen safety culture and support proactive risk management. These insights can assist safety leaders, supervisors, and training professionals in optimizing training strategies to reduce operational risk and improve behavioral consistency.

From an academic perspective, this project contributes to existing occupational safety and health literature by examining EHS training effectiveness within a highly regulated manufacturing context. The study reinforces the application of non-experimental, longitudinal research designs for evaluating safety interventions and provides a framework that may be applicable to other high-risk industries where training effectiveness and behavioral compliance are critical to operational success.

LITERATURE REVIEW

Occupational safety and health literature consistently identifies Environmental, Health, and Safety (EHS) training as a foundational element of

accident prevention in high-risk industries [2], [3]. Effective training programs equip employees with the knowledge and skills required to recognize hazards, follow standardized procedures, and respond appropriately to both routine and unexpected situations. In regulated manufacturing environments, where chemical exposure, complex equipment, and strict procedural controls are common, training effectiveness directly influences safety performance.

Regulatory agencies emphasize the role of training as a critical administrative control supporting safe operations [1]. The Occupational Safety and Health Administration (OSHA) establishes training requirements related to hazard communication, personal protective equipment, emergency response, and safe task execution. In pharmaceutical manufacturing, these requirements are further reinforced by Good Manufacturing Practices (GMP) and internal corporate safety standards. However, compliance with training completion does not always translate into consistent safe behavior, highlighting the need to evaluate training effectiveness beyond participation metrics.

Research indicates that training modality significantly influences knowledge retention and behavioral performance [4]. Interactive and hands-on training approaches have been shown to be more effective than passive instructional methods such as lectures or standalone e-learning modules. Scenario-based training and emergency drills allow employees to practice decision-making in controlled environments, improving confidence, procedural accuracy, and response effectiveness during real-world events.

Safety culture also plays a critical role in determining whether training translates into sustained behavioral change. Studies on climate safety suggest that employees' perceptions of organizational commitment to safety influence their willingness to follow procedures and report hazards [5]. Organizations that actively reinforce training through leadership engagement, supervision, and accountability mechanisms tend to experience higher compliance levels and fewer safety incidents.

Despite widespread implementation of EHS training programs, limitations remain. Common challenges include generic training content, insufficient reinforcement, and a lack of performance-based evaluation. These gaps underscore the importance of aligning training content with job-specific hazards and continuously assessing behavioral outcomes. The literature supports the need for comprehensive evaluation frameworks that integrate both leading and lagging safety indicators to accurately assess the effectiveness of EHS training interventions in regulated manufacturing environments.

METHODOLOGY

This design project employs a non-experimental, descriptive, and longitudinal research design to evaluate the effectiveness of Environmental, Health, and Safety (EHS) training programs in reducing workplace accidents and unsafe behaviors within pharmaceutical manufacturing environments. A non-experimental approach was selected because the study focuses on the analysis of existing safety and training data without manipulating variables or introducing controlled interventions.

The descriptive component of the methodology supports the examination of incident trends, near-miss occurrences, and behavioral compliance

indicators associated with EHS training completion. The longitudinal aspect enables the comparison of safety performance indicators over time, particularly before and after the completion and reinforcement of key EHS training modules. This approach allows for the identification of sustained behavioral patterns rather than short-term compliance effects.

Data for the study were obtained from existing organizational EHS records collected between 2022 and 2024. These data sources include injury and illness reports, near-miss and unsafe condition records, behavioral safety observations, personal protective equipment (PPE) compliance findings, chemical spill and environmental incident logs, and training completion records. All data were analyzed in aggregate form to ensure confidentiality and ethical compliance.

The study adopts a quantitative-dominant approach complemented by qualitative elements. Quantitative indicators were used to evaluate changes in incident frequency, near-miss reporting, and compliance trends, while qualitative information from root-cause investigation summaries and behavioral observations provided contextual understanding of safety performance patterns. Trend analysis and correlation techniques were applied to examine relationships between training modules and corresponding safety outcomes.

Table 1
Methodology

Component	Description
Research Design	Non-experimental, descriptive, and longitudinal
Study Type	Design Project
Study Period	Data collected from 2022–2024; project executed from Nov 2025 to Feb 2026
Population	Employees in pharmaceutical manufacturing operations
Data Sources	Incident reports, near-miss records, behavioral observations, PPE compliance data, training records
Independent Variable	EHS safety training programs
Dependent Variables	Workplace accidents, near misses, procedural compliance, safety behavior indicators
Data Analysis	Trend analysis and correlation of training modules with safety outcomes
Ethical Considerations	Aggregate data analysis; no personal identifiers used

Ethical considerations were addressed by maintaining data confidentiality and avoiding the inclusion of personal identifiers. The study did not involve direct employee participation, surveys, or experimental interventions, thereby minimizing risk to participants and ensuring alignment with organizational policies and academic research standards.

This project applies the DMAIC (Define, Measure, Analyze, Improve, Control) methodology to systematically evaluate the effectiveness of Environmental, Health, and Safety (EHS) training programs in reducing workplace accidents and unsafe behaviors within pharmaceutical manufacturing environments. The DMAIC framework was selected due to its structured, data-driven approach and its suitability for improving existing processes rather than designing new systems.

Define Phase

During the Define phase, the scope of the project was established through the review of historical EHS incident reports, near-miss records, and unsafe condition observations. Key safety performance concerns, stakeholders, and training-related gaps were identified to clearly define the problem and project objectives.

Measure Phase

In the Measure phase, baseline safety performance indicators were established using historical EHS data collected between 2022 and 2024. Metrics included incident frequency, near-miss reporting trends, personal protective equipment (PPE) compliance observations, procedural adherence findings, and safety training participation records.

Analyze Phase

The Analyze phase focused on identifying trends, patterns, and potential root causes affecting workplace safety performance. Comparative analysis indicated that behavior-based safety indicators were more responsive to safety training

reinforcement than equipment- or facility-related events. Increased near-miss reporting following training activities was interpreted as improved hazard awareness and safety culture maturity.

Improve Phase

Based on the analysis findings, improvement actions focused on strengthening existing EHS safety training programs. Proposed improvements included enhancing job-specific and hands-on training, reinforcing learning through drills and real-case scenarios, and increasing supervisory engagement to promote consistent safe behaviors.

Control Phase

The Control phase emphasized sustaining safety improvements through continuous monitoring of key safety performance indicators. Routine audits, refresher training, behavioral observations, and supervisory feedback mechanisms were identified as essential controls to ensure long-term alignment between training effectiveness, regulatory compliance, and organizational safety objectives.

RESULTS AND DISCUSSION

This section presents and discusses the results obtained from the analysis of Environmental, Health, and Safety (EHS) records and operational safety indicators within a pharmaceutical manufacturing environment. The findings are organized following the DMAIC (Define, Measure, Analyze, Improve, Control) methodology to ensure alignment between the applied methodology and the interpretation of results. This structured approach supports a comprehensive evaluation of safety training effectiveness and its impact on workplace safety performance.

Define Phase

During the Define phase, key safety performance concerns were identified through the review of historical EHS incident reports, near-miss records, and unsafe condition observations. The analysis revealed that workplace incidents and unsafe behaviors continued to occur despite high

Table 2

Summary of Identified Safety Performance Gaps During the Define Phase

Content	
Project Focus	Evaluate the effectiveness of EHS safety training in reducing workplace accidents and unsafe behaviors in pharmaceutical manufacturing.
Problem	Workplace incidents, near misses, and unsafe behaviors continue to occur despite high training completion rates, suggesting a gap between training delivery and real-world application.
Goal	Determine whether safety training is associated with measurable improvements in safety performance and identify opportunities to strengthen training impact.
Scope	Analysis of historical EHS records (incidents, near misses, BBS observations, PPE compliance, audits, training completion) in a pharmaceutical manufacturing environment.
Stakeholders	Employees/Operators, Supervisors, EHS Team, Training/Compliance, Operations Leadership.
Key Metrics (High-Level)	Incident frequency, near-miss reporting trends, PPE compliance, procedural adherence, training participation/completion.

safety training completion rates. This gap indicated a potential disconnect between training delivery and practical application in daily operations. Stakeholders, including employees, supervisors, and the EHS team, were identified as critical contributors to safety performance, establishing a clear foundation for subsequent analysis.

Measure Phase

The Measure phase focused on establishing baseline safety performance indicators using historical EHS data collected between 2022 and 2024. Quantitative metrics included incident frequency, near-miss reporting trends, personal protective equipment (PPE) compliance observations, procedural adherence findings, and safety training participation records. These measurements provided visibility into safety performance variability across operational periods. The baseline data demonstrated that while training participation rates were consistently high, variations in behavioral compliance and near-miss reporting persisted, highlighting the need for deeper analysis.

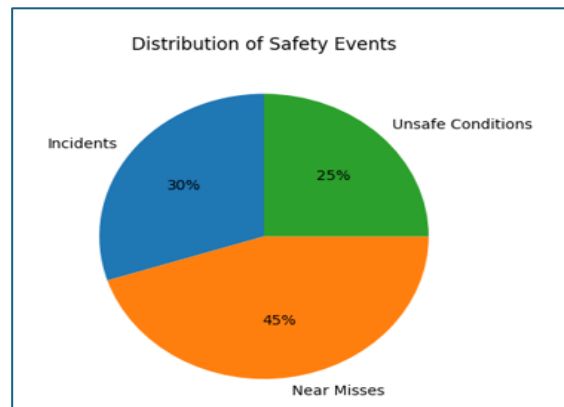


Figure 1
Distribution of Safety Training Participation and Baseline Safety Indicators (2022–2024)



Figure 2
Incident and Near-Miss Reporting Trends Prior to Training Reinforcement

Analyze Phase

During the Analyze phase, safety performance data were examined to identify trends, patterns, and potential root causes influencing workplace safety outcomes. Comparative analysis revealed that behavior-based safety indicators, such as PPE compliance and procedural adherence, were more responsive to safety training reinforcement than incident-based indicators alone. Additionally, an increase in near-miss reporting was observed following training periods. Rather than indicating deteriorating safety conditions, this trend reflected improved hazard recognition, employee engagement, and reporting culture. These findings emphasize the importance of leading indicators in evaluating safety training effectiveness.

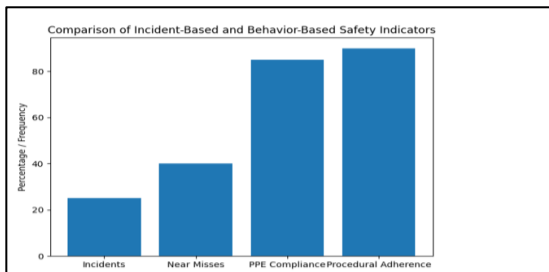


Figure 3

Comparison of Behavior-Based Safety Indicators Following Training Activities

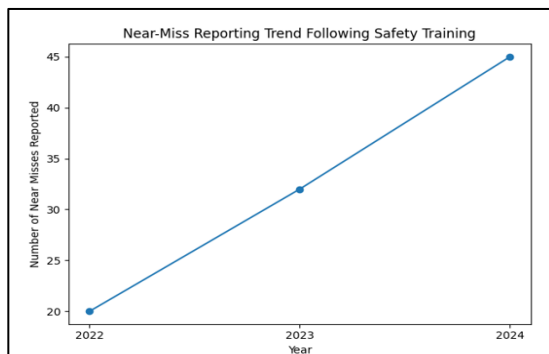


Figure 4

Near-Miss Reporting Trends Following Safety Training Implementation

Improve Phase

Based on the findings from the analysis, improvement actions focused on strengthening existing EHS safety training programs rather than designing new systems. Proposed improvements

included enhancing job-specific and hands-on training, reinforcing learning through drills and real-case scenarios, and increasing supervisory engagement to support consistent safe behaviors. Emphasis was placed on translating training content into practical application, addressing behavioral gaps, and promoting accountability across operational teams.

Control Phase

The Control phase emphasized sustaining safety improvements through continuous monitoring and reinforcement of key safety performance indicators. Ongoing controls included routine audits, refresher training sessions, behavioral safety observations, and supervisory feedback mechanisms. These controls support long-term alignment between safety training effectiveness, regulatory compliance, and organizational safety objectives. Continuous evaluation ensures that improvements achieved through training interventions are maintained over time and embedded within the EHS management system.

Table 3

Control Plan for Sustaining EHS Safety Training Improvements

Control Element	Description
Safety Indicators	Incident rate, near-miss reporting, PPE compliance, behavioral observations
Monitoring Method	Routine audits, safety observations, EHS dashboards
Frequency	Monthly and quarterly reviews
Responsible Team	EHS team, supervisors, and operations leadership
Response Actions	Training refreshers, corrective actions, and coaching

CONCLUSION

The objective of this design project was to evaluate the effectiveness of Environmental, Health, and Safety (EHS) training programs in reducing workplace accidents and unsafe behaviors within pharmaceutical manufacturing environments. Given the highly regulated nature of the industry and the critical importance of employee safety, this study sought to move beyond training completion metrics and assess whether safety training translates into measurable improvements in safety performance.

Using the DMAIC (Define, Measure, Analyze, Improve, Control) methodology, this project applied a structured and data-driven approach to evaluate EHS training effectiveness. Historical safety data collected between 2022 and 2024 were analyzed and evaluated during the project execution period from November 2025 through mid-February 2026. This approach enabled a comprehensive assessment of both incident-based and behavior-based safety indicators, ensuring alignment between methodology, analysis, and interpretation of results.

The findings indicate that EHS training plays a meaningful role in improving safety performance, particularly in behavior-driven outcomes. While training completion rates were consistently high, the analysis demonstrated that training contributes most effectively to safety performance by strengthening procedural compliance, personal protective equipment (PPE) adherence, and hazard awareness. These behavior-based indicators showed a stronger and more consistent response to training reinforcement than incident frequency alone, highlighting the value of leading indicators in safety performance evaluation.

It is important to acknowledge that incident reduction cannot be attributed exclusively to EHS training due to the influence of external operational factors such as process changes, equipment conditions, production demands, and workforce variability. However, the observed improvements in behavior-based safety indicators demonstrated a clear relationship with training reinforcement practices. Additionally, the increase in near miss reporting following training activities was interpreted as an improvement in safety awareness, employee engagement, and reporting culture rather than a deterioration of safety conditions. This finding underscores the importance of interpreting safety data within the appropriate operational and cultural context.

The application of the Improve phase emphasized strengthening existing EHS training programs rather than designing new systems. Improvement actions focused on enhancing job-specific and hands-on training, reinforcing learning

through drills and real-case scenarios, and increasing supervisory engagement to promote accountability and consistent safe behaviors. These actions support the practical application of training content and address the gap between theoretical knowledge and real-world execution.

Furthermore, the Control phase highlighted the importance of sustainability in safety performance improvements. Continuous monitoring through routine audits, refresher training sessions, behavioral safety observations, and supervisory feedback mechanisms was identified as essential for maintaining long-term alignment between training effectiveness, regulatory compliance, and organizational safety objectives. The establishment of structured control mechanisms ensures that improvements achieved through training interventions are embedded within the EHS management system and sustained over time.

Overall, this project demonstrates that the effectiveness of EHS training programs should be evaluated using a balanced combination of leading and lagging safety indicators. Relying solely on incident reduction may overlook meaningful improvements in safety culture and employee behavior. By applying the DMAIC methodology, organizations can systematically assess training effectiveness, identify opportunities for continuous improvement, and strengthen safety culture within regulated manufacturing environments. The findings of this study provide practical insight for safety leaders and organizations seeking to optimize EHS training strategies, enhance behavioral consistency, and reduce workplace risk through data-driven decision-making.

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