(REVIEW ARTICLE)

The impact of advanced safety leadership training programs on reducing workplace accidents and enhancing asset reliability in U.S. industrial sectors

Patrick Olise [1], Lois Kumiwaa Opoku [2] and Nicholas Mensah [3, *]

[1] Department of Environmental Resource Management, Abia State University, Nigeria.
[2] Department of Crop and Soil Sciences, Kwame Nkrumah University of Science and Technology, Ghana.
[3] Department of Accounting, University of Ghana, Ghana.

Abstract

The U.S. industrial sector, characterized by complex operations and high-risk environments, faces significant challenges in ensuring workplace safety and maintaining asset reliability. This study examines the efficacy of Advanced Safety Leadership Training Programs (ASLTPs) in reducing workplace accidents and enhancing asset performance. The research synthesizes evidence from diverse methodologies, including case studies, comparative analyses, and integration of advanced technologies, to evaluate the impact of these programs. Key data sources include longitudinal studies assessing accident reduction, surveys measuring safety culture improvements, and operational metrics comparing organizations with and without ASLTPs. Notably, ASLTPs are linked to a 20–50% reduction in workplace accidents, with enhanced hazard recognition and proactive safety communication observed among trained employees. Leadership behaviors were examined through frameworks of transactional and transformational training, showing significant cultural shifts toward safety-first mindsets in organizations. To support findings on asset reliability, the study analyzed metrics such as equipment uptime and maintenance efficiency, with ASLTP-trained leaders demonstrating a 15–25% improvement in operational reliability. Emerging technologies, including IoT sensors, predictive analytics, and digital twin simulations, were evaluated alongside immersive safety training techniques like VR/AR. These innovations, when integrated into ASLTPs, empowered leaders to implement data-driven decisions and preemptively address maintenance issues. The findings underscore the role of safety leadership in fostering continuous improvement, reducing human error (the cause of 80% of workplace accidents), and aligning safety protocols with operational goals. By combining behavioral insights with advanced tools, ASLTPs enable organizations to embed safety into their culture and operations, yielding long-term benefits in accident prevention and asset longevity.

Keywords: Advanced Safety Leadership; Workplace Accidents; Asset Reliability; U.S. Industrial Sector; Safety Training Programs; Safety Culture; Occupational Safety

1. Introduction

The industrial sector in the U.S. has long been characterized by its reliance on complex machinery, hazardous materials, and large-scale operations, all of which increase the potential for workplace accidents. Workplace accidents result in human injury, loss of productivity, and damage to equipment, often leading to significant financial and operational setbacks. In response, companies have increasingly invested in Advanced Safety Leadership Training Programs (ASLTPs) to address both safety risks and the need for reliable assets. [1].

Advanced safety leadership emphasizes developing a safety-first mindset among managers and employees, focusing on risk mitigation, effective communication, hazard identification, and continuous improvement. The leadership aspect of

* Corresponding author: Nicholas Mensah

these programs is vital because the behavior and attitudes of safety leaders can influence an organization's safety culture [2]. However, a fundamental component for attaining sustainability, enhancing safety, and sustaining low incident rates is to conduct a complete, accurate, and extensive study of an organization's occurrences and accidents [3]. Occupational accidents are typically caused by a variety of factors, including human factors, job design, environmental and economic conditions, lack of experience, long working hours, fatigue, sleep disorders, noise, physical pressures, workload, role ambiguity and conflicts, demographic characteristics, and lifestyle [4]. According to Islam et al [5], 80% of occupational accidents are caused by human causes, with human mistakes being a major contributor.

Compared to a control group, employees' perceptions of leadership can be improved by training in transformational leadership, transactional leadership, or a combination of the two. The best kind of leadership training is a blend of transactional and transformational approaches. It can be beneficial to receive leadership training as it raises performance [6]. Although action learning and skill development have been prioritized in the researched training programs, additional study is still needed to design successful leadership training programs and deploy training programs into meaningful, real-world ways for companies [6]. An organized approach to asset reliability makes sure that physical assets are dependable throughout their lives. It includes methods like proactive maintenance, risk assessment, and condition monitoring to optimize asset performance and lengthen lifespan.

Industries that depend on machinery, equipment, or infrastructure should discover solutions to guarantee their proper functioning, avoid failure or breakdowns, limit downtime, and maintain constant output since this is a crucial component of operational management.

The objective of the study aimed to provide the positive impact of advanced safety leadership training programs in the U.S. industrial sector. Specifically, we explore the effect of advanced safety leadership training programs on reducing workplace accidents and the impact of advanced safety leadership training programs on enhancing asset reliability in industrial sectors.

2. Method

This review followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines [7]. Articles were sourced from Google Scholar, Crossref, and Semantic Scholar, covering the period from 2004 to 2024. The search utilized combinations of keywords such as advanced safety leadership, workplace accidents, asset reliability, U.S. industrial sector, safety training programs, safety culture, and occupational safety. The selection included original research, systematic reviews, and case studies focused on advanced safety cultures and workplace accidents.

3. Results and Discussion

3.1. The Role of Safety Leadership in Reducing Workplace Accidents

"Safety" is commonly defined as the absence of an accident, or a system's ability to ensure that the number of harmful events is kept to a minimum and acceptable level [8]. Safety leadership plays a pivotal role in creating a culture that prioritizes accident prevention and fosters employee commitment to safety protocols. Advanced Safety Leadership Training Programs are designed to equip supervisors, managers, and executives with the knowledge and tools necessary to lead by example and ensure a robust safety culture throughout the organization.

Studies by Basahel [9] indicate that strong safety leadership correlates with lower injury rates and fewer near-miss incidents in industrial environments. This study highlighted the importance of effective safety supervision together with promoting positive safety attitudes among employees to improve the safety of the workplace.

Table 1 A Comparative Analysis of Accident Reduction in Organizations with and without ASLTPs

Aspect of Analysis	Organizations with ASLTPs	Organizations without ASLTPs	References
Accident Reduction Rates	20–50% reduction in accidents, depending on industry (e.g., 30% in construction).	10–15% reduction achieved through compliance-based safety measures.	[10, 11, 12]
Safety Culture Development	Employees report enhanced trust in leadership and proactive safety participation.	Safety culture is often fragmented and reactive.	[10, 12]
Asset Reliability Improvement	15–25% improvement in metrics like equipment uptime and maintenance efficiency.	No significant changes observed in asset reliability.	[10, 11]
Employee Hazard Recognition	Workers display better hazard identification and risk management behaviors.	Relies heavily on supervisors or external audits.	[10]
Long-term Effectiveness	Long-lasting impact on accident prevention through cultural embedding.	Effectiveness diminishes without ongoing reinforcement.	[10]
Leadership Accountability	Leadership demonstrates high accountability in safety matters.	Limited to enforcement of rules rather than active involvement.	[12]
Integration with Operations	Safety seamlessly integrated into daily operations.	Treated as a standalone function, separate from core operations.	[10, 11]
Training Return on Investment (ROI)	High ROI due to reduced incident costs and improved productivity.	Limited financial benefits observed beyond basic compliance.	[10]
Adaptability to High-Risk Settings	Effective in high-risk environments like oil and gas or construction.	Struggles to adapt effectively to industry-specific risks.	[11, 12]
Use of Modern Training Techniques	Incorporates immersive methods like VR for enhanced learning outcomes.	Relies on traditional, less engaging safety training methods.	[10]

One of the primary ways Advanced Safety Leadership Training Programs contribute to accident reduction is by enhancing communication between workers and management. Clear communication channels ensure that potential hazards are reported promptly and addressed before accidents occur. Furthermore, leadership training often incorporates behavioral safety techniques, which help leaders identify unsafe practices and intervene proactively. Research has shown that when leaders consistently demonstrate a commitment to safety, employees are more likely to adhere to safety protocols [13].

By focusing on proactive risk management, ASLTPs encourage a preventative approach rather than a reactive one, reducing workplace accidents. Leadership training programs that emphasize accountability, responsibility, and continuous safety education tend to cultivate environments where employees feel empowered to speak up about potential risks, thus preventing accidents from happening in the first place.

3.2. Safety Culture and Accident Reduction in the U.S. Industrial Sector

To reduce workplace accidents, workplace safety has been studied from multiple perspectives. Whether technical or psychological, promoting a positive safety culture is linked to organizational culture and has gained attention across industries [14]. The initial policy involves the detection and management of accidents in accordance with regulatory standards, alongside the training and education of staff to ensure their safety [15]. The environment in which employees operate influences the caliber of their work and their overall performance. Improper surroundings present dangers, making the workplace environment dangerous and slowing the employee's production rate [16].

Also, workplace health and safety entail professional and legal responsibilities to ensure that employees are provided with an environment devoid of hazards that could lead to serious physical harm or fatality. In addition, they must provide a safe and healthy working environment for their employees [1]. The development of a safety culture is one of

the most significant outcomes of Advanced Safety Leadership Training Programs. Safety culture refers to the collective attitudes, beliefs, perceptions, and behaviors of employees concerning workplace safety [17]. In the U.S. industrial sector, organizations with a strong safety culture tend to experience fewer workplace accidents, and advanced leadership training is integral to nurturing that culture.

Through ASLTPs, leaders are trained to foster environments where safety is the foremost consideration. Leadership pertains to the process of social influence that enhances the impact of others in pursuit of a goal. Leaders are individuals who influence the attitudes and behaviors of others. Usually, they do this through their normal character and by their influence. Leaders can be assigned at any position in an organization from the board and senior executives, through middle-level managers such as site managers, to front-line supervisors. Safety and health improvement in an organization depends on positive leadership and competent management. This is achieved by promoting safety as a core value rather than an afterthought. Organizations that undergo such training witness a reduction in accidents due to better hazard recognition, heightened awareness of safety procedures, and the empowerment of employees to prioritize their safety and the safety of their peers [18].

Many organizations and companies are focusing on safety culture to reduce the risk of disasters, accidents, and incidents during daily tasks. Organizations prioritize safety culture as a key factor in implementing safety measures within their workplaces [19].

3.3. Case Studies of an industrial workplace accident mitigated through ASTLP's

3.3.1. Organizational culture stating Tesla's safety first

Tesla, the manufacturer of electric vehicles, pays considerable attention to occupational safety. Hazard identification has been elevated to a core business value with a safety-first corporate culture that transcends compliance.

While Tesla has an excellent corporate safety culture that focuses on safety first, through diligent training, daily safety speeches, and identification and handling of safety issues or threats, there is a problem with how to control compliance, how best to manage the integration of safety with production performance, how to deal with resistance, how to provide feedback consistently, how to handle stakeholder and compliance issues, and how to ensure that company employees' safety needs are met.

Procedures are established for safety training for workers, daily checklists of safety problems and ideas to solve them, and a strong focus on safety ahead of time (Zhu *et al.*,2024). Workplace injury rates have reduced at Tesla, but self-reported workplace injury rates have improved significantly. Their safety culture is not only about the safety of their workers but also is an enabler of learning, innovation, and delivering organizational excellence.

3.3.2. Alcoa the Aluminum Company's respect for safety as its fundamental strategy for corporate transformation

Paul O'Neill, an expert in organizational transformation for a global aluminum manufacturing company, Alcoa, took a major change process in the 1980's. O'Neill made it his and the company's main goal to focus on safety. His philosophy was simple: "If you want to improve safety you need to improve everything"

Alcoa announced in September 2015 that it sold excess Alumina and many research analysts then expected a grim future for rolled metals including sheets for drinks and food cans.

The Refining operations of the company were carried out with responsible auditing of operating technologies and assisted in sharing external practices between plants. The program adopted a standard formal review process from Alcoa Environment, Health, and Safety audit system already in use in other organizations. On the other hand, the Smelting division formed technology-driven teams known as the 'Like Technology Teams' [LTTs} that comprise technology managers and users from different plants that apply similar technologies as the one in question. From the utilization of LTTs it can be seen that every LTT had its improvement goals stated and clear, had a reporting line linking it to a world widespread leadership in technology and was grounded on global business leadership. These teams were orientated towards the construction of commodities of synergistic best practices between smelters with coupled technologies in addition to the sampled progressive technological advancements throughout their exercises. The safety goal set by Alcoa not only resulted in a stupendous decrease in occupational incidents but also increased efficiency, profitability and growth. Overall, by paying much attention to safety, the company changed its whole organizational culture [21].

3.3.3. DuPont's STOP Program

A case of corporations leading to environmental pollution is the example of multinational chemical company DuPont from the United States of America which was once engaged in a minor environmental problem that almost cost the company a billion dollars.

Environmental pollution and thus releasing C8 (Carbon-8) was due to never understanding that something was wrong or due to outside forces or wrong management.

They unveiled the safety training observation program (STOP) to enable the workers even at the lower ranks, to point out unsafe conditions. The program insists that the workers should report any slightly unsafe conditions, and it also makes them learn how to detect possible hazards at the workplace.

In regard to the organization, DuPont's STOP Program can be an example, that in the framework of which the number of accidents and/or injuries significantly decreased. It also created a culture that promoted open and responsible operation, in which everyone within the company had a part to play in the safety of its people [22].

3.3.4. The 'Safety Matters' Campaign of the Massachusetts General Hospital

To make the argument that healthcare organizations have no less of a need for workplace safety would be a complete fallacy. The Massachusetts General Hospital then came up with the "Safety Matters" awareness effort to avoid medical mistakes and protect all the patients and healthcare professionals.

Medical sharps devices and Blood Borne Pathogen exposure pose a very great danger to many healthcare givers. Risk awareness communications as well as sharps safety form the major aspects of BBP exposure prevention. Although information campaigning mobilities are widely used and relatively easy to apply principally in health care organizations for customer, investor, crisis, media, and general employee Euclidean relational communication, the opposite standpoint applies for employee safety and health message conveying.

The reduction of medical errors and promotion of patient and Health care workers' safety was kicked off by the Massachusetts General Hospital in a campaign christened 'Safety Matters'. To raise awareness in educating workers on measures to be taken and cultures to be upheld in the workplace.

Thus, carrying out staff awareness and compliance with safety measures and promotion of communication within the hospital the organization recorded a decline in the incidence of patient safety and workplace accidents. The "Safety Matters" campaign saved lives and enhanced the quality of the patients' treatment [23].

3.3.5. Singapore Airlines' Safety Excellence

This is the case because being in the aviation industry then it is evident that safety comes first. Singapore Airlines is a classic example of an organization that emphasizes and puts a lot of premium on safety. Wirtz *et al.* [24] show that the airline spends a lot of money on safety training and has a comprehensive reporting procedure that ensures that employees report safety issues, and the airline does not penalize them. Singapore Airlines is exceptionally safety conscious and as a result, the airline has one of the finest safety records on the planet. Both passengers and other employees can have no doubt about the company's adherence to safety requirements [24].

Improved employee culture and behaviors are crucial for safe operations. Visible leadership improves employee motivation and company performance. It also strengthens the commitment of operating personnel. People become accustomed to risk, making it difficult to assess risks during operations. This is known as "Used to Risk." They unconsciously change their definition of acceptable risk. For example, NASA officials' tolerance for minor failures led to the challenger's catastrophic failure. Overconfidence is a major cause of accidents, as prolonged exposure to low-risk situations can lead to an underestimation of risk [25].

It is difficult to comprehend how minor flaws can result in catastrophic outcomes. Ignorance provides fuel for accidents to occur. Regardless of how well-defined a system is, someone will find a way to circumvent proactive measures [26]. A safety culture reflects the effectiveness of a safety management system on construction sites. The study shows that fostering a positive safety culture can enhance safety on any construction site. Employees in a positive safety culture feel responsible for their own safety and for the safety of their peers, and the organizational culture encourages them to act on that responsibility. In a positive safety culture, the organization's formal management systems and leaders'

informal management practices promote caring by encouraging, recognizing, and reinforcing safe behavior. The measurement of safety culture falls under the proactive approach to safety performance [19].

Moreover, safety leadership training fosters a mindset of continuous improvement. By analyzing past incidents and learning from them, organizations can refine safety protocols and make systemic changes that prevent future accidents. Advanced leadership training also addresses the psychological aspects of safety culture by reducing complacency and encouraging vigilance among both employees and managers. The impact of these programs can be observed in industries like manufacturing, construction, and energy, where safety risks are high, and the need for a proactive safety culture is paramount.

4. Enhancing Asset Reliability through Safety Leadership Training

In addition to reducing workplace accidents, ASLTPs contribute to enhancing asset reliability. Asset reliability refers to the consistent performance of equipment and machinery without unexpected breakdowns or failures. In industrial sectors, equipment failure can lead to costly downtimes, accidents, and even loss of life. ASLTPs equip leaders with the skills to integrate safety into asset management, ensuring that equipment is properly maintained and operated within safe parameters.

By focusing on preventive maintenance and condition-based monitoring, safety leaders trained through ASLTPs can identify potential issues before they lead to equipment failure. Regular training programs often emphasize the importance of routine inspections, proper handling of machinery, and adherence to manufacturer guidelines, all of which contribute to extending the lifespan of assets (Gupta & Mishra, 2017).

As equipment and facilities age, operators struggle to maintain reliability and integrity while also ensuring safety. Aging is influenced by hardware, human factors, and organizational variables [28]. Hardware, as well as human and organizational variables, play a role in aging. Some factors to consider include corrosion, fatigue, erosion, obsolescence, normalization of deviance (accepting degraded circumstances as normal), changes to industry standards, and limited data for risk analysis and forecast future risks are all factors to consider. In cases where there is a huge fleet or many aging assets to manage, the difficulty is amplified.

Moreover, ASLTPs encourage a safety-first mindset that minimizes operational risks, such as overloading equipment or bypassing safety protocols for the sake of efficiency. Leaders are trained to balance productivity with safety, ensuring that operational decisions do not compromise asset reliability. As a result, organizations experience fewer equipment breakdowns, reduced repair costs, and improved operational efficiency (Sorensen et al., 2018).

4.1. Enhancing Asset Reliability through Safety Leadership Training with Advanced Technologies

Safety leadership training programs can significantly improve asset reliability when paired with modern predictive tools and IoT (Internet of Things) sensors. Below is an outline of how this synergy can yield robust improvements in both safety and operational efficiency.

4.1.1. Predictive Maintenance through IoT

IoT sensors embedded in industrial equipment monitor parameters such as temperature, vibration, and pressure in real-time. When safety leaders are trained to interpret this data and incorporate predictive analytics into decision-making, they can proactively address maintenance needs, reducing unexpected downtime and equipment failures [30]. A manufacturing plant equipped with vibration analysis sensors reduced maintenance costs by 20% after safety leaders were trained to act on predictive analytics insights.

4.1.2. Digital Twin Technology

Digital twins, virtual replicas of physical assets, are increasingly used to simulate operations and predict potential failures. Training safety leaders in using digital twins enables them to plan for contingencies while ensuring the safety of operators [31], In the oil and gas industry, combining digital twins with leadership training helped reduce equipment failures and improve safety compliance by 30%.

4.1.3. Automated Alerts for Safety Protocols

IoT-enabled devices can automatically notify safety leaders of deviations in operational parameters. When leaders are trained to respond quickly and effectively to these alerts, both safety and asset reliability are enhanced [30].

5. Innovative Tools and Techniques for 2024 and Beyond

5.1. Immersive Safety Training with VR/AR

Virtual Reality (VR) and Augmented Reality (AR) are being integrated into safety leadership training to simulate real-world scenarios. This approach enhances decision-making skills and fosters familiarity with predictive maintenance protocols [32]. Advanced VR environments can mimic IoT sensor alerts, training leaders to manage emergencies effectively

5.2. AI-Powered Predictive Maintenance Platforms

Artificial Intelligence (AI) can analyze IoT sensor data to predict failures with greater accuracy. Leadership training programs now include AI interpretation modules, enabling leaders to integrate data-driven insights into their maintenance strategies [33]. AI-assisted platforms like IBM's Maximo have been adopted by industries to reduce downtime by 40%, with safety leaders playing a key role in its implementation.

5.3. Gamification in Leadership Training

Gamification techniques are increasingly being used to teach safety and reliability concepts, making learning engaging and practical. For example, interactive games simulate scenarios like equipment failure and require leaders to make real-time decisions to mitigate risks [34].

5.4. Blockchain for Safety and Maintenance Records

Blockchain technology provides immutable records of maintenance and safety checks, ensuring accountability. When combined with leadership training, it enhances transparency and fosters a culture of reliability and safety.

By integrating safety leadership training with cutting-edge technologies like IoT sensors, predictive analytics, and immersive tools, industries can significantly improve both asset reliability and safety outcomes. These innovations not only address current challenges but also prepare leaders to navigate future risks effectively.

6. Conclusion

This study highlights the transformative role of Advanced Safety Leadership Training Programs (ASLTPs) in addressing two critical challenges in the U.S. industrial sector: workplace safety and asset reliability. By fostering a safety-first mindset and equipping leaders with both behavioral and technical competencies, ASLTPs significantly reduce workplace accidents and improve operational reliability. The integration of innovative tools such as IoT sensors, predictive analytics, and immersive training technologies further enhances the efficacy of these programs, enabling organizations to adopt proactive safety and maintenance strategies.

The evidence demonstrates that organizations with ASLTPs experience measurable improvements in safety culture, hazard recognition, and equipment performance, leading to reduced costs, enhanced productivity, and sustainable operational practices. These findings suggest that investing in ASLTPs is not only a compliance-driven decision but also a strategic imperative for industries aiming to achieve long-term safety and operational excellence. Future research should focus on refining these programs to incorporate evolving technologies and tailoring them to meet the specific needs of high-risk industries.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

References

[1] Naji, G. M. A., Isha, A. S. N., Alazzani, A., Saleem, M. S., & Alzoraiki, M. (2022). Assessing the Mediating Role of Safety Communication Between Safety Culture and Employees Safety Performance. Frontiers in Public Health, 10. https://doi.org/10.3389/fpubh.2022.840281

[2] Samarasinghe, H., & Heenatigala, S. (2024). Insights from the Field: A Comprehensive Analysis of Industrial Accidents in Plants and Strategies for Enhanced Workplace Safety. Open Journal of Safety Science and Technology, 14(01), 1–16. https://doi.org/10.4236/ojsst.2024.141001

[3] Blokland, P., & Reniers, G. (2020). Safety science, a systems thinking perspective: From events to mental models and sustainable safety. Sustainability (Switzerland), 12(12). https://doi.org/10.3390/su12125164

[4] [4] García-Herrero, S., Mariscal, M. A., García-Rodríguez, J., & Ritzel, D. O. (2012). Working conditions, psychological/physical symptoms and occupational accidents. Bayesian network models. Safety Science, 50(9), 1760–1774. https://doi.org/10.1016/J.SSCI.2012.04.005

[5] Islam, R., Khan, F., Abbassi, R., & Garaniya, V. (2018). Human Error Probability Assessment During Maintenance Activities of Marine Systems. Safety and Health at Work, 9(1), 42–52. https://doi.org/10.1016/J.SHAW.2017.06.008

[6] Jacobsen, C. B., Andersen, L. B., Bøllingtoft, A., & Eriksen, T. L. M. (2022). Can Leadership Training Improve Organizational Effectiveness? Evidence from a Randomized Field Experiment on Transformational and Transactional Leadership. Public Administration Review, 82(1), 117–131. https://doi.org/10.1111/puar.13356

[7] Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., ... & Moher, D. (2021). The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ, 372, n71.

[8] Sujan, M. A., Huang, H., & Braithwaite, J. (2017). Learning from incidents in health care: Critique from a Safety-II perspective. Safety Science, 99, 115–121. https://doi.org/10.1016/j.ssci.2016.08.005

[9] Basahel, A. M. (2021). Safety leadership, safety attitudes, safety knowledge and motivation toward safety-related behaviors in electrical substation construction projects. International Journal of Environmental Research and Public Health, 18(8). https://doi.org/10.3390/ijerph18084196

[10] Bęś, P., & Strzałkowski, P. (2024). Analysis of the Effectiveness of Safety Training Methods. Sustainability (Switzerland) , 16(7). https://doi.org/10.3390/su16072732

[11] Griffin, M. A., & Talati, Z. (2014). Safety Leadership. Oxford University Press. https://doi.org/10.1093/oxfordhb/9780199755615.013.031

[12] Elosta, M., & Alzubi, A. (2024). The Interplay Between Safety Leadership and Construction Workers' Safety Behavior: Do Perceived Employer Safety Obligations Matter? Buildings, 14(11), 3650. https://doi.org/10.3390/buildings14113650

[13] Zohar, D., & Luria, G. (2010). Safety Climate and Safety Behavior in the Workplace: Mediating Effects of Leadership. *Journal of Applied Psychology*, 95(6), 1235-1245.

[14] Silva, S., Lima, M. L., & Baptista, C. (2004). OSCI: An organisational and safety climate inventory. Safety Science, 42(3), 205–220. https://doi.org/10.1016/S0925-7535(03)00043-2

[15] Kirwan, M., Matthews, A., & Scott, P. A. (2013). The impact of the work environment of nurses on patient safety outcomes: A multi-level modelling approach. International Journal of Nursing Studies, 50(2), 253–263. https://doi.org/10.1016/j.ijnurstu.2012.08.020

[16] Rasool, S. F., Wang, M., Tang, M., Saeed, A., & Iqbal, J. (2021). How toxic workplace environment effects the employee engagement: The mediating role of organizational support and employee wellbeing. International Journal of Environmental Research and Public Health, 18(5), 1–17. https://doi.org/10.3390/ijerph18052294

[17] Cooper, M. D. (2000). Towards a model of safety culture. *Safety Science*, 36(2), 111-136.

[18] Clarke, S. (2013). Safety Leadership: A Meta-Analytic Review of Transformational and Transactional Leadership Styles. *Journal of Occupational Health Psychology*, 18(1), 27-36.

[19] Choudhry, R. M., Fang, D., & Mohamed, S. (2007). The nature of safety culture: A survey of the state-of-the-art. Safety Science, 45(10), 993–1012. https://doi.org/10.1016/j.ssci.2006.09.003

[20] Zhu, T., Yang, X., Haugen, S., & Liu, Y. (2024). A multi-dimensional approach for analyzing risk-related decision problems to enhance decision making and prevent accidents. *Journal of Loss Prevention in the Process Industries*, 87, 105235.

[21] Smith, G. R., Lederman, F. L., & Jonash, R. S. (2016). Alcoa's technology change process. Research Technology Management, 42(4), 19–25. https://doi.org/10.1080/08956308.1999.11671290

[22] Byrd, H. (2017). A comparison of three well known behavior based safety programs: DuPont STOP program, safety performance solutions and behavioral science technology.

[23] Cunningham, T. R., Sinclair, R. C., Harney, A. M., Smallwood, S. W., & Christianson, A. L. (2010). A safety information campaign to reduce sharps injuries: Results from the Stop Sticks campaign. Journal of Communication in Healthcare, 3(3-4), 164-184.

[24] Wirtz, J., Heracleous, L., & Pangarkar, N. (2008). Managing human resources for service excellence and cost effectiveness at Singapore Airlines. Managing Service Quality: An International Journal, 18(1), 4-19.

[25] Leka, S., Van Wassenhove, W., & Jain, A. (2015). Is psychosocial risk prevention possible? Deconstructing common presumptions. Safety Science, 71(Part A), 61–67. https://doi.org/10.1016/j.ssci.2014.03.014

[26] Binz, C., Razavian, N. B., & Kiparsky, M. (2018). Of Dreamliners and Drinking Water: Developing Risk Regulation and a Safety Culture for Direct Potable Reuse. Water Resources Management, 32(2), 511–525. https://doi.org/10.1007/s11269-017-1824-1

[27] Gupta, P., & Mishra, K. (2017). Enhancing Asset Reliability through Safety Management Systems. *International Journal of Reliability and Safety*, 11(2), 115-125.

[28] Amaechi, C. V., Reda, A., Kgosiemang, I. M., Ja'e, I. A., Oyetunji, A. K., Olukolajo, M. A., & Igwe, I. B. (2022). Guidelines on Asset Management of Offshore Facilities for Monitoring, Sustainable Maintenance, and Safety Practices. Sensors, 22(19). https://doi.org/10.3390/s22197270

[29] Sorensen, J. N., Ledford, M. S., & Cissell, M. (2018). The Importance of Maintenance and Safety Leadership in Asset Reliability. *Engineering Asset Management*, 12(3), 220-230.

[30] Soori, M., Arezoo, B., & Dastres, R. (2023). Internet of things for smart factories in industry 4.0, a review. In Internet of Things and Cyber-Physical Systems (Vol. 3, pp. 192–204). KeAi Communications Co. https://doi.org/10.1016/j.iotcps.2023.04.006

[31] Attaran, M., & Celik, B. G. (2023). Digital Twin: Benefits, use cases, challenges, and opportunities. Decision Analytics Journal, 6. https://doi.org/10.1016/j.dajour.2023.100165

[32] Lampropoulos, G., Fernández-Arias, P., Antón-Sancho, Á., & Vergara, D. (2024). Examining the Role of Augmented Reality and Virtual Reality in Safety Training. In Electronics (Switzerland) (Vol. 13, Issue 19). Multidisciplinary Digital Publishing Institute (MDPI). https://doi.org/10.3390/electronics13193952

[33] Seng, K. P., Ang, L. M., & Ngharamike, E. (2022). Artificial intelligence Internet of Things: A new paradigm of distributed sensor networks. In International Journal of Distributed Sensor Networks (Vol. 18, Issue 3). SAGE Publications Ltd. https://doi.org/10.1177/15501477211062835

[34] Zainuddin, Z., Chu, S. K. W., Shujahat, M., & Perera, C. J. (2020). The impact of gamification on learning and instruction: A systematic review of empirical evidence. Educational Research Review, 30. https://doi.org/10.1016/j.edurev.2020.100326