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Is Lean Safe or is Safe Lean? A Case Study Regarding Lean vs Safety Principles

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Abstract:- The effectiveness of Lean manufacturing in improving production efficiency and reducing waste is well established, which ultimately leads to increased value. However, the impact of Lean principles on safety is not well-understood. Although incidents such as fatalities, life accidents, first aids, near misses, or property damage continue to occur, it is unclear whether Lean manufacturing plays a role in these events. To address this knowledge gap, this paper examines the relationship between Lean principles and safety performance. Additionally, the paper proposes an integrated system that uses Lean tools to encourage safe behaviors. The study was conducted as a pilot project in the finishing department of a manufacturing industry since 2018. Following the successful pilot, the integrated system was implemented across other business units and new mills and plants in the paper industry. The results indicated that safety performance was notably enhanced as high-risk situations and unsafe behaviors were successfully mitigated through the use of Lean tools.

Keywords*:* Hazards, Lean, Risk, Safety.

1. Introduction

Safety management practices have evolved from a traditional "command-and-control" approach to emphasizing worker engagement and safety behaviors over safety conditions. The goal is to create an "injury-free culture," where health and safety are core values that shape organizational culture.

In manufacturing, hazard recognition, Environment, Health, and Safety (EHS) training, and EHS drills are often done reactively in response to audits or regulatory compliance. However, to create a truly safe workplace, organizations must prioritize metrics, scorecards, safety programs, leading and lagging indicators, and a culture of continuous learning. Instead of simply reacting to incidents, organizations should aim to learn from them and make proactive improvements to enhance safety performance.

Manufacturers aim to achieve strong financial performance by reducing waste and prioritizing high-value operations through the adoption of the lean philosophy and Toyota's principles. However, this approach can create a challenge in balancing safety measures with lean principles.

The present paper aims to enhance reflection about the impact of lean implementation on safety performances and provide some areas and recommendations for a successful integration between lean and safety regardless of sectors of the activities.

This paper presents a case study that examines the effect of Lean Manufacturing on occupational safety and ergonomics. The study begins with a systematic review of relevant papers published between 2018 and 2022, as well as earlier papers, using four databases: Science Direct, Scopus, Emerald Insight and Google Scholar. The review process involved gathering all available information on the topic, summarizing it, and assessing safety and ergonomic outcomes related to the use of Lean Manufacturing methods found in the literature.

The first section of the study presents the review findings in Table 1 below, followed by a case study that compares safety versus lean and lean versus safety in separate chapters. The second section covers hazard and risk definitions, as well as how to recognize hazards. A new framework is then proposed, and success stories of the implementation of the new Lean OHS model are presented in the third section. The study specifically focuses on workers in the manufacturing sector, with an emphasis on the impact of Lean Manufacturing. To ensure clear outcomes attributable solely to Lean Manufacturing practices, studies that combined safety and ergonomic improvements were excluded. The conclusion is presented in the final section, summarizing the findings of the case study and highlighting the benefits of the new Lean OHS model. Overall, the study provides insights into how Lean Manufacturing practices can be integrated with safety measures to create a safer workplace for employees in the manufacturing sector.

2. Platform Work and Industrial Relations

In an important article examining the impact of lean on safety performance, (Hamja et al., 2019) identified 18 papers showing a strong positive effect of lean on productivity but little effect on OHS performance. However, (Murray et al., 2010) found that lean management had more negative effects on safety performance; regardless of the implementation process; and that it cannot help proactive safety beyond just reducing accidents. One of the reasons for this is the large number of safety principles involved in hazard mitigation processes, as explained by (Gambatese et al., 2017). These safety measures involve multiple layers of protection, risk assessments, Pre-job safety assessment (PJSA), permits, and other safety measures, making it difficult to optimize production rates, resulting in operations that are not valuable from a lean perspective. (Kim et al., 2006), also wonders how lean can improve safety in the healthcare industry, especially from an organizational and cultural aspect, as each patient is unique, and healthcare departments often function autonomously. Additionally, lean teaches that improving the performance of an individual area is insufficient.

It is clear from the literature that the relationship between lean and safety is complex and multifaceted. While some studies have shown that lean can have a positive effect on safety e.g.,(Lewchuk et al., 2002), (Brenner et al., 2002), others have found negative effects or no significant effect. It seems that the success of lean implementation in terms of safety depends on the quality of the implementation process, and the level of focus on worker needs and safety excellence rather than just eliminating accidents, as explained by (Longoni et al., 2013) and (Landsbergis et al., 1998), (Angelis et al., 2011). Furthermore, technical tools such as JIT, SMED, and TPM can have a significant impact on safety if not implemented properly. It is essential to understand that safety should not be viewed as a secondary concern to business KPIs. Instead, it should be considered as a holistic part of the overall lean approach to ensure long-term viability and excellence in the workplace.

On the other hand, proponents of the beneficial effects of lean on safety suggest that professionals should customize lean programs according to safety principles. Lean manufacturing concepts have been adopted worldwide in various industrial activities (EPA, 2000; Aitken et al., 2002; Aberdeen Group, 2006), and some companies have customized the lean management approach to fit their internal systems. For instance, in the automotive supply chain, the Bosch Bari plant, which produces braking systems, developed a similar approach called the Bosch Production System (BPS). This model is essentially based on personal responsibility and is considered a good example of integration between lean and safety.

So, according to (Mathis, 2012), Lean Thinking can offer potential opportunities to improve safety by putting the worker at the center of the safety process, which aligns with the first lean principle of customer orientation. By viewing the worker as the customer of the safety process, organizations can focus on providing effective safety products and services that meet the needs and wants of workers. This approach eliminates waste on safety by empowering workers and changing their habits gradually, rather than overwhelming them with multiple programs and tedious activities that do not add value to customers. Traditional safety forms tend to over-train workers with repetitive and boring training sessions, and investigations tend to fix blame rather than addressing the root cause of accidents. Common safety observation processes collect massive data without proper analysis, and safety orientation programs for new hires tend to avoid liability rather than preventing accidents. Therefore, a holistic improvement in safety principles is necessary, and lean programs should be customized to integrate safety

principles effectively. Examples of successful integration between lean and safety can be found in companies such as Bosch Bari plant, which developed a customized lean approach called the Bosch Production System (BPS) based on personal responsibility.

Mathis, (2012) also explains that in the early 1950s, many manufacturers preferred to work with a corrective maintenance philosophy. However, the Toyota Production System (lean management) promoted the idea that no matter how good something is, it can always be improved. They encouraged their operators and managers to continuously bring ideas to improve products, processes, and work conditions, which gave rise to the concept of continuous improvement. As a result, the lean approach also promotes safety by providing several suggestions for improving walking and working surfaces conditions, working at height, confined spaces, control of hazardous energy, PPE, motorized equipment, chemical management, and any other safety programs and issues that need to be addressed.

Sevilay Demirkesen's research paper titled "Measuring impact of Lean implementation on construction safety performance: a structural equation model" suggests that the implementation of Lean practices can significantly improve safety performances and mitigate near-misses, especially in the construction sector. The study demonstrates the tremendous benefits of Lean practices, which can lead to a decrease in contractor accidents. Other authors also emphasize the positive impact of Lean practices on human resources management. By encouraging worker versatility and cross-training, workers can increase their expertise and be reassigned to other jobs as needed. Studies conducted by (Snell and Dean, 1992), (Flynn et al., 2007), (Landsbergis et al., 1998), (Sakakibara et al., 1997), and (Shah and Ward, 2003) all support this claim.

The table 1 below shows samples of studies on lean occupational health and safety:

Table I: Samples of studies on lean occupational health and safety

Author	Explanation
(Hamja et al., 2019)	This article reviews how lean principles affect occupational health, safety, and productivity in the garment industry. It analyzes research on lean tools' implementation, their impact on worker safety and productivity, and challenges that arise. The study finds that while lean tools can improve productivity and safety, they can also increase worker workload and pressure, negatively affecting their health and safety. The study suggests the need for further research to identify effective strategies for implementing lean tools while ensuring worker health and safety.
(Demirkesen, 2020)	This article analyzes the impact of implementing Lean principles on safety performance in construction sites. The study finds that Lean practices positively influence safety climate, behavior, and performance. The authors suggest that the use of Lean principles can be an effective strategy for improving safety performance in the construction industry.
(Wu et al., 2019)	The article uses a system dynamics approach to study how Lean construction affects safety systems. The authors propose a model that considers Lean principles, safety culture, safety performance, and feedback loops. The study finds that implementing Lean positively affects safety systems by enhancing safety culture and performance. The authors suggest that feedback loops are crucial in maintaining these benefits, and a system dynamics approach can provide valuable insights into these relationships in construction projects.
(Jiménez et al., 2019)	The article proposes extending the Lean 5S methodology to 6S by adding a "Safety" layer to ensure occupational safety and health levels. The study suggests that this addition can promote a culture of safety and eliminate workplace hazards. The authors propose a framework for implementing the 6S approach, including hazard identification, safety procedure development, and safety measures implementation. The article concludes that the 6S approach can improve workplace safety and enhance Lean practices.
(Cordeiro et al., 2020)	This article presents a case study on the impact of Lean tools on safety in a manufacturing company. The study found that implementing 5S and Kaizen tools improved safety performance by enhancing housekeeping, reducing clutter, and increasing hazard awareness.

Author	Explanation
	Employee engagement in the Lean process was crucial for sustaining safety improvements. The study concludes that Lean tools can effectively enhance safety performance in manufacturing settings when implemented correctly with a focus on employee engagement.
(J C Sá et al., 2021)	This article examines the impact of 5S and Visual Management, two lean tools, on workplace safety. Data from a manufacturing company that implemented these tools was analyzed, and the results indicate a reduction in incidents and injuries, as well as an increased sense of accountability among workers for safety. Using 5S and Visual Management can improve workplace safety while enhancing efficiency and productivity.
(Hafey, 2017)	The article applies Lean management principles to safety management using practical strategies like Gemba-Walks and visual management. It stresses the need to involve employees at all levels to foster a culture of learning and improvement. This resource helps organizations improve safety performance and promote a culture of safety excellence.
(José Carlos Sá et al., 2021)	This article presents a case study in the textile sector that assesses the impact of implementing lean tools on production and safety using statistical analysis. The study involved collecting data from a textile company that implemented lean tools in its production process. The results showed that the implementation of lean tools had a significant positive impact on both production and safety in the textile company. The study concludes that statistical analysis can provide an objective evaluation of the impact of lean tools on production and safety in the textile sector.
(Małysa and Furman, 2021)	The article explores how selected lean manufacturing tools, such as 5S, visual management, and standard work, can improve work safety in the steel industry. The study found that implementing these tools reduced the number of safety incidents and injuries while improving workplace organization and culture, leading to increased worker engagement in safety programs. The article concludes that lean manufacturing tools can help create a safer work environment and improve efficiency and productivity in the steel industry.
(Gao et al., 2022)	The article proposes a model that examines the relationship between employees' Lean construction competence and construction safety performance. The study found that improving employees' Lean construction competence positively affects safety knowledge, motivation, behavior, and performance. The authors conclude that enhancing Lean construction competence can be an effective way to improve safety performance in construction projects.
(Ulu and Birgün, 2022)	The article proposes a comprehensive model for occupational health and safety that integrates hazard identification, risk assessment, safety management systems, and employee engagement. The model is designed to help organizations improve their safety performance and promote a culture of safety. The study emphasizes the importance of employee involvement and training in identifying and mitigating hazards. Overall, the article suggests that the proposed model can be an effective approach to improving occupational health and safety in organizations.
(Karstarlı Sevim, 2023)	This article explores the impact of lean principles on occupational health and safety in the aerospace industry in Turkey. The study involved surveying industry employees to evaluate the effects of lean principles on health and safety. The results indicate that lean principles can have a positive impact on identifying hazards and reducing the risk of accidents. The study also found that lean principles can promote a positive workplace culture and increase worker participation in safety programs. The article concludes that organizations must prioritize worker safety and well-being when implementing lean principles.
(Sá et al., 2023)	This article discusses the impact of lean principles on occupational safety in organizations. It reviews studies that suggest that implementing lean can have a positive impact on occupational safety, including reductions in workplace injuries and accidents. However, it also notes that the implementation of lean can pose challenges to occupational safety, such as

Author	Explanation
	increased workloads and pressure on workers, leading to stress and fatigue. The article emphasizes the importance of prioritizing worker safety and well-being when implementing lean tools and principles.

3. Method

It appears that there is still some ambiguity and inexactness when it comes to the relationship between Lean and Safety. This has led companies to implement standalone safety schemes that are managed separately from Lean (Pagell et al., 2015)., which can result in decisions being made during Lean implementation without a full understanding of how they may impact safety. There is a need for a model that integrates Lean manufacturing tools with behavior change and mitigates safety issues. This model should view Lean as the key input and worker health and safety as the key output, with a focus on using Lean tools to improve safety.Before starting to highlight the new model, it is important to know what the difference between hazard and risk is, and how we can recognize and mitigate hazards and what are layers of protection.

4. Hazard or Risk?

A "hazard" is…

A hazard is a potential source of harm that can cause harm depending on the energy or force it exerts upon contact. It's often confused with risk, which overlooks the possibility of exposure to hazards. Factors such as exposure frequency and duration, incident history, and other variables are used to estimate the probability of harm. However, a single exposure to a hazard can cause harm. It is important to understand that people are not hazards themselves, but they can be exposed to hazards through their actions or proximity to them.

A "risk" is…

Understanding risk is crucial for effective hazard management, as it involves assessing both the likelihood and severity of harm that may result. With this information, effective risk management strategies can be implemented to prevent or mitigate potential harm.

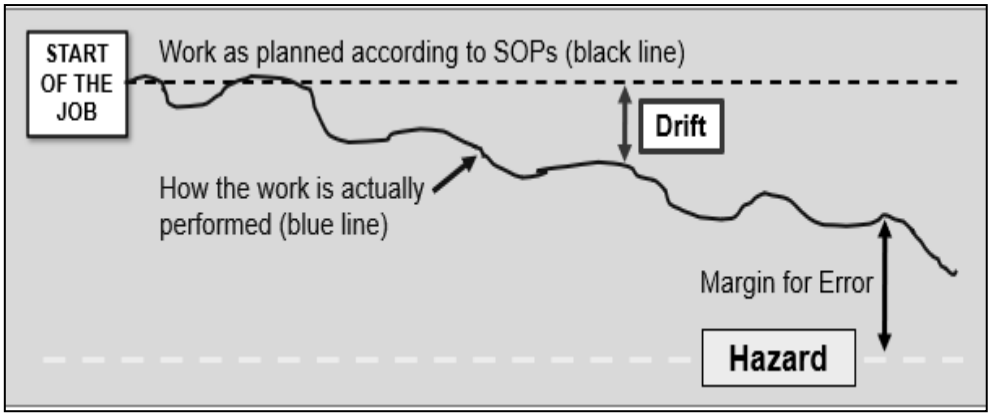

Fig. 1: What Causes Drift?

How Do We Mitigate Hazard?

To prevent workplace injuries and promote a safety culture, individuals should ask themselves four key questions before beginning a task or observing someone else perform a task. These include recognizing potential hazards, evaluating exposure levels, identifying and implementing safeguards to reduce risks, and considering how safeguards could potentially fail. By consistently applying these questions, every worker can contribute to the shared goal of achieving zero injuries in the workplace.

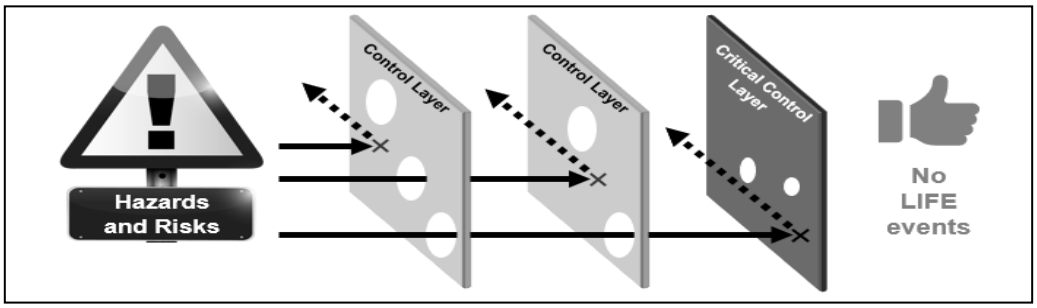

Fig. 2: Layers of Protection

5. How We Recognize Hazards?

It is important to focus on recognizing potential hazards and not be distracted by factors that could lead to false assumptions about their harm. The probability of a hazard occurring is not relevant when searching for it. The key is to identify the "root" hazard, regardless of its location or accessibility. While visible hazards have been successfully minimized, more challenging hazards require greater attention. Categorizing hazards can make it easier to recognize and address them. Hazards can be grouped into five primary categories, including physical, chemical and ergonomic hazards

6. Lean-Hazard Recognition Model Description

To improve hazard detection and reduce safety risks, a new flowchart model has been introduced that combines lean manufacturing tools with EHS practices. The ultimate goal is to use lean tools to identify hazards more efficiently and lower the overall risk to workplace safety. The key stages of the model are illustrated in Figure 4.

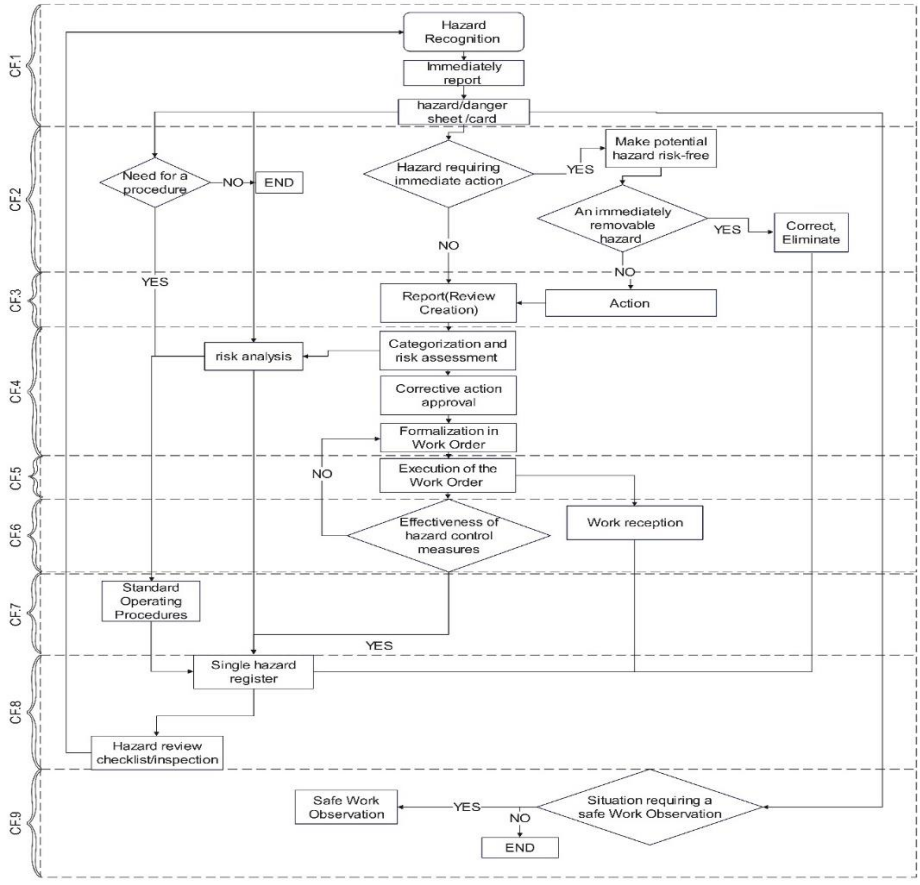

Figure 3: Lean-Hazard recognition model description

WHO?	Flowchart	WHEN?	EHS Practices	Lean Tools
Observer: 1:Jobholder, 2:Area front line Leader, 3: Area manager, 4:EHS team, Auditors, 5:Visitors, Contractors...	CF.1	If you have a near-miss or observe an accident while performing tasks or moving, conduct a job and task analysis, inform the Area Foreman and EHS personnel, and fill out the "HAZARD" form with the Front-Line Leader and/or HSE team member. Discuss potential actions and suggestions to prevent future incidents.	Pre-job safety analysis, Management by walking around, Round, Inspection, Audit, checklist, hazard recognition card, Notification…	GEMBA A3 Process Mapping
Area foreman /Manager/ EHS team/ duty manager	CF.2	Revise the accident triangle using the following steps: -Eliminate or mitigate the person, energy, or object involved. -If the situation and conditions allow for it, it is recommended to promptly eliminate the hazard	Ways to reduce exposure to hazards: - Elimination: remove the hazard by design, work at ground level or lower, fully enclosed chemical loop, etc. - Reduction: use engineering controls like fixed guards, ventilation systems, two-hand control stations, etc. - Management: use administrative controls like boundary lines, warning signs, safety glasses, PPE, and control of hazardous energy.	5 Whys Fishbone SIPOC Brainstorming Stakeholder Analysis
Any individual who has the capacity to generate a work order	CF.3	Assign a unique number to the notice and record it on the hazard identification form for proper documentation and retrieval of hazard identification information. The hazard identification form should be easily accessible to the EHS team.	Work Order, SAP, Checklist, Operational meeting, Other...	5S
Operational team and all people to review work order include facility preservation, EHS, maintenance and process team	CF.4	During an operational meeting, the hazard card should be categorized and reviewed based on work order and risk assessment. Action compliance should be approved in accordance with EHS standards, and the risk should be evaluated and assessed for residual risk.	Pre-job safety analysis, EHS Work Plan, Operational Meeting, Hazard Review Meeting	FMEA Data collection Plan Team Building
Execution Team	CF.5	The work will be carried out in accordance with the specification sheets	Safety Standard, EHS Reception Checklist, The Pre-Startup Safety Review, Job briefing	Standard Works
Observer/HSE team/area manager	CF.6	Field verification will confirm compliance, and if necessary, a request for re-execution will be made. Ideally, work orders should only be closed after successful validation of the execution.	The Pre-Startup Safety Review, Work Order, Safety Standards	GEMBA

7. What Influences Our Decisions?

Various factors influence decision-making around risk, known as "error traps." Objective hazard evaluation tools are necessary as personal opinions and cultural/conditional factors can influence behavior and perception of risk. Redesigning tasks to separate people from hazards is important, as situational factors can lead to exposure. Hazards and people are the fundamental factors for an injury, and exposure is the root cause of most injuries. Unsafe behavior may be reinforced by choosing simpler, faster, easier, and more efficient ways of completing tasks.

Table 1: The factors that affect our decision-making

Conditional Factors	Leadership Factors	Cultural Factors	Hazard Factors	Personal Factors	Situational Factors
– Low frequency task – Short duration task – Few (no) incidents – Existing method – Industry "standard"	– Safety Meetings – Safe Work Observation by team and leaders – Hazard/risk analysis for routine tasks – Pre-job hazard analyses conducted for non-routine tasks – Interaction during Moments of High Influence – Manage by Walking Around	– Safety system – Leadership behavior – Peer behaviors – Vague work guidance – Poor communication	– Not in plain view – Occurs too rapidly to react – Occurs too slowly to notice – Poor or no warning – Not an obvious hazard	– Age, Experience – Knowledge, Skill – Physical ability – Comfort level – Distractions	– High workload – Time pressure – First day of Shift – End of shift – Upset condition

8. Evaluate the Exposure

The hierarchy of controls can help us understand the probability of exposure to hazards, with stronger controls like fixed barriers having a lower likelihood of failure compared to weaker controls like procedures and signs. However, it's important to remember that even a single exposure to a hazard can cause harm, and administrative practices must be thoroughly understood to be effective in mitigating risk.

Before entering an area with an identified hazard, consider potential exposure by asking open-ended questions about potential failure modes. Consider stored energies and their potential release, operator response to upset conditions, and the exposure of others to identified hazards.

If you have any uncertainties or doubts about potential hazards, risks, or exposures, it is essential to stop and ask more questions before proceeding.

When assessing hazards, it is important to think beyond the immediate and obvious things and ask questions such as "What if this happened?" to identify potential hazards that may not be apparent. Consider other hazards in the area that may have been overlooked. By thinking critically and asking these questions, you can develop a more comprehensive understanding of the hazards present in an area and take appropriate measures to mitigate them

9. How Could Safeguards Fail?

Safeguards can fail and understanding the causes and modes of failure is crucial. Failures can be critical, especially if a person is directly exposed to a hazard while thinking they are protected. Factors such as time pressure can impact an individual's decision-making process and are often organizational in nature. Identifying the causes of these factors and exploring their impact on safeguards can help understand the actual hazard exposure an individual face when performing a task.

Several key factors can affect the effectiveness of safeguards in preventing harm from hazards including:

- Experiencing time pressure
- High workload
- Repetitive actions
- New techniques
- Changes from routine
- Confusing controls
- Workarounds
- Incorrect instructions
- Unclear instructions
- Unfamiliar with the task
- Multiple tasks
- Communication demands
- Distractions
- Stress
- Task or hazard assumptions
- Too confident with safeguards

10. Conclusion

In this study, we highlighted the various outcomes of Lean Manufacturing implementation on safety performance. A review of different company cases revealed that the Lean improvement approach varies significantly from what is presented in the literature and even differs from one Lean project to another within the same company. As a result, this has led to unintended effects on both economic performance and Occupational Health and Safety (OHS).

Following this review, it became evident that there is a need to develop a simple, flexible, and sustainable model to better integrate OHS into continuous improvement activities. To address this, a new model has been developed and explained in my second article titled *"IS LEAN SAFE OR IS SAFE LEAN? New Approach: Make Change Happen."* This model ensures a correlation between Lean results sustainability and Occupational Health and Safety (OHS) performance.

The new approach is based on a triangulated method that involves data collection through inquiries, interviews with participants, and direct observations within a manufacturing industry.

Conflict of Interest

The Authors declare no conflict of interest.

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