

Preserved in Zenodo DOI: <https://doi.org/10.5281/zenodo.18141279> The Authors are responsible for the information in this article

Lean Manufacturing Management for Occupational Health and Safety in Industrial Engineering Laboratories

Luz Karen Flores Pérez ¹  Víctor Genaro Rosales Urbano ¹ * 
Juan Valentín Leoncio Coasaca Portal ¹ 

¹ National University of San Marcos, Graduate School, Peru

*Correspondence contact: vrosalesu@unmsm.edu.pe

Received: 12/04/2025

Accepted: 12/24/2025

Published: 12/31/2025

ABSTRACT: Managing Lean Manufacturing enhances occupational safety and health in the industrial engineering laboratory. **Objective:** To determine the effects of safety and Lean techniques. **Methodology:** A pre-experimental design was applied, with a non-probabilistic sample of Peruvian small and medium-sized metalworking enterprises selected by the Machine Tools Laboratory (LMH) – UNMSM, using parametric tests and the Wilcoxon test. **Results:** Lean manufacturing improves occupational safety and health management in the LMH; additionally, as the months from January to July 2025 of the academic cycles progressed, standard procedures decreased (expressed by an adjusted slope of -0.0532), as required by standardization, showing a lower slope than preventive measures. **Conclusions/Contributions:** Safety and Lean techniques make it possible to achieve competitive advantages and reduce occupational losses. **Keywords:** Management, lean manufacturing, occupational health, laboratories

Gestión de Lean Manufacturing para la Seguridad y Salud laboral en laboratorios de Ingeniería Industrial

RESUMEN. Gestionar Lean Manufacturing genera la seguridad y salud laboral en el laboratorio de ingeniería industrial. **Objetivo:** Determinar las consecuencias de la seguridad y las técnicas de Lean. **Metodología:** Con diseño preexperimental, muestra no probabilística a pequeñas y medianas empresas metalmeccánicas peruanas seleccionadas por Laboratorio de Máquinas y Herramientas (LMH) - UNMSM con pruebas de parametricidad y Wilcoxon. **Resultados:** El Lean manufacturing mejora la gestión de seguridad y salud en el trabajo en el LMH; además a medida que transcurren los meses desde enero a julio del 2025 de ciclos académicos los procedimientos estándares disminuyeron (expresado por una pendiente ajustada de -0.0532) debido a que la estandarización así lo requirió, con una pendiente menor que las medidas de prevención. **Conclusiones/Aportes:** La seguridad y las técnicas de Lean permiten lograr ventajas competitivas y reducir pérdidas laborales.

Palabras clave: Gestión, lean manufacturing, salud laboral, laboratorios

Gestão do Lean Manufacturing para a Segurança e Saúde Ocupacional em Laboratórios de Engenharia Industrial

RESUMO: A gestão do Lean Manufacturing promove a segurança e a saúde ocupacional no laboratório de engenharia industrial. **Objetivo:** Determinar as consequências da segurança e das técnicas Lean. **Metodologia:** Foi aplicado um desenho pré-experimental, com uma amostra não probabilística de pequenas e médias empresas metalmeccánicas peruanas selecionadas pelo Laboratório de Máquinas e Ferramentas (LMH) – UNMSM, utilizando testes de parametricidade e o teste de Wilcoxon. **Resultados:** O Lean manufacturing melhora a gestão da segurança e saúde no trabalho no LMH; além disso, à medida que os meses de janeiro a julho de 2025 dos ciclos acadêmicos avançaram, os procedimentos padrão diminuíram (expressos por uma inclinação ajustada de -0.0532), conforme exigido pela padronização, apresentando uma inclinação menor do que as medidas de prevenção. **Conclusões/Contribuições:** A segurança e as técnicas Lean permitem alcançar vantagens competitivas e reduzir perdas ocupacionais.

Palavras-chave: Gestão, lean manufacturing, saúde ocupacional, laboratórios

Gestion du Lean Manufacturing pour la Sécurité et la Santé au Travail dans les Laboratoires de Génie Industriel

RÉSUMÉ: La gestion du Lean Manufacturing favorise la sécurité et la santé au travail dans le laboratoire de génie industriel. **Objectif :** Déterminer les effets de la sécurité et des techniques Lean. **Méthodologie :** Un design pré-expérimental a été appliqué, avec un échantillon non probabiliste de petites et moyennes entreprises métallomécaniques péruviennes sélectionnées par le Laboratoire de Machines-Outils (LMH) – UNMSM, en utilisant des tests de paramétricité et le test de Wilcoxon. **Résultats :** Le Lean manufacturing améliore la gestion de la sécurité et de la santé au travail au LMH ; en outre, à mesure que les mois de janvier à juillet 2025 des cycles académiques progressaient, les procédures standard ont diminué (exprimées par une pente ajustée de -0.0532), conformément aux exigences de la standardisation, présentant une pente inférieure à celle des mesures de prévention. **Conclusions/Aports :** La sécurité et les techniques Lean permettent d'obtenir des avantages concurrentiels et de réduire les pertes professionnelles.

Mots-clés : Gestion, lean manufacturing, santé au travail, laboratoires



1. Introduction

Lean Manufacturing (LM) management for Occupational Health and Safety (OHS) in Industrial Engineering laboratories emerges as an essential strategic approach to optimize operational processes in educational environments highly exposed to industrial risks, where the integration of lean principles not only increases efficiency, but also prioritizes accident prevention and the promotion of a safe and sustainable work environment. In the Machine and Tool Laboratory (LMH) of the Faculty of Industrial Engineering at the National University of San Marcos (UNMSM), a space dedicated to practical training in machining and manufacturing with 17 semi-automatic machines (including 7 CNC and 10 with operator-machine interaction), operators and students face persistent threats such as excessive noise, mechanical vibrations, cuts, snags, entrapments, particle projections, friction, abrasion, burns, and even fire risks, resulting in recurring accidents such as falls and blows, aggravated by multifactorial factors such as operator overconfidence, presence of unnecessary materials in the area, lack of cleanliness and order, absence of adequate signage in transit areas, unsafe work procedures, and excess inventory that obstructs the operational flow.

These challenges are not isolated, as they reflect global problems reported by the International Labour Organization (ILO, 2023), which documents 2.6 million annual deaths from work-related illnesses and 11 million accidents in Latin America, as well as local data from the National Superintendency of Labor Inspection (Sunafil) showing 14,086 fatal accidents in Peru during 2023 (Gestión, 2023). This underscores the urgent need to implement models like LM (Laboratory Management) to mitigate these risks in educational laboratories. This research directly addresses the general problem of how LM management improves occupational safety and health (OSH) in industrial engineering laboratories, focusing on specific issues: organizing the work area to establish safe conditions that minimize unnecessary exposures, standardizing procedures to promote safe and repeatable work that reduces human error, and visual management for the effective dissemination of preventive measures that promotes awareness and regulatory compliance.

The justification for this management approach is based on multiple dimensions: theoretically, it relies on the demonstrated synergy between Manufacturing and Occupational Safety and Health (OSH), where continuous improvement and respect for people eliminate waste that generates ergonomic and operational risks (Montero, 2016; ILO, 2023); practically, Manufacturing reduces non-value-added activities such as overproduction, excess inventory, and unnecessary movements, which often cause lower back injuries, distractions, and process defects (Rajadell, 2021); methodologically, it integrates theoretical and practical learning in a pilot manufacturing process, validating efficiency and safety indicators to reinforce student understanding and pedagogical effectiveness; and socially, it prepares future industrial engineers for competitive work environments, fostering sustainable practices that minimize environmental impacts by reducing waste of materials, time, and energy, thus contributing to the development of a skilled workforce aware of its responsibility in OSH.

The overall objective is to implement Lean Management (LM) to strengthen Occupational Safety and Health (OSH) at the UNMSM Laboratory of Mechanical and Hydrographic Sciences (LMH) during 2024, with specific objectives aimed at organizing the work area to achieve safe conditions, standardizing operating procedures to perform work safely, and establishing visual management for the proactive dissemination of safety measures. This approach not only innovates operational management in Industrial Engineering laboratories but also establishes a replicable paradigm that links lean efficiency with workplace safety, promoting educational environments where risk prevention is integral to the training process, aligned with modern industrial demands, and contributing to the overall reduction of workplace incidents in similar contexts.



2. Methodology

The management of Lean Manufacturing for Occupational Health and Safety in Industrial Engineering laboratories was investigated using an explanatory and applied approach, with a pre-experimental quantitative design that allowed for the evaluation of the impact of Lean Manufacturing intervention on OHS through sequential phases: an initial measurement (pre-test) of OHS indicators to establish the baseline, the controlled application of Lean Manufacturing techniques as an experimental intervention, and a final measurement (post-test) to compare changes and validate improvements. To arrive at answers regarding how Lean Manufacturing optimizes OHS, hypotheses were formulated: the general hypothesis postulates that Lean Manufacturing improves OHS management in laboratories, while the specific hypotheses state that the organization of the area promotes safe conditions, standardization improves safe work practices, and visual management effectively disseminates safety measures.

The variables were precisely operationalized, defining LM as the independent variable with dimensions such as organization (evaluated by 5S audits), standardization (by number of implemented procedures), and visual management (by displayed elements), and OSH as the dependent variable with indicators such as accident rate (calculated by frequency and severity), substandard conditions, safe work analysis, and preventive measures. The population was limited to 5,017 small and medium-sized metalworking companies in Peru, selecting LMH-UNMSM as a non-probability sample based on criteria of operational representativeness and the presence of OSH systems. Data collection was carried out systematically, integrating direct observation and on-site interviews to capture real-world dynamics, along with analysis of secondary records such as inventories, production reports, and OSH documentation, collected during 2023–2024 and organized in digital databases for processing.

The analysis was conducted using descriptive statistics to identify trends, parametric tests to verify assumptions, and non-parametric tests such as the Wilcoxon signed-rank test ($\alpha=0.05$) to validate hypotheses when parametric conditions were not met. Instrument validation was performed using Cronbach's alpha to ensure reliability. The theoretical framework was developed by reviewing national and international precedents to contextualize the application of LM in OSH (Occupational Safety and Health). The theoretical foundations focused on LM as a comprehensive waste elimination system, adapted to the educational context through adjustments to techniques such as Value Stream Mapping (VSM), 5S, autonomous maintenance, standardized work, and synchronization with Kanban/Heijunka.

Indicators were measured iteratively, modifying Overall Equipment Effectiveness (OEE) to include OSH factors and employing audits to monitor progress. The pilot process was executed by manufacturing a specific product to simulate real operations, while the initial diagnosis identified inefficiencies and risks to guide the improvement plan, which was implemented sequentially to stabilize, standardize and synchronize operations, allowing robust conclusions to be drawn about the effectiveness of LM in improving SST in Industrial Engineering laboratories.

3. Results

3.1. Descriptive Results



Table 1. Waste in the manufacturing process

Type of waste	Percentage (%)
Wait	25.00
Unnecessary processes	19.23
Defects	17.31
Motion	15.39
Transport	13.46
Unused talent	9.61

Source: Own elaboration, year 2024

Table 1 shows the results indicating that the main waste in the manufacturing process is waiting, at 25.00%, which represents significant downtime that affects the efficiency of the production system. Unnecessary processes are the second largest source of waste (19.23%), highlighting activities that do not add value to the final product. Defects account for 17.31%, reflecting quality problems that generate rework and resource losses. Similarly, waste due to motion (15.39%) and transportation (13.46%) suggests an inefficient layout of the work area and poorly optimized operational flows. Finally, unused talent represents the smallest percentage (9.61%), indicating opportunities for improvement in leveraging employee capabilities.

3.1.1. Application of lean manufacturing in the educational context.

Table 2 presents the relevant aspects that differentiate lean manufacturing at the industrial level from the educational level. Lean manufacturing in the educational context does not aim to produce more, but to teach better.

Table 2. Differences between industrial and educational applications of lean manufacturing.

Aspect	Industrial (production) application	Educational application (pilot process)
Purpose	Increase efficiency and improve profitability	Improve the learning process, safety, and understanding of work organization
Expected results	Economic and operational benefit	Development of technical and organizational skills in students
Management approach	Productivity and delivery time control	Diagnosis and continuous improvement of the teaching-learning environment.
Indicators	OEE, waste, lead time, operational productivity	Educational OEE, learning time, safety and well-being, team performance
Participants	Skilled workers and technicians	Teachers, assistants and students

Source: Own elaboration, 2024.

Table 2 shows that the deployment of Lean manufacturing operational techniques in an educational context involving a pilot manufacturing process is guided by a generic procedure of cumulative value stages, creating synergy between operational practices. Hernández and Vizán (2013) published a generic roadmap in this regard.

In accordance with the characteristics of the pilot manufacturing process, Table 3 presents a contribution related to the adaptation of operational techniques and Lean Manufacturing methods that must be adapted to the manufacturing practices scenario, without altering the content of industrial training and education.

Table 3. Adaptation of Lean manufacturing techniques to the educational context.

Technique	Educational adaptation	Aim
5S	Order, cleanliness and discipline in the practice area.	Safety and efficiency in teaching
Autonomous maintenance	Proper machine inspection by students before/after practical sessions.	Technical responsibility and failure prevention
Kanban/heiijunka/Visual control	Representation of learning flows (operations, times, waiting).	Identify improvements in the sequence and timing of practice
Educational VSM	Representation of the learning flow.	Locate the problems in the operations area of the pilot process





Educational OEE	It measures the operability of machines and equipment	Detection of errors and irregularities in the operation
-----------------	---	---

Source: Author's own work, 2024

Table 3 shows that Lean manufacturing (LM), which optimizes operational performance, is not exclusive to the commercial or industrial sectors. Therefore:

Adapting lean manufacturing in the educational field is legitimate and consistent with professional learning objectives.

The application of lean manufacturing does not alter the structure of the content or the nature of the courses, but rather enriches the content by linking theory and practice in a real system.

3.2. Inferential Results

Based on the question: Does Lean manufacturing improve the management of Occupational Health and Safety in the Machine and Tool Laboratory?

Statement of the null hypothesis (Ho) and the alternative hypothesis (H1).

Ho: Lean manufacturing does not improve the management of Occupational Health and Safety in the Machine and Tool Laboratory.

H1: Lean manufacturing improves the management of Occupational Health and Safety in the Machine and Tool Laboratory.

Table 4. Hypothesis testing: Parametricity test of the hypothesis

variable Statistical test		Independent OEE	Dependent accident rate
Normality: Shapiro Wilks	EITH	0.9324	0.9498
H0 = The data fit a normal distribution	ER		
H1= The data do not fit a normal distribution	Next.	0.6564	0.8318
Equality of variances: t student	t	12.21	
Ho= There is no homogeneity between the groups	Next.	< 0.01	
H1= There is homogeneity between the groups			

Source: SPSS program version 27, 2024

The results in Table 4 indicate a normal distribution, but there is no homogeneity of variances. Therefore, they do not meet the conditions for parametricity. It was decided to use the non-parametric Wilcoxon test to test the hypothesis .

Table 5. Wilcoxon test for the hypothesis

Related samples	OEE - Accident Rate
Z	-2.366
Next.	0.018

Source: SPSS program version 27, 2024

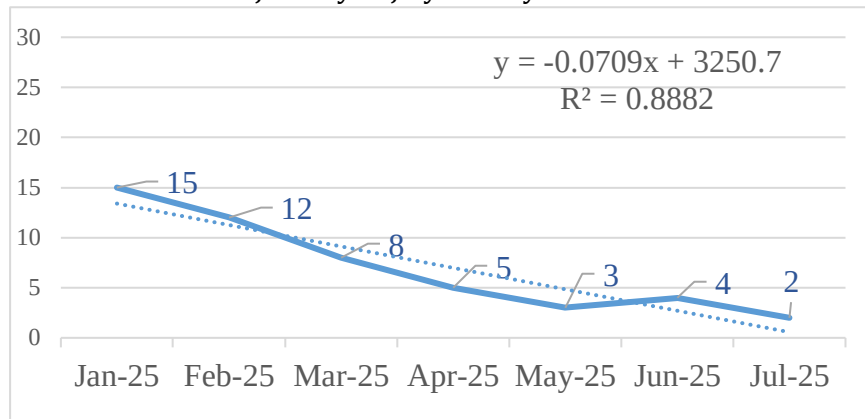
Table 5 shows that the significance level of the Wilcoxon test is less than 0.05, therefore Ho is rejected. H1 is accepted: Lean manufacturing improves the management of Occupational Safety and Health in the Machine and Tool Laboratory , with a 95% confidence level.

3.3. Prevention measures .



The results of monitoring the prevention measures are presented in Figure 1.

Figure 1. Prevention measures from January to July of the year 2025



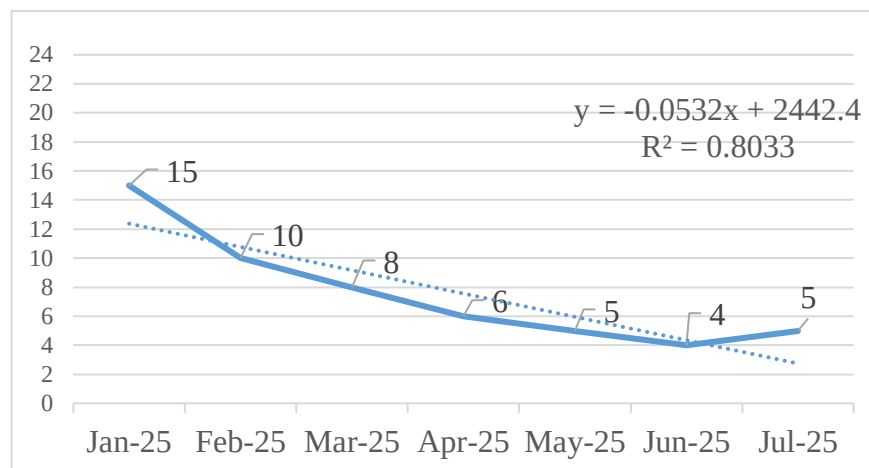
Source: Author's own work, 2025

In Figure 1, it can be interpreted that as the months passed from January 2025, the prevention measures decreased (expressed by an adjusted slope of -0.0709) because the results of the monitoring of the prevention measures required it, thus indicating that prevention measures should be inherent in industrial processes .

Standard procedures

During the investigation, the current practice guidelines were standardized, which allowed the establishment of standard documents with activities and tasks to be carried out with a revised and established guide (Figure 2).

Figure 2. Standardized operations



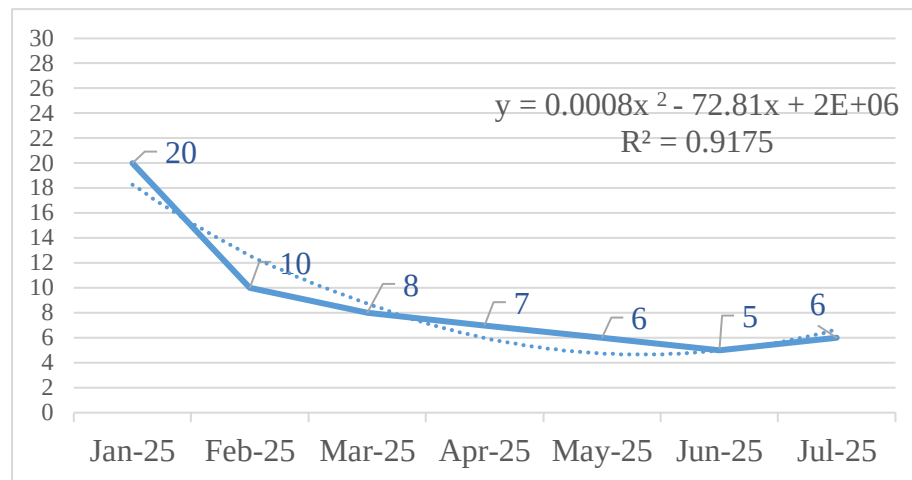
Source: Author's own work, 2025

In Figure 2, it can be interpreted that as the months passed from January 2025, the Standard Procedures decreased (expressed by an adjusted slope of -0.0532) because standardization required it, with a slope lower than the prevention measures

3.3.1. Job Safety Analysis (JSA).

The ATS was performed to validate the procedures of the Machine and Tool Laboratory (MTL) operations with the purpose of discovering potential hazards in the manufacturing process, in order to minimize occupational risks in the MTL, shown in figure 3:

Figure 3. Job Safety Analysis (JSA)



Source: Author's own work, 2025

In Figure 3. The ATS was carried out to validate the procedures of machine and equipment operations with the purpose of discovering potential hazards in the manufacturing process, to minimize occupational risks, with the lowest value being in the month of May of the year 2025 (because the vertex of the fitted quadratic equation agrees), that is, almost at the end of the first semester of the period considered.

4. Discussions

Since 2020, the scientific literature has consistently reinforced the idea that integrating Lean practices with occupational health and safety management contributes to both worker safety and organizational competitiveness. Recent research demonstrates that implementing Lean models explicitly adapted to occupational health and safety (Lean-OHS) promotes a safer work environment and improves working conditions by reducing hazards and risks through continuous improvement cycles, which in turn translates into higher levels of productivity and operational efficiency. Studies such as that by Ulu and Birgün (2024) implemented a Lean-OHS model in a university laboratory, demonstrating that applying Lean principles to safety management significantly reduced workplace hazards and improved working conditions, supporting the notion that integrated safety is not an additional cost but rather a driver of productivity within production processes. In the context of Lean Manufacturing management for occupational health and safety in industrial engineering laboratories, the findings reinforce the sequential generic route proposed by Hernández and Vizán (2013), where the integration of operational techniques generates synergies that avoid failures in isolated implementations.

In addition, systematic research has found that adopting Lean principles related to ergonomics and process standardization reduces workplace risks and strengthens the competitiveness of micro and small businesses by decreasing downtime and operational errors. These findings underscore that Lean not only optimizes workflows but can also directly contribute to the physical health and well-being of workers when implemented holistically. Furthermore, recent literature

reviews have highlighted that Lean tools such as 5S, TPM, and value stream mapping not only reduce waste and downtime but also interact with existing safety systems to create more organized and, therefore, safer environments, supporting operational continuity and improving key performance indicators.

Furthermore, reviews of quantitative and analytical studies reveal that the implementation of occupational safety and health programs integrated into the organizational culture—especially when linked with Lean practices—has a positive and significant impact on productivity, suggesting that safety outcomes improve when these programs are not isolated but part of the core of the company's operational strategy.

In terms of competitiveness, conceptual research on Lean Six Sigma in sectors such as healthcare has suggested that the combination of quality management and Lean methodologies can strengthen competitive advantages by promoting continuous improvements in both efficiency and safety and management results.

Chan and Tay (2018) on combining kaizen tools for practical applications. The operational efficiency, raised to 75.95% with a 19.38% increase and a 16.63% reduction in cycle time, is explained by the systematic elimination of waste such as waiting and unnecessary processes, aligning with Rajadell's (2021) lean approach for flexible production environments.

In standards as a basis for improvement and Castillo (2022) in production processes with +18% productivity, León et al. (2023); also in some engineering fields, according to Reyes C (2014) Implementation of Lean Manufacturing tools in the production area of Reyes Industria Textil is applicable and of relevant importance, aligning with global strategies (ILO, 2023; Oficem, 2008 in good practices)

5. Conclusions

It is evident that integrating occupational health and safety management with Lean Manufacturing techniques is a key factor in achieving sustainable competitive advantages in production systems. Effective safety management not only contributes to reducing accidents and occupational illnesses but also improves operational continuity, employee performance, and overall process efficiency.

Furthermore, the systematic implementation of Lean tools allows for the identification and elimination of waste, the optimization of resource use, and the reduction of labor losses associated with downtime, rework, and operational failures. Taken together, the strategic alignment between safety and Lean strengthens organizational management, increases productivity, and promotes safer and more efficient work environments.

References

- Al-Najjar, S., & Abdul Rahim, S. (2024). The role of Lean Six Sigma in boosting competitive advantage in the governance of healthcare organizations (El papel de Lean Six Sigma en el impulso de la ventaja competitiva en la gobernanza de las organizaciones de salud) *Journal of Governance and Integrity*, 7(1), 624–635. *Universiti Malaysia Pahang*. <https://doi.org/10.15282/jgi.7.1.2024.9441>
- Aripin, N. M., Mahmud, F., Lee, K. L., & Hussain, S. (2024). Systematic literature review: Lean ergonomics analysis in SMEs manufacturing sector (Revisión sistemática de literatura: análisis de ergonomía lean en el sector manufacturero de las PYMES) *Journal of Technology and Operations Management*, 19(1), 89–108. *Universiti Utara Malaysia*.

<https://doi.org/10.32890/jtom2024.19.1.7>

- Chan, C. O., & Tay, H. L. (2018). Combining lean tools application in kaizen: A field study on the printing industry (Combinación de la aplicación de herramientas lean en kaizen: un estudio de campo en la industria de la impresión) *International Journal of Productivity and Performance Management*, 67(1), 45–65. Emerald Publishing. <https://doi.org/10.1108/IJPPM-09-2016-0197>
- Hernández, J., & Vizán, A. (2013). Lean manufacturing conceptos técnicas e implantación (Lean manufacturing concepts techniques and implementation). *Escuela de Organización Industrial*. <https://optimiza.pe/lean-manufacturing-tecnicas-herramientas-para-implantacion/>
- José Carlos Sá, J., Oliveira, A., Hines, P., Mourão, F., McDermott, O., Marques, P. A., Zouari, A., Pathania, A., & Ulewicz, R. (2025). The effects of lean and people's behaviours on occupational safety (Los efectos de lean y los comportamientos de las personas en la seguridad ocupacional) *Production Engineering Archives*, 31(1), 1–14. Polish Association of Production Engineering. <https://doi.org/10.30657/pea.2025.31.1>
- León, J., Román, E., Romero, L., & Olea, J. (2023). Implementación de Kanban para incrementar la efectividad de un almacén tipo supermercado en una empresa manufacturera (Kanban implementation to increase the effectiveness of a supermarket-type warehouse in a manufacturing company). *Información Tecnológica*, 34(6). Centro de Información Tecnológica. <http://dx.doi.org/10.4067/S0718-07642023000600001>
- Montero, R. (2016). Relación entre Lean Manufacturing y seguridad y salud ocupacional (Relationship between lean manufacturing and occupational safety and health). *Salud de los Trabajadores*, 24(2), 133–138. *Universidad Autónoma de Occidente*. <https://www.redalyc.org/pdf/3758/375851163007.pdf> servicio.bc.uc.edu.ve
- Nelfita, N., Aprinawati, A., Lubis, D. A., Wijaya, R. H., Rumapea, Y. R., & Sampurno, M. A. (2024). Analysis of the impact of implementation of occupational safety and health programs on productivity: Literature analysis (Análisis del impacto de la implementación de programas de seguridad y salud ocupacional sobre la productividad: análisis de literatura). *Holistic Science*, 4(3), 543–550. Larisma Publisher. <https://doi.org/10.56495/hs.v4i3.762>
- Organización Internacional del Trabajo. (2023). Panorama laboral 2023 América Latina y el Caribe (Labour overview 2023 Latin America and the Caribbean). *Organización Internacional del Trabajo*. https://www.ilo.org/sites/default/files/wcmsp5/groups/public/@americas/@ro-lima/documents/publication/wcms_906617.pdf
- Rajadell, M. (2021). Lean manufacturing (2ª ed.). Ediciones Díaz de Santos. <https://www.editdiazdesantos.com/wwwdat/pdf/9788479789671.pdf>
- Reyes, C. (2014). Implementación de herramientas Lean Manufacturing en el área de producción de Reyes Industria Textil Cia Ltda (Implementation of lean manufacturing tools in the production area of Reyes Industria Textil Cia Ltda) [Tesis de maestría, Escuela Politécnica Nacional, Quito - Ecuador]. *Escuela Politécnica Nacional*. <https://bibdigital.epn.edu.ec/handle/15000/8124> BibDigital
- Ulu, M., & Birgün, S. (2024). A case study on lean occupational safety (Un estudio de caso sobre seguridad ocupacional lean). *Sigma Journal of Engineering and Natural Sciences*, 42(2), 534–548. Yildiz Technical University. <https://doi.org/10.14744/sigma.2022.00108>



Contributions of the co-authors: All co-authors have contributed to this article by mutual agreement and are responsible for all information contained therein.

Luz Karen Flores Pérez (33.3%): Conceptualization, Data Curation, Formal Analysis.

Victor Genaro Rosales Urbano (33.3%): Resources, Methodology, Software, Writing – original draft.

Juan Valentín Leoncio Coasaca Portal (33.3%): Writing – review and editing, Supervision, Validation and Visualization.

Research funding: With own resources.

Declaration of absence of conflict of interest: The authors declare that we have no conflict of interest that may have influenced the results obtained or the interpretations proposed.

Informed consent statement: The study was conducted in accordance with the Code of Ethics and Good Publication Practices.

Usability: This text is shared under the Creative Commons Attribution 4.0 International License (CC BY 4.0). You may share, copy, and redistribute the material in any medium or format, as well as adapt, remix, transform, and create derivative works from it for any purpose, even commercially, provided you comply with the attribution condition: you must give appropriate credit, provide a link to the license, and indicate if changes were made. You may do so in any reasonable manner, but not in any way that suggests the licensor endorses or approves your use.

