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Design of a methodology to incorporate Lean Manufacturing tools in risk management, to reduce work accidents at service companies

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Abstract

Lean Manufacturing tools were originally developed to improve manufacturing production systems and enhance productivity and quality in organizations. For this reason, they are used more frequently in manufacturing than in service companies. The Ergo-Lean approach applies Lean Manufacturing to the field of Occupational Safety and Health, focusing on reducing activities that do not add value and on reducing the associated muscular-skeletal disorders. The purpose of this study is to integrate Lean Manufacturing tools in risk management to help control work-related accidents. Based on work accident data at a service company, the causes of the accidents were analyzed and the main Lean Manufacturing tools were reviewed and integrated, in order to develop a new methodology for the implementation of these tools to help prevent work-related accidents and diseases and to develop a culture of self-care.

Keywords: Lean Manufacturing (LM); Occupational Safety and Health (OSH); Work accident; Risk.

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1. Introduction

Human capital is currently considered a key element for organizations because of the significant contributions that humans make to production capacity. Consequently, organizations must ensure that human resources remain in the best conditions possible to maintain production capacity. Companies are ever more aware of this, and as a result have implemented programs to promote employee health and safety.

The International Labor Organization (ILO) holds that Occupational Safety and Health (OSH) is indispensable for the effects of establishing priorities and detecting risk and hazard factors, to implement prevention programs, identify hazardous areas and apply risk management policies. At companies, the establishment of Occupational Safety and Health Management Systems facilitates compliance with a series of requirements and promotes a systematic review of all the aspects to be taken into consideration to ensure the well-being and integrity of workers and to reduce work-related accidents and diseases, by means of the implementation of a series of measures and strategies to ensure the system's effectiveness [1].

Lean Manufacturing (LM) is a production method that was first introduced by the Japanese company Toyota [2]. Implementation of the LM principles and practices has become widespread, even in the context of current growing demand for labor, to achieve higher levels of quality and flexibility at lower costs [3]. LM has been studied and applied in a wide variety of companies with positive results in production and administrative processes, but much more research remains to be done on the application of this philosophy to Occupational Safety and Health [4], [5].

According to different occupational health studies, muscular-skeletal diseases are the main cause for morbidity among the working population, producing lost days of work and decreasing business productivity [6]. The work shifts of service companies, and the tasks performed by many of their employees, may produce this type of pathologies, in addition to other risk factors such as over-exertion, repetitive motions and inadequate postures, which are often the result of poorly designed and inefficient work areas and bad practices, and which may be improved by means of LM [7].

Lean Manufacturing (LM) and ergonomics are combined for the effects of eliminating waste. The objective of LM is to eliminate all waste possible, while the objective of ergonomics is to mitigate health, safety, and workstation design problems at the workplaces [8]. This paper is organized as follows: First, a Review of the literature, which includes background information related to this study; then a presentation on Methodology, which describes the stages of the project step by step; followed by the Results, which review each result obtained from application of the methodology; and lastly, Conclusions, which provide a general discussion on the results obtained and future research opportunities.

2. Literature review

A variety of studies have focused on the implementation of tools and methodologies for the development of strategies to mitigate and reduce the risk factors of occupational accidents and diseases, and which have had a significant impact on occupational health and safety management systems. Worldwide, 270 million work accidents (WA) and 160 million occupational diseases (OD) are reported each year [9]. In Colombia, according to the Colombian Federation of Insurers (Fasecolda), there were 723,836 work accidents and 9583 occupational diseases in 2005 [10], which clearly indicates that companies need to implement programs to prevent occupational risks.

In this sense, the adequate implementation of an occupational risk management system at companies contributes to minimizing work-related accidents and diseases, which implies that companies must work hand in hand with insurers and employees, involving them to participate in training in order to further reduce work-related events [11]. The causes of these events are mostly related to poor work organization, rather than to the complexity of the operations. Such events can be prevented through the identification of threats and subsequent efforts to eliminate them [12].

Below we provide a literature review on several studies that show how to reduce work-related accidents and diseases through the application of methods, and knowledge, which are used as risk management control factors.

In a study by [13], the insurance company Mapfre proposes a behavior-based Safety approach to enable the reduction of workplace incidents. Some of the factors mentioned in the paper as causes for work-related accidents or diseases include the work environment, individual training, and individual motivation. This implies the need to provide orientation to each worker on the factors that enable him or her to perform the work activity without causing

harm. At Electrolux, ergonomics studies had generally focused on direct laborers, mainly those involved in line installation, but because indirect labor had increased in recent years. Electrolux launched a project to improve ergonomics in warehouse activities, with the objective of reviewing not only heavy lifting operations, but also at least 50% of total activities, and if possible also before starting production [14]. In Australia, safety managers at two companies believed that their long-term and continuous investment in higher-order controls, such as elimination or isolation measures to mitigate risks, was the key for successful safety management for companies in all economic environments, and consequently carried out an intentional critical case study of two heavy manufacturing plants to identify and discuss the safety issues faced by companies under financial stress [15].

[16] carried out a study at the company Preflex S.A. aimed at optimizing working conditions for the company's employees and reduce the risk of work accidents. Additionally, a study by [17] proposed designing a task rotation system to reduce the ergonomic occupational risks of workers, based on a lineal mathematical model that minimizes occupational risk and maximizes resources. As a result, they obtained a task assignment plan for a production system taking into consideration the job conditions, ensuring a minimum of ergonomic risk and worker satisfaction. There is currently also talk on using Lean methodologies to mitigate occupational accidents and diseases, taking into consideration that these methodologies help make processes leaner. This is the case of the study by [18], the purpose of which was to assess the relationship between Lean Manufacturing practices and Ergonomics at companies submitted to a lean implementation, consisting in a combination of techniques that enable the identification of shortcomings related to the application of Lean Manufacturing practices that can support socio-technical factors.

In this sense, other authors have carried out more detailed studies on this relationship, such as [19], who performed a detailed review of studies carried out in lean manufacturing environments over the last 20 years. Its objective was to identify the effects of lean production (negative or positive) on occupational health and associated risk factors. The study by [20] uses a Lean Manufacturing tool known as the 5S methodology, with the objective of optimizing work and ensuring safety at a university's engineering laboratories, based on the implementation of a work model. As a result, the laboratories' safety conditions and organization were adapted in accordance with industry practices.

Lastly, [21] used an experimental design at a company consisting of a simulation game on the implementation of Lean Manufacturing combined with human resources practices, because previous studies had indicated both positive and negative effects of Lean Manufacturing on employee perceptions and attitudes towards work. The most damaging of these was the perceived reduction in autonomy by workers. To reduce these negative consequences, the study proposes the incorporation of human resources practices in Lean Manufacturing, which produces positive results such as increased motivation, autonomy, and worker satisfaction.

3. Methodology

For the effects of this study, a descriptive-analytical study was carried out [22], based on information provided by the Occupational Safety and Health area of a services company, including statistics, work accident reports, lost work days and data provided by the company. The starting point was the characterization of the company's current situation, to identify the safety and health measures in place and to determine any proposed improvement actions or new measures, as well as to identify the areas with the greatest number of work accidents. This enabled limiting the scope of the study and focusing efforts on the process of implementing the proposed methodology. **T**his study focused on the area of Recreation, Food and Beverages. Subsequently, an analysis was performed of the causes of the work accidents using tools such as Pareto and Ishikawa charts.

To design the proposal, the most common Lean Manufacturing tools were reviewed, including an assessment of each tool's objectives. Based on this, a comparative analysis was performed with the identified causes, to assess their incidence on each cause. The Lean Manufacturing tools to be used were determined based on expert opinion, and an assessment was performed on which tools were most feasible to implement in terms of costs, resources, pros and cons and level of complexity for implementation. Weights were assigned to each factor to select the optimal risk tools for the effects of risk management. Once the Lean tools were selected, a procedure was prepared to enable the effective and integrated implementation of each tool at the services company (Fig. 1).

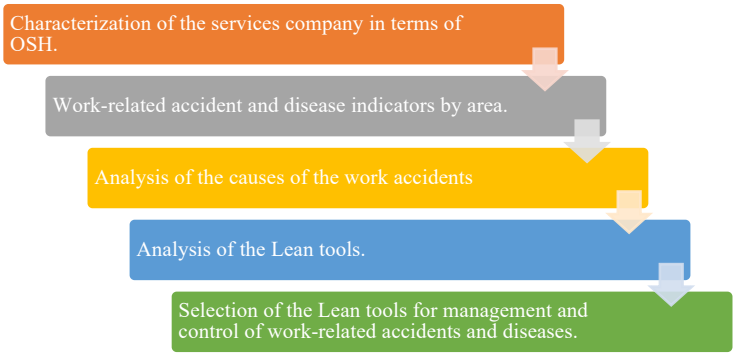

Fig. 1. Diagram of the methodological process.

4. Results

The following were the results of this study:

4.1 Characterization of the services company in terms of Occupational Safety and Health:

The service company where the study was conducted is a private not-for-profit entity, whose services portfolio includes health, recreation, sports, education, subsidies, loans, and housing services, among others. Since 2015 it has had an Occupational Safety and Health Management System in place, which establishes OSH policies, objectives, and indicators. It also has Occupational Safety and Health governance bodies, such as the Joint Employer-Employee Committee on Occupational Safety and Health (COPASST, by its acronym in Spanish). It has developed a map that identifies the hazards, assessed risks and established controls, based on the methodologies included in the Colombian Technical Standards GTC-45. Based on said map, it was established that controls are already in place for the main identified risks, including bio-mechanical, psycho-labor, physical and safety risks.

4.2 Indicator of occupational accident and/or disease rates by area:

This study used data collected by the area in charge of Occupational Safety and Health for the periods from 2015 to 2017. In these two years there were no reports of occupational diseases, but there were reports on 42 work accidents, 16 of which were in the Recreation, Food and Beverages area, as shown in Fig. 2:

Fig. 2. Number of work accidents (WA) and occupational diseases (OD) reported from 2015 to 2017 at CCF.

Of the reported work accidents at this services company, 69% had traumatic consequences, which implied days off work due to fractures or physical contusions, while 31% were non-traumatic, involving shorter sick leave days. The number of days off work due to work accidents is summarized by area (Fig. 3):

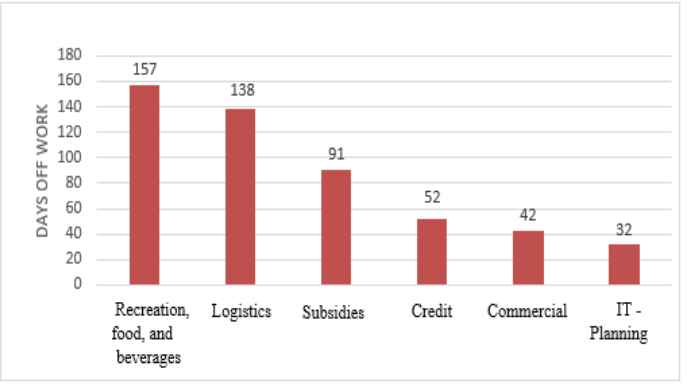

Fig. 3. Days off work due to accidents by area.

To determine the types of accidents that took place in the area under study (Recreation, Food, and Beverages), the accidents were classified by type of risk:

For the Work Accidents Pain in lower back due to lifting load of 30 kg, Fall on kitchen floor with the full body weight received by the right arm, producing strong pain and swelling and Face burned when turning on oven, the types of risk are over-exertion associated with loads, fall at same level and exposure to high temperatures respectively.

Slip on wet floor, producing first-degree hot oil burns on the face and right arm, Wound on right hand thumb, Wound on left hand index finger and Wound on left hand ring finger have the types of risk struck by or against objects.

For Sprained left ankle when climbing down cold room ladder, Fall on floor against the belly, Fall from stairs, striking hip, legs and arms and Slipped on peels, falling on the side, striking the knee, waist and right elbow the type of risk is Fall at same level.

Finally, for Ran into a glass door with no signage, producing contusion and inflammation of the brow, cheek, front of left eye and Knife slipped when cutting beets, producing a wound on the distal area of the 4th finger, the type of risk is struck by or against objects and for Slipped on wet floor, with contusion on right leg, Slipped on wet floor, producing a contusion on the left knee and Slipped, and While falling placed left hand in a box with broken glasses, producing a glass wound on the base of the thumb the type of risk associated is Struck by or against objects.

Following the classification of the work accidents in the Recreation, Food and Beverage area, a Pareto Diagram was drawn, which enabled prioritizing the accidents that require the most urgent adoption of action plans. The classification shows that most accidents in the Recreation, Food and Beverage area are same level falls and strikes by or against objects, as well as mechanical type risks associated with handling sharp tools.

The causes related to these accidents were analyzed in order to focus efforts and action plans on minimizing accidents of this type using the Lean methodology.

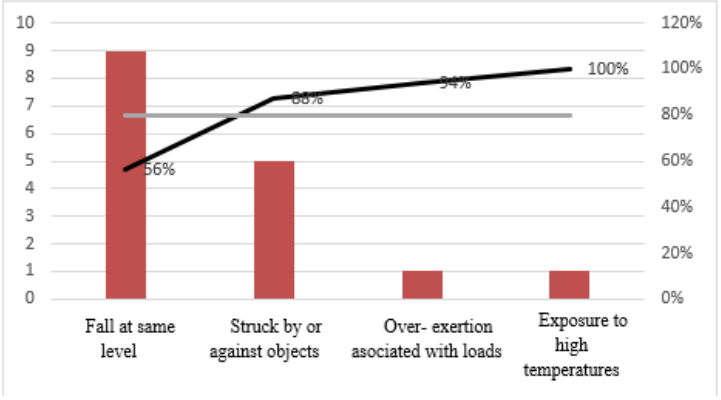

Fig. 4. Pareto Diagram -Statistical report on accidents from 2015 to 2017

4.3 *Analysis of the causes of work accidents.*

Based on the Pareto diagram, Ishikawa diagrams were developed for the "few vitals":

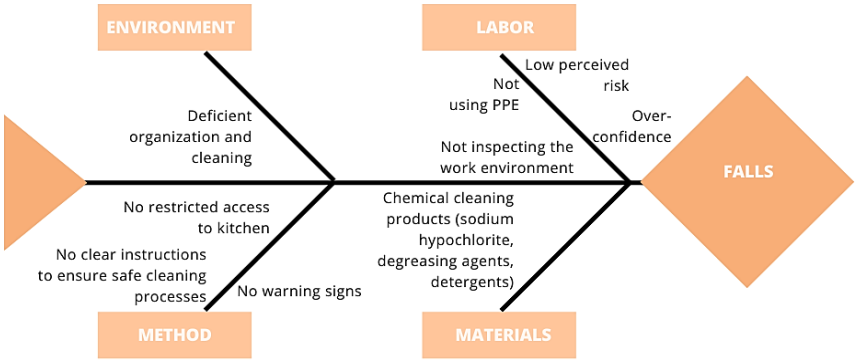

Fig. 5. Ishikawa Diagram – Cause and effect

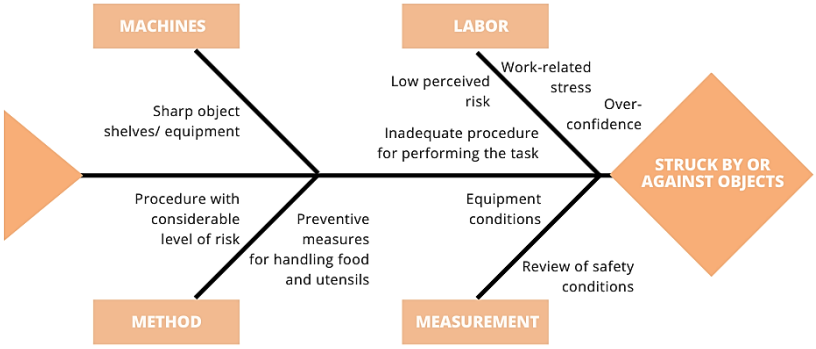

Fig. 6. Ishikawa Diagram – Cause and effect

4.4 Identification and analysis of the Lean Manufacturing tools:

A search was performed on Lean Manufacturing tools applied to enterprises, by definition, application and implementation methodology. They were assessed based on a series of questions on their influence on risk management, in terms of reducing the number of work-related accidents or diseases.

4.5 Selection of the Lean tools:

Based on the study of the Lean Manufacturing tools, the following were selected: 5S, Visual Management, Work Standardization and Kanban, based on their characteristics, their cost of implementation, their pros and cons and complexity, selecting those that are easy to apply for the design of the methodology to be used to reduce work accidents at the services company. Other tools may contribute to topics related to continuous improvement, but they do not directly address the causes studied in this paper. Below we display the way the selected tools are linked to the causes of work accidents:

5S: Deficient organization and cleaning, unsafe conditions at the workplace, no hazard warning signs, space: There are no clearly defined hallways and unnecessary movements and transfers.

Standardization: No procedure on use of cleaning chemicals, deficient operating procedure, no standardized procedure, failure to use of PPE, low perceived risk.

Visual Management: Over-confidence, no restriction of access to kitchen, no hazard warning signs, warning on use of cleaning chemicals (clorox, degreasing agents, detergents), unsafe workplace conditions.

Kanban: deficient equipment organization and cleaning, preventive measures for handling foods and utensils, review the safety conditions of the equipment, procedure with considerable level of risk, lack of workspace inspection.

4.6 Methodology Design:

These four tools can be implemented simultaneously, given that they have characteristics in common both in terms of applicability and the obtention of positive results. The standardization and 5S methodologies are the basis for application of visual management, i.e., once procedures have been standardized and each of the 5S stages are applied (sort, set in order, shine, standardize and sustain), the decision is made on where to set up the visual elements to ensure a reduction of unsafe acts and conditions. Lastly, Kanban provides for continuous process improvement by means of periodic reviews and monitoring of the applied strategies, which have a direct impact on the worker safety and ergonomics.

Based on the stages used to implement each tool, a methodology was established that integrates each of these tools into OSH management, as follows:

1. Review the procedures, instructions and safety measures and inspect the areas where most accidents have occurred. Hold meetings with personnel from the area to detect errors and improve the process.
2. Document, create or improve the procedures, instructions, signage, and measures, as required.
3. Train and apply the 5s tool (in Japanese: *Sein, Seiton, Seiso, Seiketsu, Shitsuke*).
4. Identify the critical areas based on items 1 and 2.
5. Implement the visual aids using predefined signage.
6. Disseminate the standardized procedures
7. Periodically review and monitor the adjusted processes
8. Strengthen the educational plan through Training/Talks on self-care, hazard prevention and risk control.
9. Strengthen the communications channels for workers in connection with OSH by using all corporate communications channels (Intranet, flyers, information videos, e-mail, internal messaging, etc.)
10. Upgrade the physical facilities identified during the inspection of the work areas where high risks were identified due to space restrictions.

5. Conclusions

Lean Manufacturing tools have been conceived primarily for application in the manufacturing industry, their application for the prevention of work-related accidents and diseases at the service company becomes a bit of a challenge; however, their parameters can be easily adapted to achieve adequate application in any type of company.

The adequate implementation of the appropriate strategies produces substantial improvements in the process. In this sense, Lean Manufacturing becomes a strategic tool that involves all areas at a company, not only because of its various applications within an organization, but because it can be applied at any type of company and can be adjusted to different scenarios with excellent results. This was demonstrated in this project through the review of the various Lean tools that can be applied in Occupational Safety and Health and which at the same time have an impact on process optimization.

The results of the studied areas and the analysis of the Lean Manufacturing tools based on risk mitigation and control to reduce accident rates indicate that most of the tools used at present can contribute to this purpose. Their implementation will also depend on the type of company and the activities it performs. In the case of a services company, the most applicable tools are those that focus on creating habits and raising the awareness of people, with the assistance of standardization of procedures. Tools such as 5S, Kanban, visual management, and work standardization enable adequate risk management, because these methodologies are complementary and help reduce human errors, especially errors related to methods.

An integrated and easy to implement model was developed to enable adequate and effective management of Occupational Safety and Health activities, aimed at reducing work-related accidents and diseases at a services company.

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