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Optimization of a Government Medical Warehouse Using Lean Logistics Methodology

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ABSTRACT: *Quality methodologies that increase efficiency and productivity by reducing waste in time, overproduction, overstock, over process among others, are well known in the manufacturing sector, however, these methods that improve quality and reduce waste can be ideally used in all industries where processes where any type of process is carried out. Given this, in this research, an application of lean manufacturing methodology is presented, applied in a government medical warehouse, to optimize their processes and reduce the above-mentioned waste. Once the foundations of this project have been established the Lean Logistics methodology and the appropriate tools are presented and implemented in the government warehouse, then, the improvement is measured to demonstrate the functionality of the implementation of Lean Logistics in the mentioned warehouse.*

KEYWORD: lean logistics, process, productivity, optimization, warehouse, engineering quality, control quality, medical center.

INTRODUCTION

Government Sanitary region V of Nuevo Casas Grandes has a warehouse to safeguard medication in optimal conditions, however, due to increased demand and misuse of the racks and warehouse in general, there is the problem of not complying with the general rules of the proper use of the warehouse (USTR, 2021), such as having the aisles clear at all times, having the identification and location of each product found in the warehouse, among others (Khanzode & Shah, 2017). Due to these problems, there is a need to carry out an improvement project that allows the optimization of warehouse space for its proper use and to have the products in good condition when they are required, as well as their correct identification to avoid times deaths or, where appropriate, the mishandling of medications by personnel who do not know the order of the warehouse, due to the lack of adequate control of it (Karasek, 2013). On the other hand, the goal of every company is to consolidate and increase profits. The achievement of this objective is indispensable to the company for the reason of reaching a more competitive position in the market. The best way to increase efficiency is to satisfy customers by offering them continuous improvement in the service process and this can occur through the optimization of the use of warehouses and their correct identification because in this way they will count on an exact inventory of the type of medicine and the amount that is available (Limere et al., 2011). In addition to this, the medicine and the goods that are kept in storage will be in good condition since they will no longer be on the floor or without adequate identification (SQF Institute, 2014). In this way, using the tools and Lean Logistics method, the amount of waste or changes is reduced, which gives space, and variables that are significant in the optimization can be addressed, in this case, the sanitary region warehouse V (Huang et al., 2022). The structure of this paper is as follows. The first section shows the introduction; the second section presents the Lean Logistics introduction and tools; the third part contains the Lean Logistics analysis; the fourth section shows the development; the fifth section presents the results; the sixth part shows the conclusion and the references.

LEAN LOGISTICS INTRODUCTION AND TOOLS

The production organization techniques were developed at the beginning of the twentieth century, due to the work realized by Taylor and Ford (Uddin & Hossain, 2015). The object was to use new techniques and actions to improve mass production (Jalonen et al., 2016). These techniques evolve in a considerate way in Japan due to the need to rebuild an industry destroyed after the Second World War. This is how the first shoots of Lean thinking are born. This challenge involved achieving productivity gains without resorting to economies of scale (Georgescu, 2011). Lean Logistics pursues an improvement of the production system through waste elimination, understanding waste like all those actions that do not add value to the product and the customer will not going to pay (Das & Patnaik, 2015). Lean Logistics also looks for manufacturing plant improvement with directors, managers, and workers' communication and collaboration (Huang et al., 2022). Lean Logistics is based on the

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following. Continuous improvement, total quality control, waste elimination, and exploitation throughout the value chain and workers' participation (Khalili et al., 2018). These fundaments are a group in customer satisfaction. The waste concept was defined as all that does not add value or is not essential. However, in the process there will be activities that do not add value, but are necessary, in which case waste will be assumed. Another concept that is used in Lean Logistics is Hoshin which means compass in Japanese, these means activities that aim systematically eliminate waste and everything that is unproductive. Hoshin fundamental idea is the search for simple applicable solutions through the value chain (Masai, 2018). The fundamental idea of a hoshin operation is to search for simple and immediately applicable solutions by all the personnel involved, both in the improvement of the organization of the workstation and in the facilities or production flows. Undoubtedly, one of the key points of success is the involvement of all staff, from management to operators (Hamed & Soliman, 2020). On the other hand, the recognition of the waste of each company must be the first step in the selection of the most appropriate techniques to implement and improve efficiency and productivity in the company (Abhishek Dixit, 2015). In the following section, the waste type is presented in a concrete form.

Waste Types

The first type of waste is unnecessary transportation, this means, the movement of machines and production lines should be as close together as possible, and the material flow needs to go from one station to the other without inventory queues and excess manipulation (Wilson, 2010). The next type of waste is the error in the process, this waste is one of the most accepted in the industry, however, some companies do not perceive that this type of waste gets more time and money which means an increment in the manufacturing cost. Thus, the rework or error correction needs to be improved possibly by using a proof error process and eliminating the additional inspections. The product defects should be detected at the moment that happens, and in such a way, minimize the product that needs rework or additional inspection (Vargas et al., 2016). Another waste type is overproduction which carries with other types of waste. Overproduction has costs like storage, and material waste, among others. Overprocessing not only increases the overall cycle time but also affects inventory levels. Many times, companies overprocess as a precautionary measure (Kulkarni, 2016).

Another type is inventory waste, which means, the waste produced by the material that is not processed, this includes the cost of storage and all expenses incurred in maintaining the material in optimal conditions. The waste for motion refers, to all the unnecessary movements, that include persons or machines, this type of waste is derived from a not well planning production process (Mazumdar, 2020). The waste of waiting is the waste of time, this lack of time could be produced by a constrained process, an inventory waits, or an error in the product process, among others. To avoid this type of delay, it is necessary to have trained people, a production system with workstations in balance, an adequate flow of material, etc., (Zbicinski & Stavenuiter, 2006). The last waste type, which is nothing new, is the waste of human talent, this waste means the deficiency of time, ideas, and opportunities, due to, a lack of employee motivation. Currently, is necessary to take most of the people's talent, which implies a win-win relationship (Matters & Jobs, 2017).

Lean Methods and Tools

This section presents, an overview of methods and tools of Lean Logistics used in companies to improve efficiency and productivity in the production processes. The description of these methods and tools contains an overview of the objectives and expected results (Rewers & Trojanowska, 2016). One of the mean objectives of the implementation of Lean Logistics in the industry is to achieve a production continuous flow, simple, and logical. The inventory of finished products and work in process is trying to be reduced to the minimum. On the other hand, the time of changes in machinery, process tools, etc., should be reduced as much as possible (Vargas et al., 2016).

5S Method

Another method used in Lean Logistics is the 5S, this method is basic in lean implementation, the objective of this method is to implement the order, standard, and a philosophy of continuous improvement and waste reduction. This method name is derived from five stages of work organization, i.e., seiri, seiton, seiso, seiketsu, and shitsuke. Which refers to the following (Search et al., 2015). Seiri is the selection of the only necessary items to work and in this way get a better workstation. Seiton refers to the designation and selection of a suitable place for all tools in the workstation at the selection stage. Seiso, is the way of cleaning and maintenance of the workplace, this is maintaining items of a workplace in good condition. Seiketsu, means standardize, it is the implementation of the first three steps and then making them a standard. The last one is Shitsuke, which means, creating a culture of discipline and maintaining the implementation of the previous steps as a normal operation (Mehta & Dave, 2020).

Single Minute Exchange of Die (SMED)

Single Minute Exchange of Die refers to the techniques used to reduce the setup time and it can be defined as the minimum time to change the production process. Today SMED methodology is used in the preparation of any type of machine, reducing the necessary time and also incrementing the reliability of the machines (García-Alcaraz et al., 2014).

Total Productive Maintenance

Total productive maintenance is used in Lean Logistics to reduce waste relational with the need for maintenance by capacitating all employees to get continuous production. The object of this methodology is to improve the productivity and efficiency of machinery and tools (Ching et al., 2015).

METHODOLOGY

This section presents the method that was followed to establish an adequate order within the warehouse and the optimization of storage capacity, using lean manufacturing principles and functions (see Figure 1).

Figure 1. Lean Functions

Source: The Authors.
Note: Figure 1 shows the Lean functions to a high-performance organization.

As can see below in Figure 2 there is a general flow chart that uses the Lean Manufacturing methodology, which serves as the basis for the situational analysis of the company and its problems, to establish the quality critics and know the tools to implement in the solution of problems, i.e., aid critics. It should be noted that this diagram can be modified according to the needs of each company (Internation Labour Organization, 2017).

Figure 2. Lean Process

Source: (Brau, 2022).
Note: Figure 2 presents the Lean system to achieve set objectives.

As a starting point in the identification of problems and their prioritization, information can be collected by observing the phenomenon or using techniques such as the voice of the client, in which a series of questions are sought to be resolved during the seven stages of the application of the lean methodology (Kusek & Rist, 2004).

1. Is the problem permanent or does it exist only in the case of some products/processes?
2. Does the team expect you to solve the problem?
3. Can a feasible solution be found within the predetermined period?
4. Can it be solved within the team in a predetermined period or is it necessary to hire external help?

Problem Identification

This stage serves to collect information from the warehouse area that allows an understanding of its operation and the activities carried out by the workers in the area, in addition, to analyzing the current situation of the warehouse in terms of the available indicators and critical variables (Oketunji & Omodara, 2011).

Investigation of Critical Factors

• Interview with personnel involved. Oral interviews will be made with the two people assigned to the warehouse area and with the two people from the maintenance area who support in case of reorganization to detect the needs perceived by them (ISCO-08, 2008).
• Taking measurements of racks and volumes of boxes and medicine that must be stored in said racks to determine the necessary space and the current dead space (Bartholdi & Hankman, 2016).
• Determine the root causes of critical warehouses to establish proposals for improvement (In et al., 2022).
• Analyze the critical or significant variables with the use of a modified failure effect analysis which is shown below in Table 1:

Table 1: Modified FMEA

Failure	Severity	Occurrence	Detection	RPN

Source: The Authors.

• Establish improvement measures according to the root cause analysis and RPN obtained.

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• Measure the improvements through the RPN and establish statistical hypotheses for a mean difference test and verify that the improvement is significantly functional.

Project Development

This section shows the processes carried out for the improvement in the regional warehouse V.

Identification of critical variables

An interview was conducted with those in charge of the warehouse, as well as with the people responsible for it to determine which are the problems that occur most frequently in the warehouse, the results are shown below in Table 2:

Table 2: Voice of Client

VOC 1	• Lack of record of drug outflows. • Lack of registration of incoming medication. • Lack of identifiers in the warehouse. • There is no daily record. • Clogged aisles. • Damaged boxes. • Lost medication.
VOC 2	• There is no identification of medications. • The boxes with the medications and quantities they contain are not identified. • Poor arrangement of boxes • Loss of time to use medication. • There is no monitoring of the medicine boxes and those that have already been distributed in the various health centers.
VOC 3	• Unidentified drug. • Expired medication. • There is no identification on the shelves.

Source: The Authors.

According to the interviews carried out, the most significant problem is the mishandling of input and output medications, since there is no correct identification and a record that indicates their inputs and outputs, together with expired and mistreated medications, which is a consequence of the above.

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Critical Variable Analysis with Modified FMEA

A modified FMEA was performed with the intention of identified the critics of quality and added a value to each one of these variables to determine which of the selected variables as the most relevant in problem solved presents a risk priority numbers higher. The results of the analysis are shown in Table 3.

Table 3: RPN Identification

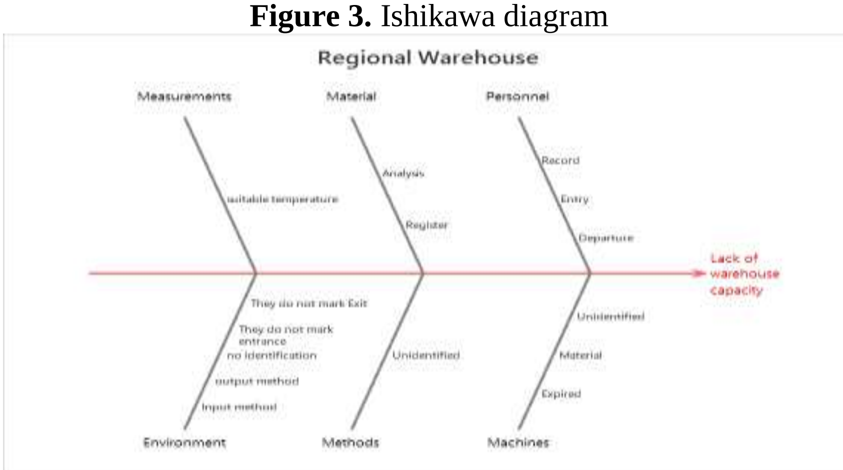
Failure	Severity	Occurrence	Detection	RPN
Identification in racks	7	10	4	280
Drug Identification	8	10	7	560
Records	9	10	7	630
Clogged hallways	9	10	10	900
Damaged drug	10	10	1	100

Source: The Authors.

Ishikawa diagram

A root cause analysis was performed to identify the root of the lack of capacity problem shown below in Figure 3:

Figure 3. Ishikawa diagram



Source: The Authors.

According to the root cause analysis that was carried out using the Minitab 19 software, the method is considered as the root of the problem of lack of capacity in the regional warehouse V, for which a 5 whys analysis is carried out to find the solution, best way to solve this problem.

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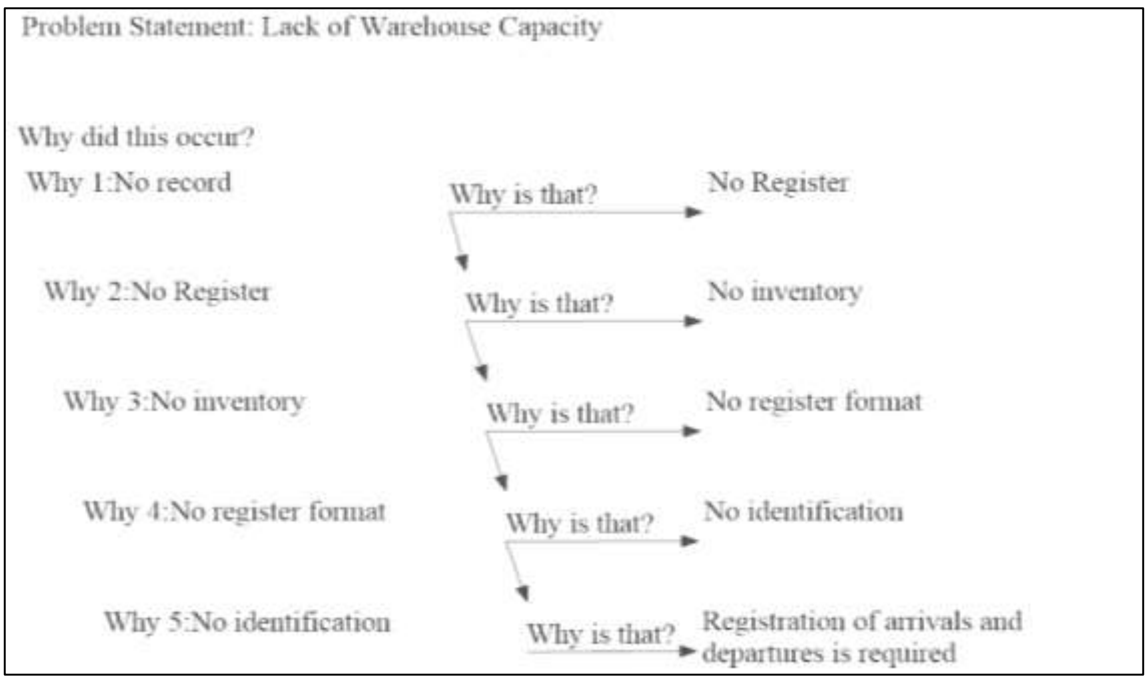
5 Whys Analysis

According to analysis 5 whys, it is considered necessary to generate the registration forms corresponding to the entry and exit of the warehouse for medicines, in addition to this, it is necessary to identify both the medicines and the racks where they are stored, to reduce waste and increase capacity, thereby meeting the project objectives see Figure 4.

Figure 4. 5 Whys Analysis

Source: The Authors.



RESULTS

This section describes the results obtained according to the causes of the problem found in the previous section.

• An inventory record format was created to verify each entry to the medicine warehouse, indicating the quantity, date, description of the medicine, and its location.

In the same way, the format for the exit of materials and medicine from the regional warehouse V was made, which is shown below in Table 4 and table 5:

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https://bjmas.org/index.php/bjmas/index
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Table 4. Medication Entry Record Form

Departure date	Material description	Quantity	Destiny	Name of Who Delivers	Departure date	Signature of the Deliverer

Sources: The Authors

Table 5. Departure Log

Delivery date	Material description	Quantity	Consumption		Destination	Location	Name of the Receiver	Date of receipt	Signature of the Deliverer
			Yes	No					

Sources: The Authors

The racks were identified with the material that should go, the location, description of the product, minimum and maximum, below, an example carried out as a test in the Kanban box is shown in Figure 5.

Figure 5. Rack Identification Example

Source: The Authors.

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The allocation of space in each rack was made by measuring the volume and weight of each box to comply with the regulations that mention that items with greater weight or volume should be stored in the lowest place in the rack and so on. And the surplus material or medicine will be identified by blue tape and its correct identification, in case the locations assigned for said medicine are exceeded and with this avoid obstructing corridors and loss of medicines, as well as their correct storage.

Statistical results

A test for the difference of means was carried out for the statistical contrast of the initial and final risk priority numbers (RPN), to verify the operation of the improvements implemented, the results and the current risk priority number are shown below in Table 6.

Table 6. Final RPN

Problem	Severity	Occurrence	Detection	RPN-1	RPN-2
Identification in racks	7	1	4	280	28
Drug Identification	8	1	7	560	56
Records	9	1	7	630	63
Clogged hallways	9	1	10	900	90
Damaged drug	10	1	1	100	10

Source: The Authors.

$H_0: \mu_1 = \mu_2$

There is no significant difference between the means of the improvements implemented.

$H_1: \mu_1 \neq \mu_2$

There is a significant difference between the means of the improvements implemented as shown.

Table 7 presents a hypothesis test for the mean difference between risk priority numbers one and two.

Analyses

Table 7. Mean Concept

μ_1: population mean of RPN-1
μ_2: population mean of RPN2
Difference: μ_1 - μ_2

Source: The Authors.

Note: Table 7 shows a hypothesis test for the difference of means for the risk priority number

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Descriptive Statistics
Table 8 shows the statistic resume for both failure mode and effect analysis.

Table 8. Data Resume

Sample	N	Mean	StDev	SE Mean
RPN-1	5	494	312	139
RPN-2	5	49.4	31.2	14

Source: The Authors.
Note: Table 8 presents a data resume of mean and standard deviation.

Estimation for Difference Test
As can see the probabilistic value for the difference of the mean of both risk priority numbers is significant according to table 9.

Table 9. Data Analise

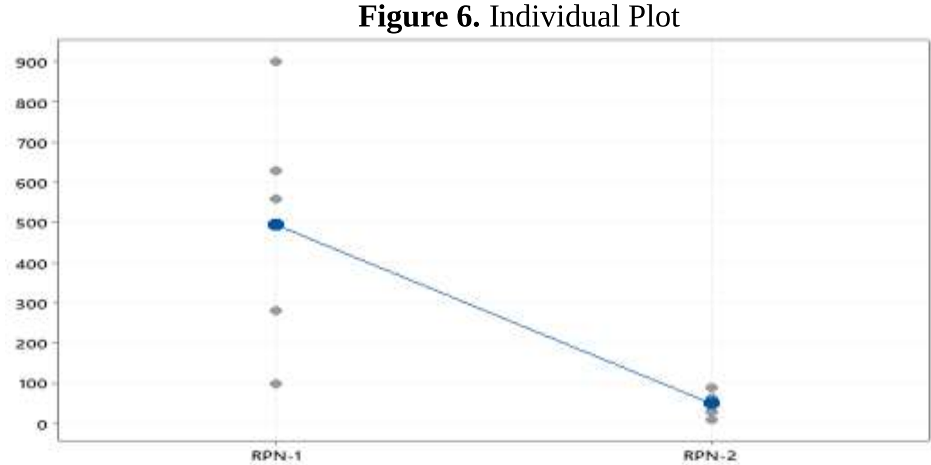
Null hypothesis	H_0: $\mu_1 - \mu_2 = 0$
Alternative hypothesis	H_1: $\mu_1 - \mu_2 > 0$

T-Value	DF	P-Value
3.17	4	0.017

Source: The Authors.
Note: In Table 9 a P-value shows to demonstrate the hypothesis test results.

According to Figure 4, the mean difference is significant which means that the improvements are efficient.

Figure 6. Individual Plot

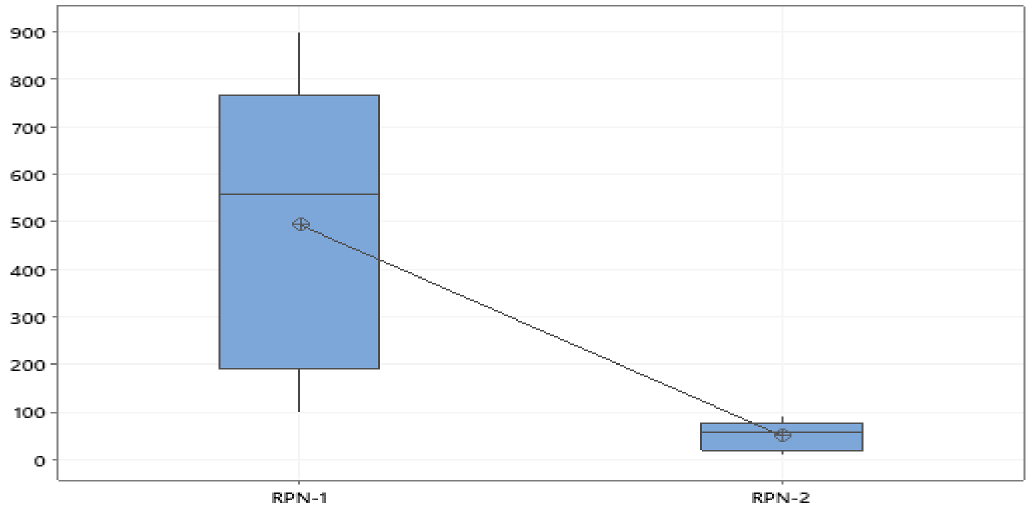


Source: The Authors.

Note: In figure 4 the mean differences are present in the two risk priority numbers.

The box plot presents in Figure 5 the difference between RPN are significant as can see follow.

Figure 7. Individual Plot



Source: The Authors.

Note: Figure 5 presents a box plot to demonstrate the difference in mean values between risk priority numbers one and two.

According to the analysis carried out at 95% confidence, there is not enough statistical evidence not to reject the null hypothesis, therefore, there is a significant difference between the initial and final mean in the risk priority number.

DISCUSSION

Lean manufacturing is a methodology that can be used in such a different company type. One input in this research is the use of lean logistics tools to improve efficiency and productivity in a medical government warehouse. Also, an application of the lean logistic methodology in a medicine distribution center is presented, which, as its name indicates, is not a traditional manufacturing company, this is highlighted because implementing the lean tools in a distribution center this method is not limited to a single type of applications which is normally thought. In this way, it can be confirmed that lean manufacturing, or in this case lean logistics has a wide range of applications in all types of business branches of both goods and services (Wronka, 2017). On the other hand, it is necessary to highlight that lean logistics uses quality tools intending to reduce the 7+1 types of waste. In addition, these tools have various applications in the stages of lean projects, six sigma projects, and lean six sigma (Duman et al., 2015). Quality tools have been developed to be implemented in different types of processes quickly and effectively. it is common that although by nature a type of tool can be used in some part of the improvement project, this same tool is almost always cataloged according to its objective, i.e., the FMEA diagram can help the analysis of critical variables and in the same way, it can be applied to verify that the implemented improvements worked (Ullah et al., 2022).

In addition, in this research can be observed how the methodology is not applied only in different types of companies as mentioned, but also how the quality tools that are used can be flexible and used in different ways according to the objectives that are set, have raised, as shown with the use of the FMEA that was transformed for the identification of variables, determine their priority risk number in the analysis stage and turn in the stage of the implementation of improvements and verification of the implementation, it is used to determine if the priority risk number has decreased according to the variables that were used. Subsequently, statistical analysis to determine significant mean differences could be applied thanks to this modification of the FMEA.

Finally, it can be seen in this manuscript the use of a hypothesis test for the difference in means, to determine if the improvements implemented are efficient, it also shows how statistical analysis can be implemented in the verification of improvements in a simple way.

CONCLUSIONS

The management of a warehouse is of the utmost importance since it deals with both raw materials and finished products or products in process, as is the case with maquiladoras. Due to the importance of storing well, having accurate records of material inputs and outputs that help to have adequate control of inventory levels that allow optimal use of warehouse capacity, is essential for any company, such as was shown in the case of regional warehouse V, in which medicine is stored that will be later sent to the different health centers belonging to the region. On the other hand, it often happens that due importance is not given to storage and its use and correct identification, which has consequences such as the danger for the workers, the loss of products, and the power to generate waste due to the same factors mentioned. In this project, it was possible to observe the application of well-known quality methods such as the 5 whys, Ishikawa diagrams, and hypothesis tests, among others. To optimize the use of regional warehouse V and to comply with the increase in demand, as well as to safeguard the integrity of the workers and the medicines that are handled within this warehouse. Finally, it is recommended that those in charge of this warehouse continue with the improvements implemented and implement a continuous improvement program for it, all to increase efficiency and, above all, that the medicines reach the users in optimal conditions and with adequate expiration date for the treatment to be followed by them.

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Future Lines of Research

Future relevant research lines would be the measure of the synergy between the use of lean quality tools, and Six sigma projects applied in Industry 4.0 to determine the effectiveness of both methodologies in the implementation of cyber physics companies. Then, the union of both concepts Lean, and Industry 4.0 would be interesting because the ability of real-time communication, big data transfer, and process in addition to the Lean tools promise significant optimization potential. It will be less important to determine which process is running in which company or plant. On the other hand, the efficiency and flexibility of companies will improve through information, communication, and intelligence. This research could be significant in the creation of intelligence nets that could be controlled in an autonomous way throughout the supply chain and plants of the world of the same company.

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