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Warehouse management model based on Lean Warehousing to improve perfect order fulfillment in a pharmaceutical warehouse

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Abstract—* This study focuses on the correct service management of pharmaceutical warehouse processes since an excellent level of service is required in the correct distribution of orders without interrupting the flow of deliveries to customers. This problem becomes more relevant because it involves medicines. For this reason, the level of perfect order fulfillment was analyzed, of which it presents a % of 85% compared to 95% of the required sector, which this gap is equivalent to S /. 411,451 in lost sales due to penalties and returns. As a contribution, Lean Warehousing tools such as 5s, standardization, Poka Yoke and TPM were implemented in the warehouse processes following a continuous improvement methodology. The solutions presented for each root cause were measured based on indicators of the perfect order, such as the percentage of complete deliveries, the percentage of quality deliveries, the percentage of on-time deliveries, and the percentage of adequate documentation. In conclusion, the application of the improvement proposal will increase the percentage of perfect orders above 95% of the standard of excellence, achieving a better flow of orders in a future VSM in less time and in a higher quality of service for the final customer.

***Keywords—* Lean Warehousing, Perfect Order, RFID, 5S, Standardization, TPM**

I. INTRODUCTION

Globally, due to the COVID-19 pandemic, the health sector has experienced different problems in supply chains, aspects such as interruptions have affected companies. Among these consequences, there was an increase in demand for medicines by 45% [1] and along the same lines, in the national context, the level of drug availability was categorized from approximately 55% from low to moderate [2]. This context has an impact on the fact that pharmaceutical product warehouses must improve the level of service in logistics processes [3] to meet the increase in demand and levels of availability following quality standards in compliance with orders.

The importance of the problem is given in the presentation of articles by authors specialized in the logistics sector and, specifically, a case study developed in a finished products warehouse [4] is detailed, where an improvement proposal for the processes is followed.

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Logistics of entrances and exits of the warehouse. In this case, the methodology used is of an analytical-descriptive type that focuses on improving processes by focusing on waste or activities without added value. This is done through layout design, standardized procedures and the constant updating of KPIs for the correct efficiency of warehouse logistics processes. Another case study [5] focuses on improving the level of service in the warehouse through the application of current VSM and the constant modification of the design of the workstation until reaching an ideal state or scenario that is validated by simulation of systems in a new improved future VSM [6]. This is what would help the warehouse manager make better decisions for on-time order deliveries by improving the order flow within the warehouse.

The motivation of this work is based on the need for the current situation of health sector to have pharmaceutical products at the required time and place. This is also since the pandemic has made logistics processes work at maximum efficiency. For this reason, there is the relevance of focusing on the supply chain process that occurs within the warehouses, this through the improvement proposal that with the implementation of Lean seeks to reduce unnecessary times, TPM preventive activities and reduce or eliminate non- value-added activities, all to increase compliance with perfect orders.

In this article, the following organization is presented: First, the introduction where a brief literature review of the background and success stories related to the sector and problem under study is explained. Second, it has the methods, where the application of the tools and their impact on the organization are detailed. Third, the results obtained are explained and finally the conclusions obtained in the present study are carried out, managing to respond to the main problem.

II. STATE OF THE ART

A. Lean Warehousing in the pharmaceutical sector and the impact on the perfect order fulfillment

The implementation of the Lean philosophy in a warehouse helps to eliminate waste that may exist in the processes of that area, also using VSM [6]. It is an economical alternative and occupies an important position in the logistics and warehouse area [7]. Through Lean tools, it is possible to redefine internal logistics spaces and flows [8].

The Lean approach in the health sector is not new, but there is a large field of research available [9]. As a result, in his study, he obtained that the level of reduction of warehouse waste of all kinds has a significant positive impact on the operational performance of the warehouse and the performance of distribution. In the case of [10], results were obtained that the daily transfer time was reduced by 8.27%. In addition, the standardized system achieved with Lean tools helps managers to have a deeper understanding with quantitative data of the state of the warehouse in its different processes.

B. *5S in warehouse logistics processes*

This methodology has been implemented in various areas including warehouses. The implementation consists of phases of classifying, ordering, standardizing and measuring [11] how they are carried out in product distribution centers. There is a relationship between 5S and the operational performance of the warehouse [12]. Among the advantages, an optimization of the space and the elements to be used in the warehouse is obtained, an increase in the productivity of the processes of such area and the standardization with checklists. Likewise, it is evident that the 5S tool has a lower implementation cost [12][13].

According to [13] the 5S in the health sector cause aspects to be considered. For example, an organized environment is obtained, efficient workplaces in terms of productivity, reduction of inventory and supply chain costs and recovery of valuable spaces and minimization of overhead costs. Also, according to [14], the 5S approach could be effective in improving the quality and productivity of pharmacy stores. These improvements were consolidated in three dimensions: operational efficiency, customer satisfaction and responsiveness.

C. *Standardization of work for logistics processes*

Work standardization refers to the establishment of processes where a work method is developed in a pre-established standard way. That is, according to [15], it identifies the sequence in which each activity is performed and the specific times of these to complete the work. This method can be applied in all areas of a company. In this case, if it is referred to for logistics processes, a facility for the execution of its processes is obtained. One of the advantages of being able to standardize the work method is that it is possible to have a better control specifically of the process under study [16][17]. For standardization, an adequate time study is needed as an initial basis to then establish the processes to be improved by eliminating non-value-added activities, to then rely on procedures, formats, standardization sheets so that operators can be coupled to the new improved process [18].

D. *TPM applied in the transport fleet*

This Total Productive Maintenance methodology indicates a strategy with a series of standard operations to be implemented to eliminate waste in the production processes caused by the state of machinery. In this case, for the transport fleet, the methodology focuses on being able to propose cleaning, lubrication, and adequate inspection standards [19][20]. These aspects are considered relevant to implement the pillars of autonomous and preventive maintenance to be applied in the investigation [21][22].

E. *Poka Yoke – RFID system*

It is a system that reduces the errors that exist in the storage process based on design and operation stages [23]. This system consists in being able to have a greater traceability of the products by the identification by means of tags of the quantities of products are in stock by means of scanner in set of the tags for consultation in real time [24][25]. In the case of [26] a system based on RFID was implemented in the warehouse and its installation covered all warehouse processes, achieving a higher percentage of inventory accuracy by 95%.

F. *Lean leadership in the organization*

The application of Lean tools is not only focused on reducing costs, it is important to create a culture of change [27], therefore the application of lean leadership ensures that all workers are committed to their daily work, with emphasis on having training so that they can introduce improvements in their processes [28]. The application of Lean requires a continuous and systemic change, with a high degree of leadership implemented as organizational culture in their workers, in this sense the promotion of some values and ideal attributes of leadership will be important to achieve Lean thinking. Companies that develop leadership obtain lean leaders capable of solving crucial problems, achieving a better flow in the processes and better productivity results [28][29].

III. INPUT

A. *Justification of the model*

Based on the literature review, the proposed model follows a warehouse management model through the application of the Lean Warehousing methodology, which has the contribution of covering the existing gap in the literature through the application of this methodology in warehouses. of the pharmaceutical sector to verify its effectiveness in this area, where it focuses on reducing waste and time of the logistics processes of both Inbound and Outbound [30] [31]. These authors follow a methodology of continuous improvement through a PDCA, which highlights the use and execution of Lean Warehousing tools to improve the efficiency of logistics processes. For this reason, under this continuous improvement approach, various Lean Warehousing tools have been linked, such as the application of 5s, standardization of work, Poka Yoke and TPM, to improve the level of service in the warehouse with the final delivery of orders. to the clients. [31] [32] [33].

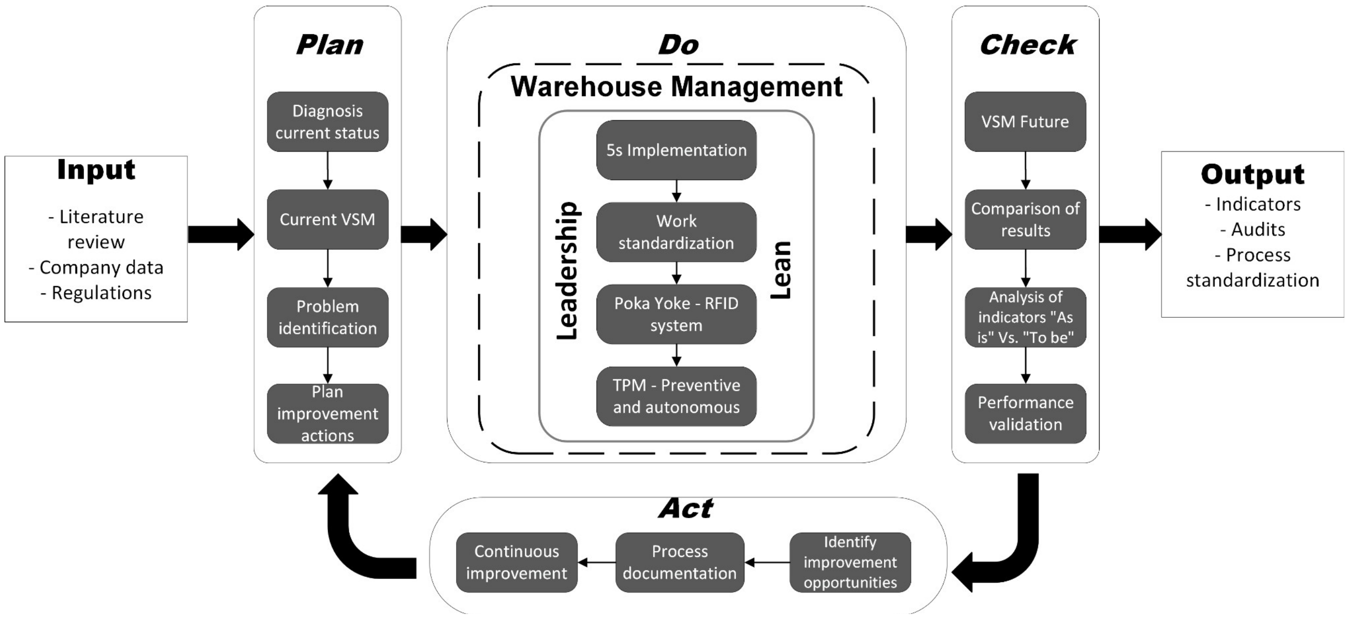

Fig. 1. Proposed model. Adapted from [31] [32] [33].

B. Proposed model

Based on the literature review of various authors focused on improving the flow of Inbound and Outbound warehouse processes, a warehouse management model is proposed following a PDCA cycle of continuous improvement with the application of Lean Warehousing tools such as Solution proposals [34][35]. The model is made up of 4 components that will be briefly explained: The first component of Planning (Plan), the current diagnosis is made and the proposals for improvement to be carried out are proposed; the second component of Hacer (Do), the solution tools proposed above are applied; the third component of Review (Check), compliance with the tools is verified based on the analysis of the results of the established indicators and finally the fourth component of Act (Act), where the standardization of the processes is established with evidence of improvement based on the previous stage. In general, the main objective is to improve the efficiency in the processes of the warehouse under study, reducing waste and unproductive time of the processes for the correct fulfillment of order deliveries to end customers [35][36].

C. Design of the proposed model

Once the proposed PCDA model has been developed, it is important to note that, for the model to work, "input" data is needed, such as a literature review, relevant company data and a review of both business and technical regulations. This input data is essential in the first instance for the model to feed into and follow the continuous improvement cycle in the other components. Having explained this, the development of the components of the proposed model is presented based on what has been developed by [37][38][39].

The first component is the Planning (Plan), where a diagnosis of the current situation is carried out, based on the treatment and analysis of the input data, managing to identify the main problems that occur and being able to carry out the analysis until finding the root causes that originate them.

The purpose is to be able to carry out an accurate diagnosis and propose improvement actions based on it [40][41]. The artifacts for initial diagnosis for this component are:

- VSM to identify the complete flow of processes and the times incurred.
- Cumulative weighting tables
- Pareto chart
- Improvement action plan

The second component is Doing (Do), where the proposed solutions are executed through the implementation of engineering tools based on the Lean Warehousing methodology [40][41]:

In the first place, the implementation of the 5s in the warehouse is detailed, which will allow ordering, organizing, and cleaning the work areas. This implementation consists of the following steps:

- Seiri (Classify): Materials are classified according to their level of utility in the warehouse and those that are not useful are discarded [42][43].
- Seiton (Sort): Once you have the classification of the pieces based on the policies to the degree of being essential or you do not proceed to order the place of location or storage [42][43].
- Seiso (Clean): Proceed to clean the work areas, especially

the equipment, components, racks, pallets, and aisles [42][43].
- Seiketsu (Standardize): Preparation of procedures and formats in each of the above processes to standardize the processes following the established standards [42][43].
- Shitzuke (Measure): Measure the compliance and performance of the tool based on audits and 5s compliance verification formats [42][43].

Secondly, the implementation of the work standardization is detailed, which focuses on the Packing and storage processes in order to improve the work method of the operators, applying the time study and validating work standards. This will allow us to have a process with fewer errors in handling orders based on quality (damaged products) and delivery time (cycle times). Likewise, the performance of the operators' activities is improved, making the work more effective, following the standards of the new work method [44][45]. The artifacts used for this implementation are:

- Matrix of taking times
- ECRS Matrix
- Process standardization format

Thirdly, the implementation of the Poka Yoke tool is detailed, which focuses on the RFID System to improve the traceability of the products from their arrival to their departure from the warehouse, generating a report of the quantity and exact location of each product at consult at any time, for this reason it is expected that precision errors can be reduced during picking, managing to deliver correct and complete orders [46][47][48]. This system requires the following artifacts:

- RFID reader
- RFID printer
- Passive type RFID tags
- Middleware RFID reader data connection system in the corporate system

Fourthly, the application of the TPM Tool is detailed, which focuses on the transport fleet of order loads sent to the different sectors. What is sought is to use the most relevant maintenance management pillars for the case under study, such as: Preventive maintenance, to establish standards and culture of preventive maintenance of units in repair shops [49].

This pillar requires the use of the following artifacts:

- Spare parts usage form
- Format of prevention action according to mileage
- Format of reported faults

Autonomous maintenance, where it focuses on the execution of maintenance activities with an autonomous focus of carriers following greasing and lubrication standards for transport units, this based on continuous training [50]. This pillar consists of the following stages to follow:

- Initial cleaning: Dismantling of internal parts for their first inspection and cleaning to find anomalies.
- Eliminate sources of contamination: Eliminate polluting sources from the establishment.
- Established standards: Implementation of cleaning, inspection, and lubrication standards.
- Inspection procedure: Preparation of the inspection training plan, based on the Hydraulic, Mechanical, electrical and refrigeration system.
- Improvement of inspection procedures: Preparation of the autonomous maintenance checklist.
- Administration and control of the workplace: Establish roles and functions, order, and organization of the workplace.
- Improvement activities: Carrying out audits for improvement. Supported using the autonomous maintenance audit sheet.

Finally, lean leadership is applied to create awareness and culture in workers when performing their daily tasks. In this case, it is based on the application of 5 leadership principles:

- Culture of improvement: employees know how to recognize the errors occurred in the work stages, but they do not know how to solve them clearly. For this reason, the leader in charge must manage his team and promote improvements using artifacts such as check sheets and reports of failures in order to take corrective actions [51][52].
- Self-development: All lean leaders are encouraged and trained to develop new competencies and skills until they become role models [51][52].
- Qualification: Leaders encourage and support the individual and collective development of their employees in their jobs [51][52].
- Gemba: A state of learning and action is sought, where good communication between leaders and workers is encouraged to better find errors or failures in the processes [51][52].
- Hoshin Kanri: Leaders are encouraged to remain focused on the continuous improvement of processes and the strategic alignment of activities [51][52].

The third component is to Verify (Check), where the results obtained in the previous component are analyzed, this with the measurement of the indicators for each established tool. For this reason, the purpose is to be able to establish the degree of improvement, whether positive or negative, to move on to the next stage. It has the following artifacts of the current component:

- Construction of future VSM based on the results obtained.
- Indicator measurement tables "As is" vs "To be"

The fourth component is to Act (Act), where two scenarios are presented according to the results: The first scenario corresponds to compliance with the expected metrics, therefore, we proceed to standardize the improved processes based on files, procedures, and manuals. The second scenario corresponds to non-compliance with the expected metrics; therefore, a corrective action plan is implemented to determine the process that still needs to be improved, and in turn, an implementation sub-schedule is developed with the metrics still to be improved [53][54].

- Improved process standardization sheets
- Action plans for tools with negative results

D. Model details

Below, Figure 2 details the flowchart in detail of the components of the proposed model.

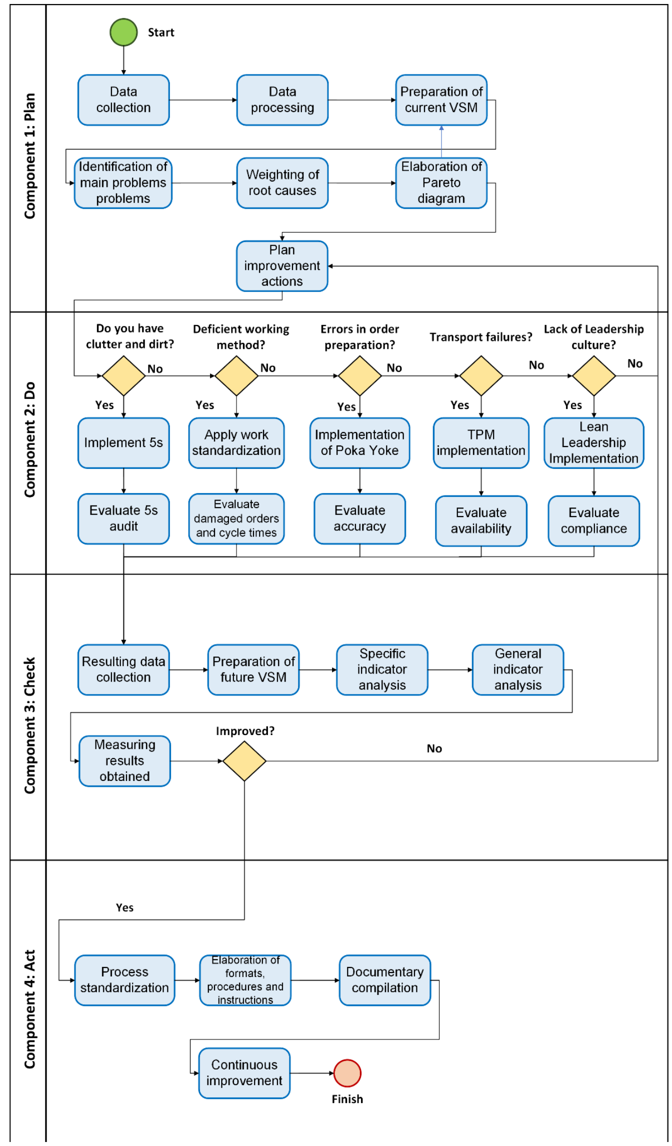

Fig. 2. Detailed flowchart of the application of the proposed model. Adapted from [53][54].

E. Model indicators

Below are the indicators aligned with the implementation of the improvement tools to measure the performance of the proposed model.

a. 5s audit compliance percentage:

Various studies applied to the Lean Warehousing methodology show that this indicator must be equal to or greater than 85% [55] [56].

$$\%\ 5s\ audit. = \frac{Total\ score\ obtained}{Total\ score} \times 100$$

b. Packing cycle time:

Various studies applied to the Lean Warehousing methodology show that this indicator should decrease by 10% [57][58].

$$Cycle\ Time = Current\ cycle\ time - Expected\ cycle\ time$$

c. Mean time to repair (MTTR):

Various studies applied to the Lean Warehousing methodology show that this indicator should decrease by 25% [59][60][61].

$$MTTR = \frac{Total\ operating\ time}{Numbers\ of\ failures}$$

d. Mean time between failures (MTBF):

Various studies applied to the Lean Warehousing methodology show that this indicator should increase by 24% [59][60][61].

$$MTBF = \frac{Total\ operating\ time}{Numbers\ of\ failures}$$

e. Availability:

Various studies applied to the Lean Warehousing methodology show that this indicator should increase by 9% [59][60][61].

$$Availability = \frac{MTBF}{MTBF + MTTR} \times 100$$

f. Lean leadership compliance:

Various studies applied to the Lean Warehousing methodology show that this indicator must be equal to or greater than 85% [62][63].

$$\%\ Leadership\ compliance = \frac{Total\ score\ obtained}{Total\ score} \times 100$$

g. Percentage of Undamaged Materials:

According to the Storage Research and Education Council (WERC), they indicate that this indicator must be greater than or equal to 95% [64].

$$\%\ Undamaged\ Mat. = \frac{Undamaged\ Mat.}{Total\ attended} \times 100$$

h. Picking accuracy percentage:

According to the Storage Research and Education Council (WERC), they indicate that this indicator must be greater than or equal to 99% [64].

$$\%\ Picking\ accuracy = \frac{Total\ wrong\ orders}{Total\ orders\ delivered} \times 100$$

IV. VALIDATION

A. Description of the validation scenario

In order to demonstrate the veracity of the results obtained for decision making, a hybrid validation has been carried out. On the one hand, tools related to process times such as TPM and work standardization have been chosen to perform a simulation of discrete systems, with the help of Arena software. On the other hand, tools related to the measurement of organizational culture and the implementation of prototypes such as 5s, Lean Leadership and Poka Yoke RFID, have been chosen to carry out pilot plans.

B. Initial diagnostic

Once the initial diagnosis of the warehouse of the company under study has been carried out, it is determined that the culture of continuous improvement, lack of standardization of processes, inadequate maintenance management and deficient traceability flow of orders, which corresponds to the application of Lean Warehousing tools previously described.

These problems generate low compliance with perfect orders, since there is a deficit of 15% of technical gap with respect to the sector, which incurs economic impacts of S/ 411,450 on the company's billing annually. This problem is measured in a general way with the indicators of % of deliveries on time and % of quality deliveries in research, since they are the ones that.

Are below what is required by the sector, which means that, by improving these indicators will be reflected in the general indicators of the project corresponding to the % of fulfillment of perfect orders.

C. Validation design and results

Once the simulation of the current system has been carried out, the solution tools are implemented, of which a new improved simulation scenario is presented. In the first place, the application of the standardization of the work method in the packing process, managed to reduce the execution time by 14% and the % of mat. not damaged was increased by 16.50%. The application of TPM in transportation reduced the execution time, based on the variables of repair times (MTTR) decreased by 43% and time between stops (MTBF) increased by 24%, increasing availability by 17% of the vehicle fleet.

In the pilot plans, the 5s was implemented, obtaining an audit rate of 90%, of which it meets the goal proposed by the company. In the same way, the application of the RFID System can improve the traceability of the products, increasing the % of picking accuracy to 99% as required. Similarly, through the application of lean leadership, 87% of compliance can be obtained in generating a culture of constant leadership.

TABLE I
RESULTS OBTAINED ACCORDING MODEL INDICATORS

Indicators	As Is	To Be	Result
% 5s audit.	73.5%	≥ 85%	90%
% Undamaged Mat	80%	≥ 95%	96.5%
% Picking accuracy	85%	≥ 99%	99.5%
Cycle time	147.23 min	< 135 min	132 min
MTTR	3.60 h/failure	< 2.30 h/failure	2.05 h/failure
MTBF	32.39 h/failure	40.22 h/failure	38 h/failure
% Availability	85%	≥ 90%	93%
% Leadership compliance	50%	≥ 85%	87%

These improvements validated by system simulation and implementation of pilot plans are reflected in the project's main indicator of percentage of perfect order fulfillment, which includes % Deliveries on time, % Quality deliveries, % Complete deliveries and % Correct documentation. An improvement of 9.2% in % Deliveries on time and 6.6% in % Quality deliveries were evidenced, demonstrating that the application of the Lean model Warehousing proposed allowed to meet the objective set out in the investigation.

TABLE II
RESULTS OBTAINED OF GENERAL INDICATORS

	% Deliveries on time	% Quality deliveries	% Complete deliveries	% Correct documentation
As Is	85.8%	88.4%	97.1%	97.8%
Results	95%	95%	97.1%	97.8%

Finally, it is necessary to highlight that this model faces the problem of the company that has an economic impact of 5.06% on the billing and according to the results of the system simulation and pilot plan, the costs would be reduced to 2.12%. Then, it is shown once again that the objective of the project is achieved with the application of the model.

V. CONCLUSIONS

In the present investigation, the problem belonging to a pharmaceutical company which consisted of the breach of perfect orders has been analyzed. The warehouse studied carried out its operations complying with 84.22% which is linked to economic consequences such as losses by the company. The figures for this problem rise to 5.06% of the annual turnover. Therefore, the pertinent literature related to the fulfillment of perfect orders has been reviewed to analyze and confirm the relevance of the problem studied. In this way, in the diagnosis of the company, it was identified that there were obviously reasons that cause the problem in the warehouse and that had an impact on the deliveries of the products to the clients. Among the reasons found, delays in the dispatch, low productivity of product preparation and storage failures were identified. Among the factors that influence the profitability of the analyzed company are the reshipments and penalties that would have to be carried out for not complying with on-time deliveries, quality deliveries, complete deliveries and deliveries with correct documentation so that it can be considered as a perfect order.

In view of this, the proposed model was developed considering the integration of Lean Warehousing tools such as TPM, Poka Yoke, 5S, Lean Leadership and work standardization so that each cause of the problem can be solved and thus increase the fulfillment of perfect orders. Thus, through the application of the model, with standardized work, it was possible to reduce the cycle times of storage processes by 29.40% and packaging by 30.24%. The application of the 5s helped to establish a culture of order, cleanliness and organization in the workplace, achieving 90% compliance in the audit, likewise, the implementation and promotion of lean leadership helped to form lean leaders with greater problem-solving capabilities, which achieved 87% compliance. This was followed by the implementation of a prototype RFID system to improve the traceability of products, both incoming and outgoing, achieving a picking accuracy of 99%. Finally, the implementation of TPM applied to the transport fleet to reduce the number of breakdowns that occurred, where it was possible to establish an availability of 90%. In this sense, through the integration of these Lean Warehousing tools previously detailed and applied, it was possible to improve and optimize the processes, reaching a 95.4% of perfect order fulfillment, demonstrating the effectiveness of the proposed model.

It is important to note that the model was validated with a pilot test and simulation with the Arena software to demonstrate the change of each secondary indicator according to before and after the improvement.

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REFERENCES

[1] Franco-Giraldo A, Álvarez-Dardet C. Salud pública global: un desafío a los límites de la salud internacional a propósito de la epidemia de influenza humana A. Rev. Panam Salud Publica. 2009;25(6):540–7.

[2] Ugarte Ubilluz, Oscar. Estrategias para mejorar el acceso a medicamentos en el Perú. Anales de la Facultad de Medicina, 80(1), 104-108. https://dx.doi.org/10.15381/anales.v80i1.15878

[3] Castro, C., Pereira, T., Sá, J. C., & Santos, G. Logistics reorganization and management of the ambulatory pharmacy of a local health unit in Portugal. Evaluation and Program Planning, 80(February). https://doi.org/10.1016/j.evalprogplan.2020.101801

[4] Parkhi, S. S., "Lean management practices in the healthcare sector: a literature review," Benchmarking: An Int. J. 26(4), 1275-1289 (2019).

[5] B. Mrugalska and M. K. Wyrwicka, "Towards Lean Production in Industry 4.0" Procedia Eng., vol. 182, pp. 466–473, 2017.

[6] Campelo, P., Neves-Moreira, F., Amorim, P., & Almada-Lobo, B. Consistent vehicle routing problem with service level agreements: A case study in the pharmaceutical distribution sector. European Journal of Operational Research, 273(1), 131-145. https://doi.org/10.1016/j.ejor.2018.07.030

[7] B. H. Moradlou and T. Perera, "Identification of the Barriers in Implementation of Lean Principles in Iranian SMEs: Case Study Approach" vol. 17, no. 1, 2017.

[8] Baby, B., Prasanth, N., & Selwyn Jebadurai, D. Implementation of Lean Principles To Improve the Operations of. International Journal of Technology, 1, 46–54.

[9] Abideen, A.Z. and Mohamad, F.B., "Supply chain lead time reduction in a pharmaceutical production warehouse – a case study", International Journal of Pharmaceutical and Healthcare Marketing, Vol. 14 No. 1, pp. 61-88. https://doi.org/10.1108/IJPHM-02- 2019-0005

[10] Oey, E. and Nofrimurti, M., "Lean implementation in traditional distributor warehouse - A case study in an FMCG company in Indonesia". International Journal of Process Management and Benchmarking, 2019. https://doi.org/10.1504/IJPMB.2018.088654.

[11] Juan Carlos Quiroz-Flores, Jakeline Campos-Sonco and Valeria Saavedra-Velasco, "Incremento del nivel de servicio en un clúster ferretero a través de la aplicación de metodologías mixtas," RISTI - Rev. Iber. Sist. e Tecnol. Inf., vol. 22, no. 47, pp. 5–22, 2022, doi: 10.17013/risti.47.5-22.

[12] Rizkya, Indah & Sari, Rachida & Syahputri, Khalida & Fadhilah, N. Implementation of 5S methodology in warehouse: A case study. IOP Conference Series: Materials Science and Engineering. 1122. 012063. 10.1088/1757-899X/1122/1/012063.

[13] Freitas, A. M., Silva, F. J. G., Ferreira, L. P., Sá, J. C., Pereira, M. T., & Pereira, J. Improving efficiency in a hybrid warehouse: A case study. Procedia Manufacturing, 38(2019), 1074–1084. https://doi.org/10.1016/j.promfg.2020.01.195

[14] Wani, S., & Shinde, D. Study and Implementation of '5S' Methodology in the Furniture Industry Warehouse for Productivity Improvement. International Journal of Engineering and Technical Research. 10. 184-191.

[15] Basumerda, C., Rahmi, U. & Sulistio, J., "Warehouse server productivity analysis with objective matrix (OMAX) method in passenger boarding bridge enterprise". IOP Conference Series: Materials Science and Engineering, 842(1). https://doi.org/10.1088/1757-899X/673/1/012106

[16] Batt., G., "Laboratory Simulation of Dynamic Compressive Forces Experienced by a Package during Transport". ASTM International, Vol. 47, Issue 1. https://doi.org/10.1520/JTE20170186

[17] Samir A. Alsobhi, Krishna K. Krishnan, Deepak Gupta and Abdulaziz T. Almaktoom. "Analysis of damage costs in supply chain systems". International Journal of Industrial and Systems Engineering, Vol. 28, No.1, https://doi.org/10.1504/IJISE.2018.088565

[18] Chalakorn Udomraksasakul, Watchara Songserm, Sukanya Cherdchoongam and Chalida Udomraksasakul, the Bringing of the Abc Analysis Technique for Using to Increase the Efficiency of Placing Products in the Warehouse Journal of Mechanical Engineering and Technology, 9(13), 2018, pp. 424–430.

[19] J. García-Arca, J. C. Prado-Prado, and A. J. Fernández-González. Integrating KPIs for improving efficiency in road transport," Int. J. Phys. Distrib. Logist. Manag., vol. 48, no. 9, pp. 931–951, doi: 10.1108/IJPDLM-05-2017-0199

[20] Alseiari, A.Y., Farrell, P., Osman, Y. Technical and Operational Barriers that Affect the Successful Total Productive Maintenance (TPM) Implementation: Case Studies of Abu Dhabi Power Industry. In: Ball, A., Gelman, L., Rao, B. (eds) Advances in Asset Management and Condition Monitoring. Smart Innovation, Systems and Technologies, vol 166. Springer, Cham. https://doi.org/10.1007/978-3-030- 57745-2_110

[21] G. Pinto, F.J.G. Silva, A. Baptista, Nuno O. Fernandes, R. Casais, C. Carvalho. TPM implementation and maintenance strategic plan – a case study,Procedia Manufacturing, Volume 51, 2020, ISSN 2351-9789, https://doi.org/10.1016/j.promfg.2020.10.198.

[22] Bataineh, O., Al-Hawari, T., Alshraideh, H. and Dalalah, D., "A sequential TPM-based scheme for improving production effectiveness presented with a case study", Journal of Quality in Maintenance Engineering, Vol. 25 No. 1, pp. 144-161. https://doi.org/10.1108/JQME-07- 2017-0045

[23] Oner, Mahir, Budak, Aysenur, and Ustundag, Alp. 'RFID-based Warehouse Management System in Wool Yarn Industry'. 1 Jan. 2017 : 165 – 189. 10.3233/RFT-171655

[24] Bottani, Eleonora et al. 'Monitoring On-shelf Availability, Out-of-stock and Product Freshness through RFID in the Fresh Food Supply Chain'. 1 Jan. 2017 : 33 – 55. 10.3233/RFT-171780

[25] Nasim, Shahzad & Khan, Moin & Ali, Faraz & Muhammad Maaz, Syed. Inventory Management through Lean Logistics and Warehousing Techniques. ISSN (2226-8235) Vol-5, Issue 10

[26] Jiewu Leng, Douxi Yan, Qiang Liu, Hao Zhang, Gege Zhao, Lijun Wei, Ding Zhang, Ailin Yu & Xin Chen. Digital twin-driven joint optimisation of packing and storage assignment in large-scale automated high-rise warehouse product-service system, International Journal of Computer Integrated Manufacturing, 34:7- 8, 783-800, DOI: 10.1080/0951192X.2019.1667032.

[27] K. Vitasek, C. Harrity, K. O´Donoghue and S. Symmesn. Supply Chain Visions. Warehousing & Fulfillment Process Benchmark & Best Practices Guide (WERC), ed. 2, 2007.

[28] Aij, K.H. and Teunissen, M., "Lean leadership attributes: a systematic review of the literature", Journal of Health Organization and Management, Vol. 31 No. 7/8, pp. 713-729. https://doi.org/10.1108/JHOM-12-2016-0245

[29] André Seidel, Tarcisio Abreu Saurin, Guilherme Luz Tortorella & Giuliano Almeida Marodin. How can general leadership theories help to expand the knowledge of lean leadership?, Production Planning & Control, 30:16, 1322-1336, DOI: 10.1080/09537287.2019.1612112

[30] Abushaikha, I., Salhieh, L., & Towers, N. Improving distribution and business performance through lean warehousing. International Journal of Retail and Distribution Management, 46(8), 780–800. https://doi.org/10.1108/IJRDM-03-2018-0059

[31] Buonamico, N., Muller, L., and Carmargo, M. "A new fuzzy logic-based metric to measure lean warehousing performance". Supply Chain Forum: An International Journal, 2018. https://doi.org/10.1080/16258312.2017.1293466

[32] H.Y. Lam, K.L. Choy, G.T.S. Ho, Stephen W.Y. Cheng, C.K.M. Lee, A knowledge-based logistics operations planning system for mitigating risk in warehouse order fulfillment, International Journal of Production Economics, Volume 170, Part C, 2015, ISSN 0925-5273, https://doi.org/10.1016/j.ijpe.2015.01.005.

[33] Zhang, J., Onal, S., Das, R., Helminsky, A. and Das, S. "Fulfillment time performance of online retailers – an empirical analysis", International Journal of Retail & Distribution Management, Vol. 47 No. 5, pp. 493-510. https://doi.org/10.1108/IJRDM-10-2017- 0237

[34] Bonilla-Ramirez, K. & Marcos-Palacios, P. & Quiroz- Flores, Juan Carlos & Ramos-Palomino, E. & Alvarez, José. Implementation of Lean Warehousing to Reduce the Level of Returns in a Distribution Company. 886- 890 10.1109/IEEM44572.2019.8978755.

[35] Sharma, R. K. ISM and fuzzy logic approach to model and analyze the variables in downstream supply chain for perfect order fulfillment. International Journal of Quality and Reliability Management, 38(8), 1722– 1746. https://doi.org/10.1108/IJQRM-09- 2020-0294

[36] Dias, J. A., Ferreira, L. P., Sá, J. C., Ribeiro, M. T., & Silva, F. J. G. Improving the order fulfillment process at a metalwork company. Procedia Manufacturing, 41,1031–1038. https://doi.org/10.1016/j.promfg.2019.10.030.

[37] Prasetyawan, Y., & Ibrahim, N. G., "Warehouse Improvement Evaluation using Lean Warehousing Approach and Linear Programming". IOP Conference Series: Materials Science and

Engineering, 847(1). https://doi.org/10.1088/1757-899X/847/1/012033
[38] Figueroa-Rivera, E., Bautista-Gonzales, A., & Quiroz- Flores, J. (2022). Increased productivity of storage and picking processes in a mass-consumption warehouse applying lean warehousing tools: A research in peru. Paper presented at the Proceedings of the LACCEI International Multi-Conference for Engineering, Education and Technology, , 2022-July doi:10.18687/LACCEI2022.1.1.120
[39] Moh Nur S. & Fardzanela, S. Perfect order fulfillment in construction supply chain performance. E3S Web Conf. 202 13001 (2020). DOI: 10.1051/e3sconf/202020213001
[40] Arana, K., Flores, K., Ramos, E., Pettit, T. & Flanigan, M. Service Level of Pharmaceutical Supply Chain Applying Optimal Policy: Case Study in Lima, Perú. Int. J Sup. Chain. Mgt. Vol. 9, No.3, IJSCM, ISSN: 2050-7399
[41] Cagliano, Anna Corinna & Grimaldi, Sabrina & Schenone, Maurizio. “Proposing a new framework for lean warehousing: first experimental validations”. Industrial Systems Engineering. pp.1-23.
[42] F. C. Filip & V., Marascu-Klein. The 5S lean method as a tool of industrial management performances. IOP Conference Series: Materials Science and Engineering. 10.1088/1757-899X/95/1/012127
[43] Salhieh, L., & Alswaer, W. A proposed maturity model to improve warehouse performance. International Journal of Productivity and Performance Management. https://doi.org/10.1108/IJPPM-01-2021-0043
[44] Rouillard, V., Lamb, M.J., Lepine, J., Long, M. & Ainalis, D., “The case for reviewing laboratory-based road transport simulations for packaging optimization”. An international Journal Packaging Technology and Science. Vol. 34, Issue 6. https://doi.org/10.1002/pts.2563.
[45] Morrissette, SM, Horvath, L, DeLack, K. Investigation into the load bridging effect for block class pallets as a function of package size and pallet stiffness. Packag Technol Sci. 2021; 34: 51–69. https://doi.org/10.1002/pts.2539
[46] Choong, C.S., Nasir, A.F.A., Abdul Majeed, A.P.P., Zakaria, M.A., Razman, M.A.M. Automatic Identification and Categorize Zone of RFID Reading in Warehouse Management System. In: Zakaria, M., Abdul Majeed, A., Hassan, M. (eds) Advances in Mechatronics, Manufacturing, and Mechanical Engineering. Lecture Notes in Mechanical Engineering. Springer, Singapore. https://doi.org/10.1007/978-981-15-7309-5_20
[47] Ngaboyimbere, F., Leo, J., Kisangiri, M., & Muteteshe, D. Development of RFIDbased Automatic Warehouse Management System: A CaseStudy of ROK industries Limited Kenya. International Journal of Advances in Scientific Research and Engineering (ijasre). http://doi.org/10.31695/IJASRE.2021.34076.
[48] Popova, I., Abdullina, E., Danilov, I., Marusin, A., Marusin, A., Ruchkina, I. & Shemyakin, A. Application of the RFID technology in logistics. Transportation Research Procedia. https://doi.org/10.1016/j.trpro.2021.09.072
[49] Nallusamy, S., Kumar, V., Yadav, V., Prasad, U. K., & Suman, S. K. Implementation of total productive maintenance to enhance the overall equipment effectiveness in medium scale industries. International Journal of Mechanical and Production Engineering Research and Development, 8(1), 1027-1038.
[50] Loures, P.C., Scavarda, L.F., de Carvalho, A.R.N. Framework for Implementation of Autonomous Maintenance with the HTO Approach. In: Tavares Thomé, A.M., Barbastefano, R.G., Scavarda, L.F., Gonçalves dos Reis, J.C., Amorim, M.P.C. (eds) Industrial Engineering and Operations Management. IJCIEOM 2021. Springer Proceedings in Mathematics & Statistics, vol 367. Springer, Cham. https://doi.org/10.1007/978-3-030-78570-3_15
[51] Parkhi, S. S. Lean management practices in healthcare sector: a literature review, Benchmarking: An Int. J. 26(4), 1275-1289
[52] Tortorella, G., van Dun, D.H. and de Almeida, A.G., "Leadership behaviors during lean healthcare implementation: a review and longitudinal study", Journal of Manufacturing Technology Management, Vol. 31 No. 1, pp. 193-215. https://doi.org/10.1108/JMTM-02-2019-0070
[53] Arana, K., Flores, K., Ramos, E., Pettit, T. & Flanigan, M. Service Level of Pharmaceutical Supply Chain Applying Optimal Policy: Case Study in Lima, Perú. Int. J Sup. Chain. Mgt. Vol. 9, No.3, IJSCM, ISSN: 2050-7399
[54] Cagliano, Anna Corinna & Grimaldi, Sabrina & Schenone, Maurizio. “Proposing a new framework for lean warehousing: first experimental validations”. Industrial Systems Engineering. pp. 11.
[55] Dixit, A., Routroy, S., & Dubey, S. K. An efficient drug warehouse operations: An application of 5S. AIP Conference Proceedings, 2200(December).pp 12. https://doi.org/10.1063/1.5141175
[56] Freitas, A. M., Silva, F. J. G., Ferreira, L. P., Sá, J. C., Pereira, M. T., & Pereira, J. Improving efficiency in a hybrid warehouse: A case study. Procedia Manufacturing, 38(2019), 1074–1084 pp. 11-5.. https://doi.org/10.1016/j.promfg.2020.01.195
[57] Rouillard, V., Lamb, M.J., Lepine, J., Long, M. & Ainalis, D., “The case for reviewing laboratory-based road transport simulations for packaging optimization”. An international Journal Packaging Technology and Science. Vol. 34, Issue 6. pp 10.https://doi.org/10.1002/pts.2563.
[58] Morrissette, SM, Horvath, L, DeLack, K. Investigation into the load bridging effect for block class pallets as a function of package size and pallet stiffness. Packag Technol Sci. 2021; 34: 51–69. pp12-13.. https://doi.org/10.1002/pts.2539.
[59] Alseiari, A.Y., Farrell, P., Osman, Y. Technical and Operational Barriers that Affect the Successful Total Productive Maintenance (TPM) Implementation: Case Studies of Abu Dhabi Power Industry. In: Ball, A., Gelman, L., Rao, B. (eds) Advances in Asset Management and Condition Monitoring. Smart Innovation, Systems and Technologies, vol 166. Springer, Cham. https://doi.org/10.1007/978-3-030- 57745-2_110
[60] G. Pinto, F.J.G. Silva, A. Baptista, Nuno O. Fernandes, R. Casais, C. Carvalho. TPM implementation and maintenance strategic plan – a case study,Procedia Manufacturing, Volume 51, 2020, ISSN 2351-9789, https://doi.org/10.1016/j.promfg.2020.10.198.
[61] Bataineh, O., Al-Hawari, T., Alshraideh, H. and Dalalah, D., "A sequential TPM-based scheme for improving production effectiveness presented with a case study", Journal of Quality in Maintenance Engineering, Vol. 25 No. 1, pp. 144-161. https://doi.org/10.1108/JQME-07- 2017-0045
[62] Aij, K.H. and Teunissen, M., "Lean leadership attributes: a systematic review of the literature", Journal of Health Organization and Management, Vol. 31 No. 7/8, pp. 713-729. https://doi.org/10.1108/JHOM-12-2016-0245
[63] André Seidel, Tarcisio Abreu Saurin, Guilherme Luz Tortorella & Giuliano Almeida Marodin. How can general leadership theories help to expand the knowledge of lean leadership?, Production Planning & Control, 30:16, 1322-1336, DOI: 10.1080/09537287.2019.1612112
[64] K. Vitasek, C. Harrity, K. O´Donoghue and S. Symmesn. Supply Chain Visions. Warehousing & Fulfillment Process Benchmark & Best Practices Guide (WERC), ed. 2, 2007.