Plan to improve the logistical management of drug distribution in the health sector using the lean manufacturing methodology in the department of Puno

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Abstract

Nowadays, ineffective logistics for the distribution of medicines causes inefficiency in the immediate delivery of these drugs to the population, producing a public health problem. In this sense, the present study, developed in the department of Puno, has the purpose of improving the distribution of medicines and supplies by applying the lean methodology, because Puno has the most deficient installed capacity in Perú.
In this work, the lean methodology has been applied in order to improve the distribution logistics management process. Puno has been selected as the study population, and as samples, the health establishments in the districts of Puno, Melgar and Carabaya have been considered.
To apply the improvement plan and carry out proper monitoring, the Lean engineering tools of VSM were used to represent the process, as well as the Just In Time system was used to apply the improvement plan and the KIPs were used to control the process.
For the distribution in Puno, a new structure of the process was proposed applying a Lean operation tool. The result evidences a reduction of 11.88 hours in the process. In addition, waiting times related to the shipment of medicines were reduced, generating a time saving of 2,5 hours.

Keywords
Process optimization, Distribution logistics management, Lean methodology, Supply chain and Agile methodologies.

1 Introduction
In recent times, logistics has been a means of studying that encompasses common fields of industrial engineering, such as distribution activity. This is a phase of the supply chain that is responsible for the distribution of products to consumers, joining the storage and delivery.
An adequate distribution logistics produces a correct supply of medicines adapted to the needs of each health center and guaranteeing that each region has a sufficient supply of hospital goods to cover their demand.

In view of the pandemic crisis in which Peru lives, distribution management in the health sector is having more relevance than before, due to this, problems of a service that should be of quality and efficient for all citizens have arisen. It is known that: "Delays in deliveries, shortages and other operational difficulties are part of the problems present in hospital logistics" [2]

In some very distant regions of Peru, it has been evidenced an ineffective distribution logistics in the health sector that makes it difficult for the population to access quality medicines. This issue has as a consequence the shortage of products in remote districts, extensive processes, and an inadequate balance of demand - supply. Our investigation will focus on the department of Puno, as it presents distant limits of decentralization from the capital, in addition, it belongs to the five departments most affected by the pandemic in Peru. As reported by ComexPeru: “Puno is, like Loreto and Cajamarca, the department with the most deficient installed capacity in the care of patients in the health sector. To this is added an inadequate distribution of doctors and medicines throughout the department. " [9].

For this study, the lean manufacturing method is used and applied to the distribution, ensures a much faster, cleaner, more efficient and safer delivery of the product. The lean methodology seeks to emphasize the reduction of various types of waste, such as: unnecessary waiting times, excess processes and inventory. This will be achieved by applying tools that optimize those processes that do not generate value or contribute positively to the final product.

The objective of this research is to evaluate the effectiveness of the logistics of medicine distribution through the application of lean methodologies in the department of Puno, analyzing the management of information and current procedures, so that there is a directed optimization in the use of resources. For this reason, the supply and distribution processes will be addressed, where the flow of information will be improved by applying an action plan to reduce times and structure the development of the process in the programming, reception and planning activities of the operation. In order to corroborate the impact of the actions taken to improve the process, key indicators will be used, such as total process time, shipping time and waiting time.

2 Methodology

In the organization of the data for the implementation of Lean, a methodology was modeled that consists mainly of an analysis of the current state of a comparative matrix of the implementation methodologies of other representative works on the subject. It is because of that the following actions related to the research topic were developed:

- Collect Lean information and improve distribution logistics.
- Collect information related to the logistics of the health sector in Peru.
- Compare the information obtained with the current distribution process.
- Identify in which stages of the process Lean tools can be applied to improve logistics through a value stream.

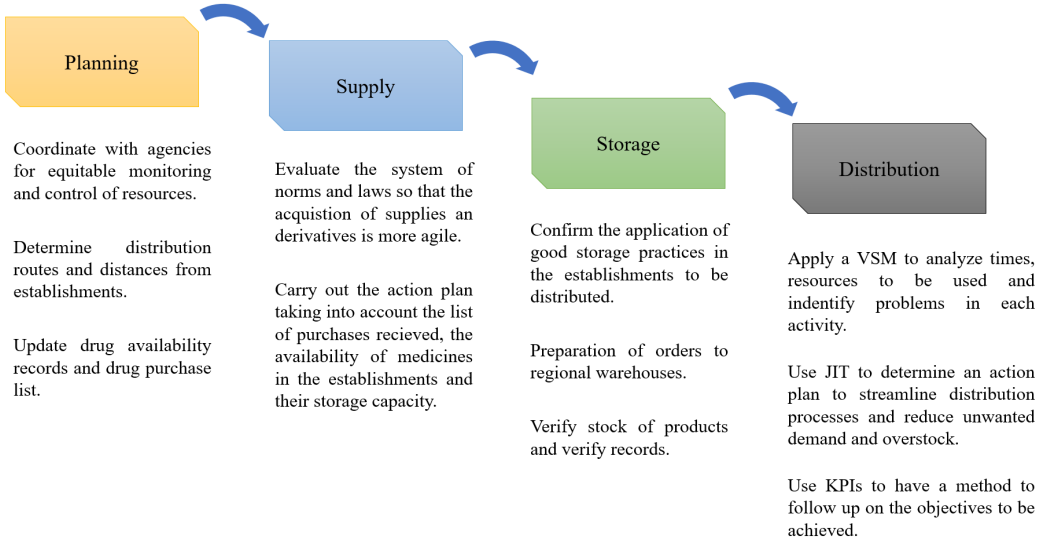

Figure 1: Value stream of logistics management. To explain the actions to take at each step of the supply chain.

2.1 Operationalization.

For the operationalization from the research work, the following variables were selected, each one with its respective dimension and indicators that are directly related to the object of the investigation.
First, it is included as a variable, distribution logistics management (see Table 1), since it is considered as a term related to the cause-effect type.

Table 1: Dimensions and indicators of distribution logistics management.

Variable	Dimensions	Indicators
Distribution logistics management	1. Distribution	1.1 Identified opportunities for improvement
	2. Lean methodology	2.1 Time-outs
		2.2 Information delays
	3. Supply	3.1 Efficiency in processes

Second, the logistics management of information will be investigated, this is the information that guides the management of the supply chain. The correct operation of the supply chain requires the nature of information and data, as well as management procedures.

Table 2: Dimensions and indicators of information logistics management.

Variable	Dimensions	Indicators
Information logistics management	1. Planning	1.1 Identified opportunities for improvement
		1.2 Dead times
	2. Agile methodologies	2.1 Information delays
		2.2 Efficiency in processes

2.2 Population and sample

For the population analysis, the department of Puno with its thirteen provinces was chosen., As a sample, three provinces were selected: Carabaya, Puno and Melgar. The reason for selecting the provinces mentioned above because they are from different poverty level strata and the aim is to compare the quality of the distribution in each province.
As a method for an appropriate differentiation of health facilities throughout the country, it is proposed to apply a categorization that represents both the infrastructure and the quality of medical staff in each location [11]. The level of categorization and a simple definition of each category are presented in Table 3.

Table 3: Categorization of MINSA.

Categorization	Definition
Category I-1	Health post with a non-medical health professional.
Category I-2	Health post with medical health professional.
Category I-3	Health center, medical center and polyclinic.
Category I-4	Health or medical center with internment beds.
Category II-2	General care hospital or clinic with a higher number of UPSS.

Note. Health establishments categorization guide (2020).

The Melgar, Puno and Carabaya provinces with a population of 250 744 persons for each province were studied. Melgar and Puno have a poverty rate between 30% and 50% while Carabaya has a poverty rate between 0% and 30%. The II-2 hospitals that function as the central distribution network for each district and each province has at least one such establishment (see Table 4).

Table 3: Categorization of Province.

Province	Categorization					Total
	I-1	I-2	I-3	I-4	II-2	

Melgar	18	7	3	1	1	30
Puno	27	12	11	1	1	52
Carabaya	10	13	4	4	1	32

2.3 Distribution process

This process begins with the purchase of the drugs, which are made with the specific document PNUME (Single National Request for Essential Drugs). This can be done in two ways: Managed by CENARES or carried out by the executing units in their own processes. Once the purchase is made, it goes to storage and distribution.

CENARES (National Center for the Supply of Strategic Resources in Health) carry out the programming, acquisition and distribution of medicines, further, CENARES has two central warehouses called CADI (Center of Warehouses and Distribution), located in the Callao region and the Lurín district (see Figure 2), from these places the medicines obtained through corporate purchases are distributed throughout the country. These drugs are received by the DIRESA of Puno, which has adequate warehouses. Then, the drugs are transferred to the provinces of Puno, Carabaya and Melgar for their corresponding distribution. In the first instance, these medicines would reach the main hospitals in each province, then the drugs are transferred to remote posts and medical centers.

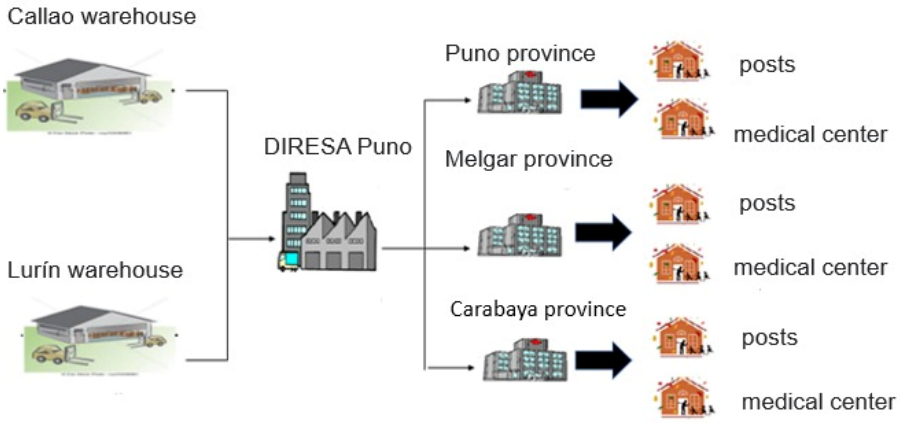

Figure 2: Distribution of pharmaceutical supplies. To explain the principal stops the process requires to reach the final client.

2.4 Lean tools

The process consists of 4 stages: planning, purchasing, storage and distribution (see Figure 1). The main problem lies in the drug distribution operation from the CENARES warehouses to the DIRESA of Puno and from there, it is transferred to the hospitals in each province (see Figure 2). This procedure generates an accumulation of inventories in the DIRESA, that is to say, the medicines remain in the warehouse and they are not distributed to their final point in the determined times. Likewise, ineffective information management is identified in the planning operation, since there is poor communication between customer demand and those in charge of generating purchases with suppliers.

For our research, the Lean Manufacturing method is used, as it is a methodology that focuses on process delays, which applied to distribution, ensures a faster, cleaner, more efficient and safer delivery of the product.

Lean tools are divided into three blocks: diagnostic, operational and monitoring. As for the diagnostic tool, the VSM (Value Stream Map) was selected, this tool is used to visualize the different activities and information flows. In the operational part, the Just In Time system was used, this tool is used to reduce the prolonged stay of the products in the DIRESA warehouse of Puno, which works as a connection between the CENARES warehouses and the categorization II-2 hospitals in each province. KPIs (Key Performance Indicator) were used for the monitoring tool. These key performance indicators are used to evaluate the success of actions and processes to the extent that they contribute to the achievement of objectives.

3 Results

3.1 Diagnosis

As a Lean diagnostic tool, the VSM was applied (see Figures 3 and 4) in order to represent the supply and distribution processes, to identify the largest number of tasks that generate downtime. Likewise, this tool helps us to identify, the information flow of the process (upper part of the Figures 3-4), the problems that are generated (middle part of the Figures 3-4), and the lead time of the process (lower part of the Figures 3-4).

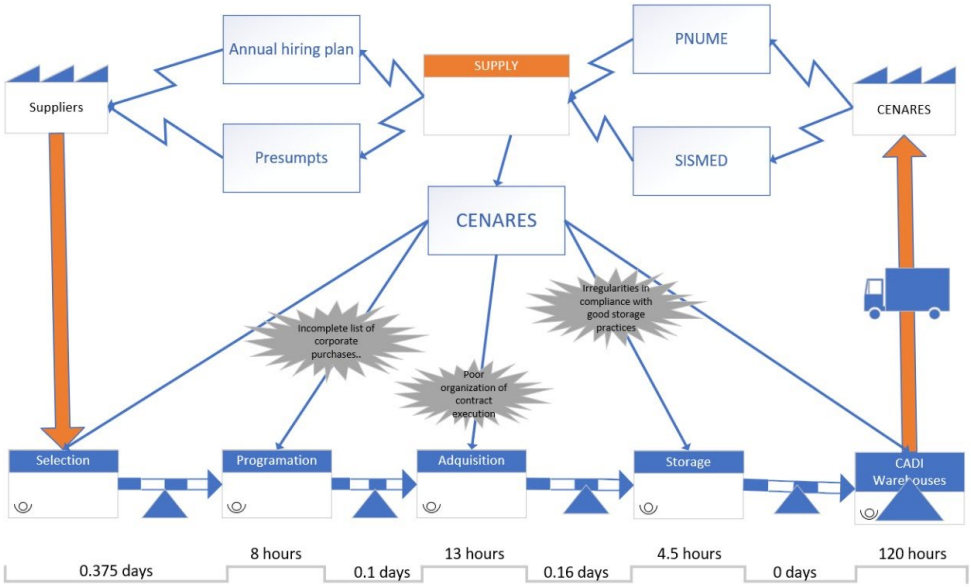

Figure 3: VSM of the supply process carried out by DIRESA of Puno. To explain the participants of the supply process, the information flow and the activities with their times.

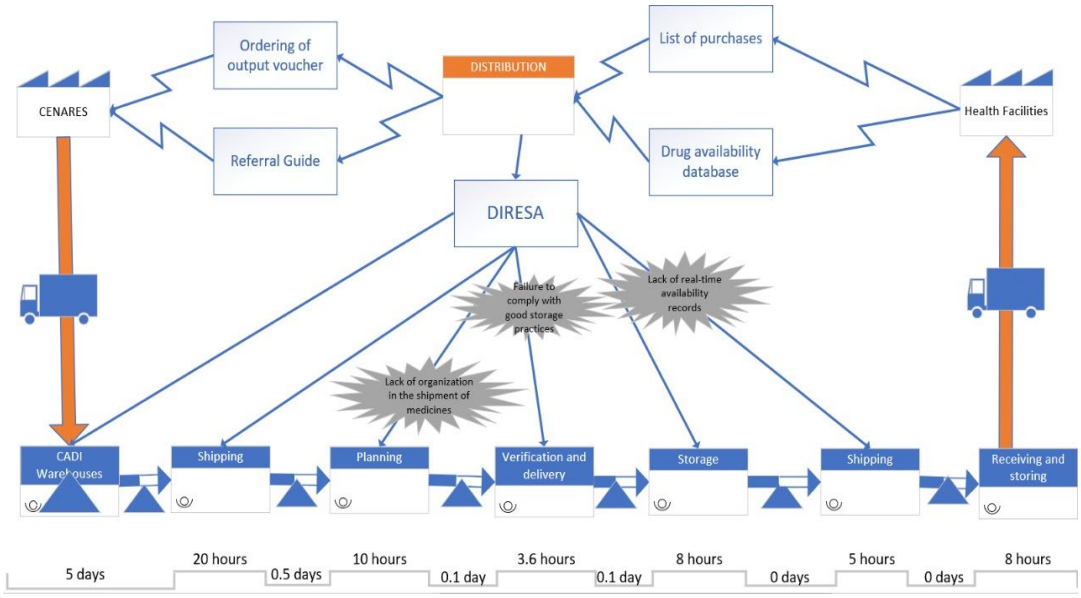

Figure 4: VSM of the distribution process carried out by DIRESA of Puno. To explain the participants of the distributions process, the information flow and the activities with their times.

3.2 Operational

As an operating tool, the Just In Time (JIT) system was applied. For this, the engineering tool, the process modeler called Bizagi Modeler, was used (see Figure 5). To reduce deadtimes, improvements were made in programming activities at CENARES, dispatch planning at DIRESA, and receiving orders at health establishments.

In planning, it is proposed to develop an action plan, applying a prediction model where it is sought to verify the availability and storage information through ERP software, also, it is planned to organize schedules of inputs and outputs of drugs as required by the health facilities. Some of this information is sent to the scheduling process to use it and advance with the preliminary tasks related to the purchase of lots of drugs.

When receiving shipments from the health facilities, they seek to verify the good condition of the products, a referral guide is signed and the records are confirmed. Likewise, the improvement of the updating of the medication availability records is applied and good storage practices are reviewed.

In the programming, the information sent by other activities is collected, this will help to improve the flow of information management of the process, the list of purchases will be updated and the acquisition of medicines will be carried out. This will help reduce acquisition time.

3.3 Follow-up.

Finally, as a monitoring tool, KPIs (Key Performance Indicator) were used. For this, the ARENA software was used with the task of carrying out time tests and controlling the process. As a result of the simulation, the data of total times and waiting times were obtained respectively, before and after applying the improvement in the process (see Table 5).

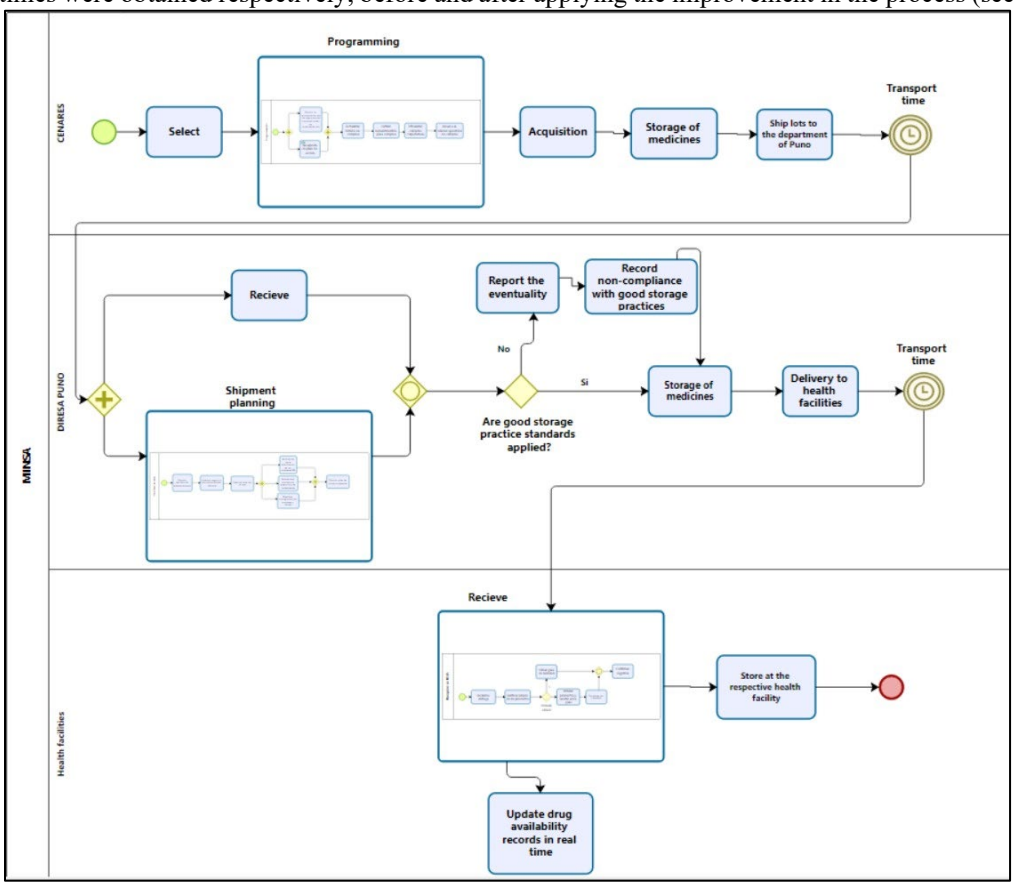

Figure 5: Representation of the flow of value using Bizagi Modeler for the implementation of the improvement plan of the supply and distribution processes. To represent the simulation of the process in Bizagi.

In arena software, the value stream is tracked based on planning, sourcing, warehousing and distribution (see Figure 6). The waiting time for the shipment of medicines is generated by the difference in times of the planning and receiving processes, which are carried out in parallel, these must end to move to the storage stage.

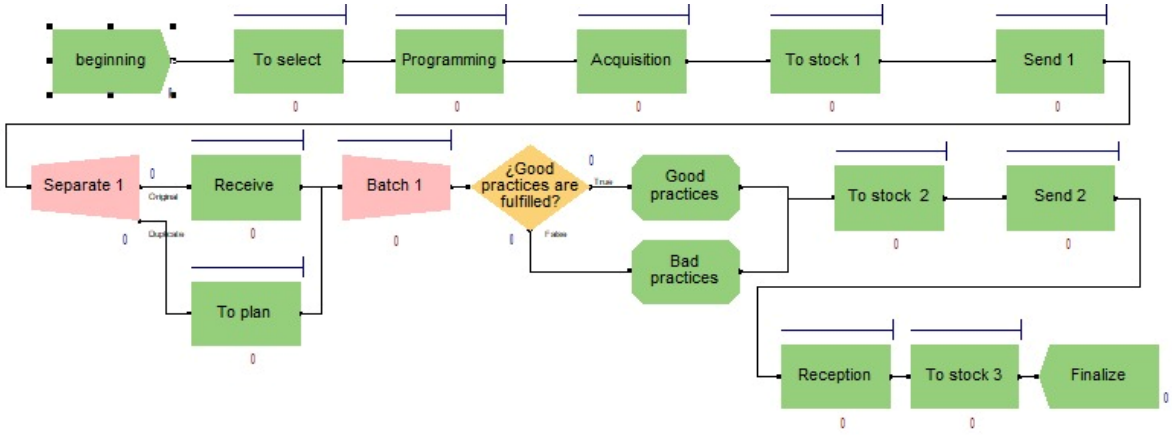

Figure 6: Simulation of the supply and distribution processes in ARENA. To represent the process in ARENA Simulator.

For the results obtained from the simulation in Arena, the confidence level used for the finished system was 95%, likewise, a mean width of 0.76 hours was obtained for the process and 0.85 hours for waiting for the shipment, which were used to find the maximum and minimum times.

Table 5: Process simulation times.

Activity	Minimum time	Real average time	Maximum time
Drug batch without process improvement	90.1329	90.8929	91.6529
Wait for shipment without improvement	4.4834	5.3334	6.1934
Drug batch with process improvement	78.2543	79.0143	79.7743
Wait for shipment with upgrade	1,9704	2.8304	3,6804

Furthermore, as a monitoring tool, Bizagi Modeler Simulation was used to reinforce, justify and verify the data obtained with the simulation in ARENA. The obtained times were collected from the applied improvement.
Also, the simulation of the process was carried out taking into account the time of 15 replications and using a triangular distribution considering ± 10% in the times of each process in order to compare the variations, since there are more replications, it allows us to obtain more real times because it takes into account any delay or advance of the activities to be carried out.

Table 6: Total times of the drug distribution process obtained with the Bizagi Modeler Simulation simulator considering the number of replicas

Name	Number of replicas	Minimum time (h)	Maximum time (h)	Average time (h)	Total time (h)
MINSA	15	72.6857	81.5994	77.6868	1165.302
To select	15	8.1749	9.5528	9.0145	135.2169
Storing medications	15	3.4314	6,6282	4.7906	71.8591
Store in the respective health facility	15	4.1593	5.4348	4.8194	72.2912
Send lots to the department of Puno	15	19.3773	21.5538	20.2359	303.5386
Shipped to US SS	15	4.3938	6.6439	5.3867	80,8001
Storing medications	15	7.2884	8,6656	8.0262	120.3926
Report the eventuality	7	0.5000	0.5000	0.5000	3,5000

Register breach of GAP	7	0.2500	0.2500	0.2500	1.7500
Receive	15	2,3641	4.6048	3.4220	51.3297
Acquisition	15	10.3125	11.8515	11.0494	165.7405
Reception	15	2,2664	3.6926	3.0810	46.2152
Plan shipments	15	4.2909	5.5710	4.9795	74.6929
Programming	15	5.5622	6.5261	5.9329	88.9941

Table 6 allows us to analyze the times of each process, this helps to reinforce the previous simulations, since we obtained a similar result for the simulated process in ARENA with the improvement applied. The obtained results evidence a real average time of 77.68 hours with real minimum time margins of 72.68 hours and a real maximum time of 81.59 hours. These real times only reaffirm the decreases in process times for the first results with the monitoring tool.

4 Conclusions

The use of Lean tools applied in an efficient way helps us to have a continuous improvement and optimize process flow times, likewise, this conceptualization is focused on increasing value in the analysis of the supply chain and application of quality tools and macro indicators.

For the distribution of medicines in the department of Puno, a new process structure was developed by applying a Lean operation tool, the result of which was a reduction of 11.8786 hours in the process, waiting times for drug shipments were reduced with a time saving of 2,503 hours.

The reduction of times helps to optimize the flow of information and streamlines the distribution process line, providing useful information to the processes that require it to reduce times in the most complex processes. In other words, this helps us solve drug availability problems in real time and move drugs in batches according to the demand in each province.

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Renzo Cabrera is a tenth cycle student of industrial engineering at the University of Lima, Peru. I am interested in the areas of logistics, project management, sales and marketing. With motivation focused mainly on project planning and process modeling and analysis. Active participant in conferences related to the improvement of the supply chain, sustainable development and planning.
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