Improvement of pharmaceutical wholesaler productivity with the implementation of the Kaizen Lean methodology

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Abstract

Warehouses are considered to be an essential part of the supply chain, as they make it possible to balance differences between supply and demand and therefore better satisfy the market. However, the requirements in terms of efficient management are constantly growing, meaning that ever higher productivity levels must be met, reducing stock levels and costs, and simultaneously improving the service provided to the customer. As a result, this article presents Company X, one of the current market leading companies in the pharmaceutical distribution sector, which seeks to increase the efficiency of its operations by improving the intrinsic processes of its warehouse in Lisbon.

This paper offers a number of Kaizen Lean tools which, when duly adopted, allowed a solution to be designed for the problem presented. Using examples given in the Literature Review, this paper describes the various stages of implementation over a six-month period. Using the methodology applied, it was possible for Company X to test solutions enabling it to improve the internal logistics of its existing warehouse, which will be applied from zero-hour at the new premises. The reduction in replenishments regarding the manual and automated picking lines achieved 23,53% and 33,33%, respectively. The number of stock-outs suffered a decrease close to 82%. A layout for the new warehouse was also suggested, allowing a comparison with the original proposal by the organisation itself, which allows a global result improvement of 13.95%.

Key words: Pharmaceutical Distribution, warehouse, internal logistics, Lean, Kaizen, Kanban, layout, KPIs.

1. Introduction

The warehouse is a key component of modern supply chains and is recognised today as one of the areas in which significant improvements and considerable cost reductions can be made (Won & Olafsson, 2005). The increase in productivity in warehousing operations has repercussions throughout all logistics activity, enabling not only improvements in customer satisfaction by reducing associated waiting times, as well as gain improvements in terms of costs and labour.

The final goal of the Kaizen Lean philosophy is to improve the performance of organisations in such a way as to enable them to grow sustainably, leading KICG to concentrate on three fundamental aspects for each and every customer: quality, costs and delivery, which together form the well-known initials QCD, and that was recently updated to QCDM, incorporating a fourth element – motivation (Kaizen Institute, 2015a).

The Kaizen methodology has five fundamental principles: Creating customer value; Mapping the value chain to survey opportunities for improvement; creating flow; Involvement of all people and continuous improvement (Kaizen Institute, 2013b).

Shingo (1989) refers to added value as being those for which a customer is willing to pay. As well as 'muda' (the Japanese word for 'waste'), Kaizen also points to two other concepts that should be eliminated by any organisation: 'mura' – the Japanese for 'variability' – and 'muri' – the Japanese for 'overload' (Imai, 2012).

Ohno (1988) identified the seven main sources of waste: 1) overproduction, 2) waiting time, 3) transporting, 4) overprocessing, 5) stock levels, 6) movement, and 7) defects. According to the same author, eliminating them explicitly increases operational efficiency, enabling operators to be freed in certain areas and their reallocation to more critical sectors of the organisation.

Despite all the constraints associated with the pharmaceutical distribution sector in recent years, Company X remains one of the leaders, with a market share of approximately 29%, 7.2% more than the second market player. With more three facilities across the country it aims to achieve excellence in customer service. Despite its privileged market position, Company X needs to make an effort to maintain this position, aiming at sustainable growth with a focus on increasing the productivity of its operations and adopting a policy of continuous improvement across all its premises. This will have a knock-on effect on levels of customer service and a potential increase in sales.

The goal of this Paper is to conduct a survey of the initial state, by collecting and analysing data, to subsequently implement a solution that integrates several continuous improvement tools. Section 2 contains a short bibliographical review, focusing on the Lean Kaizen methodology in the area of healthcare. Section 3 presents the case study describing: Kaizen Institute Consulting Group, Company X and the problem being analysed. Section 4 describes the Implementation model. Section 5 discusses the results achieved and finally in Section 6, the conclusions reached and the actions proposed to improve results.

2. Literature review

2.1 Lean Thinking

The concept appears at the beginning of the twentieth century and is associated with Henry Ford's Fordism, with the first global integration of a production process that worked sequentially along a production line (Womack et al., 1990).

According to Melton (2005) the Lean methodology has a vast number of advantages, with particular emphasis to reduced lead time to the customer, reduction in stock levels for the company, improved knowledge management, and gaining of more robust processes (with fewer mistakes and consequently less rework). The author also developed a structured approach with the various steps that form the application of Lean, considering its basic principles, as shown in Figure 1: 1) data collection, 2) data analysis 3) proposing alternatives, 4) implementing change, and 5) measuring the benefits. It should be emphasised that data collection and analysis must be continuous in order to implement new improvements.

Lean and Kaizen concepts are often confused, but Lean is defined as the goal to reach (no waste), Kaizen is defined as the method used to achieve it (Melton, 2005).

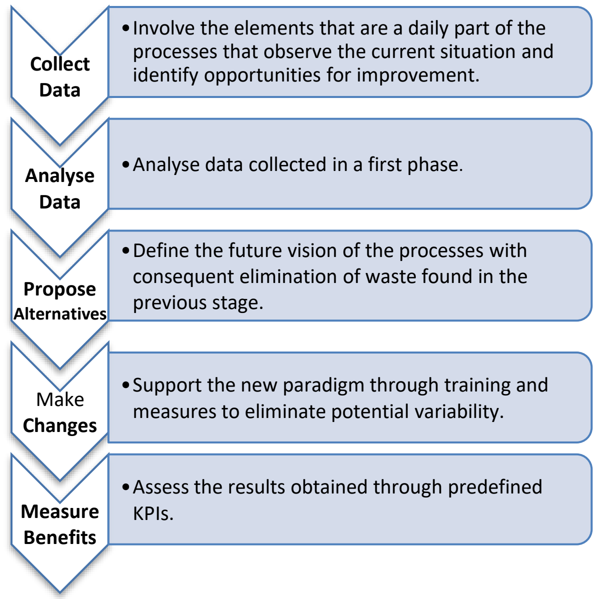

Figure 1 - Lean Thinking Structure (Melton, 2005)

2.2. Criticism of Lean

Since it appeared, Lean has been heavily criticised by the academic community, which believes it to lack the contingency and flexibility to deal with variability, the lack of consideration for human aspects and a general focus on the shop-floor methodology (Hines et al., 2004).

All methodologies have failings and Lean is no exception. However, the numerous criticisms found in literature do not consider the evolution of the methodology, largely motivated by the progress of organisations through their learning curve and by extending the Lean philosophy to other sectors with different characteristics and new challenges (Hines et al., 2004).

2.3 Lean Healthcare

Although the Lean concept was originally focused on improving production in the automotive sector, today, its principles are globally recognised and its application has become a reality in the most diverse sectors, including healthcare. This point-of-view is reinforced through the growing number of success cases in this area reported in the literature, demonstrating that Lean Healthcare is gaining ground not only because it is a 'new movement', but also because it brings sustainable results to organizations (Souza, 2009).

Sobek and Jimmerson (2003) described the implementation of Lean methodology in the pharmaceutical department of an American hospital that resulted in the evident involvement of staff in the changes, and a reduction of 40% in lost drugs. Also in the pharmaceutical sector, Esimai (2005) reports a reduction of 50% in mistakes made by pharmaceutical technicians, an increase in capacity, reduction in costs, and clear improvement in staff motivation.

2.4 Warehouse Management

The flow of materials through a warehouse can be divided into four functions (Rouwenhorst et al., 2000): 1) reception of goods, 2) storage, 3) stock picking, and 4) expediting. Note that these processes involve numerous issues defined within the scope of warehouse and operation. Available resources such as space, work and equipment require allocation to the different functions of the warehouse, and each of those functions should be carefully implemented, operated and coordinated, enabling compliance with the system requirements in terms of capacity, productive flow and service, at a minimum cost possible (Gu et al., 2007).

2.5 Lean Warehousing

Today, warehouses and distribution centres are focused on streamlining their processes. However, contrary to that expected, Lean Warehousing is still under-explored by the academic community, in contrast with all the work already undertaken in the application of Lean to production (Lean Manufacturing) or aimed at healthcare (Lean Healthcare) (Bozer, 2012).

This section aims to analyse the aforementioned seven primary sources of waste, from the perspective of a warehouse and its management (Bozer, 2012):

1. **Overproduction** – Considering that warehouses do not normally have production processes associated to them, this waste is not applicable.
2. **Waiting** – This occurs when the staff member is ready to continue working but the process does not allow him to, or when the product has to wait to proceed.
3. **Transport and handling** – Transport of products by the staff member is usually defined as a necessary process without any value to the customer, but that cannot be totally eliminated.
4. **Overprocessing** – This occurs when information is duplicated in order to carry out day-to-day work in the warehouse (multiple barcode scans, for example).
5. **Inventory** – For various reasons, warehouses rarely hold adequate stock levels, being that ideally there should be a well-defined balance that avoids scarcity and consequent unfulfilled orders, and excess.
6. **Motion** – Includes cases in which stock is warehoused in places with limited access by staff, obliging them to reach uncomfortably or need physical support to reach the items wanted.
7. **Defects** – One of the greatest challenges of a warehouse is to avoid picking the wrong item or quantity, which can lead to returns or exchanges, thus obliging a repetition of work, customer dissatisfaction and inevitable costs.

2.6 Kaizen Lean Tools

This section contains the tools applied in the case study presented:

1. **Involvement of teams in a culture of continuous improvement:** In order to enable the existence of a solid base to allow the development and sustainability of improvements in an organisation, it is vital that there is an overreaching effort to change the mindset and behaviour of all staff members (Kaizen Institute, 2015a).
2. **Value Stream Mapping (VSM):** This is the most suitable and fastest way of identifying the sources of waste in the value chain o fan organisation, providing an overall perspective of the chain and not only of specific processes or optimising specific parts (Rother & Shook, 1999).
3. **Visual Management:** Assumes that all tools, activities and performance indicators should be visible and perceptible, enabling all those involved to understand the current state of the system easily and quickly (Marchwinski et al., 2008 in Koch et al., 2012).
4. **Five S:** The 5 S is a method composed of five stages which aims to create a workspace using rules and discipline – sort, staighten, shine, standardisation and sustain (Womack & Jones, 2003).
5. **Standardisation:** A rule aims to make any deviations from the norm immediately identifiable, enabling fast corrective action. The rule should be simple and visual, specifying the safest, easiest and most effective way of undertaking a process or task. (Dennis, 2002).
6. **Kanban:** This is usually represented by a rectangular card that authorises or forbids production. It may contain other types of information such as product supplier, customer, warehousing location, and recommended conditions of transport (Dennis, 2002).
7. **Logistics Train:** According to Ichikawa (2009), the logistics train is able to supply the line with the necessary goods, in the required quantities, JIT, using the Kanban system, thus contributing to a general increase in productivity.

2.7 Conclusions of Chapter

The Review of the Literature presented enables us to conclude that the Kaizen Lean methodologies have been applied to various areas, including healthcare (Lean Healthcare) and warehousing (Lean Warehousing). From this theoretical base, the following sections show the implementation phases of the solution designed for Company X.

3. Case-study

A warehouse in central Portugal was chosen by the company's board of directors as a pilot warehouse to undertake this project. With an area of 4,800m^2, it has five main functions:

- **Goods reception and checking:** Pallets are received from the pre-wholesaler or logistics operator. They are then held until a clerk takes them to be conferred (urgent orders have priority). The goods are then transported to the pallet the now-checked goods belong to and, should the pallet become full, is taken to the storage area.
- **Goods storage:** the storage area operators go to the conferred pallets zone and, according to the wording on each box, transport the goods to dynamic racks that feed the automaton, or to dynamic or static racks that serve the manual picking line. Replenishment occurs when requests are received by any one of the picking lines and aim to ensure there are no stock failures.
- **Manual picking:** this area is composed of 31 blocks of dynamic racks, and 308 blocks of static racks, containing approximately 6,000 and 700 stock-keeping units (SKUs) respectively. Products with a slower turnaround are located here, as well as those whose characteristics do not allow them to me automatically replenished.
- **Automatic picking:** A section composed of 1,800 channels with different heights, incorporated in a total of 60 sectors, as shown in Figure 5. On average there are about 1,800 different SKUs on the automaton, which are usually reviewed once a month. Those goods with a greater turnaround are stored here, except those items that need to be stored under room temperature, items with a volume that inhibits them from being on the automaton, and veterinary products.
- **Dispatch:** Area with five bays and 27 ramps, where transport to the customer is ensured through outsourcing. Vans arrive at 06:00 to load the goods and deliver them along a pre-defined route, aiming to guarantee delivery times as defined with each of the final customers. 5,500 to 7,500 containers per day are dispatched in about 60 vans.

All these activities should be carried out with the main purpose of satisfying the final customer, that is pharmacies, with the assurance that a suitable level of service can only be guaranteed if an order contains the goods requested, is delivered within the required time-frame, at the required address and in the amounts needed. For reasons of internal logistics, there are also deliveries between warehouses of the group that, as with any other customer, need to be fulfilled objectively.

In 2016, the board of directors of Company X decided to include the central region warehouse in a project aiming to create a culture of continuous improvement in the organisation and an increase in overall productivity of its operation, through the concepts associated with the Kaizen Lean methodology and the application of some of its tools.

Considering the space limitations of the Lisbon warehouse, the board aims to move premises in the short to medium-term. Therefore, solutions were designed in pilot sectors to be subsequently rolled out to the new warehouse.

In short, the main aim of this paper is to increase the operational efficiency of the four warehouses belonging to Company X. The main objective is to obtain more organised areas and simplified flows, enabling the establishment of continuous improvement principles for the new premises and subsequently for all the warehouses in the group.

4. Application of Kaizen Lean in Company X

Based on the Melton methodology presented, data from the starting point were collected and analysed. Various phases of implementation were proposed with different solutions to tackle the waste found. The results were measured qualitatively (when measuring them was difficult), as well as through predefined KPIs. And finally, a follow-up was presented, which included the creation of the complementary solutions suggested in this paper for future work.

4.1 Analysis of the starting point

The starting point was analysing the initial state of operations in the warehouse using a Value Stream Mapping (VSM) model. Various gemba walks were undertaken that enabled the necessary data to be collected and identified opportunities for improvement in the process. In the scope of this paper, for each process defined as critical to the warehouse, a complementary analysis was done with a fluxogram to find major opportunities for improvement throughout the different operations.

The main opportunities identified for improvement were:

- Demotivation and lack of cooperation in teams,
- Poor design and comfort of workspaces,
- Lack of organisation and general identification,
- Intra-weekly imbalance in the number of orders received,
- Lack of method in replenishing lines,
- Excess of stock in the manual line,
- Inverse logistic of boxes,
- High number of empty channels,
- Layout proposed to organise the new warehouse containing conditions that limit its operational efficiency.

Therefore three different Implementation Phases were designed, each of which contains different Kaizen Lean tools in order to respond effectively to the scenario presented. Table 1 summarises the information.

Table 1 - Description of each implementation phase

Phase	Description and Tools
Phase 0	• Involvement of the teams in continuous improvement • Improvement of comfort by introducing lox-cost equipment • Organisation and identification of spaces using the 5 S and Visual Management • Weekly levelling of goods received
Phase 1	• Kanban system in the manual line. • Kanban system in the automated line. • Kanban system for the channels in the automated line.
Phase 2	• Alternatives to the proposal presented internally. • Assessment of the alternatives from operational and area indicators.

4.2 Definition of indicators

In order to control the results of the solutions integrated in the main phases of this project, the following key performance indicators (KPIs) were defined:

- **Level of minutes per conferred pallet:** This indicator monitors the results of the measures applied to reduce conferring time, included in Phase 0. The time (in minutes) per conferred pallet was analysed for four weeks (in which two weeks measure 'before' and two 'after').

$$Average\ of\ minutes\ per\ confered\ pallet = \frac{\sum_{i=1}^{n} Ti}{n} \quad (1)$$

The average level of minutes per conferred pallet in a day is obtained by the sum of the conferring time of all operators (T_i), divided by the number of pallets handled on that day. In total n pallets were conferred each day.

- **Daily level of received pallets:** This indicator monitors the number of pallets received in the warehouse on a daily basis, monitoring the output obtained with the implementation of goods reception levelling in Phase 0.

$$Daily\ level\ of\ received\ pallets = \sum_{i=1}^{n} Pi \quad (2)$$

The total level of goods received daily is obtained by the sum of the pallets received (P_i). The total contains n pallets received each day.

- **Daily level of replenishments on the manual picking line:** This indicator also monitors the application of Phase 1, with the implementation of the Kanbans on the manual line. The number of replenishments undertaken by the operators on the Storing team was analysed over a for week observation period (before and after).

$$Daily\ level\ of\ replenishments\ on\ the\ manual\ picking\ line = \sum_{i=1}^{n} RMi \quad (3)$$

The total daily level of replenishments is obtained by its sum (RM_i), being that n represents the total number of replenishments over that period. Applied to one sector.

- **Daily level of stock on manual picking line:** This indicator aims to monitor stock levels on the manual line on a daily basis, in order to assess the success of implementing the Kanbans, inherent to Phase 1.

$$Daily\ level\ of\ stock\ on\ manual\ picking\ line = \sum_{i=1}^{n} Si \quad (4)$$

The stock level on the manual line in one day is obtained by the sum of stock values of each article on the line (S_i). In total there are n items in stock.

- **Daily level of replenishments on the automated picking line:** This indicator assesses the performance of the Kanban System designed for the automated line, applied in Phase 1. The number of replenishments on this line was monitored over a two-week observation period.

$$Daily\ level\ of\ replenishments\ on\ the\ automated\ picking\ line = \sum_{i=1}^{n} RAi \quad (5)$$

The total number of replenishments on the automated line is obtained using its sum (RA_i). There were n replenishments in total on each day. Applied to one sector.

- **Weekly level of channel stock-outs on the automated picking line:** This indicator allows the performance assessment of the application of the last measure in Phase 1, with the application of Kanbans on the automatic channels.

$$Weekly\ level\ of\ channel\ stock - outs\ on\ the\ automated\ picking\ line\ =\ \sum_{i=1}^{n} RMi \quad (6)$$

The total number of channels per week that experience a stock-out is obtained by its sum (CV_i). In total, there are n empty channels in each weak analysed. Applied to only one sector.

For Phase 2, the operational and area KPIs are integrated in the simulation, considering that they have been developed specifically for the assessment of layout alternatives.

5. Implementation Phase

The three implementation phases of this paper are now described in greater detail.

5.1 Phase 0 – Basic Stability

Aiming to ensure basic stability of teams and processes, various measures were applied. The creation of a culture of continuous improvement transversal to the organisation is understood to be a priority, through the introduction of standardised meeting, analysis of indicators and discussion of solutions to problems identified. To enable better ergonomic conditions for the operation, with particular reference to conferring the product, there was a proposal to restructure the working space combined with the introduction of new, low-cost equipment. To reduce probability of errors and high searching times, spaces should be organised in the warehouse. The 5 S and Visual Management are the tools to meet this requirement. In order to eliminate the clear misalignment in receiving orders each week (Figure 2), working meetings were held with the Buying team to implement changes to the time windows that exist through delivery levelling. The continuous line represents the initial state and the dashed line illustrates a future target after six months of implementation.

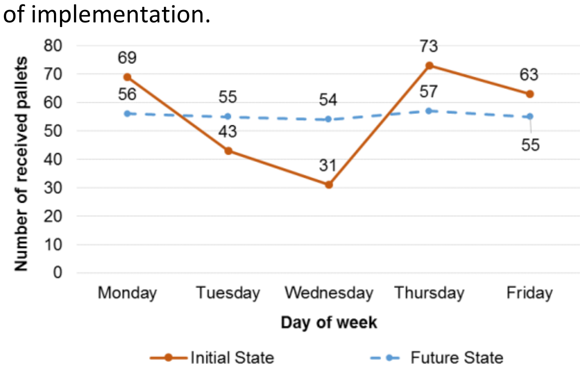

Figure 2 - Number of received pallets per day of week

5.2 Phase 1 – Replenishment Pull

In order to simplify operational flows and guarantee a standardised method of replenishing both supply lines and channels of the automated line, three distinct solutions were designed, based on Kanban theory. To all of them was calculated the Replenhisment Level (RL) by:

$$RL = Average\ Consumption \times LT + \ Safety\ Stock \quad (7)$$

Thus, it was necessary to calculate the Safety Stock (SS) for each product (Kaizen Institute, 2015b):

$$SS = (maximum\ consumptio - average\ consumption) \times LT \quad (8)$$

A Kanban in the form of a card was proposed for the manual line. The card is placed in a specifically determined position, being that when the picker meets the order point, he should remove and scan the Kanban in order to trigger the product request. The Kanban applied to the dynamic racks of both supply lines needed two characteristics: the ability to consider the correct level of replenishment and visibility. An iron prototype was designed, based on a counterweight system, fixed by a slot in the rows of dynamic racks, thus making the system more automated and efficient. Finally, low-cost, electronic Kanbans with LEDs were introduced as a result of the need to make the process of stocking the channels more efficient and, therefore, it was essential to implement a system that prioritised the channels, taking into consideration the recent search history.

Phase 2 – Layout alternatives to the new warehouse

5.2.1 Assumptions and initial layout

In the final stage of this paper, various possible layouts for the new warehouse are suggested, using AutoCAD simulations. A number of assumptions are made for this analysis, considering the aims of Company X. Company X wants goods to be distributed and rotated in the new warehouse according to the Pareto principle. Therefore, it is possible to establish groups of products by level of activity and consequently improve the internal logistics of the premises. Thus, the predetermined allocation of goods by type A, B, and C in the warehousing structures is contemplated, i.e. type A – automated line, type B – automated and manual line with replenishment by dynamic racks, and type C – manual line. The initial layout, designed by the organisation itself, is in Figure 3.

Figure 3 - Initial layout proposed by Company X

5.2.2 Alternatives to the initial layout

- **Vertical layout proposal**

Figure 4 illustrates the first alternative.

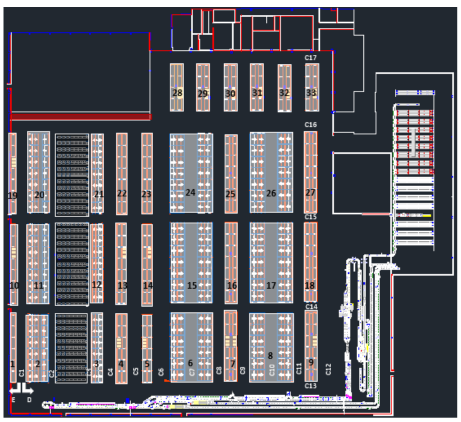

Figure 4 - Vertical layout proposal

It is named a vertical layout given that it shows all corridors in that position. Has, as its main advantage, the alignment of the vertical lines of the warehouse as common corridors, enabling an optimisation of the internal logistics through its simplified distribution. The major disadvantage is the considerable distance from the warehousing zone of Type A products in relation to the Dispatching zone.

- **Horizontal layout**

Figure 5 presents an alternative with a horizontal layout.

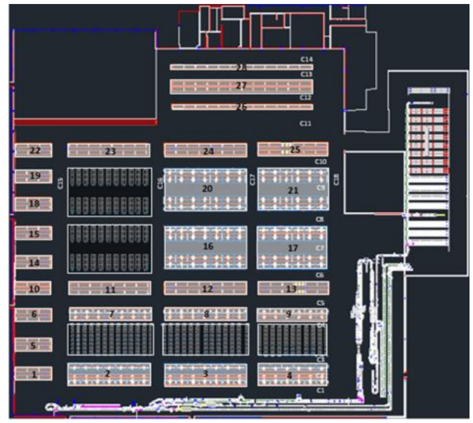

Figure 5 - Horizontal layout proposal

The main advantage is the proximity of the supply zone and corresponding warehousing of type A products to the Dispatch and pre-storage zones. Italso allows the alignment of horizontal lines as common corridors. The disadvantage is in the reduction of warehousing positions due to the introduction of shorter racks.

- **Mixed layout**

Finally, the combined alternative in Figure 6 is presented.

Figure 6 - Mixed layout proposal

This alternative has as its main aim the high level of usage of space for warehousing. A possible inconvenience is the non-contiguous central zone for the automaton, reducing the efficiency of the system (slower and greater space used

5.2.3 Definition of Indicators to assess the alternatives

In Table 2 were presented the operational and area KPIs.

Table 2 – KPIs to evaluate the layout proposals (adopted by Bello, 2011)

	Name, description and nomenclature	Formula and unit
Operational KPIs	**PPal: Number of pallet positions in each block (the higher the better)** **Number of pallet positions available in block j.** No.racksj is the number of racks in block j that was a determined number of warehousing positions. Nív.racki corresponds to the number of levels in each rack i. No.Pos.Pal.i corresponds to the number of positions for the warehousing of pallets in each level of rack i.	$PPalj = No.racks_{j} \times Nív.rack_i \times No.Pos.Pal._i$ (9) (units)
Operational KPIs	**NV: Number of travels for storing the loads in each block (the lower the better)** A forklift only transports one pallet at a time. Qij is the total number of pallets stored in position i of block j. I represents the sum of positions. J represents the sum of the blocks. The total number of journeys (NVtot) is the sum of all the NVij.	$NVij = \sum_{i=1}^{I} \sum_{j=1}^{J} Q_{ij}$ (10) (units)
Operational KPIs	**DP: Total travelled distance for storing the loads in the storage lane by forklift (the lower the better)** Dj is twice the distance travelled from the pre-storage zone to the middle of block j (return). NVj is the number of journeys made until block j. The distance travelled DPtotis the sum of the distance travelled from the pre-storage zone to the middle of each block (DPj).	$DP_j = \sum_{j=1}^{J} D_j \times NV_j$ (11) (m)
Area KPIs	**$DE_{média}$: Average distance to dispatch by product type (the lower the better)** This distance is travelled by the containers along a conveyor belt. Dj is the distance between the midpoint of block j to Dispatch. J is the total number of blocks.	$DE_{média} = \frac{\sum_{j=1}^{J} D_j}{J}$ (12) (m)
Area KPIs	**ABU: Total base area available to store the loads per block (the higher the better)** Ci is the length in metres of the position of warehouse i. Li is the width of the position of warehouse i. No.racksj corresponds to the number of racks that have a determined number of warehousing positions.	$ABU_j = C_i \times L_i \times No.racks$ (13) (m^2)
Area KPIs	**PP: Percentage of useless storage space (the lower the better)** A_{tot} is the total area of the plant, in this case, 9772 m^2.	$PP = \frac{Atot-ABU}{Atot} \times 100$ (14) (%)
Area KPIs	**PPE: Percentage of storage useless space, considering corridor area as useful space (the lower the better)** Acorr corresponds to the area occupied by the corridors in the warehouse plant (primary and secondary). Asecções includes the Reception and Conferring zones, Exchanges and Returns, Supply, Dispatch and others. Others include offices, canteens, changing rooms and bathrooms.	$PPE = \frac{Atot-Acorr-Asecções}{Atot} \times 100$ (15) $Asecções = Arec + Atr + Aaviam + Aexp + Aoutros$ (%)

6. Benefits analysis

The benefits analysis was concluded by examining the results of the KPIs presented and observed during the project implementation phase. The next sections present the results obtained in each phase.

6.1 Results of Phase 0

The effort applied for the creation of a culture that is cross-cutting throughout the organisation and aims to include all staff in achieving continuous improvement culminated in a general increase in motivation, team spirit and cooperation. In parallel, very satisfactory results were achieved in the KPIs associated with the tools applied to Phase 0. Table 3 brings these results with a comparison with the initial layout represented using percentages (green indicates and improvement, red a deterioration). From the improvement in ergonomic conditions and organisation and identification of spaces, a fall of 17.31% was registered in time spent conferring goods.

Until the moment of publication, it was not possible to establish an agreement between the Buying Team and various suppliers/transporters enabling the total establishment of distribution of weekly goods reception designed for a Future Vision. However, it was possible to reach a reduction in the misalignment variation coefficient of 40.22%.

Table 3: Results obtained with the improvement activities of Phase 0

KPI	Initial State	Current State	Improvement
Average time per pallet conferred (mins)	52	43	**17.30%**
Weekly goods reception variation coefficient (%)	28.91%	17.28%	**40.22%**

6.2 Results of Phase 1

Within the scope of Phase 1, very positive results were obtained, as illustrated in Table 4. It should be emphasised that all the solutions applied in this phase were implemented inpilot sectors to test and measure results. Subsequently, they will be applied to the whole of the new Lisbon warehouse.

The introduction of the Naban system in the manual line had an impact on the total number of daily replenishments throughout the observation period, with a reduction of 23.53%. This result allows the complexity of flows to be reduced, meaning fewer operator journeys and more effective replenishment, considering the real needs of the line. As well as this improvement, it enabled a reduction of about 22.2% in stock by eliminating reserves and making picking more efficient and less subject to mistakes.

The implementation of standardised replenishment and the pull on the automated line brought about a reduction of 33.33% if the number of replenishments in comparison to the initial observation.

The benefit achieved by the electronic Kanbans exceeded 80%. The total elimination of the product-free channels is not manageable, considering the existence of recurring stock-outs in the warehouse itself, a common phenomenon in the pharmaceutical sector, considering the high number of products sold out.

Table 4: Results obtained with the improvement activities regarding Phase 1

KPI	Initial State	Current State	Improvement
Daily level of replenishments on the manual picking line (units)	34	26	**23.53%**
Daily level of stock on manual picking line (units)	123887	96384	**22.20%**
Daily level of replenishments on the automated picking line (units)	21	14	**33.33%**
Weekly level of channels stock-outs on the automated picking line (units)	1697	303	**82.14%**

All the observations from Phase 1 were undertaken over two weeks, both in the initial situation, as well as following implementation, with the exception of the Kanban system in the automated channels that lasted five weeks.

6.3 Results of Phase 2

From a general perspective, the proposal with a horizontal layout was greater in all operational KPIs, being that the losses in the area KPIs were not sufficiently relevant to change the result. The average improvement in terms of the initial layout was 13.95% when the improvements and deteriorations are incorporated, and 26.63% when the percentage improvements are aggregated. Considering this, the second best layout was the combined one, with improvement rates of 8.71% and 12.44% respectively.

Table 5 presents the results of the designed indicators.

Table 5: Results obtained with the improvement activities of Phase 0

KPI	Initial Layout	Layout 1	Layout 2	Layout 3
DE$_{média}$ (m)	522842	607681.80 **16.23%**	477057.20 **-8.76%**	555307.60 **6.21%**
DPtotal (m)	137	91.50 **-33.21%**	42.50 **-68.98%**	87 **-36.50%**
ABU (m^2)	1087.24	1114.96 **2.55%**	991.8 **-8.78%**	1130.36 **3.97%**
PPal (units)	4320	3918 **-9.31%**	3930 **-9.03%**	4605 **6.60%**
PP (%)	88.87	88.59 **-0.32%**	89.85 **1.10%**	88.43 **-0.50%**
PPE (%)	35.67	34.78 **-2.50%**	34.9 **-2.16%**	33.72 **-5.47%**

7. Conclusions

The case study described in this paper was undertaken at Company X, aiming to increase the overall productivity of its Lisbon warehouse.

During the project phase, the company decided that it would need to change premises due to the lack of space and general conditions. Therefore, the proposals designed aim to be easily adapted to a new warehouse.

Three phases of implementation were defined using Kaizen Lean tools. Phase 0, given this name on purpose, started by ensuring the basic stability of processes and the integration of all the teams in continuous improvement. Phase 1 guaranteed the installation of Kanbans that allowed pull replenishment and a simplification of warehouse flows, by eliminating inverse logistics and reduction or stock on the supply line. Finally, Phase 2, which includes a complementary work by the author close to the end of the project, which aimed to analyse the layout proposal presented by the organisation and assess possible alternatives through defining operational and area KPIs. This analysis considered premises enacted by Company X.

The final results show gains in Phase 0 of 17.31%, with a reduction in conferring time for a pallet and levelling of goods received of 58.82% in comparison with that initially planned, thus reducing the value of the variation coefficient from 28.91% to 17.28%.

Standardised and pull replenishment enabled a reduction of 23.53% and 33.33% in the number of replenishments in the manual and automated lines, respectively. It was also possible to reduce stock levels by 22.2% on the manual line by eliminating product reserves. The electronic kanbans installed in the automated supply channels brought a benefit in terms of equipment stock-outs of 82.14%.

By analysing KPI results to assess the layouts, it was concluded that the best alternative is the horizontal layout, because although it means a reduction in the number of positions for pallets, it allows an added value in terms of total distance covered and average distance to dispatch. The rate of improvement in comparison to the original layout is 13.95% if the improvements and deteriorations are included, and 26.63% if only improvements in each KPI are included.

In the future some steps should be implemented like: the introduction of standard boxes for the standardisation of the warehouse unit; the introduction of a logistic train to concentrate all transport waste in this element; the application of a simulation to assess the allocation of products by type; the optimisation of routes in the warehouse to ensure the best picking routes; and the application of a Multicriteria Methodology to aggregate indicators in order to obtain an overall indicator of the project. Furthermore, it is essential to adopt all the best practices introduced into the new warehouse at the initial phase, as well as to all the other warehouses of Company X, in order to increase its operational competitiveness in a transversal way.

8. References

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