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Research Article

Proposition of a New Methodology Based on the Lean-logistic Approach for Enhanced Performance of the Hospital Supply Chain

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Abstract: In the context of the current reform of the healthcare sector, Hospitals are under a serious pressure to improve their performance. Our paper intends to propose a methodology based on Lean-logistics approach to improve the hospital pharmacy performance. The proposed methodology is validated through a case study. As a result of our study, the redesign of the hospital supply chain is necessary to minimize healthcare costs, improve the quality of care and patient safety. Costs generated by all forms of waste in the hospital pharmacy are minimized in the case of Pharmacies grouping that allows a better control of stocks and inventories, a better management of orders with a better visible traceability.

Keywords: Costs, hospital supply chain, lean-logistics, methodology, performance, waste

INTRODUCTION

Nowadays, a big pressure is exerted on healthcare establishments to improve their quality of care, patient satisfaction and productivity while reducing all forms of waste. Managers must develop new tools of decision making support to better manage their establishments under the budgetary constraints (Serrou and Abouabdellah, 2015a, 2015b, 2016). Hospital logistics are defined as a complex function that manages health products flows and different distribution canels (Hassan, 2006; Fremont, 2009). Several researches demonstates that the logistics costs present a important part of totat expenditures whithin hospitals. Some estimate that hospital logistics costs represents 33% of the hospital budget (Garvey and Wiitala, 2002), others estimate that it could attain 42% (Henning, 1980) or even 46% (Chow *et al*., 1994). This important part shows that Logistics is a crutial component that must be improved. Therefore, healthcare establishments begin using Lean approach in order to improve their processes. The use of Lean in the hospital sector is very recent (Radnor *et al*., 2012). Nevertheless, the results of its implementation in this sector are satisfactory. Table 1 illustrates the Lean approach contribution in the hospital sector. Lean allows studying processes, identifying potential no-added value activities and eliminating them by simple and continuous changes (Liker, 2009).

Figure 1 summarizes some of the possible reductions of the implementation of a Lean methodology in hospitals (Dagenais, 2012). In that context, our paper intends to demonstrate that the application of Lean-Logistics principals and techniques in the hospital supply chain gives good results in terms of costs reduction, processes improvement and patient satisfaction. Our methodology helps managers choosing the most appropriate scenario related to the management of medicines and medical devices flows in the hospital pharmacy.

Organizational problems represent a noticeable link between Lean and hospital Logistics. In fact, the litterature reviewd shows that Lean helps adressing organizational problems. In the other hand, the most frequent problems related to logistics are due to the organizational aspect. In our study, we'll focus on that common problem and try to adress it using a methodology that shall support managers in the choice of the most suitable organizational scenario in order to minimize costs generated by waste in the hospital pharmacy. Figure 2 illustrates some of problems faced by logistics and those generally solved by a lean methodology.

MATERIALS AND METHODS

In the context of the hospital pharmacy performance improvement, a new methodology of continuous improvement is proposed based in the Lean-Logistics approach in the aim of producing more with

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Table 1: The use of Lean approaches in the hospital sector

Lean results	References
Quality of care improvement	Hummer and
Efficiency increase in terms of number of prescription completed at the end of each day	Daccarett (2009)
Reduction of errors related to medicines	Radnor *et al*. (2012)
Improvement of quality of care, patient satisfaction and productivity	Womack *et al*. (2005)
Improvement of patient security and work atmosphere	Aherne (2007)
Augmentation of the available number of beds and the number of patients treated.	
Reduction of employees moves, inventories and overtime	Poksinska (2010)

Fig. 1: Possible reductions by the use of a lean methodology in a hospital

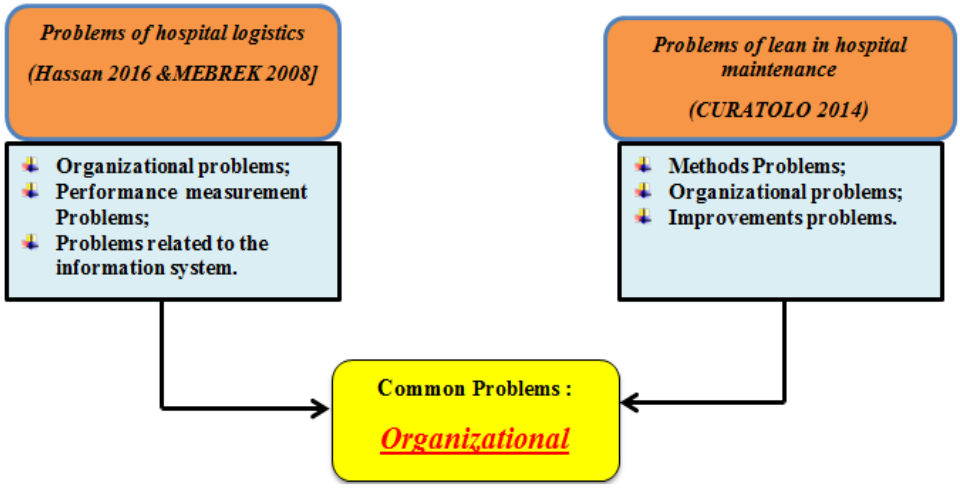

Fig. 2: Common issue between hospital logistics and Lean approach

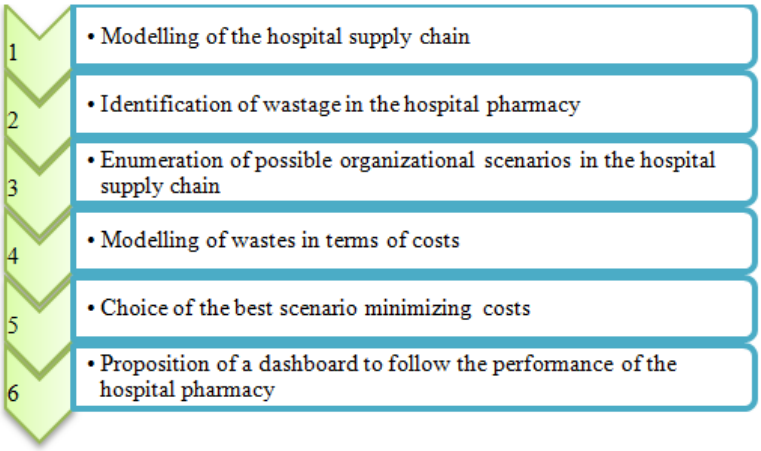

Fig. 3: Lean-logistics methodology proposed

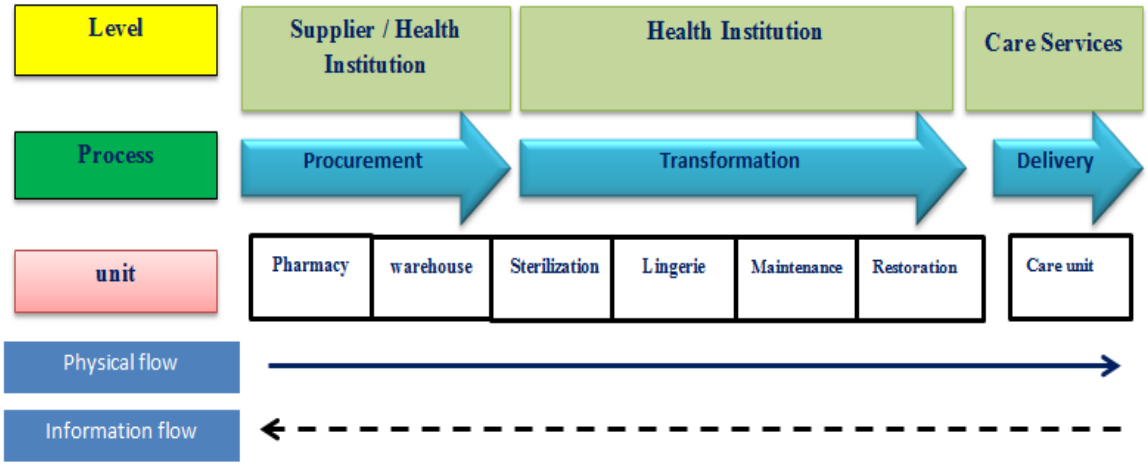

Fig. 4: Modelling of the hospital supply chain

fewer resources. Figure 3 illustrates the methodology proposed.

Modelling of the supply chain functions: The hospital pharmacy is an important link in the hospital supply chain. The improvement of its performance impacts directly the global performance of the supply chain. Figure 4 represents the end-to-end hospital supply chain.

Identification of waste within the hospital pharmacy: Since the pharmacy is an intermediate between suppliers and patients (clients); any waste in it affects directly the quality of care and the patient satisfaction. The identification of losses –that represents a principal step of a lean-logistics methodology- is a very complex task, because it requires a good control of all flows, processes and resources of the hospital supply chain and also a good comprehension of the patient needs (Khlie and Abouabdellah, 2015). An activity is considered a waste if it generates costs and delays without creating any value. Waste is classified into seven types that we call the seven Muda (Ōno, 1989). Figure 5 enumerates those Mudas that represent enormous losses in terms of costs for the hospital pharmacy.

To those 7 *Mudas*, is added an eighth one identified later by Liker (2004): the underutilization of skills. In other words, it's the lack of exploitation of potential ideas and professional skills of employees by poor listening and low involvement (Khlie and Abouabdellah, 2015). This type of wastage is very present in the hospital sector: only 40% of the employee's time is dedicated to create the value (Murphy, 2003).

Cartography of organizational scenarios of the hospital supply chain: In this step, we try to evaluate the performance of the actual supply chain. This part is dedicated to answer those questions: is the actual supply chain the optimal scenario in terms of waste costs minimization? If not, which is the best scenario? In order to answer those questions, we listed possibilities of the supply chain organization and we

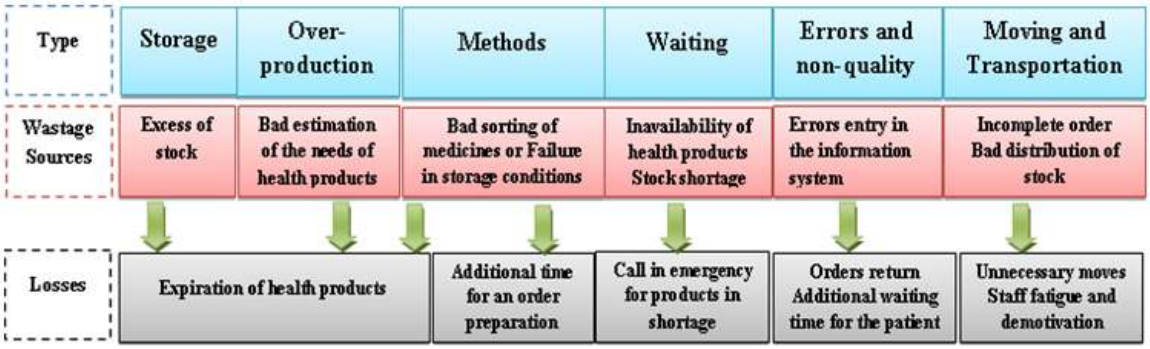

Fig. 5: Mudas in the hospital pharmacy

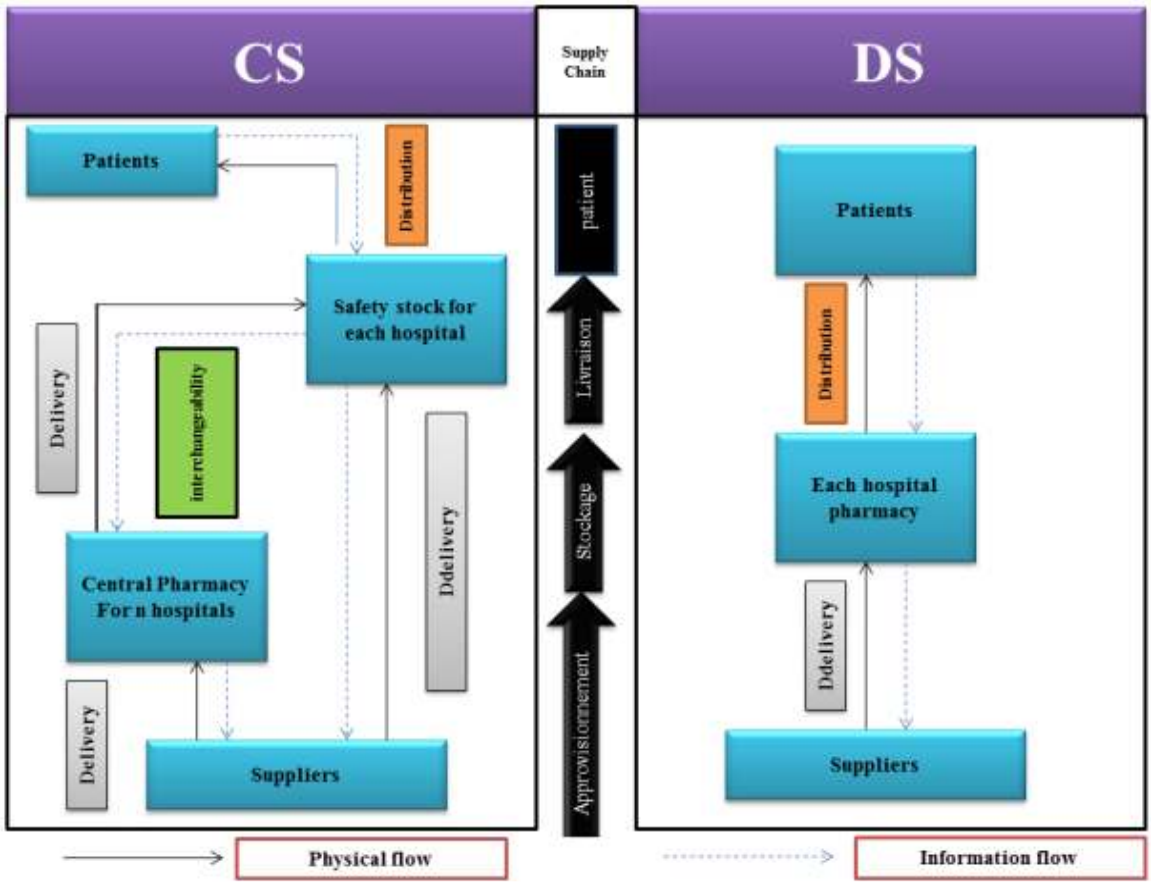

Fig. 6: Centralized and decentralized structures at the hospital supply chain (Serrou and Abouabdellah, 2015c)

found two possible scenarios, Fig. 6 illustrates the difference between the two organizational scenarios. The first one represents the actual supply chain and the second represents the case of hospital pharmacies grouping in a unique central pharmacy. In other words, this study intends to compare the two scenarios of centralization and decentralization of pharmacies.

Modelling of wastage in terms of costs: If there is a common component to the issue of waste and losses, it's with no doubt the lack of a quantitative study. In order to quantify losses, we propose a mathematical model that assembles all costs generated by wastes in the hospital pharmacy. Those costs are classified into four clusters:

- Expiration costs
- Stock shortage costs
- Costs related to facilities
- Costs related to human resources

To model those costs, notation used is represented in Table 2.

Table 2: Notation used in the mathematical model

Notation	Signification
j	Pharmacy
i	Health product
N	number of pharmacies
X_{ij}	The quantity of i ordered by j
R_{ij}	Economies of scale ratio $R_{ij} = \begin{cases} \frac{C_{\text{with economies scale}}}{C_{\text{without economies scale}}} \text{ in case of orders grouping} \\ 0 \text{ else} \end{cases}$
Ca_i	Acquisition cost of the product i
Csu_i	Storage cost by unit
S_{ij}	Expired stock of i in the pharmacy j
Y_{ij}	Quantity needed of i in case of stock shortage in j
C_{sub}	Cost of the substitution of the product i by j. $C_{sub(ij)} = \begin{cases} \text{the difference of cost between i } and\ j \\ \text{if i is cheeper that j} \\ 0 \text{ else} \end{cases}$
C_{urg}	Cost of urgent transport
C_c	Cost of an order placement
M	Number of hours worked in a year

For expired health products, cost losses are quantified by the following formula:

$$\sum_{j=1}^{N}\sum_{i=1}^{3} S_{ij}Ca_i + Csu_i * S_{ij} + C_c * \frac{Q_{ij}}{S_{ij}} \quad (1)$$

For products in stock shortage, two cases are possible:

- Substitution of the product by a similar one that is available in the stock
- In case of lack of any substitution, an emergent call is made to the supplier in order to bring the desired product.

Therefore, losses dues to stock shortage are presented as follows:

$$\sum_{j=1}^{N}\sum_{i=1}^{3}(Y_{ij}C_{sub} + C_{urg} + C_c * \frac{Q_{ij}}{Y_{ij}}) \quad (2)$$

For losses related to the acquisition, they could be modeled as follows:

$$\sum_{j=1}^{N}\sum_{i=1}^{3} X_{ij}(1 - R_i)Ca_i + C_c * \frac{Q_{ij}}{X_{ij}} \quad (3)$$

In what concerns costs related to the underutilization of the stuff and based on Murphy's study (Murphy, 2003); costs wasted are:

$$60\%*M *C_{\text{main d'oeuvre}} \quad (4)$$

So, the mathematical model proposed to quantify the waste costs is presented in the following formula:

$$\sum_{j=1}^{N}(\sum_{i=1}^{3} S_{ij}Ca_i + Csu_i * S_{ij} + C_c * \left(\frac{Q_{ij}}{S_{ij}} + \frac{Q_{ij}}{X_{ij}} + \frac{Q_{ij}}{Y_{ij}}\right) + \sum_{i=1}^{3}(Y_{ij}C_{sub} + C_{urg}) + \sum_{i=1}^{3} X_{ij}(1 - R_i)Ca_i + 60\%*M *C_{maind'oeuvre} \quad (5)$$

Table 3: Percentage of logistics costs generated by each hospital

Hospitals	% of logistics in the budget
H1	33%
H2	27%
H3	29%
H4	33%
H5	19%
H6	25%
H7	26.4%
H8	19.44%
H9	33.43%
H10	27.9%

The two last steps of the methodology that allows choosing the best scenario and measuring its performance are represented at the following part.

RESULTS AND DISCUSSION

In order to validate the proposed methodology, it's applied in a hospital center in Morocco. This hospital center is composed of ten hospitals. Table 3 presents the percentage of logistics costs generated by each one of the ten hospitals.

This study follows a comparative approach between costs generated by the two scenarios waste in a period of six months.

Evolution of losses related to expiration: This first comparison is made between the total cost of losses related to expiration for both DS and CS scenarios. Figure 7 illustrates the evolution of losses of health products due to their expiration.

Those results show that costs related to expiration in the case of the CS are lower than those of DS. This is due to:

- Control and traceability in the centralized case resulting in facilitating the product tracking dates.
- Products rotations improvement in CS.
- Interchangeability between hospitals that increases the use of products.
- Optimization of the use of resources in pharmacies because of grouping.

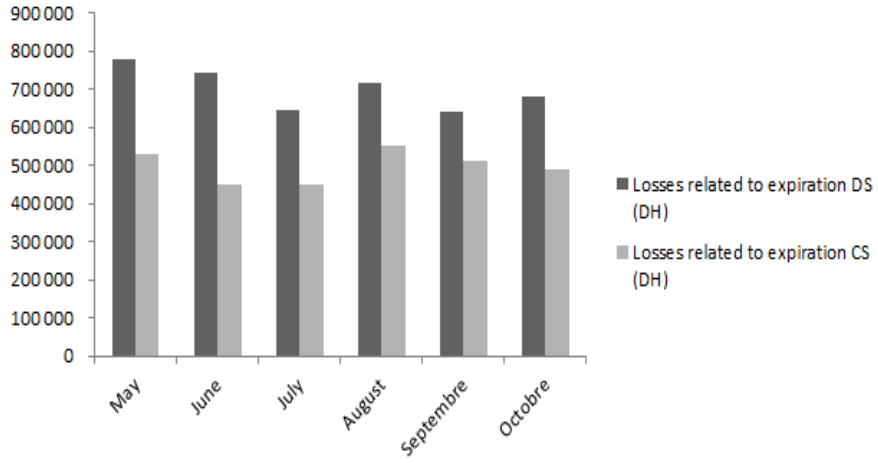

Fig. 7: Evolution of the losses related to expiration

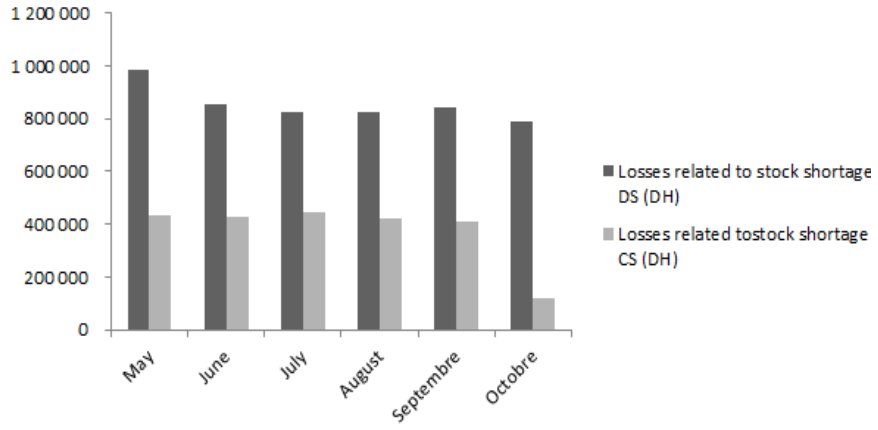

Fig. 8: Evolution of losses related to stock shortage

Evolution of the losses related to stock shortage: In this study, we compare the total cost of the losses related to stock shortage for both DS and CS scenarios; Fig. 8 compares losses costs related to stock shortage in the two scenarios.

Those results lead to the conclusion that losses related to stock shortage in the case of the CS are fewer than those generated by DS for 6 months. This is due to:

- Minimization of the stock by grouping products
- Improvement of the effectiveness of the traceability of products
- Assurance of a better rotation of health products
- Creation of exchange between hospitals in case of failure
- Monitoring of needs by the central pharmacy in real time

Evolution of losses related to the acquisition: In this study, we compare cost generated by losses related to the acquisition for both DS and CS scenarios; results are illustrated in Fig. 9.

According to Fig. 9, the acquisition of health products in the CS implies additional costs due to the multiplicity of orders placement of small quantities. The acquisition process in the DS generates less cost because of:

- Mastery of traceability and much easier price monitoring for the purchaser.
- Reduced number of orders placements.
- Interchangeability between hospitals in case of failure or refusal.
- Possibility of negotiation of price in the case of requesting bigger quantities.

Evolution of the losses related of underutilization of human resources: In this last part, a comparison is made between costs generated by HR underutilization in both DS and CS scenarios. The results are represented in Fig. 10.

From Those results, the conclusion to draw is that losses related of underutilization of HR in the case of the CS are fewer than those in the DS during 6 months. This is due to the elimination of overstocks in

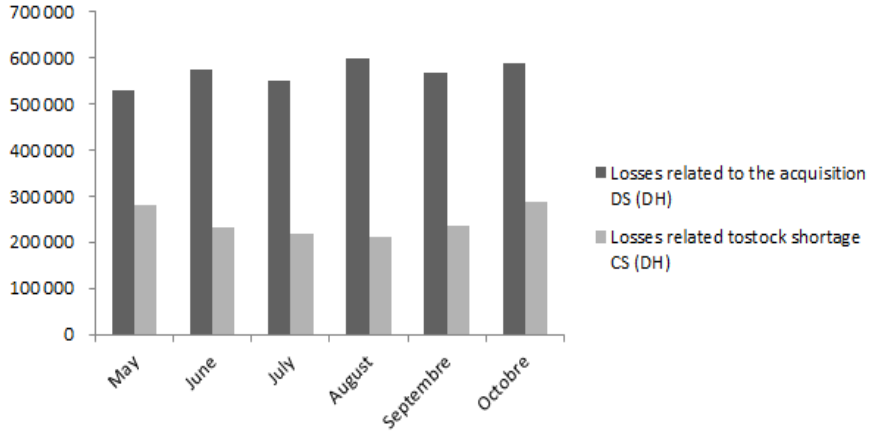

Fig. 9: Evolution of losses related to the acquisition

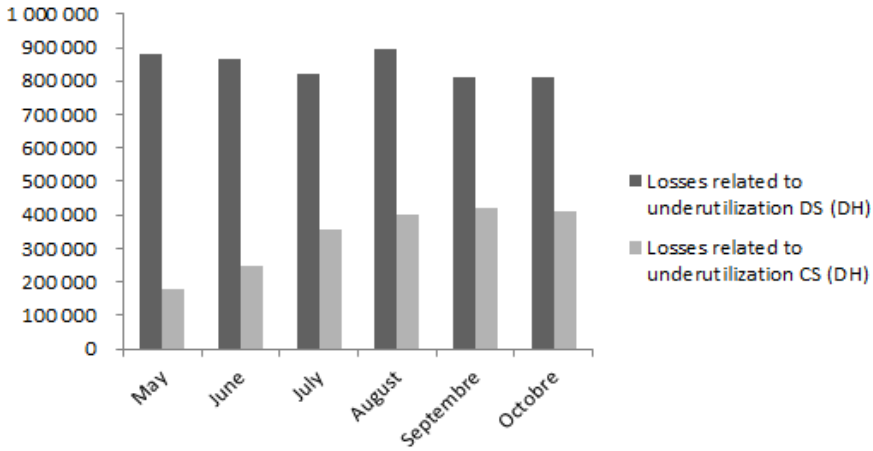

Fig. 10: Evolution of losses related to human resources underutilization

Table 4: Performance indicators in the hospital pharmacy

Waste	Performance indicators	Method of calculation	Threshold of acceptability
Storage	Stock shortage rate	(value of products in stock shortage /total value of medicine stored in the pharmacy)*100	<1%
Luck of respect of standards and methods	Rate delays caused by non-compliance with standards and methods	(Value of products subject to delay caused by non-compliance with standard and methods/total value of medicines stored in the pharmacy)*100	≥1%
Moves and transport	Unnecessary moves rate	Time of unnecessary moves/total time of work)*100	≥0.5%
Waitings	The average waiting time of prescriptions	Response time	≥2%
Error and non-quality	Non-quality ratio	(non-quality costs/total cost)*100	≥0.5%
Overproduction	Expiration rate	(value of expired products/total value of medicines stored the pharmacy)*100	≥1.5%

pharmacies due to the grouping. Once the best scenario is chosen, it's necessary to propose a dashboard to follow the performance of the hospital pharmacy in the CS. Several organisms insist on the necessity of the establishment of good performance indicators in the hospital pharmacy (McKinnon, 2001). The choice of the best indicators is one of the problems faced by hospital pharmacies. In this study, we offer a list of relevant indicators to assess the performance of a central pharmacy in the case of centralized structure chosen. Table 4 shows the performance indicators proposed for the measure in the case of pharmacies grouping (CS).

CONCLUSION

This study proposed a new lean-logistics methodology with the establishment of an

organizational decision support system based on the identification of the hospital pharmacy waste and costs that it generates. It also proposed performance indicators for hospital managers with the aim of quality of care improvement.

A prospective of our study is to consider different perspectives by integrating security and delays in the performance measurement in the health sector. Another interesting perspective is to consider the stochastic aspect of the problem which would integrate data variation relative to several factors as seasonality. Finally, the consideration of additional optimization criteria such as maximizing motivation of caregivers or maximizing their satisfaction is also an interesting research avenue to explore the importance of these criteria for improving the hospital performance.

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REFERENCES

Aherne, J., 2007. Think lean. Nurs. Manage., 13(10): 13-15.

Chow, G., T. Heaver and L.E. Henriksson, 1994. Logistics performance: Definition and measurement. Int. J. Phys. Distrib. Logist. Manage., 24(1): 17-28.

Dagenais, M., 2012. Analyse exploratoire des impacts et des facteurs de succès de l'implantation de l'approche lean dans deux centres hospitaliers universitaires québécois. M.A. Thesis, Département de Mathématiques et Génie Industriel, Ecole Polytechnique de Montréal.

Fremont, F., 2009. La logistique hospitalière. Retrieved from: www.insset.upicardie.fr/file/rapport_sdl/La%20Logistique%20Hospitalie%CC% 80re.pdf. (Accessed on: Nov. 26, 2010)

Garvey and Wiitala, 2002. Healthcare resource and materials management – The CFO's perspective. Proceeding of the AHRMM 40th Annual Conference.

Hassan, T., 2006. Logistique hospitalière: Organisation de la chaîne logistique pharmaceutique aval et optimisation des flux de consommables et des matériels à usage unique. Computer Science [cs]. INSA de Lyon.

Henning, W.K., 1980. The financial impact of materials management. Healthcare Financ. Manage., 34(2): 36-42.

Hummer, J. and C. Daccarett, 2009. Improvement in prescription renewal handling by application of the lean process, Nurs. Econ., 27(3): 197-201.

Khlie, K. and A. Abouabdellah, 2015. A methodology of lean implementation in hospitals. Int. J. Appl. Eng. Res., 10(19): 40461-40467.

Liker, J.K., 2004. The Toyota Way: 14 Management Principles from the World's Greatest Manufacturer. McGraw-Hill, New York.

Liker, J.K., 2009. Le modèle Toyota: 14 Principes Qui Feront la Réussite de Votre Entreprise. Pearson, Paris, pp: 391.

McKinnon, N.J., 2001. Sept stratégies pour consolider notre système d'utilisation des médicaments. Can. J. Hosp. Pharm., 54(2): 77-80.

Murphy, M., 2003. Research Brief: Eliminating Wasteful Work in Hospitals Improves Margin, Quality and Culture. Murphy Leadership Institute, Washington, DC.

Ōno, T., 1989. L'esprit Toyota. Masson, Paris.

Poksinska, B., 2010. The current state of lean implementation in health care: Literature review. Qual. Manage. Health Care, 19(4): 313-329.

Radnor, Z.J., M. Holweg and J. Waring, 2012. Lean in healthcare: The unfilled promise? Soc. Sci. Med., 74(3): 364-371.

Serrou, D. and A. Abouabdellah, 2015a. Measuring the financial performance of the stock process in the case of pharmacies grouping. Int. J. Appl. Eng. Res., 10(13): 33470-33473.

Serrou, D. and A. Abouabdellah, 2015b. Study of improved fiscal performance of hospital supply chain by centralizing pharmacies. Proceeding of the 45th International Conference on Computers and Industrial Engineering (CIE45). Université de Lorraine, Metz, France.

Serrou, D. and A. Abouabdellah, 2015c. Study pharmacies grouping impact on the performance of the hospital supply chain. Proceeding of the International Conference on Industrial Engineering and Systems Management (IESM). Seville, Spain, pp: 639-645.

Serrou, D. and A. Abouabdellah, 2016. Logistics in the hospital: Methodology for measuring performance. ARPN J. Eng. Appl. Sci., 11(5): 2950-2956.

Womack, J.P., A.P. Byrne, O.J. Fiume, G.S. Kaplan and J. Toussaint, 2005. Going Lean in Healthcare. Innovation Series, Institute for Healthcare Improvement, Cambridge, Massachusetts.