KANBAN SYSTEM APPLICATIONS IN HEALTHCARE SERVICES: A LITERATURE REVIEW

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None.

Abstract

Lean Management method has been applied in several fields before its implementation in healthcare area. Among the different techniques associated with Lean, in this paper, we are focused on Kanban system, which is a method that presents several benefits such as inventory holding reduction or improvement of the employees' satisfaction. Our main objective is to carry out a literature review focused on Kanban methodology applied to healthcare. In this sense, this study can serve as a script to improve hospital management in pandemic periods, such as the one currently lived on COVID-19. We carry out a literature review searching in four different databases. We combine several terms to achieve our objective. We identify several articles which describe Kanban methodology applied to health field. More specifically, we present in what areas (nursing or pharmacy, among others) this method has been applied. In addition, we show all the barriers as well as benefits caused by the implementation of this system. There are a few studies focused on analysing how Kanban is applied to healthcare. Therefore, we can affirm that this topic is still recent.

Keywords: Kanban System, Health, Hospital, Positive Effects, Barriers.

Background

In recent years, health sector is facing significant challenges such as budget reductions or costs increases due to the ageing process. Therefore, it is necessary that healthcare management is oriented to make better use of economic, material, and human resources that allow offering a high-quality service to patients.[1,2] Nowadays, all these aspects become more important because of the COVID-19 pandemic, which has affected the whole world. Resources should be used properly to optimize the care of the general population.[3]

Several institutions, hospitals and health centres apply process improvement and management systems, which allow making a more efficient use of the available resources.[4] Among all those improvement techniques, Radnor[5] concludes that Lean Management methodology prevails over other systems.

Lean Management method is a system that seeks the waste disposal to achieve an efficient and effective management, being customers in the dominant position. It is based on five guiding principles (defining value; arranging by value stream; flowing; pulling; and seeking perfection) and it is focused on the elimination of all types of waste.[6] We can define waste as any activity that uses resources and does not generate added value for customers.[7] The following categories can be distinguished: overproduction ahead of demand; waiting for the next material or equipment process; unnecessary material transport; over-processing of parts; large amount of inventories; unnecessary employees' movement; defective parts production; and not fully use employees' brainpower, skills, experience and talents.[7,8]

The interest in the Lean method application to healthcare has gained significant importance since 2009 when the first paper that applies Lean healthcare was

published.[9,10] There is a wide range of organisational settings (operating rooms, hospital departments, hospital-based pharmacy,…) and specialities (emergency medicine, surgery, gastroenterology,…) where Lean has been applied.

Concerning the positive and negative aspects derived from its implementation, the main benefits obtained from the application of Lean system to health field are avoiding waiting times, unnecessary hospital visits, cost reductions, and reduction in mistakes, among others.[11,12] Additionally, its application has increased quality, safety and efficiency by improving clinical processes.[13]

When implementing Lean philosophy, health services have a wide range of tools and techniques at their disposal.[14,15] Among them all, this article is focused on Kanban System. Kanban is a pull method approach, which allows employees to produce at a required rate as well as to control product inventories according to customer forecast.[13] Basically, it consists of a signal that asks the supplier to produce and/or deliver a new batch when material is consumed. Its main benefits are: inventory holding reduction; material flow improvement; overproduction elimination; minimization of obsolete inventory; and improvement of the management of the supply chain.[16]

According to Landry and Philippe[17], Kanban (also known as two-bin system) was first developed in healthcare in the 1980s as an alternative to other centralized approaches (exchange carts or par level). More than three decades later, it seems interesting to know how this system has been used. Therefore, the main objective of this paper is to carry out a literature review focused on the use of Kanban methodology applied to healthcare. More specifically, three research questions are stated:

- What is Kanban applied in healthcare for?

- What are the barriers found when implementing Kanban in healthcare environments?
- What are the positive effects derived from Kanban implementation in healthcare environments?

The paper is structured as follows. Section 2 describes the methodology used to develop the review according to the different databases considered. Sections 3 and 4 present the main results from all the studies analysed in this review. Finally, the paper ends with the conclusions in Section 5.

Methods

Search strategy

The methodology used in this article implies a literature review. The first stage consists of the identification of the existing research papers about Kanban applications in healthcare. First of all, the inclusion criteria were defined:

- Document type: Ful-text journal article.
- Publication language: English.
- Period: All the period available until 14th September 2020.
- Topic: Kanban applications in healthcare.

On the other side, documents were excluded if they did not meet the inclusion criteria and/or they meet the following exclusion criteria:

- Articles that do not apply Kanban as a material management system

Four different electronic databases (PubMed, Cochrane Library, Web of Science and Scopus) were searched, according to Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines.[18] The search strategy applied was a combination of any of these three terms: Kanban OR e-Kanban or two-bin ; together with any of these two: hospital OR health.

Eligibility criteria

Based on the inclusion criteria, 262 were found in the four databases under consideration (10 PubMed, 1 Cochrane Library, 174 Web of Science and 77 Scopus) and 8 papers were identified by hand searching. 46 duplicates were removed and the title and abstract of the remaining 224 papers were independently screened by two authors (PLL and LSR). Afterwards, the independent results of both authors were compared based on the decision matrix shown in Table 1.

[INSERT TABLE 1 ABOUT HERE]

After comparing the results of authors 1 and 2, 52 were included, 164 were excluded and 8 were classified as undecided. Author 3 (DCP) was responsible for analysing those eight papers. Based on their decision, the papers would be finally included or excluded. Finally, 6 of the 8 undecided papers were included. Therefore, 166 were excluded and we consider a final set of 58 articles to assess for eligibility in this survey. Of these 58 papers, 38 were not included due to the following reasons:

- Non-Kanban approach: 13 articles did not adopt this approach, which is the one we are focused on.
- Non-Health area: 2 papers analysed Kanban methodology in a different field of healthcare.

- Non-available full text: 12 articles were not accessible for us.
- Language: 1 article was written in a language other than English.
- Type of document: 10 papers were not primary articles but reviews or protocols.

Therefore, we have finally considered 20 studies in the qualitative synthesis.

Figure 1. Flow diagram of the paper selection process.

Source: Authors' elaboration.

Extraction of studies' information was independently performed by the authors through a pre-set table. Then, a common revision was carried out and consensus was reached to include several characteristics of the articles considered.

Results

Just before content analysis, a bibliometric analysis was conducted, including brief and clear quantitative analysis in order to measure the production and generation of knowledge about the publications time patter, the authors and journals on the topic.[19]

As shown in Figure 2, the first paper about Kanban applications in healthcare settings was published in 2008. From that moment onwards, 19 additional papers have been published. The time evolution has been inconsistent since 2008, registering strong differences from year to year. Thus, the highest number of papers was published in 2015 (5 papers), in contrast with the years 2009 and 2019 when none papers were published.

Figure 2. Evolution of published papers over time

Source: Authors' elaboration.

Concerning the authorship, 48 different authors were identified. Only two authors appear in at least 2 publications: Pat Patterson from the Massachusetts General Hospital (Boston, USA) who wrote 3 papers and Victor G. Aguilar-Escobar from the University of Seville (Spain) with 2. As for the journals, Table 2 summarises the distribution of publications. Among the 15 identified journals, four of them have published more than one paper: *OR Management* (3 papers), *Engineering Management Journal* (2), *International Journal of Healthcare Technology and Management* (2) and *Revista de Calidad Asistencial* (2).

[INSERT TABLE 2 ABOUT HERE]

Finally, papers were classified based on the methodology applied. The vast majority of papers (17 out of 21) were case studies. Among them, different data collection techniques (action research, surveys) and methodologies (descriptive statistics, exploratory factor analysis) were identified. The rest of the papers could be defined as: technical papers focused on model development and simulation (2) and theoretical papers (1).

KANBAN applications

As it was seen in the previous section, there are two main kind of articles according to the methodology used. The paper of Patterson[20] which, with an informative perspective explains the basics of Kanban system apply to the operating rooms, is the only

theoretical paper. The rest of the works, which are case studies or model development papers, are briefly explain throughout this section. Additionally, we describe all the articles selected according to the product/service where it was applied (Table 3).

[INSERT TABLE 3 ABOUT HERE]

Persona *et al*.[21] use Kanban tools to obtain an efficient management of ward materials. The hospitals introduce several investments to achieve the objectives related to Kanban system. The authors analyse two case studies focused on the supply ward of materials, the first one examines the case of Padua City Hospital; and the second one, a hospital in Turin. In both cases, it is shown the advantages of establishing this method.

Bendavid *et al*.[22] develop a case study analysis to examine a two-bin "e-Kanban" replenishment system based on passive high frequency Radio-Frequency Identification (RFID) technology, which has been implemented in a hospital nursing unit. Their results show that this implementation presents several benefits (reduction of on-hand inventory at distributed storage locations and the inventory shrinkage, productivity gains, time saved for logistics processes, and the optimization of inventory levels), being the time saved the most relevant impact. It also presents an impact on nursing staff such as employee turnover and retrieval of products from storage locations as well as the improvement of business and operational performance.

Xu *et al*.[23] develop a pilot case study to examine the integrated medical supply inventory control system. The authors use the two-bin method, among others, to solve the problems associated with inventory management issues. Their results show that implementing these systems implies certain benefits in order to manage medical supply and achieve better service for patients.

In the case of healthcare furniture, Patterson[24] applies Kanban system to the management of medicine trolleys, which will be taken to the OR. He finds efficiency gains as well as improvements on quality projects.

In this line, this same author[25] analyse Kanban system as a solution to the existing barriers with stock management such as stock-outs, lack of control or disorganization. In addition, he uses this method as a measure to reduce operating costs in the hospital. Therefore, the author decides to implement a two-bin Kanban system to improve the job environment by reducing employees' frustration, stocks value and stock-outs number.

Aguilar-Escobar and Garrido-Vega[26] carry out a case base study between 2005 and 2010. Their objective is to examine the applicability of Lean Production principles and practices to manage the supply chain of a hospital in Seville, Spain. To solve the existing problems, the hospital implemented several measures throughout a strategic plan. The authors show a reduction of stock as well as of the nursing assistants' and supervisors' routine workload. In addition, the implementation of Kanban system avoid inventory mistakes and stock is updated in real time, among other advantages.

On the one hand, the main objective of Bhat and Jnanesh[27] is to decrease the cycle time of outpatient department service in a rural hospital. Their findings indicate a decrease in the cycle time of the process of almost 3 minutes (from 4.27 to 1.50), a reduction of the average waiting time (97%), from 32 minutes to 1 minute, as well as the queue length (91%), from 11 to 1 of patients. The main barrier was the ignorance of Lean Six Sigma methodology by the employees.

Aguilar-Escobar *et al*.[28] want to measure nurses' satisfaction in logistics of medical consumables, using Kanban methodology. Their findings reveal a high level of satisfaction in all features, varying between user groups according to age, workplace,

job category or seniority, among others. In addition, they show that nursing work related to material management is reduced, stores are more orderly, and they require less space, and there are fewer expired items. They conclude that Kanban system is better than the conventional system due to it increases nurses' satisfaction.

Pineda-Dávila and Tinoco-González[29] evaluate the reduction in costs and the increase in time devoted to the patient by applying three Lean tools: Kanban, 5S and 2P. They concluded that, by applying Kanban, material costs decreased by 43%, the cost of consumables per patient treated was reduced by 19% and time dedicate to patient treatment increased by 7%.

Wilson *et al.*[30] describe a pilot implementation of a fixed order quantity Kanban system, focusing on supply replenishment in an outpatient clinic at a cancer centre. They show a reduction in the percentage of stock-outs, excess of stock, stock value as well as time devoted to stock control. Therefore, the Kanban system seems to be useful and might be considered to be implemented in other hospital units.

Jeffries *et al.*[31] create a Demand Flow process, based on the use of a "two-bin" Kanban system. Their main objective is to ensure that supplies are delivered to the adequate location, at the correct time, in the exact quantity to the supply needs of the cardiac intensive care unit of a certain hospital. The hospital establishes several improvements in the unit, according to the products and health professionals involved in the process such as nurses, pharmacists, or respiratory therapists, among others.

Papalexi *et al.*[16] present a case study in which Kanban method is applied to a drug distribution process. The authors support the implementation of Kanban system despite the drawbacks considered in the study, being the worst the lack of experience of the employees and the fear that the system did not work, resulting in shortages of the

required medicines. In short, Kanban system is a positive experience, which means a reduction in stored products as well as in costs.

Donnelly *et al.*[32] describe and evaluate the performance of a two-bin Kanban supply delivery system in the radiology service of a children's hospital. After implementing it, they identified significant time savings which, in turn, improves the quality of the overall service: risk to patients was reduced as a result of reducing employee distraction related to stock management issues.

Through the application of a two-bin system with a periodic control system, López-Ramírez *et al.*[33] seek to provide a solution to the problems arising with the administration and control of inventories of a hospital in Cali (Colombia). They develop a model for the management of inventories in the organization.

Lim *et al.*[34] suggest the application of Kanban method to the orders and the management system of vaccine doses, which imply a complex labour. As a solution, the authors propose the implementation of Kanban system. They affirm that one of its main strengths is the easy implementation system compared to other methods, being especially useful when staff does not have the necessary or adequate training to implement more complex systems. In addition, they show that management mistakes are decreased after the implementation of Kanban system.

Kanet and Wells[35] examine the two-bin Kanban model and develop a total cost model that includes holding and replenishment costs. The minimum total costs bin size/reorder point was calculated subject to a specified customer service level. Additionally, an extension of the problem to the case of n-equal bin (n>2) was also provided.

Mouaky *et al.*[36] aim at redesigning and improving the logistical components of the Moroccan public Pharmaceutical Supply Chain. In order to do so, they propose an

Adaptative Kanban System to manage pharmaceuticals inventory, being the main different with the "traditional Kanban" that the number of Kanban cards is adjusted according to the status of the inventory. Specifically, they focus on the drugs for human use, as they represent the most representative product in terms of turnover and volume. Through a case study and simulation methods, they show how to apply this new inventory management system through the application of a five-step process.

Castro *et al*.[37] present a case study in a hospital pharmacy in Oporto. Having identified recurring stock-outs and over-stocks in this unit, it was decided to implement Lean tools such the Kanban System and other advance inventory management techniques in order to improve the unit performance. As a result, both stocks-outs and over-stocks were reduced (30% and 66% respectively), together with operational costs.

The most recent evidence, showed by Gurumurthy *et al*.[38], demonstrate that inventory reduction is possible employing appropriate tools and techniques of Lean Thinking. The authors carry out a case study of a hospital that implement those techniques, using a multi-unit selective inventory control methodology which combines consumption value, criticality and lead time or ease of availability. They mainly focus on the problems solved due to inventory in the healthcare sector.

KANBAN implementation barriers

First, it should be noted that 9 of the 19 articles analysed do not mentioned any problem or barrier when implementing Kanban.[22-24,31-33,35-37] Meanwhile, in the remaining 10 articles, we have identified 14 different barriers (Table 4).

[INSERT TABLE 4 ABOUT HERE]

We show that the main barrier when implementing Kanban methodology is the employees' lack of knowledge on how to apply this system.[16,27,29,38] In addition, this barrier could be associated with other ones such as internal resistance[30] and fear or rejection of a new work methodology due to staff' ignorance.[16] Similarly, other disadvantage that is founded several times is the fear of shortage of the required medicines.[16,21,38] These findings are in line with other studies, which conclude that low participation of the staff and lack of commitment of senior management are determinants that hinder Kanban application.[38,39]

KANBAN positive effects

Concerning the positive effects, 38 different benefits have been identified that might be grouped in three main types: stock management improvements, productivity improvements and patients/service improvements.

Regarding the positive effects associated with stock management (Table 5), the most mentioned one is the stock size reduction, being identified in 10 of the 19 papers reviewed.[16,21,22,24-26,30,36-38] This benefit can be associated with those that imply costs reduction,[16,21,29-32,36,37] storage area optimization and better organization.[26,28,31,34]

[INSERT TABLE 5 ABOUT HERE]

Table 6 shows those benefits related to productivity, being time savings the most common positive effect,[16,19,22,23,26,28,29,32] followed by the good impact on professional 'staff.[19,22,25,26,28]

[INSERT TABLE 6 ABOUT HERE]

Finally, Kanban implementation also suggests positive effects on patients (Table 7). The findings show the improvement of the service offered to patients after applying Kanban. In addition, it is found that mistakes and the anaesthesia time decrease.[16,19,32,34] Besides, the hospital stay length and hospital infection rates are reduced.[28]

[INSERT TABLE 7 ABOUT HERE]

In short, the results are in line with some studies carried out in other fields such as the manufacturing one.[39-41]

Discussion and conclusion

The COVID19 pandemic has put on the spotlight the strategic importance of health logistics. Along the last months many hospitals have suffered from equipment, medical products, and safety elements stockouts, compromising patients and healthcare professionals' own security. Therefore, it seems paramount to implement and develop new management systems aimed at improving the healthcare supply chain. Taking this into consideration, this paper aims to conduct a literature review about Kanban system applications in healthcare settings.

To achieve this objective, we carry out a literature search in four databases (PubMed, Cochrane Library, Web of Science and Scopus). After applying the inclusion and exclusion criteria, the sample was reduced to 20 articles. Due to the limited number of studies and the fact that most of them are individual cases, the incipient state of this field of study might be concluded. This is a surprising result if we take into consideration that the first application of the two-bin system occurred in 1980. This may

lead us to think that the virtues of Kanban are not sufficiently well-known among healthcare managers and professionals.

We consider that this study presents a double contribution to the existing literature. On the one hand, it provides a general view of what has been written about Kanban application on health field, being useful for researchers interested in this topic and favouring the identification of gaps as well as the approach of future research lines. Additionally, as far as we know this is the first literature review that examine the use of Kanban methodology applied to healthcare field. On the other hand, this paper allows health professionals to know what Kanban methodology is, how it can be used and what barriers and benefits are derived from it. It should be noted that this methodology is relevant in healthcare due to it solves real problems in health sector, helps to avoid errors as well as it improves patient safety, professional satisfaction and the sustainability of the healthcare system.

Our findings are in line with those obtained in other fields, different from healthcare. Looking to a manufacturing companies, a beneficial aspect is the inventory control or even its reduction[42-44] as well as the improvement of staff coordination[45], which confirm our results on improving staff communication.

On the other hand, negative effects such as ignorance of the methodology and lack of training of staff are also found.[46] Complicated data collection is sometimes presented as a barrier. By contrast, other studies point out that information management is one of the key aspects when evaluating the difficulty of the Kanban method.[47] Therefore, it may be relevant for companies, hospitals and health centres, to focus on decreasing this barrier which is so important for success. Besides, human resource resistance is found as a

negative aspect. Therefore, staff plays a very relevant role in the application of Lean methodology.[10]

Our results, focused on the healthcare field, are in line with those obtained in previous studies based on other sectors such as software development manufacturing[40]. Therefore, we can conclude that Kanban methodology is an appropriate and useful tool across different sectors. Nevertheless, the method presents distinctive features for each one.[9,48]

Meanwhile, the main limitation of this study is the limited literature dealing with Kanban methodology applied to healthcare field because of the novelty of the topic. Another limitation found is that we focused only on articles published in English.

As a future research, we can expand the scope of the review and the period considered, specially, an ex post analysis considering a period which covers the COVID-19 pandemic. It would be likely to increase the number of studies considered in our review according to the objective and research questions established. Meanwhile, as a future research line we suggest developing more research about healthcare Kanban, being of special interest the development of quantitative indicators that allow managers to measure its impact.

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Table 1. Decision matrix

		Author 1 decision about paper		
		Include	**Doubt**	**Exclude**
Author 2 decision about paper	**Include**	Included	Included	Undecided
	Doubt	Included	Undecided	Excluded
	Exclude	Undecided	Excluded	Excluded

Source: Authors' elaboration.

Table 2. Number of publications by journal

Journal name	**Published papers**
OR management	3
Engineering management journal	2
International Journal of Healthcare Technology and Management	2
Revista de calidad asistencial	2
Business process management journal	1
Enterprise Information Systems	1
Evaluation and program planning 80	1
International Journal of Combinational Optimization Problems and Informatics	1
International Journal of logistics Research and Applications	1
Investigaciones Europeas de Dirección y Economía de la Empresa	1
Journal of the American College of Radiology	1
Omega	1
Pediatric and Congenital Cardiac Care	1
Supply chain forum: an international journal	1
The TQM Journal	1

Source: Authors' elaboration.

Table 3. Summary of the case studies

Article	Country	Health field	Product	Objective
Persona *et al*.[21]	Padua and Turin (Italy)	Hospital	Medical consumables	To show efficient management results in a healthcare structure to manage the storage system using Kanban tools.
Bendavid *et al*.[22]	Canada	Nursing	Medical products	To study a two-bin "e-Kanban" replenishment system based on RFID technology.
Patterson[20]	Missouri (USA)	Operating room	Operating room supplies	To describe a brief case study about how Kanban was implemented and its main results in an OR.
Xu *et al*.[23]	The United States	Dental Hygiene Care Facility	Medical products	To examine the integrated medical supply inventory control system using the two-bin method.
Patterson[24]	New York	Operating room	Medicine trolley	To implement Kanban to improve the management of medicine trolley.
Aguilar-Escobar and Garrido-Vega[26]	Spain	Hospital	Medical consumables	To analyse the principles, practices and applicability of Lean Production to manage the supply chain.
Bhat and Jnanesh[27]	India	Hospital	Medical records	To reduce the cycle time of outpatient department service in a rural hospital.

Aguilar-Escobar *et al.*[28]	Spain	Nursing	Medical consumables	To examine nurses' satisfaction and see how they valued implementation of Kanban method in hospital supply chains.
Pineda-Dávila and Tinoco-González[29]	Spain	Outpatient rehabilitation	Medications and consumable health material	To evaluate the reduction in costs and the increase in time devoted to the patient by applying three Lean tools: Kanban, 5S and 2P.
Wilson *et al.*[30]	Texas	Health centre	Medical products	To describe a pilot implementation of a fixed order quantity Kanban system for supply replenishment in an outpatient clinic at a cancer centre.
Jeffries *et al.*[31]	Seattle	Cardiac intensive care unit	The activity of mechanical ventilation	To create a process, based on the use of Kanban, to ensure that supplies are delivered to the right location, at the right time, in the right quantity.
Donnelly *et al.*[32]	The United States	Radiology	Radiology supplies	To describe and evaluate the performance of a demand-flow supply-chain replenishment system (Kanban).
Papalexi *et al.*[16]	Greece	Pharmacy	Medicines	To explore the implementation of the Kanban system in the pharmaceutical supply chain.
López- Ramírez *et al.*[33]	Colombia	Hospital	Medications and consumable health material	To provide a solution to the problems arising with the administration and control of inventories of a hospital in Cali.

Lim *et al*.[34]	Benin and Niger	Health centre	Vaccine doses	To propose alternative ordering policies based on using inner pack quantities and draw upon visual management (Kanban).
Kanet and Wells[35]	-	-	Medical supplies	To examine the two-bin Kanban model and develop a total cost model that includes holding and replenishment costs
Mouaky *et al*.[36]	Morocco	Pharmaceutical Supply Chain	Pharmaceutical inventory	To propose the Adaptative Kanban System to manage pharmaceuticals inventory of the Moroccan public Pharmaceutical Supply Chain.
Castro *et al*.[37]	Portugal	Hospital ambulatory pharmacy	Medications and consumable health material	To increase the efficiency of hospital ambulatory pharmacy by applying Kanban.
Gurumurthy *et al*.[38]	Kerala (India)	Hospital	Medical materials	To apply Lean Thinking techniques to achieve inventory levels reduction, save costs, and increase the efficiency of stores and purchase executives.

Note: RFID (Radio-Frequency Identification). Source: Authors' elaboration.

Table 4. Barriers founded when applying Kanban system in the articles reviewed.

	Papalexi *et al.*[16]	Persona *et al.*[21]	Patterson[20]	Aguilar-Escobar and Garrido-Vega[26]	Bhat and Jnanesh[27]	Aguilar-Escobar *et al.*[28]	Pineda-Dávila and Tinoco-González[29]	Wilson *et al.*[30]	Lim *et al.*[34]	Gurumurthy *et al.*[38]
Ignorance of the methodology	**X**				**X**		**X**			**X**
Data confidentiality					**X**					
Complicated data collection					**X**					
Biased analysis						**X**				
Small sample						**X**				**X**
Fear of shortage of the required medicines	**X**	X								**X**
Fear of key suppliers' failure to deliver on time	**X**									
Fear to implement a new and innovative technique	**X**									
Human resource resistance								**X**		
Sizing the bins			**X**							
Determining the products' lead time for ordering			**X**							
New transportation devices needed									**X**	

Moderate increase in operational costs							**X**			
New investments needed				**X**						

Source: Authors' elaboration.

Table 5. Benefits related to stock management derived from Kanban implementation.

	Stock reduction	More orderly stores	Expired items reduction	Stock outs reduction	Storage space optimization	Mistakes avoided	Multi-order preparation	Stock updated in real time	Products' internal tours reduction	Time for delivery was reduced	Reliable availability of supplies	Increase packing efficiency	Better stock turnover rate	Reduction of storage delay	Cost reduction
Papalexi *et al.*[16]	**X**										**X**				**X**
Persona *et al.*[21]	**X**	**X**	**X**			**X**			**X**						**X**
Bendavid *et al.*[22]	**X**														
Xu *et al.*[23]								**X**							
Patterson[24]	**X**														

Patterson[25]	X			X										
Aguilar-Escobar and Garrido-Vega[26]	X				X	X	X	X	X					
Aguilar-Escobar *et al.*[28]		X	X	X	X									
Pineda-Dávila and Tinoco-González[29]			X											X
Wilson *et al.*[30]	X			X										X
Jeffries *et al.*[31]				X	X									X
Donnelly *et al.*[32]			X								X			X
Lim *et al.*[34]					X	X						X			
Kanet and Wells[35]						X								
Mouaky *et al.*[36]	X									X			X	X	X

Castro *et al*.[37]	**X**			**X**						**X**					**X**
Gurumurthy *et al*.[38]	**X**			**X**											

Source: Authors' elaboration.

Table 6. Benefits associated with productivity after the application of Kanban system.

	Time saved	Productivity gains	Create a continuous flow during the production process	Improving medical records	Impact on professional´staff (satisfaction)	Decision process and job simplification	More agile communication	Waste reduction	Statistical process control increase	Less paperwork	Risk of accidents reduction	Better smoothing of the workload over the year	Workload reduction
Papalexi *et al*.[16]	**X**	**X**	**X**			**X**		**X**					
Patterson[20]	**X**				**X**								
Bendavid *et al*.[22]	**X**	**X**			**X**								
Xu *et al*.[23]	**X**												
Patterson[25]					**X**		**X**						

Aguilar-Escobar and Garrido-Vega[26]	**X**	**X**			**X**						**X**		
Bhat and Jnanesh[27]				**X**									
Aguilar-Escobar *et al*.[28]	**X**				**X**								
Wilson *et al*.[30]	**X**												
Jeffries *et al*.[31]								**X**					
Donnelly *et al*.[32]	**X**												
Mouaky *et al*.[36]												**X**	
Castro *et al*.[37]		**X**											
Gurumurthy *et al*.[38]						**X**							**X**

Source: Authors' elaboration.

Table 7. Positive effects on patients after Kanban implementation.

	Better service to the patient. Increase service quality	Quick and accurate service of patients	Mistakes reduction	Hospital stay length reduction	Complaints reduction	Time dedicate to patient treatment increase	The organisation knows better customer needs	Anaesthesia time reduction	Safety issues reduction	Hospital infection rates reduction
Papalexi *et al.*[16]	**X**							**X**		
Patterson[20]								**X**		**X**
Aguilar-Escobar *et al.*[28]	**X**			**X**						
Pineda-Dávila and Tinoco-González[29]						**X**				
Donnelly *et al.*[32]			**X**					**X**		
Lim *et al.*[34]			**X**							
Castro *et al.*[37]	**X**									

Source: Authors' elaboration.

Figure 1. Flow diagram of the paper selection process.

Figure 2. Evolution of published papers over time.