PONTIFÍCIA UNIVERSIDADE CATÓLICA DO PARANÁ
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LEAN IN HEALTHCARE: A SYSTEMATIC LITERATURE REVIEW AND SOCIAL NETWORK ANALYSIS

CURITIBA
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Dissertação apresentada ao Programa de Pós-Graduação em Engenharia de Produção e Sistemas. Área de concentração: Gestão de Produção e Logística da Escola Politécnica, da Pontifícia Universidade Católica do Paraná, como requisito parcial à obtenção do título de mestre em Engenharia de Produção e Sistemas.

Orientador: Prof. Dr. Sérgio E Gouvêa da Costa

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ABSTRACT

In order to address the inefficiencies reported in health care, the application of Lean thinking has been gaining increasing attention from both the academic world and industry over the past decade. As a result of this interest, a substantial amount of research on the theme has been published in recent years, presenting an opportunity for broad literature reviews for organizing the research and proposing lines of research for the future. Taking this background into account, this dissertation aims to map out and analyze the development of scientific research in Lean Healthcare, identifying current research topics and setting a course for future research. In order to achieve this objective, a systematic review of the literature was conducted involving meta searches in six databases resulting in a total set of 280 papers. Exploration by Bibliometric citation/co-citation, Social Network and content analysis were employed respectively as the strategies for investigating progressive extracts from the articles sampled. These analyses are divided into three main phases. First, a general set of papers was classified according to the data they contained, methodology used, country of origin and source. Based on citation/co-citation the key documents and authors that are a reference for the knowledge available in this field were also determined. In the second phase, a sample selected based on Journal citation report (JCR) indexes was analyzed by more sophisticated Social Network analysis techniques revealing the main contributors in lean healthcare, knowledge groups and main themes. In the third phase, the most cited empirical research was explored using content analysis presenting an overview of the practices and performance gains for Lean in healthcare. The studies developed reveal a still emergent field marked by the striking presence of descriptive empirical research and limited exploration of the research methods. Still among the main authors the data indicated low levels of individual productivity and discontinuity of the research efforts, resulting in implications for the theory building and delays in the transference of theory to practice. The intellectual structure of the field presents substantial knowledge and still poorly explored relationships, indicating abounding possibilities for research and involvement of Operations management in this emergent area.

Keywords: Lean Healthcare. Social Network Analysis. Scientific production.

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SUMMARY

1. INTRODUCTION

Fostered by international concerns around healthcare systems performance, over the past decade Lean thinking has been increasingly applied in hospitals for improving quality and reducing costs (GROVE ET AL., 2010). Although its roots are in manufacturing, the initiatives demonstrate highly successful results in healthcare, as several authors have referred to it as one of the most widely used methodologies for process improvement in the healthcare industry over the past decade (DE SOUZA, 2009).

This popularity, in turn, has been attracting increased academic interest and a substantial amount of publications in journals and conferences, such that the theme has begun to appear as a recurring research topic, deserving some attention as a field of study. Hence, since it has reached some relevance, concerns are emerging regarding its development as scientific research.

In this vein, several authors highlight the importance of effective literature reviews as an instrument for promoting the progress of research fields (HART, 1998; BARNES, 2005; WEBSTER & WATSON, 2002).

As a first benefit, the method helps to identify what is already known in the body of knowledge and how one can contribute something new (LEVY AND ELLIS, 2006). It is said that literature reviews facilitate theory development by closing areas where there is already an excess of research, and determining areas where research is needed (LEVY AND ELLIS, 2006). Additionally, as highlighted by Taylor and Taylor (2009), reflecting on the past and current state of a discipline is fundamental for determining future directions and trends.

Taylor and Taylor (2009), further reinforce the importance of this practice for personal career advancement by knowing which themes are most likely to be the “winners” and “losers” in terms of importance, publication potential, and academic standing (TAYLOR AND TAYLOR, 2009).

Hart (1998) also emphasizes that this practice may not be underestimated and quotes the example of some fields such as engineering, where the absence of proper literature reviews has resulted in hindered theoretical and conceptual progress.

This is because, more than providing a direction for research, literature reviews facilitate the theory building process. For theories to be formed, it is

necessary to go through iterative cycles, where researchers build upon the work of others (CARLILE AND CHRISTENSEN, 2005). Literature reviews in this sense, bring to the surface existing knowledge allowing researchers to perceive the progress and take advantage of other's discoveries, expanding the field further (LEVY AND ELLIS, 2006).

As a last point, it is well known that the validity and reliability of a study is ensured by the quality of the sources that serve as foundation for its development (LEVY AND ELLIS, 2006). Assuming that all published material is not equal in quality and relevance to a particular topic, Pilkington and Meredith (2009) suggest that another and more relevant contribution of a literature review lies in revealing the intellectual structure of a research field by identifying the most influential and important publications in the area and their relationship to each other, providing subsidies for researchers to be able to channel efforts into what is really important. (PILKINGTON AND MEREDITH, 2009).

Furthermore, building theoretical foundations based on quality resources enables researchers to better explain, as well as understand, problems and solutions that address actual issues with which practitioners are struggling. (LEVY AND ELLIS, 2006)

In relation to Lean in healthcare research, no major reviews of the field have been presented. Among the articles identified in the related search, six papers that attempt to review part of the literature were found. Most of them, however, were focused on implementation issues or are restricted to a determined setting.

Among the ones that seem to present broader coverage of the field, we can quote the research of De Souza, that provides general characteristics of the field and its evolution based on a literature review of more than ninety papers and also classifies these papers into six different categories, offering a good view of what constitutes the Lean healthcare literature. Poksinska (2010), on the other hand, concentrates her analysis around the tools and practices of Lean healthcare inside a broad research scope where barriers, challenges, enablers and outcomes are also studied, based on a review of thirty (30) studies. As the last example, Mazzocato et al (2010) is devoted to analyzing the practices and results of lean healthcare and pointing out possible improvements in the method based on an analysis of 33 papers. As far as this research

extends, studies devoted to provide an outline of the Lean in Healthcare literature in its general scope are not yet present in the current literature, specially regarding to which actors and topics are in fact relevant for this field.

Therefore, taking into account the background presented, this dissertation aims to map the development of scientific research in Lean Healthcare identifying the main practices and current research topics. By promoting the mapping of the field, the most important authors and publications of Lean in healthcare and the relationships among them will be determined, as well as general characteristics of research in the area.

In order to achieve this objective, the systematic literature review method was adopted, aiming to grant more objectivity and reliability to the analysis, avoiding in part the highly personal and interpretative character of common literature reviews (SHAW, 1995). As the analysis techniques, Bibliometric citation/co-citation, Social Network and content analysis were employed respectively as the strategies to investigate progressive extracts from the sampled articles.

1.1. RESEARCH PROBLEM

The recent transference of Lean to Healthcare has shown a rising interest both in the academic world and industry. This relevance is reflected by an increasing number of publications in journals and congresses dealing with the theme.

On the other hand, many researchers hold that there is a low level of understanding about how the Lean philosophy should be applied in healthcare companies and the variables involved in this process (PAPADOPOULOS, RADNOR AND MERALI, 2011).

Taking the affirmations above into account, one can infer that the researchers in the field have been failing on some level or encountering difficulties in building upon the work of others, which results in implications for the theory building process and delays in the transference of developing theory to practice. One of the possible causes for this can be explained in terms of an absence of proper literature reviews in the area, which, according to Shaw (1995) contributes to the lack of theoretical and conceptual progress in the

research field. Therefore, taking this background into account, this study aims to contribute to the development of research in Lean Healthcare by posing the question as follows:

How the research in Lean Healthcare has been developed and what are the main research areas, gaps and contributors for this field?

1.2. RESEARCH OBJECTIVES

1.2.1. General Objectives

To map the characteristics of scientific research in Lean Healthcare identifying the main contributors for this field, research areas and opportunities.

1.2.2. Specific objectives

As specific objectives:

OE1) Perform a systematic review of the literature, providing a general perspective of the research area and identifying the main themes and contributors to the field;

OE2) Identify the main practices employed and particularities of the Lean initiatives in the area in order to identify underused tools and implementation difficulties to be explored by research;

OE4) Based in the results of the topics OE1, OE2, and OE3 elaborate a research agenda;

1.3. JUSTIFICATION

Although often employed in some areas of knowledge related to Medicine (Mulrow, 1994), we have found that there is an opportunity for the application of a systematic literature review in Lean healthcare to organize the amount of already published results that have not yet been properly explored and propose lines for future research. We justify this position based in preliminary studies that indicate the existence of few reviews and the absence

of examples involving more sophisticated methods of analysis and exhaustive meta-searches. Some reviews can be found, however, they address empirical questions usually based on simple qualitative analysis. On the other hand, the literature already reached a volume of publications that allows the development of a literature review.

1.4. METHODOLOGY

This research is a systematic literature review that employs a combination of quantitative and qualitative methods for analyzing a database. Regarding the strategies of analysis basically three methods are employed: bibliometrics (including citation and co-citation), social networks and content analysis.

Therefore regarding the research method, this research can be framed as a theoretical/conceptual study, since it is totally based on conceptual discussions about the literature (CAUCHICK, 2012). Its nature is predominantly descriptive, since the main concern is posed in terms of describing and classifying a population or phenomenon (SELLTIZ, WRIGHTSMAN AND COOK, 1987).

This research can also be framed as a documental study, since it employs a set of 280 scientific articles from the Lean Healthcare literature as a data source. Regarding the moment the data collection occurs in a longitudinal approach since the collected information occurs at several moments on a time line, aiming to analyze evolutionary aspects of a concept, not the state at a specific moment (FREITAS, OLIVEIRA, SACCOL, & MOSCAROLA, 2000).

Taking into account the unique nature of systematic literature reviews, beyond the methodological characteristics, several details are involved in the research process (Conforto, Amaral and Da Silva, 2011), and need to be specified. These topics are treated in the third chapter which is devoted to presenting the conceptual background behind each technique justifying their choice and detailing the intended goals with their application. The procedures for acquisition, delimitation, data treatment and details of the sample considered in each analysis are also presented.

1.5. RESEARCH STRUCTURE

This dissertation is structured around five main chapters, complemented by an introductory and final conclusions section.

The relation among the research objectives and these chapters are presented in the table below (table 1).

Table 1 - Structure of the research development.

#	Objectives	Topics addressed	Research method
2nd Chapter	Comprehend the basic concepts of the application of Lean in Healthcare	1. Lean practices and tools 2. The Healthcare environment 3. Determine how the Lean tools can be employed in this context.	Literature Review
3rd Chapter	Determination of the model, analysis techniques and procedures for systematic literature review	1. Systematic literature review models; 2. Bibliometric methods including citation and co-citation; 3. Social Network Analysis; 4. Content Analysis	Literature Review
4th Chapter	Trace the evolution of the theme and identify the main research themes and contributors for the literature in the field	1. Research methods; 2. Countries with major publication representativeness 3. Publication outlets 4. Main authors and documents 5. Main knowledge groups and macro themes	Bibliometric methods and Social Network analysis.
4th Chapter	Determine how the research has been developed in the area by analyzing the current patterns for knowledge construction in the field revealed in the citations and co-citations	1. Level of knowledge exploration in the field 2. Analysis of the level of collaboration for the articles construction; 3. Evaluation of the level of continuity if the research efforts in the field; 4. Determination of the most central authors; 5. Determination of the authors that most cite and are cited in the field (SA); 6. Analysis of the publication sources of the SA; 7. Determination of the research method of the SA; 5. Classification of the SA according to subject area; 6. Determination and analysis of the knowledge groups of the field; 7. Determination of the main research themes;	Bibliometric methods and Social Network Analysis.
4th Chapter	Identify the main practices employed and particularities of the Lean initiatives in the area in order to identify underused tools and implementation difficulties to be explored by research	1. Tools and strategies employed in Lean healthcare; 2. Outcomes of these initiatives.	Literature review and exploratory Content Analysis.
5th Chapter	Elaborate a research agenda.	1. Central articles and pioneer initiatives in LHC; 2. Recommended reading and research opportunities in articles reporting applications in LHC; 3. Recommended reading and research opportunities when adapting lean to the healthcare context.	Citation and qualitative analysis.

1.6. RESULTING PUBLICATIONS

Until the present moment, five publications derived from this study, which are presented below (table 2).

Table 2 - Publications derived from this research.

Reference
BUZZI, D AND PLYTIUK, C (2011). Pensamento enxuto e sistemas de saúde: Um estudo da aplicabilidade de conceitos e ferramentas Lean em contexto hospitalar *Revista Qualidade Emergente (2011) V.02, N.02*
LEITE et al., (2012). Lean office, logistics and health: Um estudo sobre a aplicação de ferramentas e princípios lean. *XIX Simpósio em Engenharia de Produção.*
PASQUALINE et al. (2012). Performance management in healthcare: A Bibilometric review. *Proceedings of the 2012 Industrial and Systems Engineering Research Conference. Orlando, EUA*
PLYTIUK et al. (2012). Lean Thinking in Health care: An overview of the research characteristics, themes and knowledge groups (1998-2011). *Proceedings of the 2012 Industrial and Systems Engineering Research Conference. Orlando, EUA*
PLYTIUK et al. (2013). Practices and Performance gains of Lean Healthcare: An analysis of empirical papers. *Proceedings of the 2013 Industrial and Systems Engineering Research Conference. San Juan, Puerto Rico.*

Source: Elaborated by the author.

2. THEORETICAL BACKGROUND

This section is devoted to present a general perspective of what is Lean Thinking, including a historical perspective and mainly the practices and tools usually attributed to its implementation. Once, the scope of the research is the specific application of Lean in the Healthcare sector, on the following are discussed some characteristics of the services sector and healthcare, as well as the profile of the Lean initiatives in this area.

2.1. LEAN THINKING

2.1.1. Historical perspective

The roots of lean manufacturing can be traced back to the practices of Japanese automotive industries, especially innovative methods developed by the Toyota Motors Corporation around 1945 (SMEDS, 1994). At this time, a series of post-war difficulties start to come up, compelling the local manufacturers to find alternatives to recover its competitiveness (OHNO, 1988). The adoption of mass production was quoted as a pathway, nevertheless characteristics such as the scarcity of resources, need of diversity and low volume of production showed that the model was inappropriate to the local reality, boosting the creation of a new method: The Toyota Production system (WOMACK & JONES, 1990).

Different perspectives point also contrary to the establishment of a single date, arguing that the system may be more adequately framed as a concept in constant evolution (CUSUMANO, 1985; FUJIMOTO, 1989). According with them, the system is an outcome of a dynamic learning process that emerged from previous practices of the Toyota's family in the textile sector, which dates back 1918, and will do it so on (HOWEG, 2006). Hines, Howeg and Rich (2004) enforce this evolutionary feature presenting four different stages of evolution, by which the philosophy crossed over the years.

At the global level, the first signs of interest by the theme appeared around 1970, when the western manufacturers suddenly started to lose market share to Japanese competitors, as presented in the figure 4 (HOLWEG, 2006). As a reflection of this interest, the early English literature started to arise in the

following years, with authors such as Shingo (1981), Monden (1983) and Ohno (1988), one of the pioneers and main responsible for the development of the philosophy (SOHAL & EGGLESTONE, 1994).

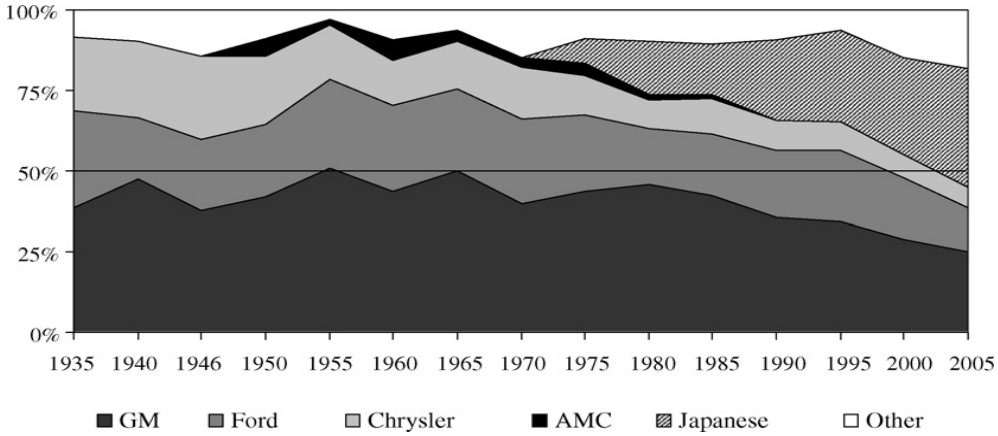

Figure 1- Passenger market share by company 1935-2005.Excludes light trucks.
Source: Wards'Yearbooks, 1950-2005 *apud* HOWEG (2006).

The literature of the epoch may be represented by the remarked works of Hayes (1981), Monden (1981a; 1981b; 1981c) and Sugimori, Kusunoki, Cho and Uchikawa (1977), whatever exemplify the Hines, Howeg and Rich (2004) first evolutionary stage, being them characterized by a focus on shop-floor techniques restricted to industry environments, mainly just-in-time systems and aspects related to it (SCHONBERGER, 1982).

About this epoch, the comprehension of the system was limited to a "silos perspective, where hardily the observers were able to see the methodology as a "mutually reinforcing set of best practices" (SCHONBERGER, 2007). Instead of, this perspective seemed to convey an idea where several positive behaviors and outcomes are almost naturally associated with the single employment of just-in-time, generating a expected cause and effect relation as depicted in the figure (figure 5). At this time also, was common to erroneously assign the superiority of the eastern industries to features such as high level of automation, government support and mainly employee's culture, with a hint of criticism and poor attention to the method itself (ALBERNATHY, CLARK, & KANTROW, 1981).

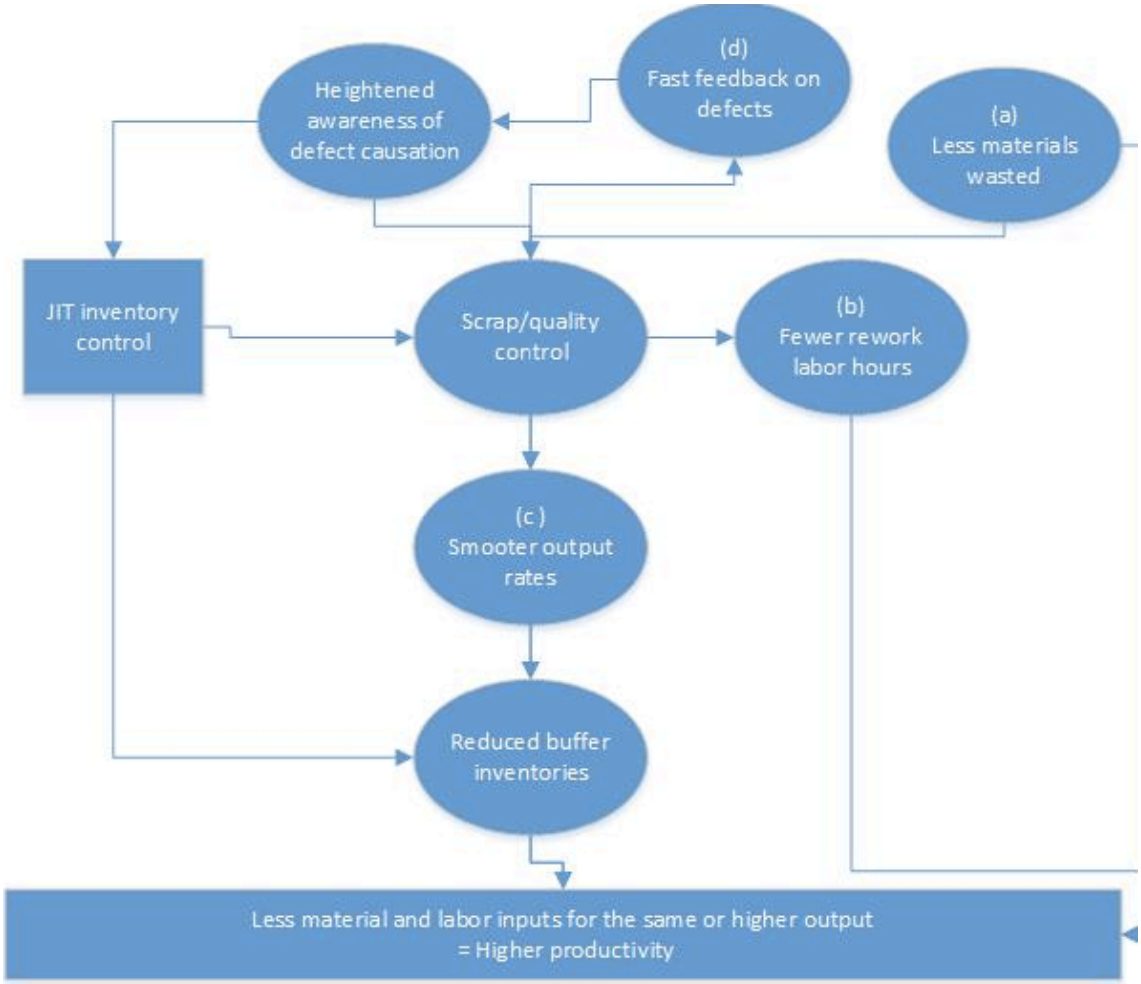

Figure 2 - Effects of JIT production Management.
Source: SCHONBERGER (1982).

The picture starts to change with the publication of the book “The Machine that changed the world” in 1990, which highlights clearly the performance gaps between the Japanese and other carmakers. The book, alongside other works of the epoch, starts to change the focus from isolated techniques to the TPS as a system or philosophy, then named by them as “Lean production” (WOMACK & JONES, 1990). As an important contribution, the book emphasizes further that the method is universally applicable, being possible the transference to other regions or different industries (WOMACK & JONES, 1990).

Regarding to implementation projects, the early initiatives occurred in the Toyota’s car engine manufacturer area around 1950, following in 1960 to the assembly line, and extending to the supply chain ten years after (HINES, 2004). Yet as primary emulations from external organizations can be quoted the cases

of Hewlett-Packard, Kawasaki and Tennant Company, all JIT implementations reported by Schonberger already in 1987 (SCHONBERGER, 1987).

Initially, the extent of the applications was restricted to manufacturing like environments, which are characterized by a strong similarity with the system cradle in terms of volume, product and specie of product (HINES, HOWEG AND RICH, 2004). Thus, some criticism arose and still is sustained regarding to what extent the system really fits and can be effective under non-familiar conditions (COONEY, 2002; LEE & ALLWOOD, 2003). What sounds in some way natural, once the visualization of the analogy among industry and other environments might be more laborious. The still reduced amount of literature and scarcity of reliable successful cases in peculiar sectors can be quoted also as features that contribute to the sustainability of this paradigm.

Nevertheless, sparked by the amount of positive results achieved in manufacturing, gradually this picture has been changing and the extent of the applications has become wider, covering early initiatives in diverse environments from the services sector, including even very peculiar scenarios as hospital and other organizations related to it (DE SOUZA, 2009).

Nowadays, the technique is massively present in literature and industry presenting many successful cases in diverse sectors of business (HINES, HOWEG, & RICH, 2004). Although still existing a high tendency of acceptation from manufacturing organizations, in order to deal with several struggle questions, such as customer satisfaction and quality, the interest by uncommon environments has growing steadily.

Once proper characteristics impede the original model to fit perfectly, adaptations and complementary concepts have been a recent alternative increasingly considerate (HINES, HOWEG, & RICH, 2004). Based on this, nowadays can be observed many researches and case studies reporting use of Lean Six-Sigma or combinations of constrains theory, which has been allowing successful implementations in differentiated sectors, becoming possible environments before discredited to the use of Lean.

Therefore, the concept perseveres to evolve still nowadays, carrying on the recommended continuous improvement cycle. Thus, recovering the lost simplicity of the original structure: the instinct of adaptation from Taiichi Ohno and the Toyota Company that made possible the creation of the own Lean

Philosophy, and mainly, the success of the company in their initiatives (OHNO, 1988).

2.1.2. The Philosophy

Since its creation, countless works about Lean have been published, expressing several different perspectives about how to define the philosophy. Some of them were simply pointing important aspects, but all, in some way, assisting to comprehend more clearly a piece to the synergy behind the Toyota Production System.

The table bellow shows some of the main frameworks and definitions proposed through the years in order to express the essential foundations of the philosophy (Table 3).

Table 3 - Definitions of Lean.

Source	Definition	Detail
(GRABAN, 2009) (LIKER, 2004)	Toyota triangle	System builds upon the integration among human development, technical tools, management approaches, and philosophy creating a Lean organizational culture.
(LIKER, 2004) (GRABAN, 2009) (GLENDAY, 2005)	Toyota House	*Just in time* and *Jidoka,* supported by a central attention in people development, as the pillars that sustain the high quality, low cost and fast delivery of the TPS's. At the base, the operational stability that sustains all the system is build upon the assistance of diverse tools, which vary according to the author.
(WOMACK & JONES, 1996)	Five Principles	1. Specify *value* 2. Eliminate of *the value stream* steps that do not create value; 3. Keep the process *flowing*; 4. *Pull systems;* 5. Pursue *perfection;*
(LIKER, 2004)	Four "P's" of the Toyota Model	I) *Philosophy* as the foundation; II) The appropriate *process* will produce the right outcomes;

		III) *People* development IV) *Problem Solving:* Continuous elucidation at the root cause leads to organizational learning.

Source: Adapted from Graban (2009).

Following a chronological line, the first formal definition appears around 1996 with Womack and Jones in the book “Lean Thinking: Eliminate waste and create wealth into your corporation”. The book is one of the pioneers in the adoption of a focus turned to the method itself, describing specifically the practices and concepts involved, titled by them as “Lean production”. In their work, Womack and Jones present the philosophy as fundamentally based in five guiding principles (WOMACK & JONES, 1996):

1. Value: Define value from the standpoint of the ending customer. As enforced by Waring and Bishop (2010), the definition of value should not be dominated by the provider interests, but instead reflect what the customer will value;
2. Value stream: Identify value-added steps across the department boundaries (the value stream), eliminating steps that do not create value. That is, must be maintained in the process only steps that will in fact add value to the product;
3. Flow: Keep the process flowing smoothly by eliminating causes of delay, such as batches and quality problems. As means to achieve this can be quoted forms of problem solving and change management, and often the re-drawing of activities that add value (WARING & BISHOP, 2010);
4. Pull systems: Avoid pushing work on the next process or department; let work and supplies be pulled, as needed. Therefore, the activities will be directed according to the final customer needs, rather than suppliers;
5. Perfection: Pursue perfection through continuous process improvement. The organization should have embedded in its

> culture the idea of strive yourself continually in the search by perfection in your operations (WARING & BISHOP, 2010).

This vision surfaced aiming to fill the existing gap at the time, where, sparked by the Toyota outcomes and promise of replicability presented in previous publications (WOMACK AND JONES, 1990), arose an interest by a more explicative and practical approach (WOMACK AND JONES, 1996). Thus, the Lean Thinking, is actually a way to summarize and turn explicit the main aspects behind the philosophy as a whole (WOMACK AND JONES, 1996).

However, despite the reliability of the representation, the approach seams to be a little oversimplified when compared to the Toyota fourteen principles, for example. The definition tends to emphasize the principles itself, treating more smoothly essential practices as the philosophical vision and people development. In light of the fact that the acceptance of the lean manufacturing as a set of principles is fairly rooted in the literature (JAMES-MOORE & GIBBONS, 1997), and having in account the content of a reasonable amount of papers, can be inferred that this approach might lead some people to misunderstand the concept, comprehending the Lean philosophy as a species of “cookbook” approach, extremely contrary to the Toyota’s beliefs.

Already, in the representation proposed by Liker (2004), the TPS is presented as more than a production model or merely a set of tools and methods. The representation emphasizes the system as a composed grounded upon a philosophical background, which focuses in add value to the customers and all around through an approach turned to people development (LIKER, 2004).

Behold to the formal definition, the theory is asserted against four basic principles: I) the company must follow its philosophy as the main orientation to your decisions, making the enterprise something more than a way to obtain profits; 2) Suit your processes. The right process will produce the right results; 3) Respect your people: add value to your enterprise steadily challenging your employees and partners to grow; and 4) Elucidate continually the problems at the root cause, allowing organizational learning.

Upon these four topics, fourteen statements were also deployed, forming a broad vision that includes technical, practical and philosophical aspects.

As it follows:

1. Base your management decisions on a long-term philosophy, even at the expense of short-term financial goals;
2. Create a continuous flowing process, in a such way that the problems will come to light;
3. Use pull systems to avoid overproduction;
4. Flush the workload;
5. Establish a culture of stopping and fix the problems, aiming to always obtain quality at the first time;
6. Standardized work as the foundation for continuous improvements and employee learning;
7. Employ visual management, so no problems are hidden;
8. Use only reliable and tested technology, that really attends the needs of employees and processes;
9. Develop leaders that truly understand the job, live the philosophy, and teach it to others;
10. Cultivate exceptional people and teams that follow the company philosophy;
11. Respect your partners and suppliers, challenging and assisting them to improve;
12. Go and see by yourself, to thoroughly comprehend the situation;
13. Make decisions slowly by consensus, considering all the options, and implement the improvements promptly;
14. Become a learning organization through a restful reflection and continuous improvement.

Proceeding to the remaining definitions, two common are “The Toyota Triangle” and “The Toyota’s House, both more adequately framed as representations than formal definitions. These kind of representations are currently used by diverse authors and practitioners as a way to communicate the philosophy, emphasizing in simple words what are the main aspects of it, or establishing how each practice interacts and supports others in the system. Therefore, the correct establishment of authorship of each became somewhat

confusing, since it is a common practice the adaptation of the model, keeping common central ideas, but making minor changes according to differences of interpretations of each author. As examples of the category can be quoted the models provided by Graban (2009), Liker (2004), Glenday (2005), and others. Referring to the content, a generalist definition of each is presented in the table 3 (pg. 35).

Despite of minor changes among the models, some aspects tend to be enforced in the majority of the frameworks: A central attention in people, making reference to customers needs, internal collaborators and suppliers; jidoka and just in time as the main pillars that maintain the system; and the Toyota's philosophy as the background that serve as the basis for all decision making. In the surface appear usually tools and practices that enable the main principles working, that are proceedings, directed related to Lean or not, employed to assist the operationalization of the target concepts (OHNO, 1988). Examples of the species of variations observed in the frameworks are presented in the figure 6 and 7.

Figure 3 - Example of Toyota's house representation.
Source: Larman and Vodde (2009)

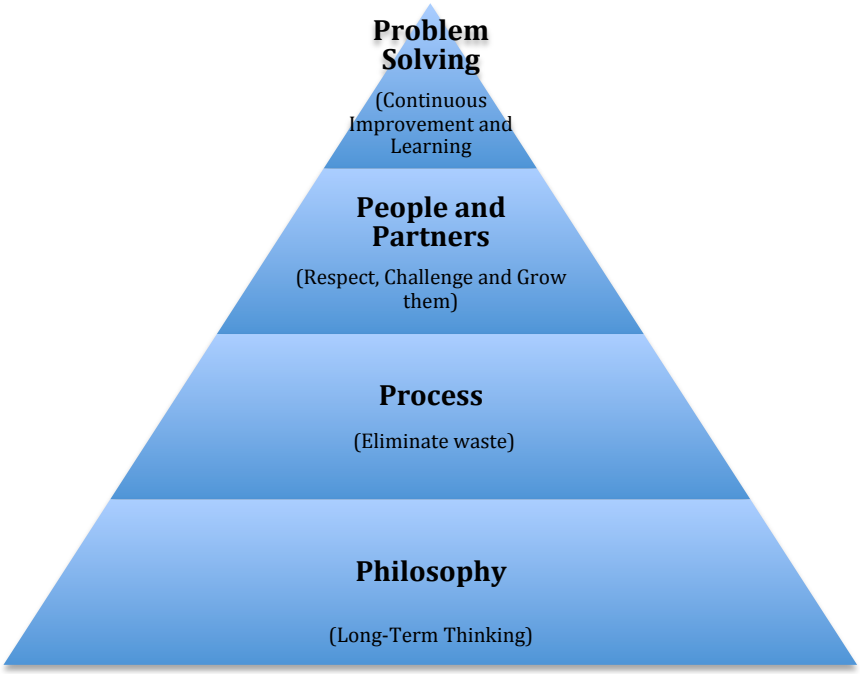

Figure 4. Example of the Toyota's triangle representation.
Source: Liker (2004).

Compiling main aspects of diverse interpretations, the Lean can be understood, in summary, as an arrange of techniques that act together to create a streamlined, high quality system capable to produce finished products following the rhythm of the customer needs, with minimal wastes in the transformation processes (SHAH & WARD, 2003).

Nonetheless, despite of simplistic summaries, the Lean system is actually more than is usually pointed, encompassing mainly philosophical aspects as the foundation of the whole. Several of the core concepts of the philosophy are usually related to raised assumptions and tacit knowledge (LIKER & MEIER, 2007), which are often obscured by the practical and attractive characteristic of the Lean tools.

Based in the philosophical characteristic of the concept and in the light of the exposed, is comprehended that the limitation to a single point definition might neglect important features of the system. Therefore, in order to clarify the concept as a whole, the practices and characteristics conceived as the core concepts behind the philosophy will be appraised individually in the following.

2.1.2.1. The Relation between value and waste

According to Ohno (1988), the foundation of the Toyota Production System is the absolutely elimination of muda, Japanese term that associates to the notion of waste. For them, the efforts of enterprises in order to reduce waste, in turns reduce costs and improve customer satisfaction (SPEAR, 2004)

The core element lies in the visualization of all work as it contributes to an overall end-to-end process (FILLINGHAM, 2007) learning to separate motion (performed tasks) from value (performed tasks that contributes to the value package)(GRABAN, 2009).

Nevertheless, is important to highlight that a meaningful feature of Lean production is its coverage away from a merely focus on cost or waste reduction, to an approach sought to enhance value, or perceived value, to customers (HINES et al., 2004). Task that, still following the Hines, Howeg and Rich (2004) perspective, might be performed through two different ways:

- Internal waste is reduced, as the wasteful activities and the associate costs are reduced, increasing the overall value proportion for the customer;
- Offer of additional features or services valued by the customer. As examples we can quote shorter delivery cycle or smaller delivery batches, which might not create additional costs.

As enforced by Ohno (1988), this orientation is a key feature of the methodology, as the purchase decision is based in what extent the product is in line with the customer requirements, being irrelevant the level of internal costs that the supplier had to obtain the product. Ensuring a kind of strategic positioning, as the alignment between the product features and the customer requirements is continually reviewed (SOHAL & EGGLESTONE, 1994).

The Lean methodology proposes also three specific rules to assist in the process of the differentiation between Value-added (VA) and non-value-added (NVA) activities, being held only steps which are completely according to the following (GRABAN, 2009):

1. The customer is willing to pay;
2. Transform the product or service in some way;
3. Is done correctly at the first time.

Became necessary also the definition of a third kind of activity: the non-value-added, but required activities (GRABAN, 2009). Term defined aiming to make reference to non-value-added, but necessary steps within some processes that have the function to allow the development of the value-added steps. As an example of this category, we can quote the displacement of the professional to perform a VA task. Although, this activity is necessary to allow the development of the VA task, in fact it does not add any value to the product or service.

Following the taxonomy proposed by Ohno (1988), the wastes in the productive processes are elaborated in seven different areas:

1. Transportation: Unnecessary movement of the product, employee and customers in a system. Ex: Distances traveled due to poor layout design.
2. Inventory: Cost associated with inventory excess. Ex.: Own inventory cost, storage, movement costs, spoilage, wastage.
3. Motion: Unrequired movement by employees in the system. Ex.: Part of employee action not associated with addition of value to the product.
4. Waiting: Waiting to the next event to occur or next work activity. Ex.: Customers waiting, unemployed workers.
5. Overproduction: Excessive material production. Ex.: Produce more than is requested by the customer or do it sooner than needed.
6. Over processing: Activities related to unrequested tasks, or to produce a result that will be never used. Ex.: Activities concerning excess of bureaucracy, processes caused by quality requirements not aligned with customer needs.
7. Defects: Losses related to tasks or products performed incorrectly. Ex.: Inspecting for errors or fixing errors.

Several authors add also an eighth designation, the waste of human potential, making reference to the talent inherent in the professions that is unexplored (GRABAN, 2009).

2.1.2.2. Human aspects

According to Liker and Meier (2007), Lean is about adding value to customers, using “people” as the way, affirmation that might be interpreted in many different perspectives, even due to its vagueness.

Ohno (1988), for example, although presents the method as tied directly to a continuous accomplishment in eliminates waste, emphasize that a similar effort in “respect people” is crucial.

Building upon thoughts awakened by Garrahan and Stewart (1992) and Williams et al (1992), Hines et al (2004) enforce the value of the human factor arguing about the importance of motivation, empowerment and respect for people, even making reference to these elements as key factors to the long-term sustainability of the lean programs.

Bringing together the exposed and several other definitions as the ones exposed by Liker (2004), Womack and Jones (1990, 1996), Schonberger (2007) and others, the resulting leads us the idea that the human factor acts in the lean enterprises as responsible for some specie of complementarity or support to other practices. In other words, is the effort devoted to the human aspect that allows the development of a series of skills and practices essential to the working and sustainability of the Lean Systems.

Therefore, some practices and techniques are characteristic of the philosophy; being expected its presence in any environment of mature Lean enterprises. The table bellow presents some of the most important ones and the corresponding definitions (table 4).

Table 4. Some important Lean practices and their definitions.

	Related practices	Behavior
Work design	√ *Standardized work* √ *Experimentalism* √ *Flow of production*	Every activity is realized according to a single defined method *(standardized work),* which was previously designed, and continually improved, through the scientific method *(experimentalism).* The production must flow continually in order to reveal problems when they appear *(production flow)*
Power distribution	√ *Empowered work force* √ *Power decentralization*	Every professional must be equipped with a high level of autonomy, including being accountable for several responsibilities usually attributed to management *(Empowerment).* Thus, ceases to exist the need of several management levels, once the power and responsibilities are shared with the professional. *(Power decentralization).*
Level of specialization (workers and	√ Multi-skilled work force √ Flexible Machinery	Workers shall be fitted with various qualifications, allowing rotation of tasks and replacements. The workers must have also additional skills such as simple machine repair, quality control, cleaning and materials request. *(Multi-skilled work force).* The machinery adopts the same line, being desirable simple and flexible technology (*Flexible machinery).*
Problem-solving behavior	√ Prompt problem solution √ Focus at the root-cause	Obstacles that impede the process to flow must prompt removed, avoiding error propagation *(Prompt problem solution).* The countermeasures must focus in attack directly the root cause of the problem *(Focus at the root-cause).*
Information sharing	√ Information highly shared √ Simple and effective information dissemination systems	The information must be highly shared, allowing anyone to answer promptly to problems and know the global situation *(Information highly shared).* In order to allow this practice, are used simple and effective methods for information dissemination, as such *kanban* and *andon.*
Sense of commitment	√ Organization highly committed √ Employees highly committed	The organization adopts and follows rigorously a high committed human resource police, encouraging a sense of shared destiny in the factory *(Organization high commitment).* The employees in turn offer similar positioning, allowing mutual gains. *(Employees high commitment).*
Improvement Police	√ Continuous process improvement √ Incremental improvements	Pursue perfection through a continuous process improvement *(Continuous process improvement).* Instead of radical modifications, the problems must be addressed through constant incremental progresses *(Incremental improvements).*

Source: The author.

It is important to highlight that in an ideal perspective, the Lean practices must be fairly rooted in people behavior, being the philosophical background naturally the guidance for every step, from the development of new projects to the accomplishment of routine activities. Thus, is expected from people to develop over the time a constant “Lean behavior”, resembling to an achieved capability.

Following the same line, Spear (2005) summarizes in an interesting

manner the Lean philosophy characteristic behavior in terms of four capabilities, which if properly developed and nurtured, are supposed to allow the organization to deliver the kind of operational excellence exhibited at Toyota and companies like it. They are:

1. *Work is designed as a series of ongoing experiments that immediately reveals problems:*

This first rule refers to the Lean concept of standard work. By the term can be understood that “all the work should be highly specified as to content, timing and outcome”(LEE & ALLWOOD, 2003); and performed by all exactly according to the specification, until a second order (SHINGO, 1985).

As pointed by Spear and Bowen (1999), such rigidity regarding to the work methods can lead to the idea of “system inflexibility”. However, in the Lean organizations, the method imposed represents only “The current one best way to safely complete an activity with the proper outcome and the highest quality”. That is, the method imposed is merely the best one defined at the time, which remains constantly exposed to be modified and improved by all (GRABAN, 2009).

As a first benefit, the use of a single method ensures consistent performance levels, while not limited to costs but extending mainly to the dimensions of quality and safety. This because the Toyota focuses in the reduction of the “global cost” through the elimination of wastes, which are directly tied to random activities, inconsistent methods and your inherent variation, the antithesis of standard work (LIKER & MEIER, 2007). As enforced by Ohno (1988), the insufficient rationalization and standardization create muda (waste), mura (inconsistency) and muri (nonsense) in the work procedures and times, favoring the production of defects.

Changing the prospect to focus in hand labor, among the main purposes that justify the employment of standardization, lies in the simplification of work routine. The establishment of a defined method allows the collaborators to devote your time and energy to what is really important, as fees them from the small decisions referring to daily routine (GRABAN, 2009). Still according to Graban (2009), the standardization of the work allows also the proper determination of the process times, avoiding overburdening employees and

unnecessary pressure under them.

The process problems is also an important aspect to be pointed, as one of the purposes of the practice is that the determination of the work method forces the employees to obtain a detailed and proper knowledge about the process and make it explicit. According to Spear (2005), this broad comprehension of the method favors the problems to be immediately discovered, since any unexpected outcome will signalize the existence of previous processes complications, allowing the proper decisions to be taken.

Another feature that contributes strongly to the problems to surface is the production in flow. According to Liker and Meier (2007), one of the main benefits of the creation of flow lies in the easy visualization when a problem occurs (LIKER & MEIER, 2007). This because the term *flow* makes reference to a practice through which the resources are allocated in orders to reduce the displacement distance and the waiting time between operations. Every station in the process are supposed to process the piece at the same time and within the same time interval with no intermediary buffers, in a manner that the component moves along the production line in a single flow of one piece in a complete synchrony. Therefore, in the case of a problem occurrence, it will be immediately perceived once the flow will stop.

2. *Problems are addressed immediately through rapid experimentation;*

Once the problem appears, the philosophy advocates the prompt resolution of the question, even if it implicates in stop the line and reduces productivity in the short term (LEE & ALLWOOD, 2003). Any obstacles or imperfections that impede in some way the production to flow smoothly should never be worked around or passed away (LIKER & MEIER, 2007).

The logic behind this practice lies in avoid to the maximum the propagation of defective products through the system and prevent the corruption of depend processes, besides recurrence of the problem (WOMACK et al, 1990; SPEAR, 2005).

Other important feature of this rule is found in the way that the problem should be dealt: the focus must be pointed in remove completely the obstacle. In other words, eliminating the root cause of it instead of only surface

ramifications or palliative solutions.

In a philosophical perspective, the systems design that favors the problems to become apparent accompanied by the proper problem solving behavior are pointed as the key elements that allow the development of the kaizen (LIKER & MEIER, 2007). According to Ohno (1988), “the key to the improvement process is allow that the shop floor workers to feel the need”. As explained by Liker and Meier (2007), is the discomfort that is felt against a line stoppage or difficulty that powers the process of creating a new alternative, forcing those involved to evolve or fail.

3. Solutions are disseminated adaptively through collaborative experimentation;

This third rule makes reference to the level of communication inside the Lean enterprises and the valuable culture of collaboration and cooperativeness.

According to this practice, “local improvements made in one area need to be shared with other departments to prevent everyone from having to go though the same improvement cycles on their own”(GRABAN, 2009).

However, as weighted by Spear (2005), the improvements achieved are not shared with the aim of simply make replications in other sectors. Instead of, the purpose resides on an intense sharing of experiences by professions of different areas and disciplines with the aim of enrich the knowledge with the several perspectives of the group. Hereinafter, based on experiences of others, each sector became free to emulate or not the model, make their own adaptations or even criticize the method.

4. People at all levels are taught to become experimentalists;

As a final characteristic, the Lean philosophy advocates the decentralization of control and power, being conceptualized as an opposite of the traditional systems where the actions are dictated by a central source (LIKER & MEIER, 2007).

According to the structure, occurs a distribution of the responsibilities over the processes, in such way that every collaborator is responsible for keeping their work and the system flowing and under constant improvement (LEE & ALLWOOD, 2003). The concept lies basically in transfer the maximum

of tasks and responsibilities to the employees that really add value to the product (WOMACK & JONES, 1990).

Since the primary impetus for improvement ceases to be directed and controlled by the administration, individuals are encouraged to provide by themselves answers for their area problems, fostering the creative process (LIKER & MEIER, 2007).

Contrasting to the traditional architecture, benefits can be obtained through the replacement of the mindset, which are pointed by Liker and Meier in terms of two aspects:

- Leverage: all the employees are trained and encouraged to employ the process daily, which allows a tremendous efforts leverage, since the efforts of many individuals to solve the problem are combined, each of them making frequent, small and continuous improvements;
- Focus: The resources are employed to deal with problems in all organization levels, and the efforts can be concentrated, applying greater leverage and multiplying the outcomes. The Toyota applies also the 80/20 rule, effectively applying 80% of their energy under the 20% of the problems that will produce 80% of the total benefit.

From the literature, is clear that this active involvement of workers and shared sense of responsibility is crucial to Lean implementation and that many benefits may emerge from this behavior (BOYER, 1996; MACDUFFIE, 1997; OLIVER et al, 1998; POWER & SOHAL, 1997 apud LEE & ALLWOOD, 2003).

However, as discussed by Spear (2005), some difficulties are likely to be found the search by these capabilities. According to him, the skills formation process must involve intense coaching, mentoring, training and assisting activities to achieve proper results, in other words, the “exceptionally adaptive and self-renewing organization”. Boyer (1996) enforces also this idea, arguing that training is fundamental to develop the employees in order that they became capable enough to support the high level of responsibility required, be multiskilled and provide improvements continually (BOYER, 1996).

Womack and Jones (1990) points also about the importance of the organizational commitment in this process, arguing that the employee's reaction occurs only when exists an awareness that the company really values the qualified workers and will make sacrifices to keep them. In other words, is indispensable the legitimacy of this responsibility from of the organization, being it furthermore able to cause that the employees realize the existence of this engagement.

2.1.2.3. Just-in-time and Jidoka

In addition to these practices, can be quoted also the Just-in-time system and jidoka, two key practices in the achievement of the Lean enterprise, both, according to the Ohno's analogy, the pillars that sustain the Lean systems (OHNO, 1988).

Regarding to the concept of just-in-time, its basic meaning implies that each process should be provided with the right part, in the right quantity at exactly the right point in time (KARLSSON & AHLSTRÖM, 1996). Nevertheless, bearing in mind the purpose of expressing the logic that drives the flow of materials in the Lean philosophy, the concept need to be viewed as a agglomerate where just-in-time, single-piece-flow and pull production act in concern.

Single-piece-flow corresponds to the manner in which the products must go through the production systems. According to this concept, the expected goal lies in allocate the processing of pieces in a continuous single flow, where every station is able to process its activity in a similar time interval, processing one piece at a time and passing it along with no intermediary stocks, acting in a perfect synchrony (LIKER & MEIER, 2007).

Pull correlate to the rule that governs the decision about what and when to produce: the ending customer needs. In other words, the production of a good or service should not be initiated without the customer of the subsequent process request it (WOMACK & JONES, 1996).

Therefore, three basic elements compound the logic that drives the materials in the Lean systems:

1. Definition: an agreement is set out between customer and supplier with specified limits regarding to product volume, mix of models and sequence of the mix;
2. Dedication: items that are shared between two parts should remain dedicated to them. This includes space, storage and others, besides a common reference time (takt-time);
3. Control: Simple methods of control that are visually apparent and physically restrictive keep the agreement.

Owing to an ideal state of the system, is aimed that every process should be provided with one part at a time, exactly when that part is needed (KARLSSON & AHLSTRÖM, 1996), with no stocks and minimal wastes in any part of the process. Being the way to achieve this goal the use of Pull systems to determine quantity and moments to produce, the flow as the manner by which the products flow through the process and a just-in-time production as the rule that conduct all the system working (LIKER & MEIER, 2007).

Alongside of just-in-time, Ohno points out a second important practice as the second pillar of the TPS: the jidoka. Through this peculiar Japanese term Ohno makes reference to specie of differentiated automation. According with him, to achieve the entire benefits of the traditional automation the machines must be endowed by a human touch.

Ohno (1988) argues that the traditional automation provides in fact high level of performance, producing elevated quantities of materials by itself. However, they are unable to recognize and stop when a problem occurs, rapidly spreading high amount of defective components through the system and for this reason needy of constant supervision.

Therefore, jidoka or automation with human touch constitutes a system doted of mechanisms that cause a machine stoppage in case of problems, replacing the employee's inspection role. Thus, is expected from this practice to provide the following benefits:

- Prevent the error propagation through the automatic machine stoppage when a problem is detected;

- Reduce the human direct inspections need, allowing to a single employee to supervise several equipment.

2.1.2.4. Technical tools

In the previous topics we explored the concepts and characteristics that compose in general a Lean environment. These topics can be considerate the core features of the structure, being them the elements that in fact compound the philosophy itself. By way of explanation, the Lean philosophy can be seen as a set of statements or guiding principles that are supposed to allow an aspired behavior, which in turn theoretically sustain the achievement of many benefits in different areas.

Nevertheless, the translation from theory into behavior is likely to include some difficulties, becoming desirable some assistance in order to simplify and facilitate the improvement processes. Thus, as an artesian or a goldsmith that makes use of special instruments to perform his work, similarly the Lean philosophy developed through the years proper methodologies to assist in the operationalization of several of the Lean concepts, the Lean tools.

Owing to the system as a whole, the Lean tools act in a function of auxiliary or support to the guiding concepts, providing important assistance in tasks such as process analysis, improvement of organization and flexibility. Therefore, although the tools represent a secondary role when compared to the principles and concepts, the application of these instruments by itself is already capable of achieve representative improvements in aspects such as reduction of errors and variability, production increasing and overall quality level (PROTZMAN, MAYZELL, & KERPCHAR, 2011).

Therefore, sparked by these potential positive results, several organizations have been trying to replicate Toyota's systems through the exclusively implementation of the production tools. This behavior has led to some misunderstanding about the concept, where the simple tools implementation is wrongly regarded as an adoption of Lean Thinking (HINES, HOWEG, & RICH, 2004).

According to a survey performed in Australia's industry, from 82% of the

enterprises that claim to be adept of Lean production, only approximately 61% present requirements that confirm this assertion, and of this just 10% have the philosophy properly instituted (SOHAL & EGGLESTONE, 1994).

In order to clarify the positive and negative aspects of this positioning, McGill and Slocum (1993) propose a framework that illustrates the relation between cost, value and waste. As can be observed in the figure (figure 8) and argued by Hines et al (2004), the organizations that opt by these direction assume the company desires (quality, cost, delivery) as value to the customer, neglecting the strategic aspects of Lean thinking and limiting itself to cost solutions.

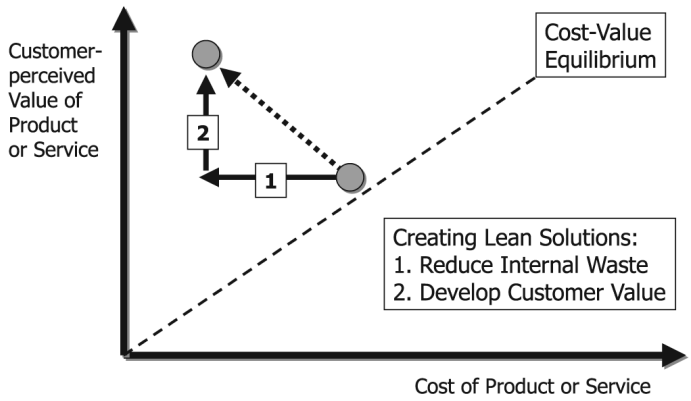

Figure 5. Relation of value, cost and waste.
Source: (MCGILL AND SLOCUM, 1993)

Although the exclusive implementation of the Lean tools may still be attractive for several companies, Hines et al (2004) enforces that the initiatives must be build upon an basic understanding of the difference and relation between the Lean operational level (tools) and the Strategic level (principles), allowing a correct choose by determinate tool or customer value strategy.

Regarding to the tools by itself, the main quoted ones can be pointed as:

- Value stream mapping (VSM): Process by which all the steps across disciplines/departments in a value stream are identified, allowing the determination of which in fact add value to the product and which not. Thus, allowing visualization of the process as a whole and elimination of unnecessary steps (WOMACK & JONES, 1996).

- 5’s: Improve of visual management and workplace organization through five steps (YIH, 2011):
    - Seiri (Sort): Separate out unneeded items.
    - Seiton (Straighten): A place for everything and everything in its place.
    - Seiso (Shine): Clean the workplace up
    - Seiketsu (Standardize): Create standard rules, standard work and standard procedures.
    - Shitsuke (Sustain): Maintain the improvements you have made.

It is important to highlight the last step, once one fundamental feature for the tool effectiveness lies in create a habit of continually execute the steps one to four, allowing the maintenance of a appropriate workplace (WOMACK & JONES, 1996).

- Poka-yoke: Device or procedure intended to impede the error occurrence throughout the processes (WOMACK & JONES, 1996). As examples of this toll we can quote (OHNO, 1988):
    - In case of a fabrication error, the material will not fit in the instrument;
    - If there is any irregularity in the material or work error, the equipment will not start to work.

- Kanban: Visual mechanism used to regulate the flow of material in the factory (WOMACK & JONES, 1996). In other words, kanban is an instrument that signalizes to the supplier the need for more material from of the customer. It can be a simple mechanism as a card, an empty car or an electronic sign that allow the supplier easily visualize quantity and moment to produce (LIKER & MEIER, 2007). In practice, when became necessary the customer removed the material from the established point, signalizing to the supplier that is the moment to replace the quantity removed.
- Cells arrange: Production layout established in order to allow continual flow of material and more effective exploitation of the

human labor (WOMACK & JONES, 1996). According to this arrangement, equipment capable of perform different operations are allocated in a rigid sequence, in general U-shaped, allowing the supervision of a higher number of machines per operator.

- Root-cause analysis: According to Lean philosophy, in order to take correct decisions and solve problems is necessary deep understanding of the question and factors involved, which must be obtained through personal verification of the information (LIKER & MEIER, 2007). In other words, go to the source of the problem, observe and analyze deeply (*genchi genbutsu*), (LIKER & MEIER, 2007). Only then, a decision is taken, which must be defined in order to solve completely the problem and prevent reoccurrence. That is, eliminate the problem directly in the root-cause. To achieve this aim, several tools were elaborated in order to assist in this process. As examples of them we can quote A3, 5 Whys, Ishicawa and others.
- SMED: Once the Lean Production advocates the production in small batches, naturally the frequency of set-ups tends to be higher (OHNO, 1988). Therefore, in order to reduce the expenditures related to non-operational equipment, Shigeo Shingo developed the Single Minute exchange of dies (SMED) or rapid exchange of tools. It corresponds to a method designed to be employed every time that is necessary to make changes in an equipment to resume operation or before start another, allowing to reduce the time required to perform the procedure (LIKER & MEIER, 2007).
- Visual Management: All the information necessary must be maintained in a total visual place in order to allow the employees to perceive if the process under standard condition or if it is occurring any kind of deviation instantly (LIKER & MEIER, 2007). This practice provide also for all the involved in a process the understanding of the whole situation, allowing the correct positioning and decision making (WOMACK & JONES, 1996). This practice is extended to all materials and information, since

organization of supplies and tools, material flow, performance indicators, standard procedures and so on (OHNO, 1988).

- Heijunka: Fluctuations in the quantity produced upraise directly the level of wastes, once additional resources must be maintained to be able to deal with demand peaks (OHNO, 1988). Therefore, according to the TPS is necessary to provide actions in order to reduce the system fluctuations, keeping the quantities as leveled as possible, reducing resources needs and unnecessary process wastes.

2.1.2.5. Practices based in clear needs

In order to conclude, it needs to be mentioned a crucial and often neglected element of the Lean thinking, which we opted to name as “Needs and proposals foundation”. Using this expression, is intended to make reference to the belief that boosted the Lean Thinking idealizers to an inherent and continuous behavior towards the improvement of every task. This mindset can be more fully understood as a pleasure to make better, facilitate and enable the development of the activities under the best conditions possible.

Nevertheless, the aspect that we want to explore lies in the steps taken usually by these people to achieve the improvements. And the foundation that makes possible the birth of every one of the practices that involve the Lean philosophy is the establishment of clear needs and defined proposals (OHNO, 1988).

In order to understand deeply this question, might be interesting to observe how the evolution occurs from mass production to Lean production and note how this is tied to the tools and practices of the philosophy (Figure 9).

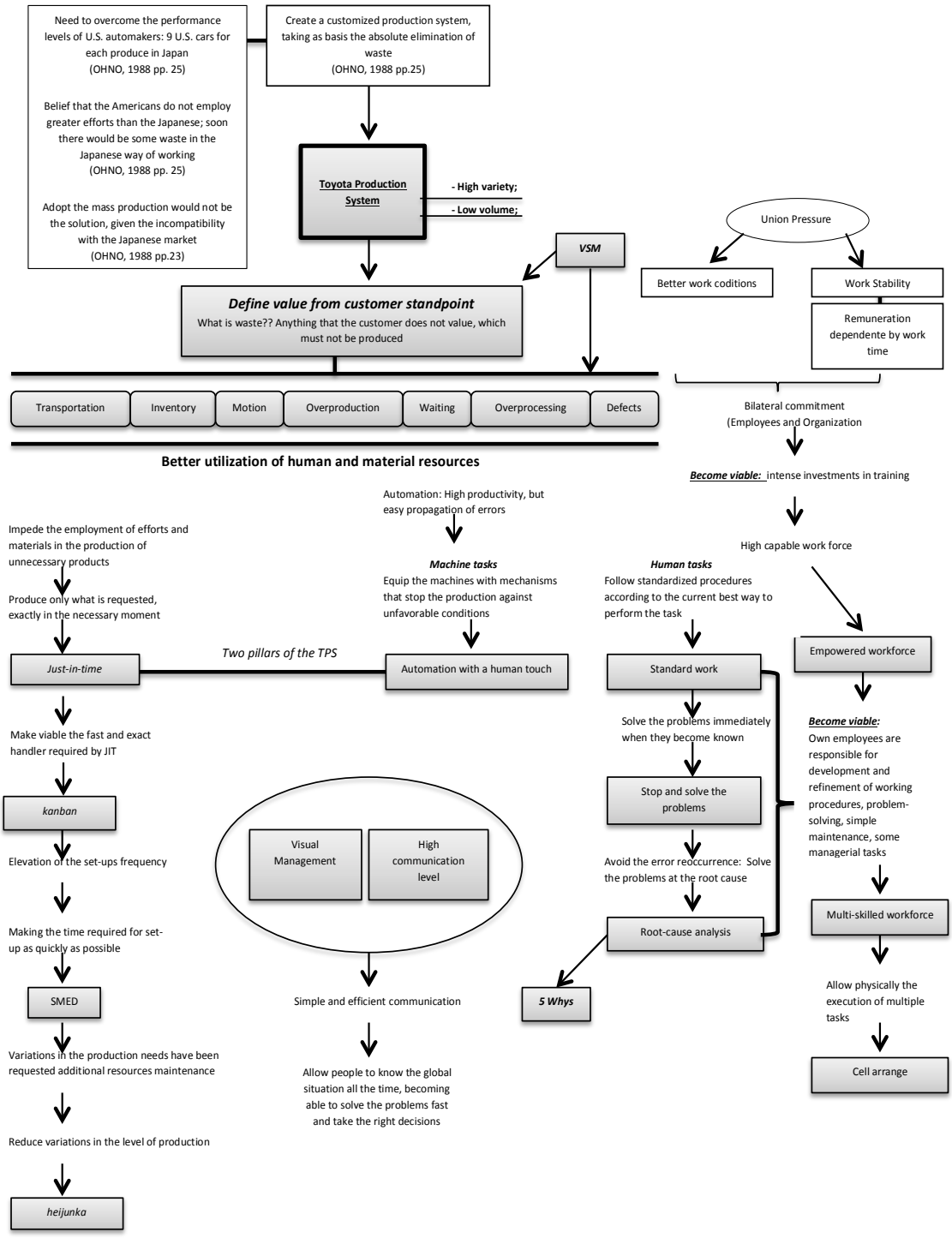

Figure 6 - Toyota's needs and proposals and their relation with the elaboration of the Lean tolls and Practices.
Source: The Author based in OHNO (1988) and WOMACK & JONES (1990)

As exposed, both internal characteristics (market and culture) and resources scarcity made the mass production an inappropriate model to the Toyota's reality. Therefore, the urgency in achieving the US productivity level allied with the impossibility to adopt the current method forced the Toyota to find

alternative solutions to keep surviving.

One interesting feature to be observed lies in the form in which the tools are tied with the Toyota problems of the epoch. As may be seen, the tools were developed in order to solve a determinate question, what made of each of them appropriate and productive. In other words, every tool and practice of the philosophy has a clear motive and proposal to be there.

Thus, as well as an organization that emulates Lean today may fit perfectly with the system, it may not occur, once the company probably has different capabilities and also suffers from distinct problems. Although many of the Lean tools were designed to contain problems that are common in industry, other Toyota's characteristics may or may not be present in different environments making the model inappropriate or incomplete in other situations.

Proper characteristics such as local culture and market as well as played a similar role, as they enforced particular behaviors, which were also recognized and used in favor of the company. As examples of this question we can quote:

- New labor laws and union pressure obligate the adoption of more favorable work conditions and employment stability (WOMACK & JONES, 1990). Thus, became interesting for the organization the provision of intense training, encourages a health relation between employee and employer, resulting in a more motivated and specialized workforce. This in turn, enables broad employment of hand labor and reduction of management levels;
- The work force in turns was subjected to remuneration related to service time, in a manner that was extremely uninteresting leaving a job, once in other organization start from scratch will result in a reduced salary (WOMACK & JONES, 1990). Therefore, the employee commitment was also elevated, once he is dependent from the company success.

Unfortunately, this element tends to be despised by the literature and consequently by the practitioners, in favor of emphasize the Lean tools and their outcomes. The way in which the literature dealt with the theme sounds pleasant

under the eyes of the entrepreneurs and encourages a behavior towards the punctual adoption of tools (LIKER & MEIER, 2007).

On the one side, no problem in emulates the Toyota's solutions. On the contrary, if the company is in a search for a technical solution for a specific problem and found a Toyota tool that will fit for the problem solution, the initiative might be very positive, resulting in outcomes as elevation of productivity, quality improvement or cost reduction.

By other side, considerable negative aspects arise from this positioning, such as the indistinct employment of the tools. Occurs that several organizations start to employ the Lean tools in your departments, and many times through the complete organization, without a clear motive to do it, resulting many times in dissatisfaction with the Lean program, since the results do not appear or appear in an unsatisfactory level.

Other important question posed by some authors lie around the sustainability of the Lean program. According with them, this kind of misunderstanding about the lean concepts tends to impair the sustainability of the initiative, in a manner that is common that the results are lost and programmed to be dissolved in the long term (LIKER & MEIER, 2007).

In fact, the point lies exactly in this: the complete understanding of the situation through the direct observation, clear definition about what is the need, and deep reflection under the problem (LIKER, 2004). Only then came the decision to create an appropriate solution, emulate a Toyota tool or complement with other production method.

Sohal and Egglestone (1994) makes reference to this aspect, arguing based in the observation of the variability by which the Lean is adopted in a sample of several Australian organization that the implementation of the philosophy is positive even if it involves some format modifications in order to best suit particular business needs. In this same line, Hines, Howeg and Rich (2004) states that in fact the Lean method has its limitations, particularly when employed out of the heavy industry. Thus, is not only possible but recommended make associations to other approaches that allow dealing adequately with questions such as variability, volatility and variety. He argues even that besides the complementary with other approaches, the Lean tools even need to be used since the organization practices are aligned with the

philosophy principles.

Hence, is important, as first step to be successful in the lean initiatives, to devote some attention to a basic understanding of the Dynamics and synergy that is involved in Lean thinking and pounder about what are the real factors that allow the Toyota Motors company the achievement of so superior results.

This positioning, allied to a clear definition of own needs and expectations, may allow channeling efforts in the right direction, saving energy and resources.

2.2. THE SERVICES SECTOR

Over many years the economy carried forward dominated by manufacturing, remaining to the services sector a secondary role both within practice and academic concerns (BOWEN & YOUNGDAHL, 1998). This amenity of external pressures resulted in delayed management practices when compared to the development observed in manufacturing, which in turns resulted in inefficient and primitive service systems (LEVITT, 1972).

Nevertheless, around 1970 as a consequence of an increase in the market participation, the quality of the services started to rise, once the sector was not able to maintain its levels against the new demand. Thus, as a response to the concerns of the epoch, Levitt published his first seminal article, which clearly advocates the adoption of manufacturing practices as a potential solution for the problems of the service sector (LEVITT, 1972). According with him, the services sector established the performer of the task as the source to promote improvements, causing the efforts to be erroneously concentrated in change attitudes. On the contrary, manufacturing focuses on the technology. In other words, in finding new alternatives and more effective manners to circumvent and solve the problem, assuming the existent limitations. Still according with him, this humanistic posture prevents the organizations to reach out for new alternatives, compromising future developments.

Therefore, following the industrial paradigm of the time, the services remained focused in replicate the mass-production logic, which may be explained by strict management control, narrow task definition, low-skill and low-paid workers (THOMPSON, 2003; THOMPSON, WARHURST &

CALLAGHAN, 2001).

This practice in turn boosted the employment of new technologies and less qualified hand labor, allowing the achievement of several progresses in the sector, mainly turned to cost reduction (QUINN & GAGNON, 1986). Nevertheless, negative consequences arose alongside, such as the mechanization of the customer contact (QUINN & GAGNON, 1986).

Thus, from the late nineties the services sector once more starts to suffer for shiftings in demand regarding to better quality from of the customers and internal needs by cost reduction (PIERCY & RICH, 2009a). According to researches, the sector is now facing similar situation that was faced with manufacturing, following the tendency of decline fruit from the adoption of mass-production (QUINN & GAGNON, 1986; PIERCY & RICH, 2009; BOWEN & YOUNGDAHL, 1998).

However, the services today represent much more opportunities that previously represented. Actually the sector constitutes the majority employer and source of income for developed economies, accounting for three quarters of gross domestic products in the USA and UK (ZEITHAML et al, 1990). In Brazil, the sector responds for 68,5% of the gross national product and 77,3% of formal employment in the country in 2009 (O Ministério do Desenvolvimento, Indústria e Comércio Exterior – MDIC, 2009). In spite of its economic importance, the sector has not been receiving the proper attention, once the level of the service is whom hath the consumer requested, and have been showing a tendency of decline through the years (DICKSON, FORD AND LAVAL, 2005).

Therefore, as well as manufacturing the services sector finds itself obligated to find alternative approaches to conduct its operations in order to overcome operational difficulties and external pressures (THOMPSON, 2003; THOMPSON, WARHURST & CALLAGHAN, 2001). Thus, from this period onwards the Lean Manufacturing started to be quoted as an alternative also in the service sector.

Nowadays may be observed successful applications of Lean in the service sector. Although is argued that exists a tendency of applications in areas were a physical product exists (PIERCY & RICH, 2009), currently examples in pure service environments may be also observed (PIERCY &

RICH, 2009a; 2009b).

Bowen and Youngdahl (1998) were one of the early papers to mention applications of Lean in services, where they present the cases of initiatives conducted in retail, airline and healthcare. Piercy and Rich (2009a; 2009b) report the achievement of improvements in quality and cost reduction, through low investments in three UK call centers of the financial services sector. Swank (2003) addresses the case of a typical U.S. full-service life insurance and annuities company, which after cross an acquisitions process, adopted the Lean management in order to improve its performance. Through the implementation the company was able to obtain drastic reductions in turnaround time, total labor costs and reissues due to errors (SWANK, 2003).

An interesting work to mention also is the research performed by Maleyeff (2006). Despite of the fact that the focus of the work is not analyzing the results of applications, he examined around 60 different service systems and pointed out similarities between them under a lean perspective. The results showed several common characteristics among organizations from diverse acting areas, presenting the group under analysis as a fertile field for the implementation of the method. Between the features observed may be quoted the lack of standard procedures, long service times, communication breakdowns and poor personal management. (MALEYEFF, 2006).

Nevertheless, despite of the success of several initiatives, many authors argue that the method is still not enough established in the area, requiring additional research to confirm its validity.

Such skepticism may be largely attributed to the belief that the services sector is fundamentally different from manufacturing, being therefore the methods developed in industries inappropriate to deal with the operational management in the third sector (LEVITT, 1972). According to Bowen and Youngdahl (1998), one of the critiques posed lies in the unpredictable nature of the customer demand for service and the excessive standardization of the tasks. Berry (1995) points also that the mentality to manage service employees compromises the service quality, once in this area additional employee discretion and flexibility is necessary (BOWEN & YOUNGDAHL, 1998).

Nevertheless, as pointed by Bowen and Youngdahl (2009 a), if on one side the services posses several characteristics that in fact differentiate them

from manufacturing (intangibility, heterogeneity of encounters, lack of standardization and customer co-production), in the other their practices are also fundamentally based in combinations of transformation process.

Regarding to the services sector characteristics, Grönroos (1990) poses two fundamental aspects that differentiate the management in manufacturing of Services:

- A shift from an interest in internal consequences of performance to an interest in external ones;
- Replacement of the focus in structure to a focus on process.

According to him, it is necessary once the characteristics of services production and consumption modify the original line of thinking, requiring that the main concerns be made around the customer satisfaction (GRÖNROOS, 1990). Affirmation that is endorsed by several other works such as Normann (1984), Albrecht and Zemke (1986), Albrecht (1988), Zemke (1989) and Grönroos (1983, 1990). This because in services the factor that drives profit is the customer perceived quality, which in good part of the services is fruit of the process of services provision, instead of solely in the expected outcome as in manufacturing (HAYNES, 1989).

Exploring better this question, in the following is posed some of the factors that differentiate the services sector from manufacturing:

- Inseparability of production from consumption (GRÖNROOS, 1990) (HAYNES, 1989);
- Role of customer as co-producers (GRÖNROOS, 1990) (HAYNES, 1989);
- Broad interface between service provider and customers (GRÖNROOS, 1990);
- Capacity may be time-perishable with no inventory (HAYNES, 1989)
- Services are often land labor intensive (HAYNES, 1989).

Returning to the work of Grönroos (1990), during his work he poses also some other implications for management positioning due to the sector peculiarities:

- Internal efficiency and cost of operations still being important, nevertheless they must be managed more carefully, as a secondary topic that can not prejudice the external efficiency (costumer satisfaction);
- Front line employees must be endowed with enough authority to take decisions in front of deviations, transforming critical situations in opportunities to correct quality mistakes. Hence, the decision making must be as decentralized as possible;
- Standardized procedures need to be implemented carefully. In services is necessary a more elevated level of flexibility to allow the proper handling of special wishes and other questions. Rigid systems may impede the employees to adopt the correct positioning in front of a differentiated situation.

Nevertheless, despite of general characteristics of the sector, some authors propose also typologies inside of services domain based in the levels of presence of the factors according specifically to the kind of business. It is argued that the classification is necessary taking into account that a better awareness of the situation can allow strategic positioning and additional gains.

Chase (1978), proposed a classification regarding to the level of contact with the costumer in the service provision. The operation must be evaluated considering this aspect and classified in a continuous scale that arose in high contact and finished in the operations that had low contact with the costumer (SILVESTRO, FITZGERALD, JOHNSTON, & VOOS, 1992). Lovelock (1983), proposed a classification regarding to four aspects: nature of product, type of costumer relationship, factors affecting demand variation, characteristics of service delivery. The classification is made choosing a quadrant that corresponds to the business in case in individual matrixes, which one dealing with one of the aspects mentioned previously considering two variables each.

In this same service classification line, other works were also performed

such as Thomas (1975), Kotler (1980), Mainster and Lovelock (1982), Johnston and Morris (1985), Haynes (1990), Schmenner (1986) and Schostack (1987) (SILVESTRO, FITZGERALD, JOHNSTON, & VOOS, 1992). However, in general each of the schemes focuses on determinate dimensions.

Nevertheless, the classification proposed by Silvestro et al (1992) adopts a broader and differentiated approach. Based in an analysis of diverse service systems he discovered patterns in the behavior of six different aspects according to the volume of customers processed by day, that allow the separation of services into tree groups: Professional services, mass services and service shops. This framework is made interesting once it summarizes multiples dimensions in a single framework, which was previously only addressed separately. The aspects considered in the model were:

1. Establish if the core element of the process lies in determinate equipment or people (staff contact);
2. Level of contact time with the costumer per transaction
3. Degree of customization necessary in the service;
4. Extent to which the front line workers can exercise judgment in altering the service package or process referring to superiors (degree of discretion);
5. Determine if the most part of the value is added in the back office or in the front office;
6. Establish if the emphasis lies in the final product or in how the service is delivered (process).

The classification attributed to each of the business kinds regarding to these aspects, already considering the separation into clusters may be observed in the figure 7. May be observed also the kind of business included in each category.

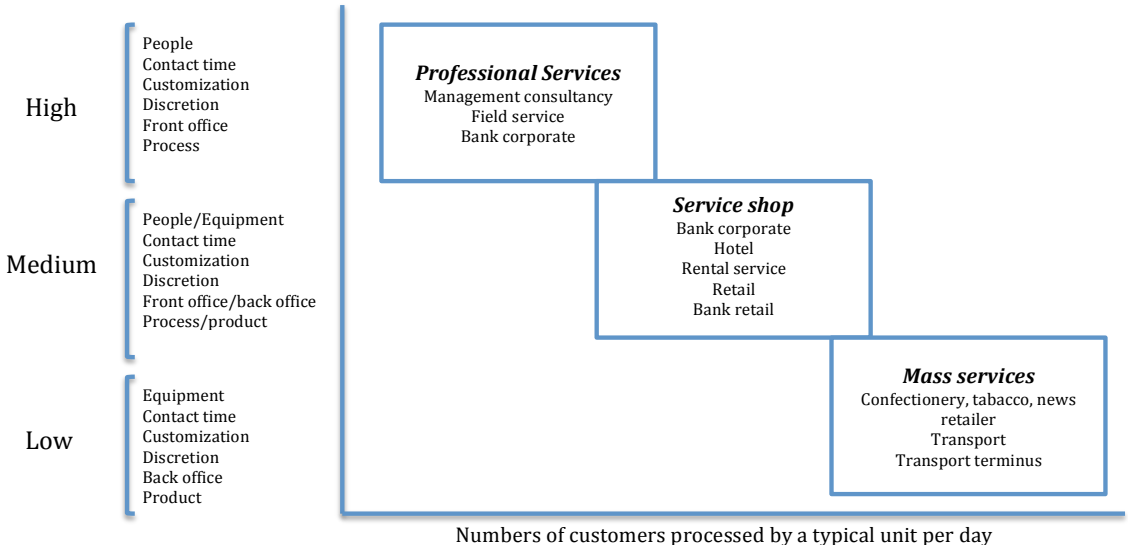

Figure 7 - Services typology according to Silvestro et al (1992).

As a final commentary, Silvestro at al (1992) considers the elaboration of additional typologies within each one of the three categories proposed. According to him, some questions arose from managers of specific areas arguing that exist additional differences in the groups, which if better studied can provide helpful insights regarding to strategic and operational positioning.

Hence, following this line of thinking is interesting to explore additional characteristics concerning the hospitals environments, once it is the object of concern of the present research.

2.2.1. The healthcare environment

Several characteristics are posed by the pertinent literature as peculiarities of the health care environments. Between the main quoted, we found physician culture, variability, outmoded management systems and so on.

As point of departure, healthcare nowadays is a system that suffers because of poor performance in diverse important dimensions of its business such as quality, cost, timeliness, capacity and safety. Raised in these questions, not only the hospital as organization is deteriorating internally, but also has made them a dart shot of public and government pressure (WARING AND BISHOP, 2010).

The safety can be considered the problem with most public emphasis. The concern represents considerable magnitude to the point to cause reactions

of important institutions such as the Institute of Medicine of the United States (IOM, 2000/2001) and National Health Services and department of health (UK) (FILLINGHAM, 2007). Public reports came to disclose publically the occurrence of excessive preventable medical errors, attributing the problem to the poor design of processes observed in hospitals (IOM, 2001). In addition to the official documents, the question is almost a generalized concern, being mentioned in the majority of the area papers.

Nevertheless, despite the greater movement be observed in the United States, the presence of initiatives towards circumvent of similar questions demonstrated the confrontation of significant problems in other locations such as United Kingdom, Australia. (DE SOUZA, 2009).

Despite the most complicated questions, the hospital as business has not been shown to be capable also to attend appropriately to the customer needs. Several researches provide indicia that the hospitals usually are not able to deal appropriately even with the simple aspects as effectiveness of the treatment and timeliness. Is characteristic the involvement of long waiting times to obtain first attendance, during and between medical procedures (FILLINGHAM, 2007). In addition, several times the treatment is not effective, causing the patient to return to the point of attendance for the same motive. As a complicating factor, as well as general services, the demand by differentiated products is rising, as specific examples we can quote customized and patient centered care, promoting additional challenges to these organizations (YIH, 2011).

From an organization point of view, the internal organization of the work systems enforced by peculiarities of the medicine has been culminating in high costs of operation. Compounding the situation, researches point that the questions tend to worsen, caused by factors such as shifting in service demand, population aging and multiplication of treatment varieties, result of the accentuated medicine development (YIH, 2011). According to specialists, the health costs is rising in an accelerated pace to the point of unsustainability (DE SOUZA, 2009; FILLINGHAM, 2007; NHS CHOICES, 2009). The Medicare, American social insurance program, for example concluded that, based in the actual indexes of costs increasing, its system will be insolvent in less than a decade (YIH, 2011). The crisis extends to both public and private sectors, once even the own organization has to bear additional costs, the transfer of the

increase to payers or customers is laborious or restrictive for a considerable amount of the population.

Proceeding to the factors that provide the actual situation of the system, initial considerations may be posed around the growth of medical science and demographic and demand changes (YIH, 2011). Nevertheless, an important role falls to the characteristics of the physician culture and manner by which the profession and organizations related to it has been developed through the years.

According to Yih (2011), due to several old physician responsibilities, education and contextual features, the health professionals are endowed with a culture strongly focused on autonomy (YIH, 2011). As a result, in the medicine exercise most of the work is performed individually and there are few opportunities to learn the skills of a shared decision-making (LAWRENCE, 2002). The organizational structure is also differentiated, being physicians the figures that occupy the top of the hierarchy and almost the single responsible for decision-making (POKSINSKA, 2010). Thus, in these organizations the management plays a more tenuous and laborious leadership than is expected in a traditional business. Therefore, the positioning of the medical professionals represents a significant factor in the manner by which the work is performed in hospitals and related organizations.

Hence, perhaps due to these factors in hospitals the tendency to innovation and replication of manufacturing techniques has developed more slower than in other businesses services (Figure 11) (DE SOUZA, 2009).

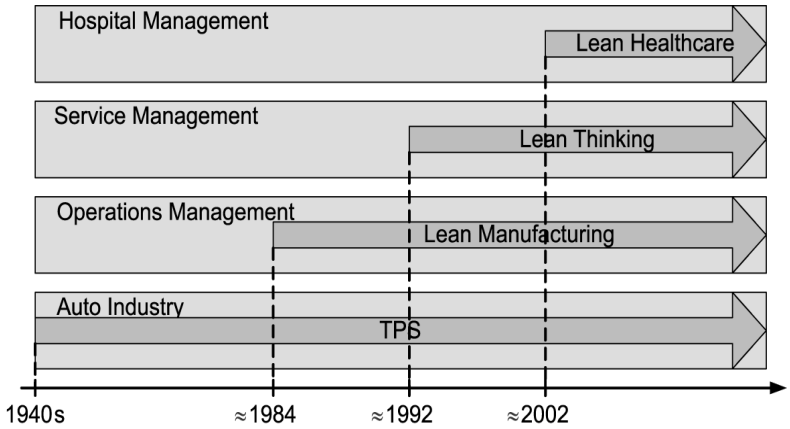

Figure 8 - The evolution of lean healthcare from a historical perspective.
Source: De Souza (2009) adapted from Laursen (2003).

Researches showed that exists a frequent opposition to manufacturing techniques due largely to the apparent dissimilarity between the health environments and the traditional industry (PROTZMAN, MAYZELL, & KERPCHAR, 2011) (FILLINGHAM, 2007). Occurs that in dealing with healthcare the establishment of an analogy between the routine of a factory and a hospital is not so clear, often preventing the professionals to see opportunities for improvement in the methods. Often even, the production methods employment in health is seen as an insult both regarding to patients and employees. For them, sounds disrespectful to see the patients as products and somehow limit the autonomy of the high skilled health hand labor (YIH, 2011).

Proceeding in this same line, Waring and Bishop (2010) mention in their article several critiques that usually underpin the resistance of work force regarding to standardized work practices, a common technique among the main manufacturing approaches:

- The limitation to structured procedures would lead the physicians to lose skills related to other areas of practice;
- Limit the career development;
- Compromise the departments ability to deal with unanticipated changes;
- Belief that the manner by which the procedures are performed must be established by the physician, and may not be subjected to determination of managers;
- That the standard procedures generates additional tasks, which apart the physician of their real responsibilities.

Another factor that difficult the effective design and successful implementation of standard procedures in healthcare settings may be posed also in the inherent characteristics of the environment.

As first aspect, can be observed that the hospitals and related organizations are usually organized in departmental silos, such as radiology, emergency department and cardiology (FILLINGHAM, 2007). In this configuration, the work procedures and decisions are taken independently and

exists a “lack of reliable mechanisms for integrating the individual elements into a coherent whole required for safe and effective care” (SPEAR, 2005). These characteristics imply in an absence of vision of the whole from of the professional involved (FILLINGHAM, 2007), which often creates opportunities for ambiguities. According to Spear (2005), in hospitals often is not clear “Who is responsible of exactly what and how”, producing favorable circumstances to errors occurrence.

The complexity and nature of the procedures may also be quoted as an important factor (FILLINGHAM, 2007). In medicine, the procedures often involve numerous variables, which are subject to change every moment, since immediately before a procedure to the end of it, modifying the whole situation and consequently adequate attitudes. In addition, the product in question is a patient. Based in these and other questions, several decisions and procedures could not be performed by non-physicians, as they are subjected to considerable level of risk (FILLINGHAM, 2007). As well, the medicine exercise is subjected to several jurisdictional boundaries, socio-legal and regulatory pillars (WARING & BISHOP, 2010).

In addition, exists a tendency from the health professionals to work around the problems, instead of eliminate the cause of it (SPEAR, 2005). This implies in a high frequency of recurrent problems, causing in several situations serious consequences. According to Fillinghan (2007), the professionals become used with the problems and tend to accept that and face these situations as “part of the day to day of hospital life”. Waring and Bishop (2010) argues also the existence of problems regarding to the maintenance of standardized procedures in the medical routine through the time. According to their research, exists a tendency to abandon structured practices when the physicians face more busy periods or emergency situations.

As a final point, the poor knowledge of the change leaders concerning the clinical practices and regulatory boundaries is a frequent aspect quoted in the area researches as an important limitation to the manufacturing approaches transference to hospitals (WARING & BISHOP, 2010; POKSINSKA, 2010). According to the professionals of the area, the manufacturing experts often are not endowed with the proper knowledge about the environment, what imped them to positionate themselves appropriately referring to the question. This lack

of knowledge limits the trust in the professional and in his purpose (the method), compromising the process as a whole (WARING & BISHOP, 2010).

2.2.2. Profiling Lean implementations in Healthcare

In the literature about the theme it is possible to observe also a considerable amount of material treating specifically of applications in healthcare settings. The representativeness of these papers is very significant, in a manner that the presence "success histories" can be quoted as a clear feature of the literature of the area.

Despite the methodological failures mentioned before, through this material it is possible to obtain indicia about the manner in which the method has been applied in the hospitals sector. The table below shows some features of applications described in the literature (table 5).

Table 5 - Characteristics of Lean thinking implementations concerning healthcare environments.

Organization	Setting	Aim	Tools	Main Outcomes
Good Hope Hospital (Birmingham, UK) (YOUSRI, Khan, Chakrabarti, Fernandes, & Wahab, 2011)	Trauma and Orthopedics	Improve the outcome of fracture neck of femur patients	VSM	● Reduction of 5% in the overall mortality and 9,3% in the 30-day mortality; ● LOS[1] from 14 days to 12 days; ● Reduction in door-to-theatre time[2] (≤ 24h, from 40,8% to 47,8%) ● Further improvements were also noted in use of trauma beds, but in a statistically insignificant level;
Series of Pilot tests in units linked to Intermountain Health care (Salt Lake city, EUA) (JIMMERSON, WEBER, & SOBEK, 2005)	Shock/trauma ICU, a medical ICU, a general medical/surgical unit, Emergency department, laboratory, dietary support services, Pharmacy staff.	Redesigning work and problem-solving	VSM, A3 Report.	● Reduce the time from a generation of a new medication order to treatment initiation from 4 hours to 12 minutes ● To glucose check in ICU from 17 minutes to 4 minutes; ● Time for unit checks to processes new physician orders from from an average of 43 minutes to 10; ● Increase of 60% in complete charts, improving the chart flow;

[1] LOS (*length of stay)*: Time between admission and discharge of the patient;
[2] Door-to-theatre time: Time between the admission of the patient to the emergency department and the induction of the anaesthesia (YOUSRI *et al.,* 2010).

				● Savings of $849000/year in the process of payment of large vendor accounts due to the new electronic process;
Flinders Medical Centre (Bedford Park, Australia) (BEN-TOVIN, et al., 2008)	Emergency department	Deal with overcrowding.	VSM	● Increase in the number of patients Who did not wait for treatment, from 6,1% to almost 10%; ● Average of LOS on the emergency from 5.4h to 4.8h; ● Less unplanned readmissions[3] ; ● Increase in the number of treatments commenced in compliance with protocols of their triage categories, from 74.2% in 2002, to 79.2% in 2005 (average between the five triage categories); ● Decrease in the number of notifications due to serious medico legal adverse events to its insurers, from 91 in the financial year before the program began, to 19 incidences;
Virginia Mason Medical Center (Seattle, EUA) (NELSON-PETERSON AND LEPPA, 2005)	All Organization	Design your system and process around the patient's needs and eliminate waste.	VMSP[4]	● Improve the floor space in 41%, reducing in 44% the distance traveled by the people and in 72% by the product; ● Reduction in set up time on order of 82%, ● 36% more productivity; ● 53% less inventory; ● Cancellation of investments in expansion: $ 1 million for a hyperbaric chamber, $ 1 to $ 3 million for endoscopy suites, $ 6 million for new surgery suites;
ThedaCare, Inc (Northeast Wisconsin - Eua) (Cima RR, 2011.)	All Organization	Improved staff morale, productivity and quality (reduction	TCIS[5]	● $ 3,3 million in savings in 2004; ● Saved $ 154000 in the Catheterization Lab supply procurement processes;

[3] Unplanned readmissions: Readmission in the emergency department after less than 28 days within the same major diagnostic category (BEN-TOVIN *et al.,* 2008).

[4] VMPS *(Virginia Mason Strategic Plan):* Company's strategic plan, which is represented graphically by a pyramid where the patient is in the top, representing its priority, supporting by four pillars: People, quality, service and innovation. The tool was built based on the VMPS (Virginia Mason production system), a method developed by the company itself modeled on the Toyota production System (WOMACK *et al.,* 2005).

[5] TCPS *(ThedaCare Improvement system):* Like Virginia Mason, ThedaCare create its own improvement system based on Lean Thinking. This system is sustained in three basic tenets for change: 1) Respect for people; 2) Teaching through experience; 3) Focus on world-class performance.

		of defects)		● Reduced accounts receivable from 56 to 44 days equating to about $ 12 million in cash flow; ● Reduced by 50% the time it takes to complete paperwork on admission;
The Mayo Clinic (Rochester - EUA) (Cima RR, 2011.)	Operating Suite of 3 surgical specialties: Thoracic, gynecologic and general/colorectal.	Improve Operating rooms efficiency	LSS - VSM, DMAIC	● Reduction on time to admission of patients; ● Increase in the number of patients arriving on time to the preoperative area, ● Reduction in the overall turnover time and number of surgeries realized after 5PM, result in in an increase in the OR financial performance: TS 22%, GYN 16% and Gen/CRS 50%.
Netherlands Cancer Institute - Antony Van Leeuwenhoek hospital (Amsterdam, Netherlands) (VAN LENT, GOEDBLOED, & VAN HARTEN, 2009)	Oncology	Improve the efficiency of a chemotherapy day unit (CDU).	VSM, root cause analysis techniques, PDCA cycle, benchmarking, RPA[6]	● 24% growth of treatments and bed utilization; ● 12% increase of staff member productivity; ● 81% reduction of overtime;
The Johns Hopkins Hospital (Baltimore, EUA) (Heitmiller ES, 2010)	Overall hospital	Reduce Red blood cell (RBC) product wastage.	LSS[7] - DMAIC	● Overall RBC product wastage from 4,4% to a sustained rate of less than 2%, corresponding to 4300 less RCB units wasted/year; ● Savings in order of $800000 over the 4-year period of the study;
Nationalwide Children's hospital (Ohio, EUA) (L'Hommedieu & Kappeler, 2010)	Pharmacy Operations	Reduce waste in i.v medication preparation and dispensing.	VSM	●Wasted doses dropped from 1339 (16,6% of the total doses dispensed) to 853 (8,6%), representing weekly savings of $ 8197,00; ●Reduction by 2,6% of the annual drug expenditure;

[6] RPA *(Rapid plant assessment)*: Assessment containing a framework that allows to determine if a department is lean or not, and a questionnaire about the application of best practices (VAN LENT *et al.,* 2009).
[7] LSS: Lean Six Sigma Methodology.

Glostrup hospital (Copenhagen - Denmark) (Engelund, Breum, & Friis, 2008)	Kitchen	Increase production efficiency, reduction in the number of employees, maintain both product quality and quantity.	VSM, 5s, kaizen blitz[8]	●Reduction of waste for excess meals distribution from more than 10% to 5%; ●Perception of an increase in the team spirit and efficiency.
Medical Center Groningen (Groningen, Netherlands) (NIEJMEIJER, TRIP, AHAUS, DOES, & WENNDT, 2010)	Traumatology department	Reduction of the average LOS to create more admission capacity and reduce costs.	LSS - SIPOC[9], DMAIC, D-AEP	● Reduction in LOS from 10.4 to 8.5 days, almost 50% of the inappropriate hospital stay;
University of Michigan Medical School (Michigan, EUA) (KIM, MBA, BILLI, & LAWRENCE, 2007)	Radiation oncology department	Improving the delivery of treatments to patients with bone and brain metastases in a timely manner	VSM, One piece flow, standardization.	● Increase in the number of patients receiving consultation, simulation and treatment within the same day, from 43% to nearly 95%.
Metropolitan Hospital (New York, EUA) (Mullaney, 2010)	Central sterile supply	Improve the process of supplying central sterile instruments to the operating room.	A3, Value and waste analysis, Root cause analysis, Standard work, PDSA.	● Reduce the number of flash sterilization from 7/month to 2/month; ● Eliminate surgeries canceled due to missing, mislabeled or defective CSS instruments, before responsible for the average of 4 cases/day.

Source: Elaborated by the author.

As may be observed, are presented several gains derived from Lean initiatives in hospitals. The benefits disclosed reflect that different levels and natures of improvements can be obtained; nevertheless results around safety, capacity, timeliness and reduction of operational costs are substantially

[8] Kaizen blitz: Events where employees and management come together to promote breakthrough improvements concentrating efforts in a specific area. Is a kind of "here-and-now" process where the changes are made enabling the emerge of new ideas (ENGELUND *et al.,* 2008).
[9] SIPOC: *Supplier-input-process-output-client analysis* (NIEMEIJER *et al.,* 2010).

presented.

Negative results on the other hand moreover proved rare. During the preliminary researches no example of completely unsuccessful initiative was found, being possible to observe only failure or insufficient results in specific parts of the projects. These breakdowns are usually poorly explored by the authors, which are likely to focus in the whole, that tend to be positive. Despite of the limitations of this stage to take conclusions, negative results seems to be in fact difficult to be found, once authors of other reviews mention the observation of similar feature (DE SOUZA, 2009; POKSINSKA, 2010; YIH, 2011).

The area where the initiative is conducted is variable, being possible to observe initiatives already performed since in manufacturing-like environments such as laundries, kitchen and supply sterilization; as well as improvement of medical areas as procedures in operating rooms (DE SOUZA, 2009). Regarding to the extent of the initiatives, the papers usually report implementations in specific areas, being unusual tentative in the entire organization.

It is also important to highlight that seems to exist an inclination of the initiatives around the application of isolate tools and principles. In general, seems to be clear the value creation and the waste reduction as a core feature of the method, once this principle is usually put into practice by the organization or unless mentioned in the articles. Nevertheless, the employment of the other tools and methods vary substantially, regarding both to extent and kind of method.

Some authors pose critiques regarding to these feature. One focus of concern lies in the difficulty in measuring and comparing results in large scale. According with them, the lack of uniformity in the method impedes to take conclusions about the best methods or outcomes extension. On other side, it is argued also that additional gains may be obtained from more faithful emulations of Toyota methods.

The papers reflect also some confusion about the concept, once the philosophical aspects of Lean, the core of the philosophy tend to be neglected. Further, these different positioning may be interpreted as a sign that the organizational practice in healthcare calls for some adaptations in the original model.

3. METHODOLOGY OF THE SYSTEMATIC LITERATURE REVIEW

As pointed out in topic 1.5, this chapter is devoted to specifying details of the research process and analysis techniques employed in the present study including the systematic literature review method and the three analysis techniques employed: Bibliometrics, social networks and content analysis

3.1. SYSTEMATIC LITERATURE REVIEW

According to Conforto, Amaral and Da Silva (2011), a systematic literature review can be defined as a scientific method for researching and analyzing articles from a given area of science.

The rationale behind its use is grounded in the need to efficiently integrate unmanageable existing information in the literature and provide data for rational decision-making (MULROW, 1994).

Mulrow (1994) emphasizes the use of the method for identifying, justifying, and refining hypotheses; recognizing and avoiding pitfalls of previous works; estimating sample sizes; and delineating important ancillary or adverse effects and covariates that warrant consideration in future studies.

Cook, Mulrow and Haynes (1997) highlight the difference between the narrative literature review and the systematic literature review. The systematic technique, although also narrative in character, is based on the application of more rigorous scientific methods, and consequently can achieve better results and reduce errors and researcher bias.

Webster and Watson (2002) discuss the effects of systematic reviews in terms of theory development. According to them, an effective review creates a firm foundation for advancing knowledge. It facilitates theory development, closes areas where a plethora of research exists, and uncovers areas where research is needed.

According to Shaw (1995), some fields of study, such as engineering, have chronically suffered from a lack of proper literature reviews, which has hindered the theoretical and conceptual progress.

Nevertheless, in order to produce a good review it is necessary to pay attention to some aspects. As highlighted by Conforto, Amaral and Da Silva

(2011), a systematic literature review must be methodical, transparent and replicable.

In order to contribute to the rigorousness of the process, the literature offers some established models that can be followed in order to operationalize the review.

Among these models we can quote the process proposed by Biolchini et al (2007) that include the following steps:

(a) Planning: Definition of the objectives and development of the research protocol (Research question, key words, search strings, methods, etc).

(b) Execution: Database assembling and delimitation;

(c) Analysis: Extract and compile the documents selected.

As a second example, we can quote the method proposed by Levy and Ellis (2006). As can be observed in the figure below, their model is based on the basic process model of input, process, output. Nevertheless, their model includes the use of analysis cycles in the process stage until the objectives of the review are achieved.

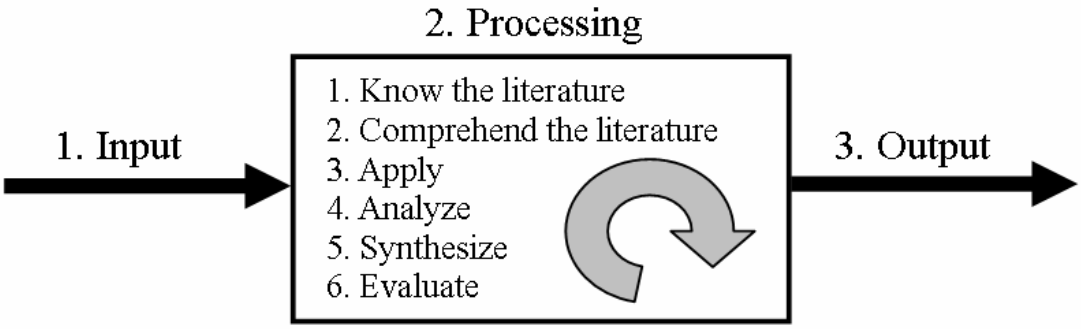

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Figure 9 - The three Stages of an effective literature review process.
Source: Levy and Ellis (2006).

In the specific case of the current research, the model utilized consists of an adapted version of the strategies described above. In order to circumvent limitations found in the process, some aspects were modified and some steps added. An illustration of the model employed can be verified below.

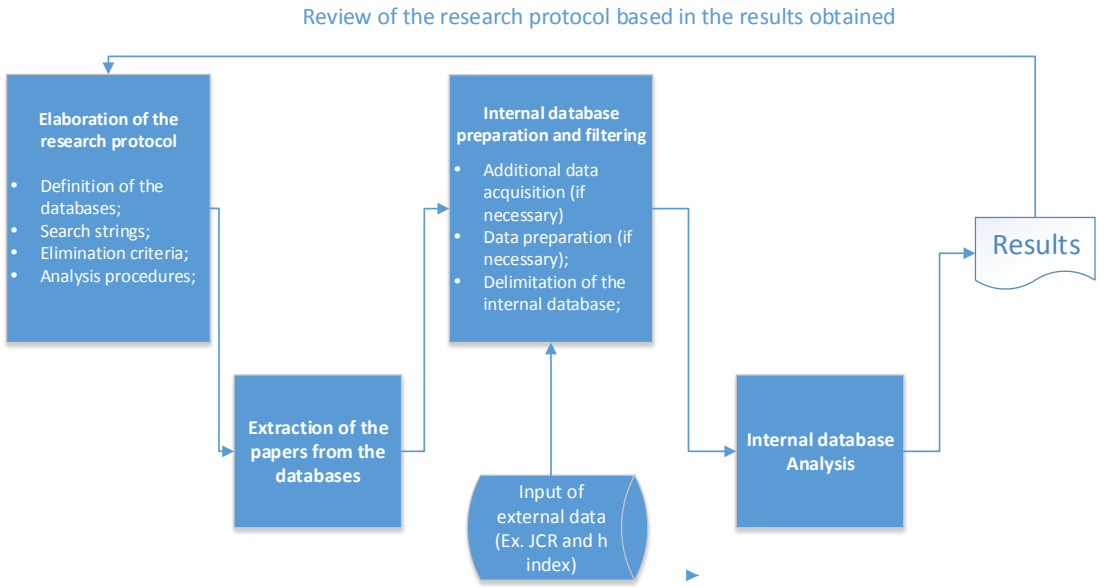


Figure 10 - Procedures followed in the systematic literature review.
Source: Elaborated by the author.

As can be seen, the procedures proposed differ from the models below basically in the following aspects:

- Includes external input of attributes of the primary documents employed in order to execute filters that are not supported by some databases (ex. Journal Citation report (JCR) score and Scopus researcher h index);
- A complete second cycle of the procedures in order to overcome limitations found in the first research protocol and enhance the coverage of the search strings.

The execution of these complementary steps is justified by two topics

- Due to our lack of familiarity with the research topic, we chose to add complementary procedures in order to ensure the appropriateness of the defined procedures;
- The recognition of methodological limitations in the articles selected in the first round, additional filters were applied in order to limit the analysis to relevant sources.

3.2. ANALYSIS TECHNIQUES

3.2.1. Bibliometics

According to Eom (2004), bibliometrics can be defined as the identification of patterns and trends in scientific communications by analyzing quantitatively and qualitatively an aggregate of information regarding authors and documents (conference proceedings, journal articles and books). The bibliometrics allow for the identification of trends in subjects such as core journals and patterns of library use (RAVICHANDRA RAO, 1983).

For Björneborn & Ingwersen (2004) bibliometrics can be further defined as a sub technique of Infometrics, which consists of the same procedure extending the objects of analysis to the electronic communication of media including the Internet and World Wide Web, books, and journals.

Vanti (2002) points to several possibilities for the application of bibliometric, scienciometric and infometric techniques, they include:

- Identifying trends and the growth of a topic or knowledge area;
- Identifying the core journals of a discipline;
- Predicting publication trends;
- Measuring the extent and patterns of collaboration between authors;
- Measuring the productivity of individual authors, organizations and countries.

According to Eom (2004), the application of the bibliometric method can also encompass an analysis of citations and co-citations, which in turn may involve different approaches such as bibliometric coupling, document co-citation analysis, author co-citation analysis, and co-word analysis

Since the present research is restricted to the employment of citation and co-citation analysis, the methodological review will be restricted to these methods

3.2.1.1. Citation and co-citation analysis

The citation and co-citation analysis is grounded on the premise that the frequency of citations of an author or document represents an indication of its importance to the research field. And consequently they tend to exert greater influence over the group than the rest (HANNEMAN AND RIDDLE, 2005).

Thus, based on the citations and co-citations pattern, several analyses can be performed allowing for the extraction of key concepts, methods, or experiments in a field, and visualization in great detail of the relationships between these key ideas (SMALL, 1973).

As highlighted by White and Griffth (1981), this technique presents particular advantages for mapping a research field, since it is characterized by impartiality of judgment and the results are based on hundreds of citers rather than a single researcher.

Citations and co-citations in turn consist of different perspectives of analysis. In citation analysis researchers are interested in identifying the patterns of how published articles are read and cited over time (EOM, 2004). As highlighted by Eon (2004), the citations analysis is concerned with simply counting the citations of a document or set of documents authored by an individual without considering intellectual linkage.

On the other hand, the co-citation analysis is devoted to analyzing relations among pairs of documents cited by a third document, as defined by Small (1973):

> "The number of identical citing items defines the strength of co-citation between the two cited papers. An identical citing item is simply a new document which has cited both earlier papers; therefore, co-citation is the frequency with which two items of earlier literature are cited together by the later literature […] In measuring co-citation strength, we measure the degree of relationship or association between papers as perceived by the population of citing authors"

The co-citation analysis can be done by using different methods including bibliographic coupling, document co-citation analysis, author co-citation analysis, and co-word analysis (EOM, 2004).

All the co-citation analyses are identical in terms of the processes: the totality of the possible relationships among the analysis units must be expressed in a matrix, which is by definition square, binary and symmetric. Thus, the results obtained indicate the existence of relationship (binary) or lack thereof among all the actors under analysis (square), not considering the direction of these relationships (symmetric). Depending on the type of analysis, differences are found only in the level of analysis (papers, authors, words) and the combination of relationships analyzed (author-author, author-paper, etc).

Small (1973) highlights the importance of co-citation analysis as a technique for analyzing the structure of a research field. According to him, assuming that frequently cited papers represent key concepts, methods or experiments in a field, consequently the result of a co-citation analysis is a map that presents the relationships among these key ideas in great detail.

3.2.2. Social Network Analysis

According to Otte and Rousseau (2002), Social Network Analysis (SNA) can be defined as a broad strategy for investigating social structures. As they point out, in SNA the analyses occur from a perspective inverse to traditional techniques, focusing on evaluating the relationships among actors as the first priority and individual properties play a secondary role in the analysis.

> The network perspective is based on the assumption that any system can be viewed and analyzed as a set of interrelated actors or nodes, which in turn, represent persons, firms, countries and so on. (BORGATTI AND LI, 2009).

Borgatti and Li (2009), also state that they can result from different types of relationships (competition, friendship, etc.) and occur along multiples dimensions (Duration, frequency, etc.).

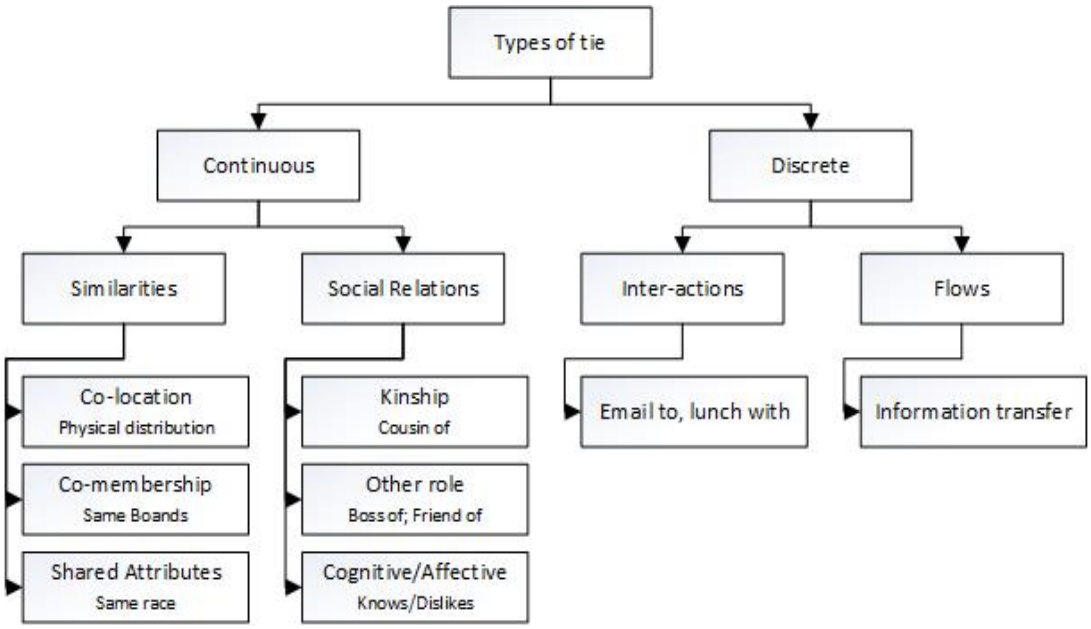


Figure 11 - Typology of types of ties among persons studied in the Social Networks literature. Source: BORGATTI AND LI (2009).

Applications of SNA for analyzing the structure of a research field are already observed in several areas such as information sciences (OTTE AND ROUSSEAU, 2002), Engineering (AHUJA, MAGNANTI AND ORLIN, 1993) and operations management (PILKINGTON AND MEREDITH, 2009), reinforcing the applicability of this concept in the intended context.

Regarding the purpose of the analysis, Pilkington and Liston-Heyes (1999) see this approach as instrumental in identifying groupings in a research field and comprehending the way in which these clusters relate to each other (Pilkington and Liston-Heyes, 1999).

Regarding the basic elements that compound the networks, Wasseman and Faust (1994) point to the following items:

- Actor: Social entities such as authors and documents. The interest of social network analysis is for understanding the relationships among these social entities and the implications of these connections.
- Relational lace: Link that establishes a relationship between actors.
- Dyad: Tie between two actors. Dyadic analysis focuses on evaluating aspects of the relationship between two authors. For

example, verifying if there is reciprocity or if the two relationships tend to occur simultaneously.

- Triad: Similar to the dyad, the triad is a relationship among three actors. Analysis is based on the possible ties that could be analyzed among the three actors.
- Subgroup: Any subset of actors, and all the relationships among them. The identification and analysis of these groups and their respective characteristics is an important stage in social network analysis.
- Group: Consists of a limited set of actors that are treated together based on a certain definition (conceptual, theoretical, empirical) on which network measurements are made.
- Relationship: The set of ties of a specific kind among authors in a group.
- Social network: The set of actors and the relationships formed by them make up the social network.

Once the network has been established, several algorithms can be employed for interpreting the results. Since it would not be possible to address all the possibilities, for the methodological review we will focus only on the elementary ones employed in this research. For a more complete view, authors such as Wasserman and Faust (1994), Burt (1992), Garfield (1997) and Hanneman and Riddle (2005) are a source for several possibilities of analysis.

Hence, the set of techniques considered in this research follow the work of Otte and Rousseau (2002) and are limited to covering aspects related to the network structure (cohesion) and the roles played by different actors, as described below:

- Density: Indicates the overall level of network connectivity. This measure compares the current level of connections in the network with the total possibilities, indicating at which level connections are already being exploited
- Centrality: Makes reference to the position of the actor in the network. The position is related to the importance of the actor,

since depending on the location, it is possible to make more or fewer connections. Three measures are tied to the concept of centrality:

- Centrality Degree (CD): It is defined as the number of connections that a node has in the network. It is understood that the greater the number of connections, the more privileged the position of the author, impacting on their ability to influence others.

In order to adopt complementary perspectives of analysis, the centrality degree measure (CD), when fed by asymmetric matrixes may also be evaluated regarding the direction of the relationship, or in degree and out degree indicators. These measures refer respectively to the number of connections that an author receives and performs with other nodes in the network.

The last technique refers to the analysis of subgroups or clusters. This technique relates to identification of sub-groups within the network based on established criteria. Once more, several algorithms can be employed to perform this analysis.

Hanneman and Ridle (2005), present the algorithms as divided in two groups: Bottom-up approaches and top-down approaches. The two groups differ regarding the approach for constructing the groups. In the bottom-up approach, the groups are built from the diad (basic relationship among two others) and evolve to a group adding components according to the requisites of the specific algorithm applied. Among the bottom-up approaches, we can quote Cliques, N-cliques, N-clans, K-plexes, K-core and F-groups, according to the possibilities offered by the UCINET software. The difference among them lies in the criteria for establishing the relationship, the first being the most demanding and the subsequent more relaxed respectively. All the algorithms consider only binary relationships, except the F-groups that take into consideration the strength of the relationships. The top-down approaches on the other hand build the groups based on inverse logic. It starts from the network as a whole and identifies sub-structures as parts that are locally denser than the whole.

In this research the delimitation of the groups will be determined using the k-cores algorithm. According to the definition of Hanneman and Hidle (2011), this approach considers as criteria, adding a component to a group, the

existence of a minimum of k relations among the actors and some actor in the group, k being an input defined at the moment of analysis.

Finally, beyond the structural variables (density and centrality), the analysis will consider the composition variables of the structure at several stages, following one of the approaches proposed by Wasserman and Faust (1994). Composition variables can be understood as attributes of the authors such as affiliation, country of origin and areas of research.

3.2.3. Content analysis

According to Bardin (2011) content analysis can be defined as a set of techniques through which systematic and objective descriptions of messages seek to obtain indicators that allow for making inferences related to the conditions of production and reception of these messages.

As highlighted by Rocha and Deusdará (2005), the main concern of content analysis is to conduct an in depth analysis of the texts using an objective and replicable technique, in order to ensure greater validity for the results obtained.

The use of inferences is inherent to the method. As pointed out by Bardin (2011) content analysis is not restricted to the data expressed directly in the messages, but also to the implicit information. In content analysis it is possible to manipulate data by inference of knowledge about the topic under study thus making it possible to obtain significant results based on data (FREITAS AND JANISSEK, 2000).

Still according to Freitas and Janissek (2000), different sources of data can be employed in content analysis, in such a way that several distinct approaches may also be posed in order to appropriately explore, process and analyze the data.

Regarding the approach, the analysis process may use quantitative data, qualitative or a mix of both (FREITAS AND JANISSEK, 2000). As highlighted by Bardin (2011), content analysis may or may not use quantitative data, but can also use qualitative analysis, quantify the discoveries and then analyze qualitatively again, employing a mixed approach.

Henry and Moscovici (1968) also propose two types of content analysis, they include closed analysis, when pre-defined categories are imposed and open and exploratory where non restricted and less structured procedures for analysis are employed. Regarding to the procedure itself, Bardin (2011) presents three steps to perform the analysis:

- Pre-analysis: Corresponds to the planning and organization of the research to be carried out. To perform this stage appropriately, the following steps must be completed: (a) Delimitation of the universe to be analyzed, (b) Development of hypothesis and objectives; (c) Index referencing and development of indicators; and (d) Preparation of the material.
- Exploration of the material and treatment of results: Consists of applying the analysis procedures defined in the pre-analysis. In this phase the codification, decomposition and enumeration occur, according to the established rules.
- Inference and interpretation: The results are prepared in order to become significant (application of simple or sophisticated statistical operations), resulting in tables, figures or models that summarize the information obtained. Then, based on the data inferences and conclusions are made.

3.2.4. Database preparation and applied procedures

This chapter aims to present the research protocol and procedures developed in each of the phases that compound this systematic literature review. The study is made up of three main stages of analysis and two data collection procedures.

The three phases can be generally described and are as follows:

(I) Phase 1 – Provide an overview of general aspects of the research field;

(ii) Phase 2 – Perform a deeper analysis of a selected set of documents, determined based on the results of phase 1;

Phase 3 – Analyze the content of a selected sample of case/field studies from phase 2, a characteristic of research in the area.

To obtain the results presented in each phase described above, two search procedures were performed and different extracts of the leading samples were analyzed according to the research phase. The details of the samples employed in each phase are described in the figure 12.

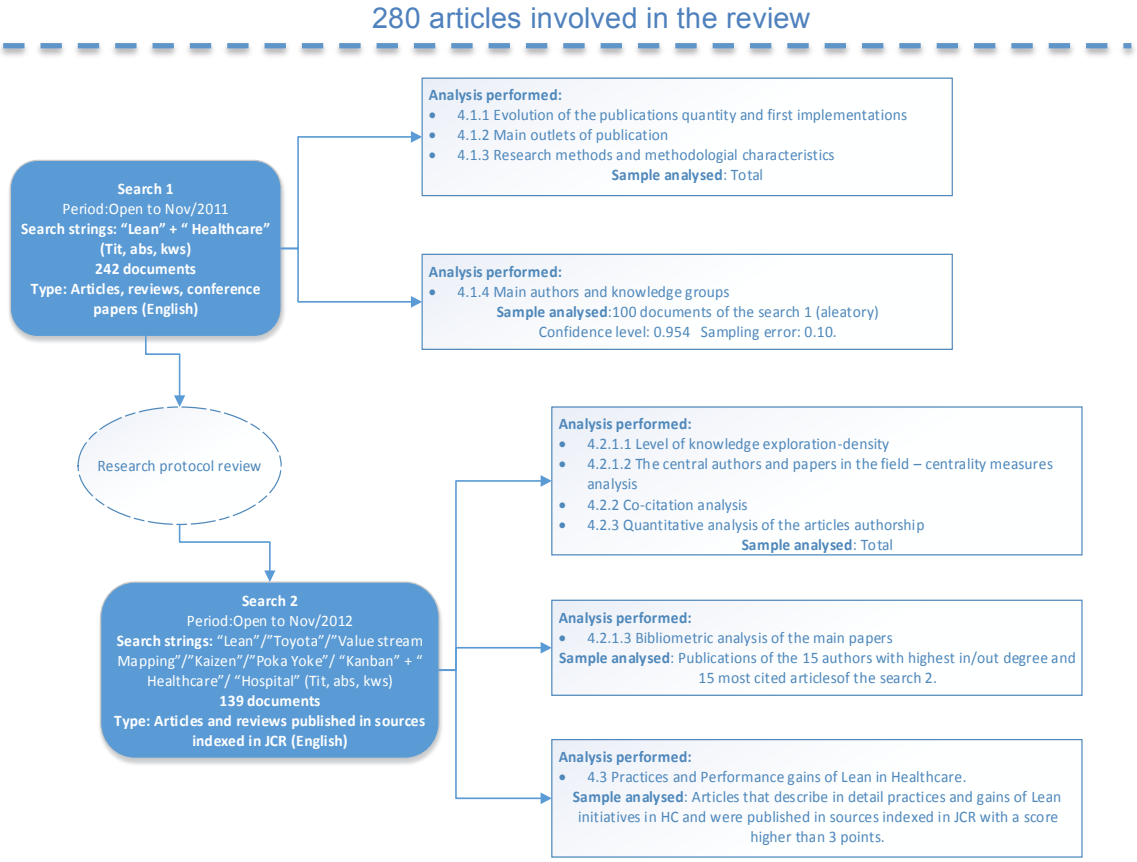


Figure 12 - Samples employed in each phase of the systematic literature review.

The details on data collection, applied procedures and methodology employed in each phase are addressed individually below.

3.2.4.1. Research protocol and details of phase 1

The selection of articles was based on searches performed in six databases for articles that contained the words "lean" and "healthcare" in their abstract, title or keywords. The databases considered for review were: Thomson Reuters Web of Knowledge SM (formerly known as ISI), Scopus, Science Direct, Emerald, Ovid Sp and Wiley.

The search yielded 1272 results. From reading the abstract articles that were not about the application of lean production in the area of health were eliminated, and repeated results were removed. Articles written in languages other than English were also eliminated as well as abstracts, editorials, letters, reviews and similar documents. After all of these filters, 242 documents remained for analysis.

Based on these data, a bibliometric analysis was applied considering the following perspectives: survey of standard information of the documents, Citation analysis combined with a network analysis of co-citation data.

As a result of the first step the following information was obtained: (a) year of publication, (b) country of origin of the document and (d) research method used. Based on the frequency of citations, the key authors in the research field were also determined, as well the most quoted documents.

For the co-citation analysis, 100 documents were considered. The sample was determined according to the method for defining the sample size in a finite population presented by Wimmer and Dominick (2006), considering a confidence level of 0.954 and sample error of 0.10.

In order to perform the co-citation analysis, the entire set of references of all the 100 articles in the composition of the citation matrix were considered, resulting in 2309 rows (authors) and 100 columns, elaborated on an excel spreadsheet. The 3583 citations of this matrix were then compiled in a co-citation matrix containing only authors connected by more than 5 co-citations, which corresponds to a total of 36 authors and 428 relations among them.

Once the matrix was established, the NETDRAW® software part of the UCINET SNA® package was used to graphically show the intellectual structure of the field, allowing us to visualize relationships compiled in the co-citation matrix. For the network analysis, in this preliminary step sub-groups was determined based in a visual analysis of the network. On the following a qualitative analysis of the research theme related to author in each group was performed, resulting in a general view of the main themes in the field.

3.2.4.2. Research protocol and details of phase 2

Based on the results and characteristics found in the preliminary analysis (phase 1), a second search was performed, aiming to build a selected database of relevant research for a more sophisticated analysis.

Seven search strings were also added to the search strategy corresponding to main lean tools and the term “hospital”, since it is synonymous with “healthcare” and could recover any lost results from the first phase. An updating of the database was also performed, complementing the results up to October, 2012. Compared to phase one, two kinds of documents were eliminated: Conference proceedings and papers from non-indexed sources in the Journal Citation Reports® (JCR®).

Journal citation reports consist of a recognized index that classifies journals according to statistical information based on citation data (THOMSON REUTERS, 2013). This measure helps to measure the research influence and impact of the journal, indicating the quality of a publication.

Using this strategy, a set of 139 was obtained, corresponding to a set of 435 authors. This stage of analysis is concerned with analyzing the connections among these 435 authors and the respective documents in the sample. Hence, contrary to stage one that posed a generalist perspective, this stage is restricted to this group, disregarding cited references that do not allow it. The analysis performed is divided into two main approaches: citation and co-citation analysis.

As with the first analysis phase, citations and co-citations were compiled in an excel spreadsheet and then used as input in the Netdraw, revealing graphically the relations among the authors. Citations and co-citations were analyzed from different perspectives:

Citation:

- Evaluation of the research exploration based on the density of the network;
- Determination of the main authors in the field based on the centrality degree index;
- Determination of the most influential and theoretically grounded authors based on the in-degree and out-degree index;

- Determination of the set of article attributed to the main authors (in/out degree) and survey of bibliometric data of these authors in terms of: publication source and area, affiliations and author subject area.

Co-citation:

- Determination of the main research groups and themes by cluster analysis using the k-core algorithm;
- Quantitative analysis of the authorships in the network determining the level of collaboration in the articles construction and productivity of the authors.

3.2.4.3. Research protocol and details of phase 3

For phase three an even more select sample was considered for analysis. Since the determined objective was the set of Lean practices used in healthcare, the selection was primarily based on the presence or absence of empirical data. Articles were included if they specifically describe a Lean intervention in a healthcare setting.

Additionally, only articles whose source was indexed in the Journal citation reports (JCR) and obtained a score higher than 3 points were selected for analysis. This criteria was imposed in order to limit the analysis to publications with scientific rigor, aiming to circumvent the difficulties found by other authors against the representative presence of methodological and measurement limitations in case studies in the field (VEST AND GAMM, 2009; POKSINSKA, 2010; MAZZOCATO et al., 2010). Were also discarded articles that with insufficient clarity in the methods employed, absence of real performance results (simulation) or if they are already reviews of other papers; Applying the filters eleven (11) articles was identified as appropriate for the analysis according to the established criteria.

The set of articles was then analyzed using exploratory content analysis. Hence, restricted categories were not established beforehand, but only major topics of analysis. From each article included, we extracted basic information

regarding three aspects: (a) objectives and environmental characteristics; (b) interventions performed; and (c) outcomes of the initiatives.

The extracted data was coded, grouped into categories and then analyzed. The selection process, tabulation and categorization was performed with the assistance of a data extraction sheet (Microsoft Excel 2009; Microsoft Corporation, Redmond, Washington, USA).

4. SYSTEMATIC LITERATURE REVIEW RESULTS

In this chapter are presented the results obtained with the systematic literature review performed according to the procedures described in the previous chapter.

4.1. OVERVIEW OF THE LITERATURE ON LEAN HEALTHCARE

This sub-item is devoted to provide an overview of the evolution, intellectual structure and main characteristics of the research in Lean in Healthcare. The results include the analysis of the publications in terms of four main aspects: evolution of the publications quantity and first publications, main outlets of publications, research methods and methodological characteristics, and main authors and knowledge groups. To finalize, in the last topic is also examined the macro themes treated by the main authors found and proposed a grouping in terms of similarities in the macro themes treated by each knowledge group.

4.1.1. Evolution of the publications quantity and first implementations

From the systematic search performed according to the procedures described in the chapter 2 (pg 26), a total of 242 articles meeting the inclusion criteria were identified, for which the publication dates ranged from 1998 to 2011. As can be seen in figure 12, although the first articles date from 1998, the number of articles published only became significant in 2002.

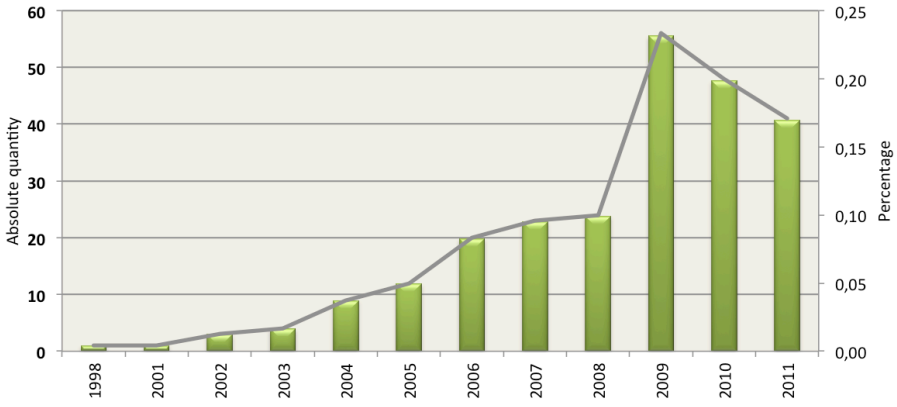


Figure 13 - The evolution of lean healthcare papers quantity.
Source: (PLYTIUK, PASQUALINE, GOUVÊA DA COSTA, & PINHEIRO DE LIMA, 2012).

From that year on, the number of studies in this area grew steadily, reaching a peak in 2009, when they accounted for 23.1% of all the articles published in the study period. Breaking the study period into five-year blocks yielded the following result: 2011-2007 (79.34%); 2006-2001 (19.83%); and before 2000 (0.83%).

Among the first articles found, a study by Bowen and Youngdahl in 1998 dealing with the Lean philosophy advocates the application of production-line approaches to service operations. The authors describe examples of the application of these approaches, such as Shouldice Hospital, whose processes, according to them, follow the Lean philosophy. The first document reporting specifically applications of Lean Thinking appeared in 2003 and described the implementation of a pilot test using the principles of TPS at the University of Pittsburgh Medical Center (UPMC) (FEINSTEIN & GRUNDEN, 2002) (THOMPSON, WOLF, & SPEAR, 2003). The interventions used included the redesign of processes, the elimination of losses defined from the perspective of customer value, the identification of the root causes of problems and the enabling and motivating of the employees themselves to solve problems in their work environment. Results reported included incremental and continuous improvements in patient care and greater satisfaction among the employees involved.

However, in a review covering only empirical articles, De Souza (2009) cited three earlier documents that included applications of tools related to lean practices but did not refer to them by that name: Heinbuch (1995), Jacobs and Pelfrey (1995), and Whitson (1997). In these cases, an improvement initiative was reported and by the description was possible to recognize similarities between the Lean practices and the techniques employed. However, the Lean philosophy was not mentioned at any moment as the initiative foundation. He also identified the applications by Bushel and Shelest (2002) and Feinstein et al. (2002) as the first applications of the Lean philosophy.

4.1.2. Main outlets of Publication

In terms of countries, as can be seen from Figure 10, the USA was the

main contributor in terms of number of articles (60,7%), followed by the UK (13.6%), Netherlands (5.4%), Canada (3.3%), Australia (2.9%), and Sweden (2.5%), which together accounted for a significant 88.4%. The other documents (4.5%) were distributed between eight countries in individually less significant numbers.

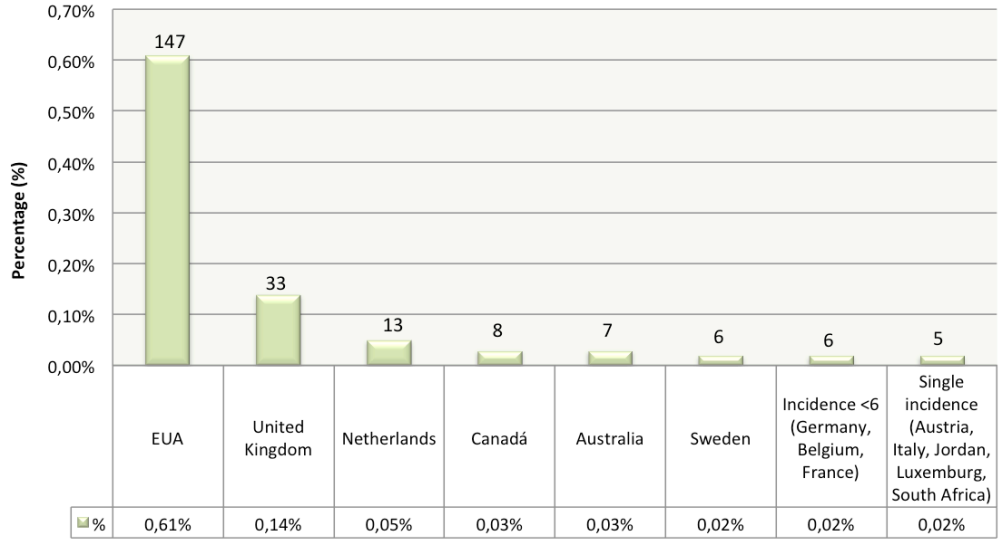
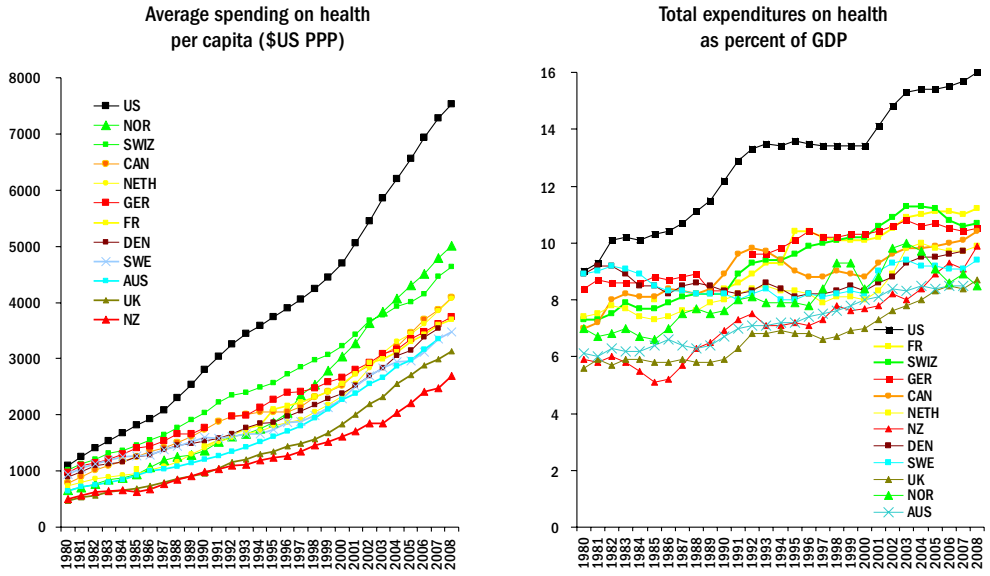


Figure 14. Number of publications according to the countries of origin of the first author. Source: (PLYTIUK, PASQUALINE, GOUVÊA DA COSTA, & PINHEIRO DE LIMA, 2012).

An explanation for the incredible prominence of U.S. over the other countries is that probably an important factor of pressure lies in the poor performance of the American health system. According to 2010 annual report from the Organization for economic cooperation and development (OECD), the U.S expends $ 7,538 per capita in health, which corresponds to more than the double of the OECD median and far more than any other country (SQUIRES, 2011). Still according to Squires (2011), the country suffers also from factors that impact in quality as the reduced number of physicians and hospital beds, high prices and superior probably of drug utilization. Another interesting feature to be observed is the rising characteristic of the U.S. expenditure regarding to the Gross domestic product (GDP), which is presented in the figure below. As may be observed, the proportion has been steadily rising since 1980, and represents today costs considerable superior to the other countries under comparison (Figure 14).



Note: PPP = purchasing power parity—an estimate of the exchange rate required to equalize the purchasing power of different currencies, given the prices of goods and services in the countries concerned.
Source: OECD Health Data 2010 (Oct. 2010).

Figure 15 - International Comparison of Spending on Health, 1980–2008.
Source: (SQUIRES, 2011).

Considering the other countries where the movement for Lean Healthcare is more representative, may be observed that all of them suffer by related questions, once each of the six most quoted in the present research are found with levels of expenditure superior of the OECD median (Figure 12). It is interesting to observe also that the second most quoted country in terms of amount of publications, the UK, poses also the highest average in real growth rate per capita.

	Total Health Spending		
	Per capita[c]	Percent GDP	Average annual real growth rate per capita: 1998–2008
Australia	$3,353[a]	8.5%[a]	3.6%[a]
Canada	$4,079[e]	10.4%[e]	3.4%[e]
Denmark	$3,540[a]	9.7%[a]	3.5%[a]
France	$3,696	11.2%	2.3%
Germany	$3,737	10.5%	1.8%
Netherlands	$4,063[e]	9.9%[e]	4.1%[e]
New Zealand	$2,683	9.9%	4.4%
Norway	$5,003[e]	8.5%[e]	0.8%[e]
Sweden	$3,470	9.4%	3.9%
Switzerland	$4,627[e]	10.7%[e]	1.9%[e]
United Kingdom	$3,129	8.7%	4.9%
United States	$7,538	16.0%	3.4%
OECD median	*$2,995*	*8.7%*	*3.9%*

[a] 2007.
[c] Adjusted for differences in cost of living.
[e] Estimate.
Source: OECD Health Data 2010 (Oct. 2010).

Figure 16. Health Spending in Select OECD Countries, 2008
Source: (SQUIRES, 2011).

Proceeding to a deeper level, the sources in which these studies were published revealed that there is a reasonable spread of journals: of the 242 articles analyzed, 39.67%, or 96, were published in 96 different sources. The sources with the greatest number of articles were Journal for Healthcare Quality (12) Quality Management in Health Care (10), Society for Health Systems Conference and Expo (8), American Journal of Clinical Pathology (7), IIE Annual Conference and Exhibition (7), Leadership in health services (5), Quality & Safety in Health Care (5), British Journal of Health Care Management (4), and Global Business and Organizational Excellence (4), which together accounted for 62 documents, or 25.62% of all the articles.

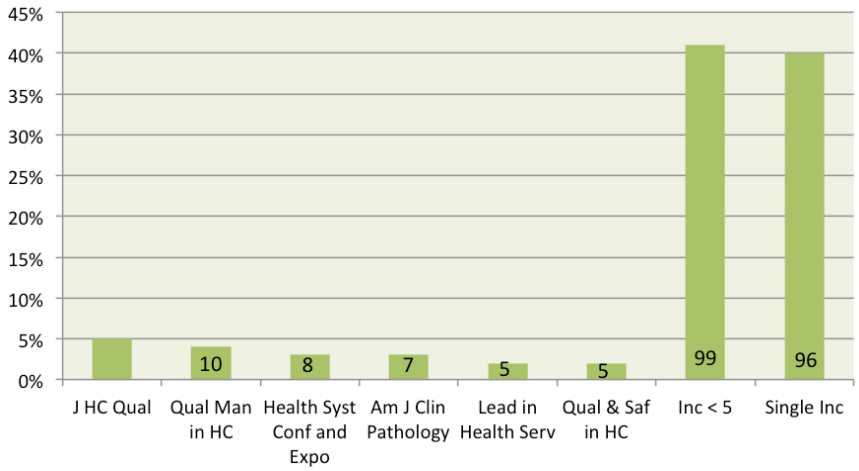


Figure 17. Most quoted sources for Lean Healthcare Publications.
Source: (PLYTIUK, PASQUALINE, GOUVÊA DA COSTA, & PINHEIRO DE LIMA, 2012).

Regarding to the area of expertise of the sources where these articles are usually published, clearly exists an interest of higher proportion about the theme among the journals specialized in medicine or hospital management. It is possible also to find among the traditional management journals researches dealing with macro themes that encompass Lean healthcare or that treat about the philosophy with no specific context. These articles may be also used to enrich the theoretical foundations about Lean health care, nevertheless they usually are generic leaving a gap about the characteristics and specific needs of the context, even when the focus is posed in broader sense, as management in the services sector.

4.1.3. Research methods and methodological characteristics

Considering the research method employed, the articles reviewed could be divided into two categories: Conceptual works and Empirical studies. Following a classification based in those proposed by De Souza (2009) and Poksinska (2010) in a research similar to this one. The first category consisted of articles containing purely conceptual discussions. The second category it is composed of documents containing every kind of analysis based on empirical data. Surveys, focus groups and qualitative research can be quoted as examples included on this group. Some of the papers analyzed include vast illustrative examples, so as they were not of an empirical nature, they were maintained in the first group.

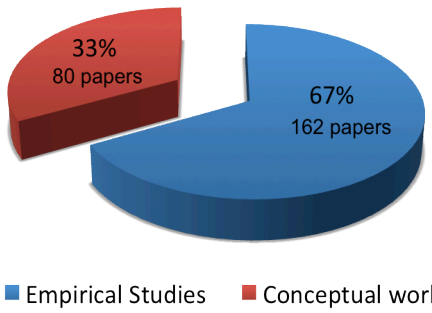


Figure 18 - Distribution of the research methods employed in the Lean healthcare researches. Source: (PLYTIUK, PASQUALINE, GOUVÊA DA COSTA, & PINHEIRO DE LIMA, 2012).

As can be seen by the figure (figure 17), empirical studies predominated (67%). However, many of these studies are only descriptions of industrial practices provided simply to report on the results of Lean implementations and are not intended to test or develop theories.

Initially, the intention was to propose a more specific classification concerning the research methods employed. Nevertheless, the lack of methodological rigor was found as a striking feature of the research in the field, becoming the classification intended excessive laborious to the research purpose at this moment. The main motive for this is that rarely the method employed was released in the article, and when it was several characteristics

led to believe that the determination pointed by the author was not correct. Hence, unless it was established criteria in order to determine according to text characteristics the method employed, the results presented would be imprecise.

Regarding to the characteristics mentioned, the following ones could be observed among the articles analyzed, which were often defined by the authors as case studies: a lack of a well-defined study protocol; transfer between researcher and research object (the author himself carries out the study and at the same time is the object of study); and, mainly, use of a single source of evidence, one of the most important issues regarding data collection in case studies (YIH, 2011).

This issue was also noted by other authors in studies related to this subject, such as Vest and Gamm (2009), De Souza (2009) and Poksinska (2010) and is considered an obstacle to the validation of results. De Souza (2009) considers such studies to be “too simple”, and asserts that a lack of detail or content can lead to a misunderstanding of the content being analyzed. Vest and Gamm (2009) concluded from an analysis of a series of documents that various quality strategies in health-related organizations have been “universally successful” but cautioned that the “vast majority” of studies with methodological limitations can compromise the validity of results.

Varkey et al (VARKEY, RELLER, & RESAR, 2007) also draw attention to this type of study, which they call “quality improvement projects”, and note that they typically use samples that are too small and research protocols that change frequently. They also point out that there is a degree of confusion in this field of research as to whether these documents should be considered research and cite other documents that discuss the same issue such as Venn-Treolar (1998), Cassel and Young (2002), Cassaret and Karlawish (2000) and Choo (1998).

The main obstacle derived from this low literature quality lies in the compromise of the theory construction process and evolution of the concept. Taking the Lean healthcare as a concept yet in the first stages of the theory-building, many authors enforce the importance of loyal and accurate documentation of the actual practices, mainly in empirical studies (FLYNN, 1990; VOSS, TSIKRIKTSIS & FROHLICH, 2002; CARLILE & CHRISTENSEN, 2004). These because the theory-building stage is marked by the early steps of

elaboration of a theory, where the first constructs are developed. These hypotheses are supposed to be tested in posterior researches, creating a continuous cycle where the authors build upon others work allowing the concept to evolve and become more accurate as the years go by (CARLILE & CHRISTENSEN, 2004). Therefore, if this stage is not appropriately dealt, the process of knowledge construction becomes compromised, delaying the evolution of the concept and consequently impeding the organizations to have available theories more appropriate and likely to be effective.

Seeing the picture through a non-academic view, under the eyes of practitioners the methodological failures may not sound so important, once the observational data is not totally unreasonable, particularly when the same opinion is so intensely shared and the traditional data controls is not well established, as is the healthcare sector case. From this point of view, the positive experience of other organizations facing similar situations may provide useful insights regarding to methods or results perspective. Nevertheless by other side is scarce the amount of reliable material concerning particularities involving negative experiences. This because, considering real organizations, is likely that people that face negative experiences in their initiatives become less inclined to disclose your histories. Therefore, for this side also the benefits is reduced, once observations arising from unsuccessful implementations would provide similar insights regarding to the factors involved, very helpful to future initiatives.

4.1.4. Main authors and knowledge groups

In this stage of the study, the objective is posed in order to determine what are the main authors and works used as reference to build the knowledge in Lean healthcare and main concerns revealed in the researches. Hence, looking to reflect more faithfully the reality, we choose to avoid the filters defined previously and enlarge the source size using the references of the articles collected as the analysis object.

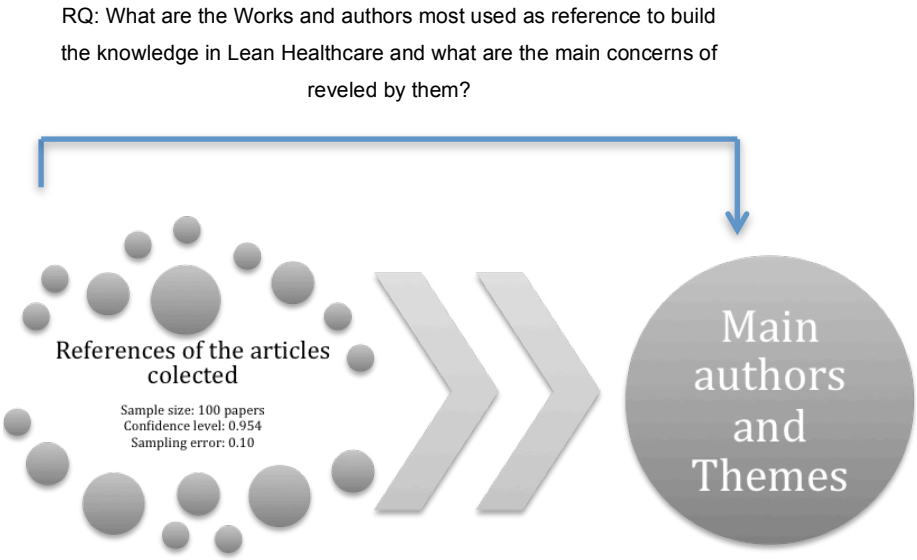


Figure 19 - Representation of the citation data collection process and analysis. The Author. Source: Elaborated by the author.

Based in this, the first analysis performed was a citation analysis. This technique is fundamental on the premise that frequently cited articles or authors tend to have a greater influence on a field than others; therefore, it is a way of recognizing important aspects of or activities in a particular field (PILKINGTON & MEREDITH, 2009).

Therefore, was counted the frequency in which each author and title was cited as reference in the sample analyzed, allowing us to rank the ten most influent ones. The results obtained are shown in the table below (table 6).

It must be noted that in this stage no constraints of any kind were imposed on the type or source of document in the reference, which could therefore include books and other documents in other languages. The purpose of the review was to focus on individual authors, so that documents produced by institutions were disregarded in the construction of the citation/co-citation matrix, which was used both for the present and the next step of analysis.

Table 6. Most quoted authors and documents in Lean Healthcare Publications.

#	Main Authors	Citations	#	Main Documents	Citations
1	Jones, D T	60	1	**Womack and Jones (1996)** – Lean Thinking: Banish waste and create wealth to your corporation	30
2	Womack,	58	2	**Womack, Jones & Roos (1990)** – The	18

	J			Machine that changed the world.	
3	Spear, S J	32	3	**Liker (2004)** – The Toyota way	10
4	Towill, D R	21	4	**Ohno (1988)** – Toyota Production System: Beyond large scale production	10
5	Roos, D	19	5	**Spear (2005)** – Fixing healthcare from inside, today	9
6	Does, R J M	19	6	**Spear (1999)** – Decoding the DNA of the Toyota production system	9
7	Berwick, D M	18	7	**King, Ben-Tovin & Bassham (2006)** – Redesigning emergency department patient flows: application of Lean Thinking to healthcare	6
8	Van Den Heuvel, J	16	8	**Jimmerson, Weber & Sobek (2005).** Reducing waste and errors: Piloting Lean Principles at intermountain Healthcare	6
9	Ben-Tovin, D	13	9	**Rother, Shook, Womack et al. (2003)** - Learning to see: Value stream mapping to create value and eliminate muda	6
10	Liker, J K	12	10	**Deming (1986)** – Out of the Crisis	6

Source: Adapted from (PLYTIUK, PASQUALINE, GOUVÊA DA COSTA, & PINHEIRO DE LIMA, 2012).

Proceeding to a second analysis, the same data was further explored in a co-citation analysis. Nevertheless, after compile the citation data into a co-citation matrix, the authors that was co-cited less than five (5) times were eliminated from the analysis.

In this analysis the documents are used as analysis units and citations between pairs of documents or between documents and authors as the variable that defines the distance between them, allowing a separation into groups (WHITE & GRIFFITH, 1981). In other words, we determine how often the authors are cited together and used this data to establish the closeness of relations among the authors. Hence, considering all the relations together it is possible to observe separations into groups.

From these groups then, it is possible to see which topics, authors, sources and research methods are central to, and which peripheral to the field in question based in the manner by with the relations are tied in the group

(PILKINGTON & MEREDITH, 2009). Co-citation analysis is thus a way of mapping the relationships between different aspects in great detail on the basis of an assessment made up of hundreds of citations rather than just the opinion or an analysis by a single author (WHETHERELL, PLAKANS, & WELLMAN, 1994).

Considering the practical aspects, once the data is manually launched in an excel spreadsheet and properly compiled, the file must to be used as input in a specific software able to map the relations recorded in the data. In this case, the NETDRAW®, software which comes with the UCINET SNA® package was applied. In other words, the intention lies in reveal graphically the intellectual structure of the field, allowing us to visualize relationships compiled in our citation/co-citation matrix.

Based in the information obtained, several analyses may be performed, from the simplest to most complex making use of diverse algorithms, available in the own program. The focus of analysis may vary also, comprising authors, documents, keywords, and so on.

In the present case, the initial analysis will be performed in a simple level, considering only a visual analysis. Therefore, the authors that were pointed in the network were considered as the main ones, and subjected to a direct examination. Thus, in the following the documents assigned to these authors were analyzed individually, revealing the characteristic themes of each author. Then, based in the closeness of the relation and the similarities among themes, the authors were separated in groups, which are presented in the figure below and characterized in the following (Figure 19).

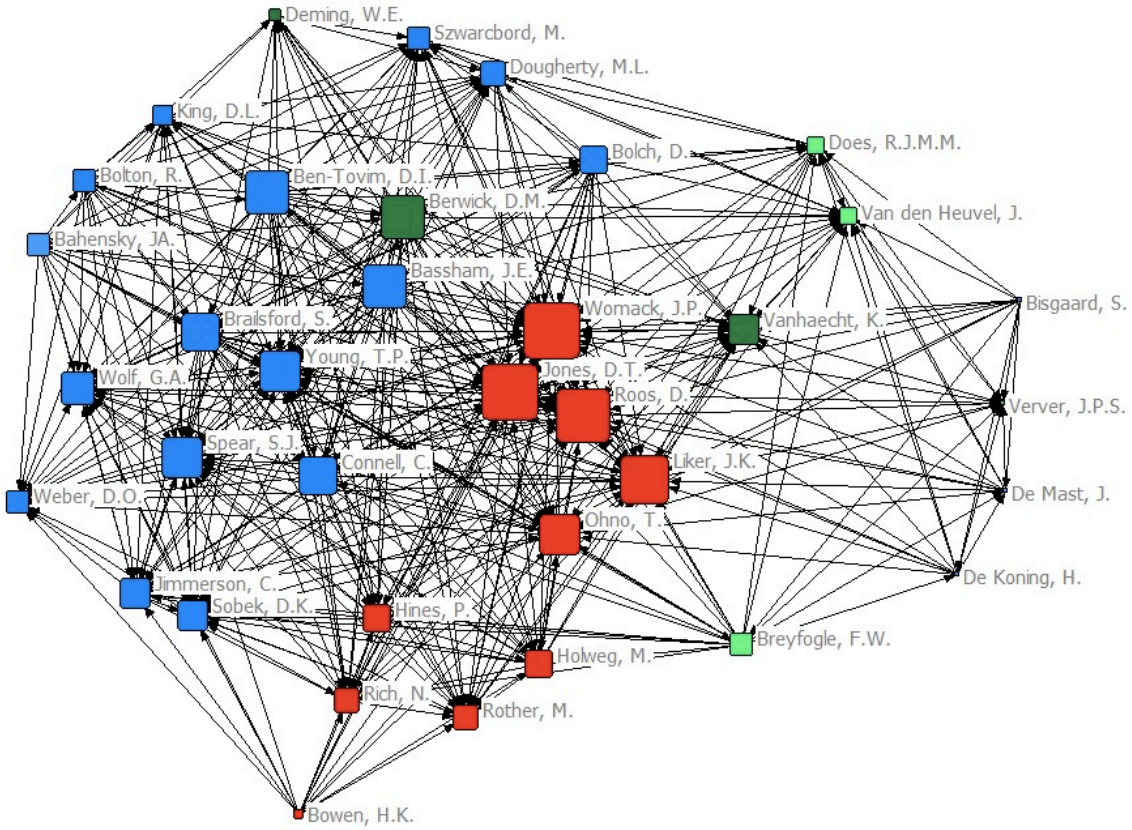


Figure 20 - Lean Healthcare knowledge structure (1998-2011).
Source: Elaborated by the author.

Differentiated by color, in the chart four main groups of authors can be identified: (1) Lean Six Sigma in light green, (2) The roots of Lean Thinking in red, (3) Health Care Quality Improvements in blue and (4) External contributions in dark green:

- Lean Six Sigma (Van den Heuvel, Does, Verver, De Konig, De Mast, Bisgaard, Breyfogle): The main theme are issues related to the use of Six Sigma on its own or together with Lean thinking in health care, as well as sometimes at a more general level, as in services. The publications in this group include articles and books dealing with conceptual aspects as well as the applicability and potential of Six Sigma both in isolation (VAN DEN HEUVEL J. , DOES, BOGERS, & BERG, 2006) (DE KONING & DE MAST, A Rational reconstruction of Six Sigma breakthrough cookbook, 2006) (BREYFOGLE, 2003) (DOES, VAN DEN HEUVEL, DE MAST, & BISGAARD, 2002) (VAN DEN HEUVEL, DOES, &

VERMAAT, Six Sigma in a Dutch hospital: Does it work in the nursing department, 2004) and together with Lean (DE MAST, DOES, & KONING, 2006) (VAN DEN HEUVEL, DOES, & DE KONING, 2006) (DE KONING, VAN DEN HEUVEL, VERVER, BISGAARD, & DOES, 2006) (BREYFOGLE & SALVEKAR, 2004) ; many include abundant examples of applications and their results (VAN DEN HEUVEL J. , DOES, BOGERS, & BERG, 2006) (DOES, VAN DEN HEUVEL, DE MAST, & BISGAARD, 2002) (VAN DEN HEUVEL, DOES, & DE KONING, Lean Six Sigma in a Hospital, 2006) (DE KONING, VAN DEN HEUVEL, VERVER, BISGAARD, & DOES, 2006) (VAN DEN HEUVEL, DOES, & VERMAAT, 2004) . Documents specifically intended to report on applications of Six Sigma (VAN DEN HEUVEL, DOES, & BISGAARD, 2000) (DOES, VERVER, BISGAARD, & VAN DEN HEUVEL, 2009) (VAN DEN REUVEL, DOES, & VERVER, 2005) and Lean Six Sigma (NIEJMEIJER, TRIP, AHAUS, DOES, & WENNDT, 2010) can also be found. The main documents in this group in terms of number of citations when only those documents including the Lean philosophy are considered, are two books: “Lean Six Sigma in Sickness and in Health” (BREYFOGLE & SALVEKAR, 2004) and “Lean Six Sigma for Service and Healthcare (JIMMERSON, A3 Problem Solving for healthcare, 2007)”, both of which address conceptual aspects of the application of Lean Six Sigma in hospitals.

- The Roots of Lean Thinking (Liker, Roos, Jones, Womack, Ohno, Holveg, Rich, Bowen, Rother, Hines): This is made by authors and documents that are of great importance to the Lean philosophy and address the roots, or origins, of this philosophy. Of the groups identified, this group has the highest average number of citations per author. Another important feature of this group is that the articles are of a conceptual rather than an empirical nature and although they did not focus on one sector in particular, articles related to manufacturing tended to predominate. Documents produced by authors in this group include the books “The Machine

that Changed the World" (WOMACK & JONES, 1990) and "Lean Thinking". (WOMACK & JONES, 1996) The former, which is the first publication to discuss the Lean philosophy, describes, based on an in-depth study of practices in Japanese manufacturers, the techniques used by these companies and carries out a benchmarking exercise to find ways of increasing the performance of Western companies and enabling them to escape from the crisis they were in the midst of. The latter describes the guiding principles behind the philosophy. The two documents are the most frequently cited among the references analyzed.

- Health Care Quality Improvements (Ben-Tovim, Bassham, Szwarcbord, Dougherty, Bolch, King, Young, Brailsford, Connel, Spear, Wolf, Weber, Jimmerson, Sobek, Bolton, Bahensky): Broader group covering issues related to quality in health and is not restricted to Lean. Four other subgroups covering the following subjects can be clearly identified in this group:
  - ***Sobek et al*** *(Sobek, Jimmerson, Weber):* Aspects of Toyota Motor Corporation practices used in health care, particularly those related to problem-solving tools. The documents found included articles and books discussing conceptual aspects of the applicability of the A3 report tool (JIMMERSON, A3 Problem Solving for healthcare, 2007) (GLOSH & SOBEK, 2006) and field studies dealing with the main issues and results of the implementation of the Lean philosophy as a whole (JIMMERSON, WEBER, & SOBEK, 2005) as well as specifically seeking to validate Spear and Bowen's work by applying "the first three design rules" in a hospital setting and checking the results (GLOSH & SOBEK, 2006).
  - ***Spear et al.*** *(Spear, Wolf):* A general feature of this group was that best practices were followed, as though in an attempt to identify the critical factors required for success (SPEAR & SCHMIDHOFER) (SPEAR & BOWEN, 1999) (SPEAR, 2004; BARRAT, CHOI, & LI, 2011) (LIKER, 2004) (SPEAR, 2008) (ARMSTRONG, MACKEY, & SPEAR, 2004),

with comparative studies involving other practices very often being carried out (SPEAR & SCHMIDHOFER) (ARMSTRONG, MACKEY, & SPEAR, 2004) In “Decoding the DNA of the Toyota Production System” (SPEAR & BOWEN, 1999) and “Learning to Lead at Toyota” (SPEAR, 2004) two of the most important articles, Spear looks at various factors behind practices at Toyota Motor Corporation and argues that many companies fail in their attempts to replicate Toyota’s success because they attribute this success to techniques and tools, when in fact it is the result of rules and principles that form the basis of these practices. In “Fixing Healthcare from Inside Today” (SPEAR, 2005) common problems in health systems are presented, and the lean philosophy as a possible mean of dealing with these questions; good TPS-based practices peculiar to health care are analyzed, and the main issues involved are described. Other topics are also addressed in other studies, such as aspects related to physician education, (ARMSTRONG, MACKEY, & SPEAR, 2004) (SPEAR) problem-solving behavior (SPEAR & SCHMIDHOFER) (TRUCKER, EDMONSON, & SPEAR, 2002) and cases where the Lean philosophy is applied in health care (THOMPSON, WOLF, & SPEAR, 2003) (the last of these being described in empirical articles).

- ***Young et al.*** *(Young, Brailsford, Connel):* Three documents related to this group were found, all of which discussed conceptual aspects of the application of Lean and other techniques to health care. The documents consisted of a theoretical essay exploring how the concepts behind Lean Thinking, the Theory of Constraints and Six Sigma can be related to the field of health; a systematic review of the literature in which the way Lean has been used in different areas of health care and the results are analyzed (YOUNG & MCCLEAN, 2008) and a short discussion about critical

challenges that need to be developed so that the Lean philosophy is more widely accepted and applied in patient care (YOUNG & MCCLEAN, 2009) The main features of these works are a more critical vision of lean health care that looks at difficulties and challenges and areas that need to be better developed.

- ***Ben-Tovin et al.*** *(Ben-Tovin, Basshan, Szwarcbord, Dougherty, Bolch, King):* This group involves studies of a more empirical nature that focuses on describing the methods (YOUNG, BRAINSFORD, CONNELL, DAVIES, HARPER, & KLEIN, 2004) used in Lean initiatives in hospitals and the corresponding results. Five articles describing applications were found; these included initiatives in NSW Health (BEN-TOVIN, DOUGHERTY, O'CONNEL, & MCGRATH, 2008) and Flinders Medical Center (BEN-TOVIN, DOUGHERTY, O'CONNEL, & MCGRATH, 2008) (KING, BEN-TOVIN, & BASSHAM, 2006) (BEN-TOVIN, Redesigning care at Flinders Medical Centre in Adelaide South Australia) (BEN-TOVIN, BOLSH, MARTIN, MARGARET, DOUGHERTY, & SZWARCBORD, 2007) (BEN-TOVIN, et al., 2008).

Bolton and Dabensky were also classified in this group, given the nature of the citations and co-citations. However, the subject they discuss in the work cited is the application of Lean Six Sigma in health care (BAHENSKY, ROE, & BOLTON, 2005), which was dealt with by the Lean Six Sigma group, described earlier.

- External contributions (Berwick, Vanhecht, Deming): This category is accounted by authors who do not deal with the Lean methodology directly but with areas that are in some way related to it and for this reason are frequently used as sources in studies in this area. Included in this category is Berwick, who wrote a series of articles and is the author with the greatest number of publications, cited in the documents analyzed. However, these deal with a variety of issues and tools related

to quality in health care (BEN-TOVIN, et al., 2008; NOLAN, SCHALL, BERWICK, ROESSNER, & CARVER, 1996; BERWICK, 1991; BERWICK, 1998; BERWICK, 2005). Also included in this category are Blesser (2006), Vanhaecht and Sermeus (2002; 2003), who discusses various issues related to clinical pathways, and Deming, whose works deal with quality.

4.2. THE SOCIAL NETWORK OF LEAN IN HEALTHCARE

In this chapter a set of 139 articles is analyzed under the perspective of Social Network Analysis (SNA) combined with standard bibliometric analysis. The sample is composed by articles about Lean in Healthcare published in sources indexed in Journal Citation Reports (JCR). The whole process of database extraction and selection criteria was performed as described in the chapter 2 (pg.26). Conducting a second phase imposing different criteria aims to circumvent/solve the following issues that arose from the previous stage:

(i) Once the citation/co-citation analysis of the first phase was performed based in the total set of references cited by the papers analyzed, it was suspected that authors from related themes (Lean in manufacturing, Quality improvements in Healthcare) could be hindering already developed research of the field;

(ii) The substantial presence of methodological limitations found in the articles of the first phase cause that some limitation was imposed in order to reduce this problem;

Two main stages of analysis are performed: A citation analysis and a co-citation analysis. The combination of methods was employed aiming to circumvent limitations in each of them and benefit from the different perspectives offered by each.

Co-citation analysis is concentrate in analyze relations independently of the direction of them, being not possible to determine if the connection is passive or active in relation of the authors involved. In this specific case this means that would be impossible to determine if an actor is central in the network because he cites many authors in the sample or if is because he is very

cited by the others. Thus, citation analysis was employed primarily, determining the authors that cite more in the sample (out-degree) and that ones that are very cited (in-degree).

On the other hand, co-citation analysis covers the social perspective of the relations among authors. As highlighted by Guarido Filho, Machado-da-Silva and Rossoni (2010), “At least in principle, it is not possible to make any inference on social relations between authors based on only the citations made by them”. This because citation determine just which work is important to whom, however nothing is known about real relations among this authors. By co-citations however, when determining the frequency by which two authors are quoted together by a third author, frequent relations of co-authorship results in high co-citation frequency allowing us to visualize the existent partnerships. Additionally, high co-citation frequency also could indicate similarity in theme, pointing possible relations among these authors. Citations, on the other hand, are more susceptible to let related research entering the network, since that it is based in direct quotation.

Additionally, exist differences in interpreting the network. In analyzing citations, an author is indeed the body of knowledge produced by him, that is we are measuring the level with which that knowledge mediates the development of other researches, how it is central in the field and so on. In co-citations already the author is the body of knowledge produced by him and the author (person).

Hence, this chapter is developed as follows. Firstly, the general density of the citations network is measured indicating the level of current exploration of the knowledge in the field and is determined the most central authors in terms of citations made (out degree) and received (in degree). In the following, the group of articles that compound the body of knowledge of the authors that most cite and are cited is profiled according to institutions, publication sources, author subject area and are also explored issues related to these dimensions. In a second moment, a co-citation analysis is performed revealing the main knowledge groups in Lean Healthcare and the themes addressed by them. As the last analysis, the authors in the network are evaluated according to productivity and level of cooperation among researchers.

4.2.1. Citation analysis

4.2.1.1. Level of knowledge exploration - density

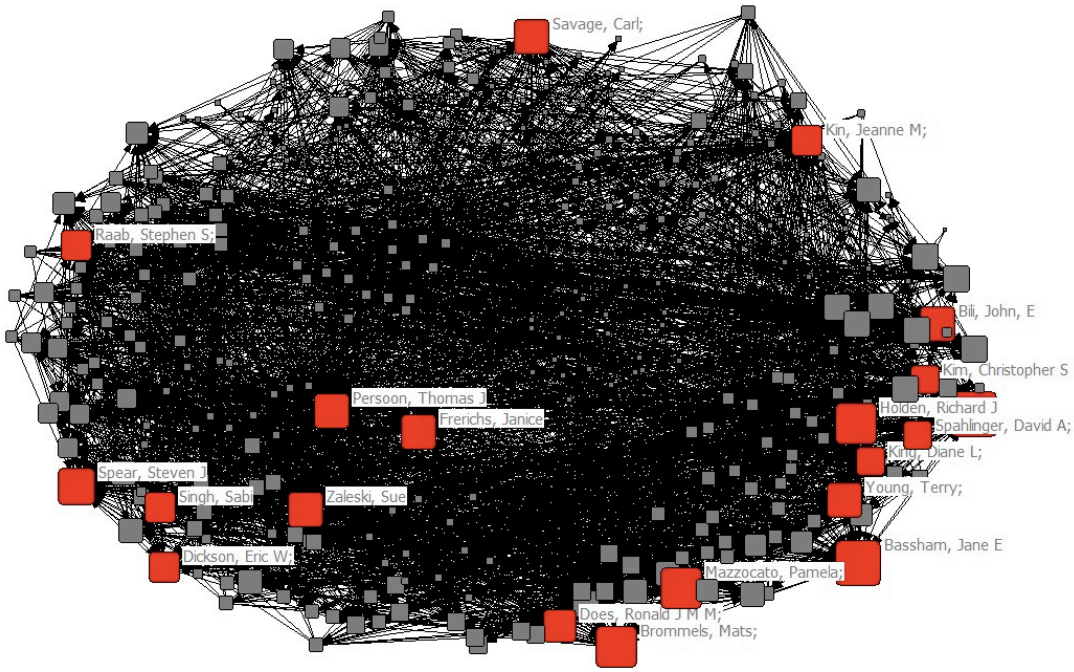


Figure 21 - Lean in Healthcare knowledge structure based in citations.
Source: Elaborated by the author.

The first topic analyzed was analyzed the indicator *density* or *Gamma index (D)*. This measure evaluates the general level of connectivity in a network by comparing the amount of existing relations with the possible supported by the network (HANNEMANN AND RIDDLE, 2005). Performing the calculation by the assistance of Netdraw is obtained an index of density of 2,44%, standard deviance of 0,1581.

Following the literature, we can interpret than that currently the level of exploration of the knowledge in the field is pretty limited.

Considering also the pattern pointed by Hanneman and Hiddle (2005), the network is far from being considerate dense, once that to achieve this attribute is required that the network reaches a minimum density of fifth 50%.

4.2.1.2. The central authors and papers in the field – centrality measures analysis.

As mentioned in the methodology chapter (pg. 16), the centrality degree index is calculated based on the number of ties that an author has in the network, corresponding the level of power that an individual has in terms of its position. The results the degree indexes, as well as another attributes of the 15 most central authors may be seen in the table 21. In its graphic form, the network of Lean in healthcare may be observed in the figure 20.

Figure 22- Fifteen most central authors in the field

#	Author	Affiliation	Articles in the	Degree
1	Bassham,JaneE	Flinders Medical Centre, Bedford Park, Adelaide, Australia	3	75
2	Ben-Tovin,DavidI;	Flinders Medical Centre, Bedford Park and Faculty of Health Sciences, University of South Australia, Adelaide, SA	3	75
3	Aronsson,Hakan;	Linköping University, Department of Management and Engineering, Linköping, Sweden	3	71
4	Brommels,Mats;	Karolinska Institutet, Medical Management Centre, Stockholm, Sweden	2	66
5	Holden,RichardJ	Vanderbilt University School of Medicine, Department of Medicine and biomedical informatics, Nashville, USA	2	66
6	Mazzocato,Pamela;	Karolinska Institutet, Medical Management Centre, Stockholm, Sweden	2	66
7	Thor,Johan	Karolinska Institutet, Medical Management Centre, Stockholm, Sweden	2	66
8	Spear,StevenJ	Harvard Business School and Institute for Healthcare Improvement, Massachusetts, USA	2	64
9	Bili,John,E	University of Michigan Health System, Ann Arbor, USA	3	59
10	Savage,Carl;	Karolinska Institutet, Medical Management Centre, Stockholm, Sweden	1	58
11	Frerichs,Janice	University of Iowa, Department of Pathology, Iowa City, USA	1	57
12	Persoon,ThomasJ	University of Iowa, Department of Mechanical and Industrial Engineering, Iowa City, USA	1	57
13	Young,Terry;	Brunel University, School of Information Systems, computing and Mathematics, Uxbridge, UK	3	57
14	Zaleski,Sue	University of Iowa, Department of Pathology, Iowa City, USA	1	57
15	Does,RonaldJMM;	Uneiversity of Amsterdam, Department of Quantitative Economics, Amsterdam, Netherlands	8	54

Source: Elaborated by the author.

This centrality index in turn, may be analyzed according to the amount of relationships made (out-degree) and received (in-degree). According to

Hanneman and Ridle (2011), if an actor has a high in-degree, then it is considered “preeminent”. If he has a high out-degree, is considered one “influent” actor. In this context however, is necessary to interpret the data inversely: An author who receives many citations may be considerate an influent author, once if he receives many citations, he is influencing several other authors that are using its research as reference to build other researches. On the other hand, if an author has a high out degree, he cites more articles of the area than the other researchers, in such that we may interpret that his works tend to contain more robust theoretical base of the field questions. Once the sample used to represent the study field is composed only by journals indexed in JCR, is also a signal that this theoretical base of the field tends to be relevant. Thus, the table below presents the fifteen most important authors in terms of in-degree and out-degree separately.

Figure 23 - Fifteen authors with the highest in and out degree in the sample.

#	Author	Outdegree
1	Aronsson, Hakan;	64.000
2	Holden, RichardJ	64.000
3	Brommels, Mats;	59.000
4	Mazzocato, Pamela;	59.000
5	Thor, Johan	59.000
6	Savage, Carl;	46.000
7	De Bucourt, Maximilian	36.000
8	Teichgräber,UlfK;	36.000
9	Backman, Ulrika;	31.000
10	Elg, Mattias;	31.000
11	Sermeus,Walter;	29.000
12	Sol, Johannes;	29.000
13	Siebert, Joseph	28.000
14	VanVliet, Ellen J;	28.000
15	Guercio, Steven;	24.000

#	Author	In degree
1	Bassham, JaneE	74.000
2	Ben-Tovin, DavidI;	74.000
3	Spear,Steven J	64.000
4	Frerichs, Janice	57.000
5	Persoon, ThomasJ	57.000
6	Zaleski, Sue	57.000
7	Raab, StephenS;	50.000
8	Kin, JeanneM;	48.000
9	Bili, John,E	47.000
10	Kim, ChristopherS	47.000
11	King, DianeL;	47.000
12	Spahlinger, David A;	47.000
13	Does,Ronald J M M;	45.000
14	Young,Terry;	45.000
15	D’Angelo, Rita;	41.000

Source: Elaborated by the author.

As presented in the table 21, two authors that obtained similar centrality indexes lead the ranking: Ben-Tovim and Jane Bassham, both from the Flinders Medical Centre, Australia. Its preeminence is explained in terms of three articles from the period of 2006 a 2008 that report methods and improvements of a Lean initiative conducted in its hospital: “Redesigning Emergency department patient flows: Application of Lean Thinking to Healthcare”(12 citations) (BEN-TOVIM et al., 2006); “Lean thinking across a hospital: redesigning care at the: Flinders Medical Centre” (9 citations) (BEN-TOVIM et al., 2007); and “Redesigning care at the Flinders Medical Centre: clinical process redesign using "lean thinking" (4 citations) (BEN-TOVIM, et al., 2008)

On the following comes second group compound by Hakan Aronsson, Matts Brommels, Richard Holden, Pamela Mazzocato, Johan Thor and Carl Savage, that has its position mainly conquered by two papers collaboratively produced: “Lean thinking in healthcare: A realist review of the literature” (2010) (MAZZOCATO et al., 2010) and “How does lean work in emergency care? A case study of a lean-inspired intervention at the Astrid Lindgren Children’s hospital, Stockholm, Sweden” (MAZZOCATO et al., 2012). When comparing then the indexes of in and out degree, may be observed that the preeminence of this last group in sustained based in the citations made (out-degree), instead of received. Hence, it is an indicative that these articles have solid theoretical bases on Lean in Healthcare knowledge.

4.2.1.3. Bibliometric Analysis of the main papers

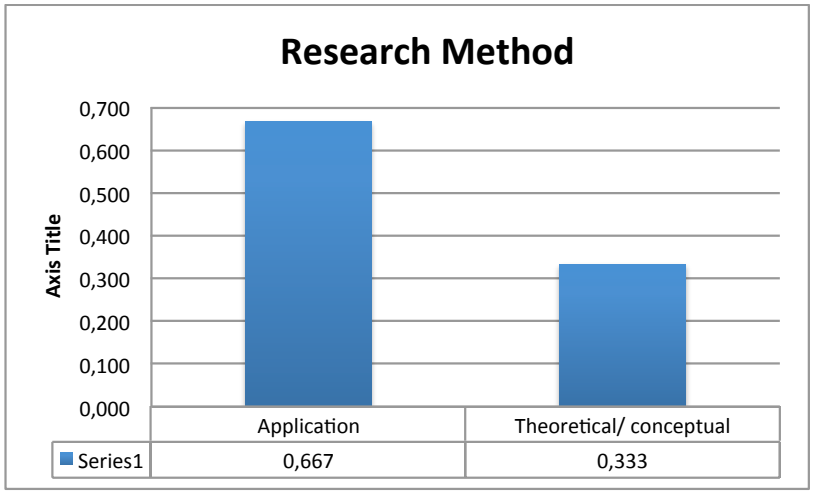
Grouping the publications of the authors of highest in/out degrees and the most cited articles of the sample is obtained a set of third papers. Grounded in citations, this group represents the core of the literature on Lean in Healthcare among 1995 and 2012.

Analyzing these publications, based in the affiliation of the first authors fourteen institutions was found as the contributors of these researches. The Henry Ford Health System (HFHS) and the University of Pittsburg leads the ranking with a total of four papers. In the case of the HFHS, the publications correspond to a series of publications reporting the application of Lean its

hospital among the period of 2006 and 2008. Similarly, in the fourth position, the body of articles from the Flinders Medial Center reports three improvement initiatives from 2006 to 2008. The University of Pittsburgh (second position) also is responsible for three empirical studies reporting applications of Lean, but also one conceptual/theoretical article that call healthcare organizations for improvement through Lean methods. The Brunel University has two theoretical/conceptual articles and a literature review.

Regarding to the research methodology of these articles, papers intended to report applications of Lean in determinate area of Medicine practice is the dominant type of document found (67%), followed by conceptual/theoretical papers containing simple concepts of Lean in healthcare (33%). Comparing the results obtained with this selected sample and the results of the first phase (broad sample - chapter 1), the indexes point exactly the same proportion of research methods.

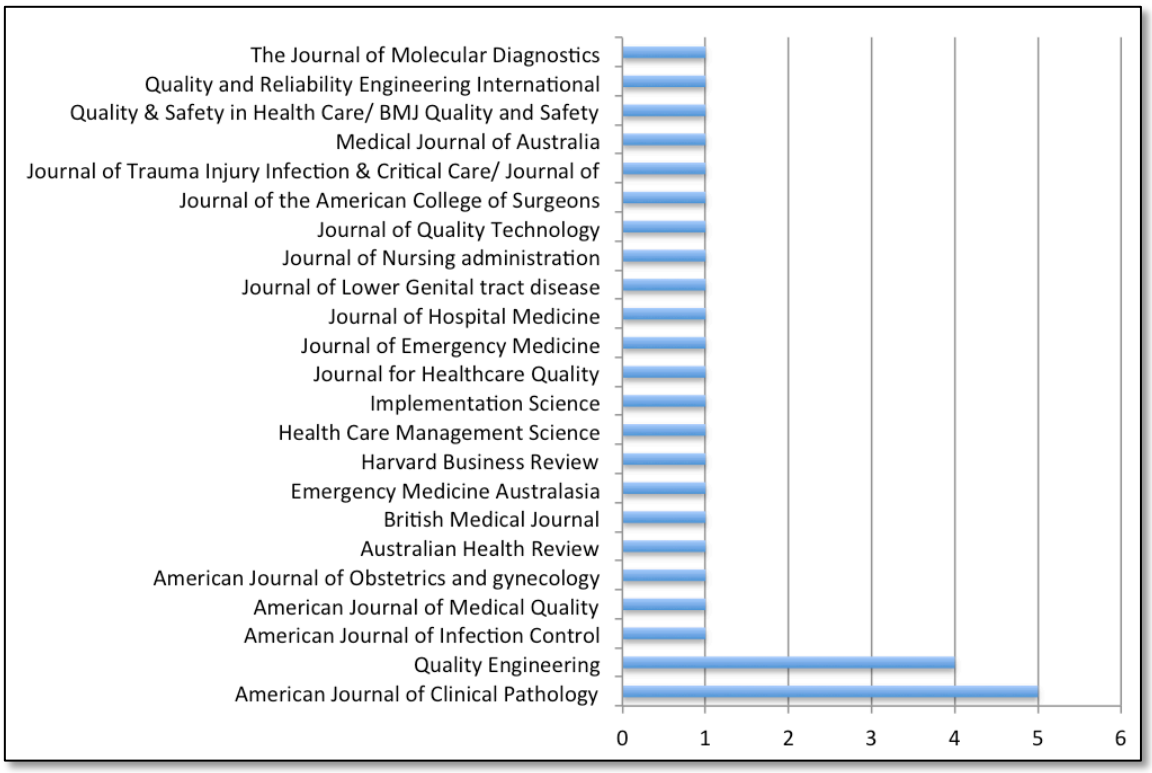
Figure 24 - Classification according to the research methods employed.



Source: Elaborated by the author.

The table below presents also the distribution of these publications across the journal where they were published. As may be observed, a more substantial quantity of publications found only in two journals: American Journal of Clinical Pathology (5 papers) and Quality Engineering (4 articles), the remaining quantity is distributed along 21 different journals.

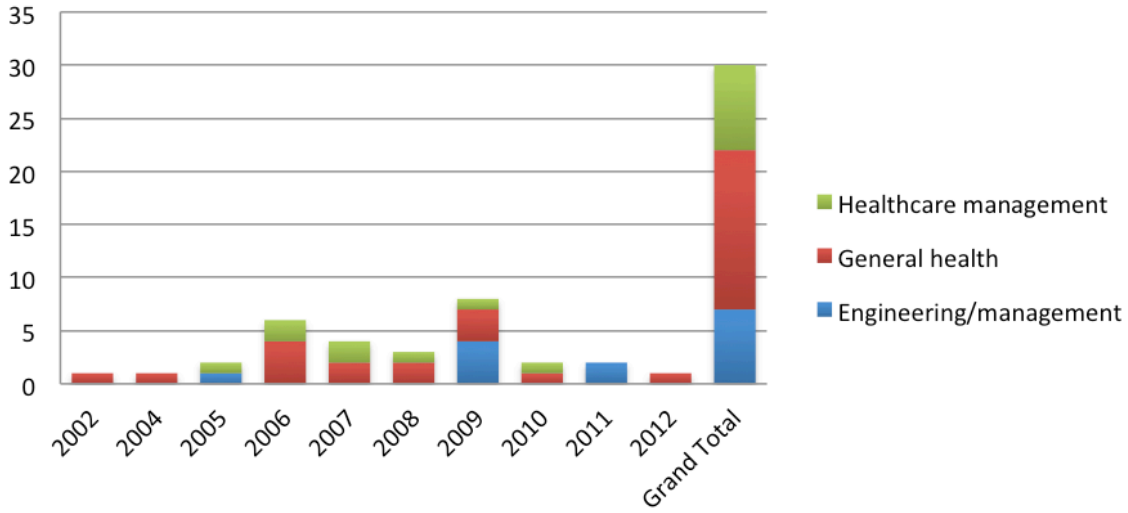
Figure 24 - Distribution of the publications according to the publication source



Source: Elaborated by the author.

These journals were then subdivided into categories according to its aims and scope revealing the subject area where the publications tend to be concentrate. Three main categories of sources were found: General Health (Medicine), Healthcare Management (journals focused in health care management and quality) and Engineering/Management. The distribution across the categories may be seen below.

Figure 25 - Distribution of the publications according to the journal subject area.

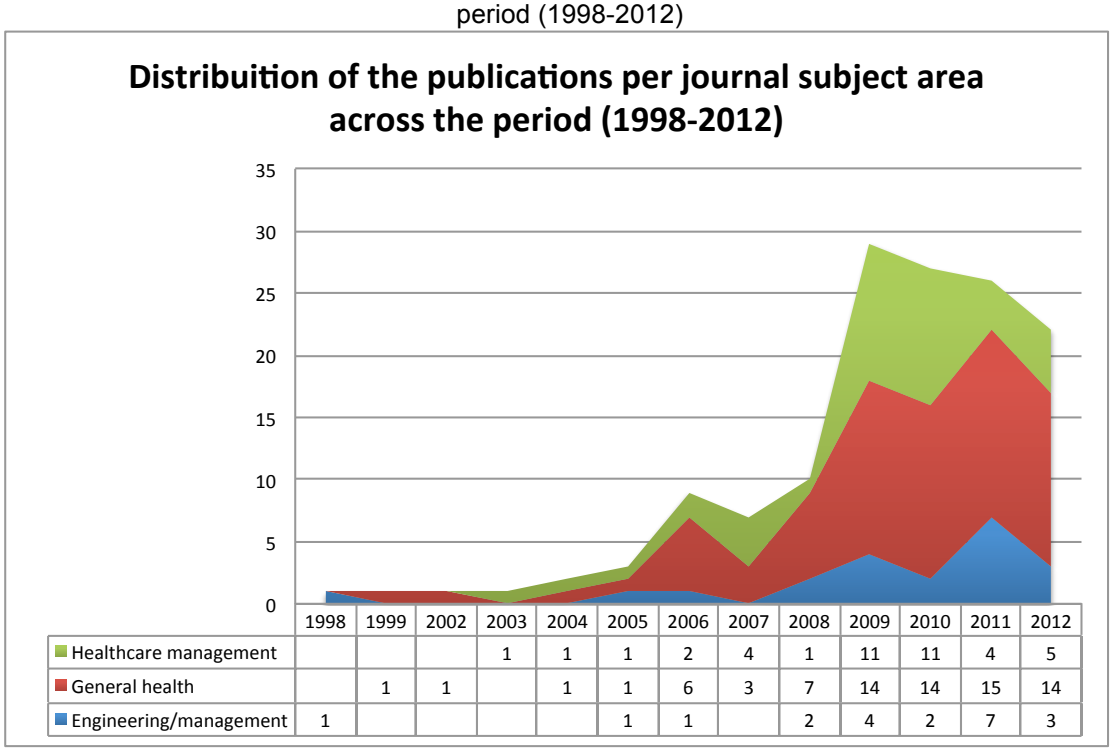


Source: Elaborated by the authors.

Publications in journals of Medicine predominated (53%), followed by Engineering/Management (27,7%) and Healthcare Management (23,3%). Grouping the healthcare Management and Medicine results, once the two areas are related, an amount of 73% is found, showing a significant preeminence against Engineering/Management journals. Performing the same analysis with the total set of the articles of this phase (139 papers), the participation of medicine remains relative the same, while the Engineering/Management journals starts to have even lower representativeness (14,7%), remaining the difference to the Healthcare Management Journals (30,15%).

The distribution of the papers per area was then distributed according to the period under study (1998-2012).

Figure 26 - Distribution of the publications according to the journal subject area across the period (1998-2012)



	1998	1999	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Healthcare management				1	1	1	2	4	1	11	11	4	5
General health		1	1		1	1	6	3	7	14	14	15	14
Engineering/management	1					1	1		2	4	2	7	3

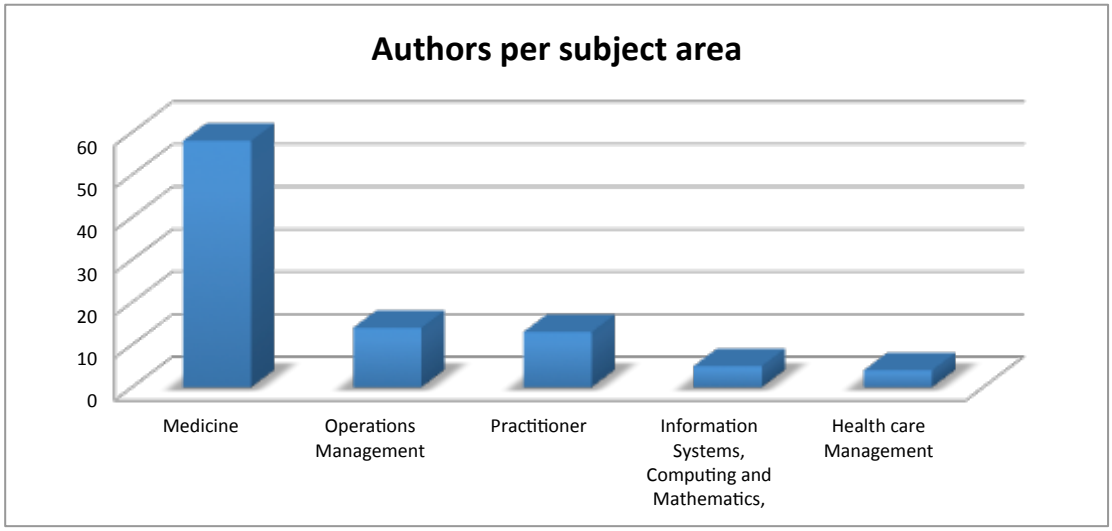
Source: Elaborated by the author.

As may be seen in the figure (figure 26), the results demonstrate a trend of increase of papers published in journals of medicine and variations in the proportion of publications in Healthcare management Journals. The participation of Engineering/management sources on the other hand, remains relatively flat over the period. Considering that the first publication of the sample

was made in an Engineering/Management journal (International Journal of Physical Distribution and Logistics Management) and that the Lean manufacturing is a research theme that originally belongs to the Operations Management field, the results do not provide indications which can explain the low amount of publications in journals of the area.

Considering that authors of operations management could be publishing in other areas, the set of 94 authors involved in the 30 main publications were classified according to its subject area. The classification was based in the affiliations and positions reported in the articles. Authors affiliated to Universities and Research centers were classified according to the subject area of its department: Medicine (Nurses and Physicians), Information systems, computing and informatics, Healthcare management (departments focused in hospital management) and Operations Management (Industrial Engineering, Management and logistics). Physicians, nurses, consultants and other professionals not affiliated to education and research institutions were classified as “practitioners”. The results are presented in the chart bellow.

Figure 27 - Distribution of the authors according to the subject area.



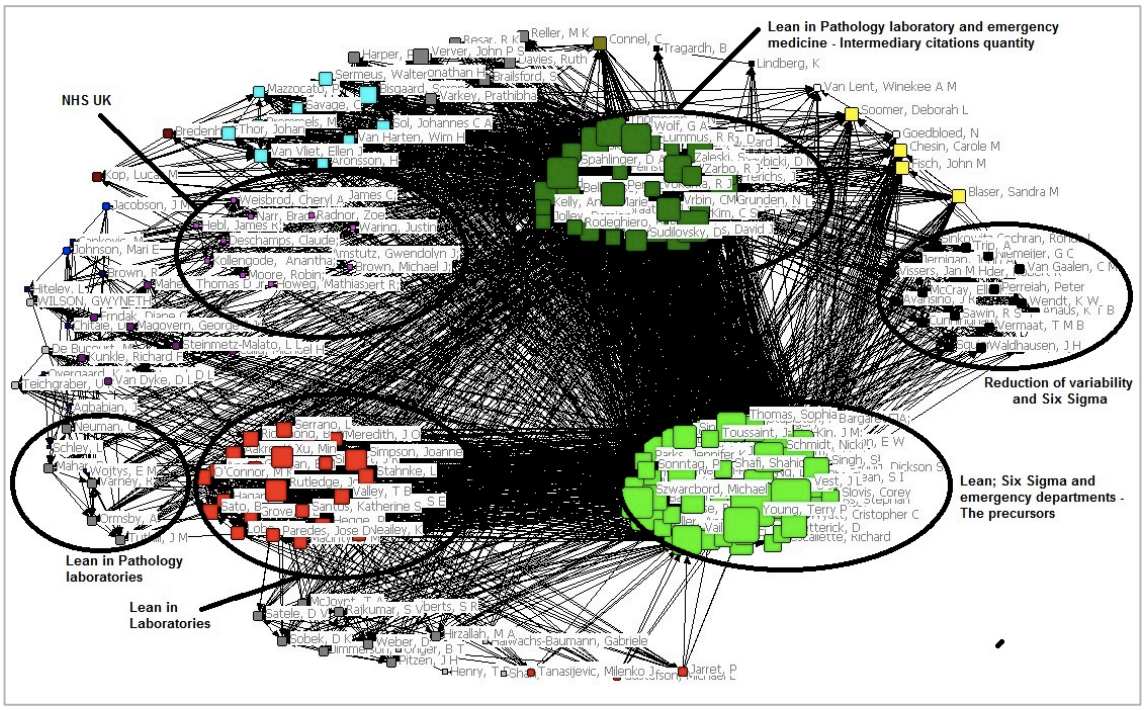
Source: Elaborated by the authors.

The results once more point the medicine area as dominant also among the authors responsible for the papers analyzed. Professionals from information systems, computing and mathematics appear also as a representative group.

4.2.2. Co-citation analysis

4.2.2.1. Main knowledge groups and themes

Figure 28 - Knowledge groups in Lean Healthcare according to k-cores augorithm.



Source: Elaborated by the authors.

In order to determine the main knowledge groups of the field, the k-core algorithm was employed revealing sub-groups in the co-citations network. Twenty and two (22) groups were found.

Since 41% (57 papers) of the sample does not contain keywords, in order to determine the research themes treated by the groups a tag of two or three words was determined for each article based in the abstracts content.

The analysis based in co-citation data reveals relations among authors based in two types of connections: co-authorship and theme affinity, showing already existent relations among authors and possible opportunities. These connections however are determined considering as raw data the citations among authors. It is assumed that an author cite works that he considers relevant for the construction of his research, emerging then the assumption of affinity in research themes.

Nevertheless, in performing the analysis of the groups in the Lean in healthcare network, in general the groups do not show representative affinity in theme considering the abstract content. Among the twenty-two groups pointed by the k-cores algorithm, major affinities among the authors were found only in six (16) cases; however nine (9) of the groups are responsible for only one article in the sample. The relation among the keywords of the six (6) groups with higher similarity are presented in the table below (table 8).

Table 7 - Groups defined bu k-cores that present theme symilarities.

Color in the figure	ID of the group	Keywords
Purple	NHS UK	NHS UK (3); Empirical research (2); Social dimensions (1); Application (1) Operating room suites (1), Lean and Six Sigma (2); implementation models (1); PDSA (1), Applicability (1); Socio-technical dimensions (1); Actor network theory (1); Simulation (1),
Dark gray	Lean in Pathology Laboratories (3).	Evaluate Lean results (1), surgical pathology laboratory (2), amended reports (1); Pathology laboratory (1);
Black	Reduction of variability and Six Sigma (6)	Cataract surgery (1); Lean Six Sigma (3); Trauma care (1); discharge procedure (1); Protocol for infection prevention (1); reduce variability (1); Medical visits in high volume surgery clinics (1), Operating rooms (1)
Red	Lean in Laboratories (7)	Laboratory (1); phlebotomy (1), blood draw (1); Lean six sigma (1); radiology (2); NHS (1); Pathology laboratory (2); autopsy (1); implementation methods (1);
Dark green	Lean in Pathology Laboratory and Emergency Department (18)	Implementation methods (1), Thyroid gland fine-needle aspiration (1); Pathology laboratory (7); Emergency department (2); Implementation Models (1); Nursing unity (1); Cardiac surgery (1); patient flow in a medical clinic (1); Teach lean in residency programs (1); Evaluate Lean results (1); amended reports (1); otolaryngology (1) operating room (1);
Light green	Lean, Lean Six Sigma and Emergency departments (31)	Implementation models (4); Emergency department (9); Lean Six Sigma (9); constraints theory (2); Literature review (3); evidence of effectiveness (1); Six Sigma (1), Studer's Hardwiring Excellence (1); Trauma care (1), discharge procedure (1); lean capabilities (1); Trauma resuscitation unity (1); Pediatric unit (2) Operating rooms (1); chronic obstructive pulmonary disease (1); socio technical dynamics (1), simulation modeling (1); Supply chain (1); operating rooms (1); infusion pumps (1)

Source: Elaborated by the author.

Despite of fact that do not exist much cohesion referring to the theme into the groups, three themes were representatively presented in the network, being found in mixed groups: Applications of Lean in Emergency departments and Laboratories (mainly Pathology laboratories) and the use of Lean combined with Six Sigma.

Taking into consideration that the field is still emergent in terms of research, a possible cause for this dissimilarity may be the absence of works in that specific theme, causing that the authors end up using what they consider as more related to its research.

A major number of members and consequently papers were found in two groups: the group represented by the light green in graph (55 members) and dark green (32 members). As the main groups of the field, they were most specifically analyzed. In order to find some similarity regarding to the theme, small groups were identified and named according to the main researcher of the group (high centrality degree).

4.2.2.2. Analysis group 1 – The precursors of Lean in Healthcare

The group one is the most representative in terms of both citations/author and quantity of authors in the group.

Spear, S J: The most central author in the group is Spear, S J (centrality degree = 146), which is also the most central author of the whole network. Steven J Spear, has two papers in the sample. The first: “Driving improvements in patient care: Lessons from Toyota” (2003), talks about the experience of the University of Pittsburgh Medical Center (UPMC) Health System, one of pionners initiatives of Lean in Healthcare. And the second paper is the famous “Fixing Healthcare from inside, today” (2005), which presents the Lean method as a possibility to fix the vast amount of problems faced in healthcare, calling for improvement. Spear's “Fixing Healthcare from the Inside, Today,” won a McKinsey Award as one of the best Harvard Business Review articles in 2005 and Spear's fourth Shingo Prize for Research Excellence. In our sample, this article was the most cited, obtaining 17 citations, being cited by 12,31% of the articles analyzed.

Flinders Medical Center: This group is formed by Ben-Tovim, D I and nine other authors that collaboratively produce three articles that report initiatives conducted in the Flinders Medical Center with the assistance of Lean methods. The articles date from the period between 2006 and 2008, and report initiatives that begun in 2003, such that based in our sample it represents another of the pioneers in implementing Lean in Healthcare.

Terry Young: This author has three articles in the sample, all of them theoretical/conceptual. Among them the paper "A Critical look at Lean Thinking to Healthcare", which was produced in collaboration with McClean, S I. It is one of the most cited articles (%) and the first literature review of the sample.

Does, R J M M - *Institute for Business and Industrial Statistics (IBIS UvA), University of Amsterdam, The Netherlands)* - This group is marked by the study of the Lean methodology combined with Six Sigma in Healthcare. Much of the articles of them derived from the experience of the The Red Cross Hospital (Beverwijk, The Netherlands) in implementing Lean Six Sigma from 2003 onwards. Another feature is the productivity. Does, R J M M is the most productive author of the sample, being responsible for 8 papers among authorship and co-authorship.

Dickson E W: This group is composed by several authors, being the most involved Dickson, E W and Eller, Andrew. The focus of the group is the application of Lean in Emergency departments.

4.2.2.3. Analysis Group 2 - Intermediary group

Among the group 2, four small groups may be highlighted:

Kim et al *(Departments of General Internal Medicine; Pediatrics and Communicable Diseases; and Internal Medicine of the University of Michigan, Ann Arbor, Michigan)*: In collaboration with three (3) other authors from medicine departments, Kim, CS is responsible for two (2) conceptual/theoretical works that defend the use of Lean in Healthcare and the teaching of quality improvement practices to residents. The paper "Lean Healthcare: What hospitals can learn from a world-class automaker" is the typical conceptual

paper found in Lean in Healthcare literature and one of the most cited papers of the sample (10 citations).

Raab et al. (Departments of Pathology and Obstetrics and Gynecology, University of Pittsburgh School of Medicine, University of Pittsburgh Medical Center, Pittsburgh, PA): Three articles in the sample belong to this group, all of them applications of Lean. The focus of these applications is the improvement of accuracy of tests for cancer diagnostic, most specifically the biopsy of nodules in thyroid and Papanicolau tests.

Persoon et al. *(From the Departments of Pathology and Mechanical and Industrial Engineering, the University of Iowa, Iowa City.)*: This group is quoted among the main articles based in citations attributed to a single article: “Improving Preanaytic process using the principles of Lean Production”. The article reports an application of Lean in a Clinical Chemistry Laboratory focusing in the improvement of preanalytic processes.

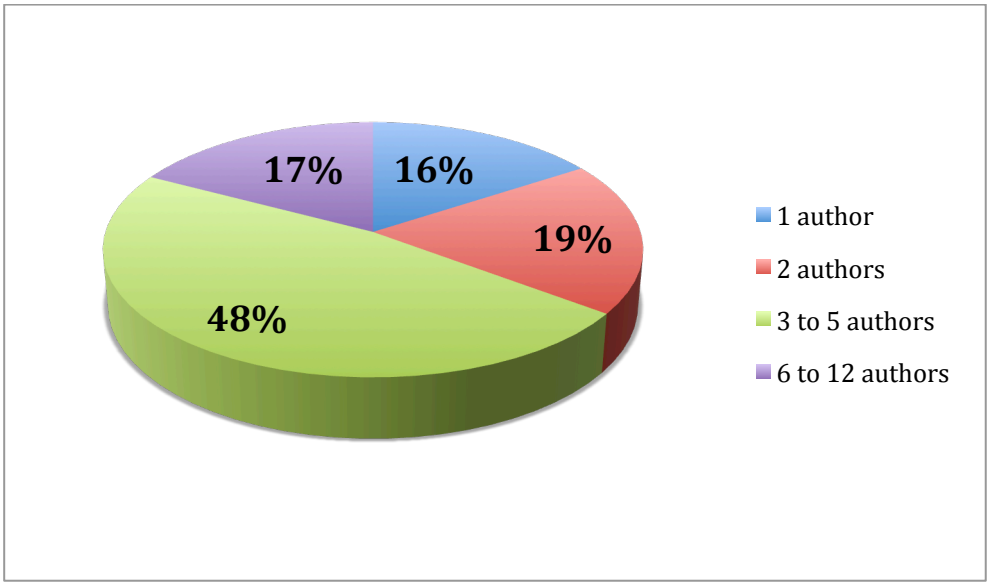
Zarbo et al. ***(The Henry Ford Hospital):*** Includes five articles that report initiatives to provide improvements in histology and Pathology laboratories of The Henry Ford Hospital.

4.2.3. Quantitative analysis of the articles authorship

From the total of 139 papers, 435 authors can be extract as the responsible for the publications. Based than in these data two additional analyzes could be performed: the level of cooperation in the researches construction and productivity.

Regarding to the first aspect, an elevate number of authorships per article is observed, indicating that the researches in this area tend to be constructed in collaboration. As may be observed in the chart, 48% of the papers of the sample have between 3 and 5 authors and 17% have more than six authors, reaching a maximum of 12 authorships in one only paper. Comparing these results with the area of finance in Brazil, based in a study of 815 articles, the data present an inverse pattern where 82,5% of the articles has among one and two authors and the remaining 17,5% are distributed among three to six authors per article (LEAL, OLIVEIRA AND SOLURI, 2003).

Figure 29 - Distribution of authors quantity per paper published.



Source: Elaborated by the author.

Analyzing the individual productivity of these authors, a total amount of 89,20% of the authors published just one article along the period of the fifteen years (1998-2012) analyzed. On the other hand, only 10,80% of the authors of the field have published more than one article, achieving a maximum of 8 articles per author.

In order to compare the pattern found with other areas, the number of publications per author was analyzed according to the parameters established by the Lotka's Low, which is widely used to evaluate the productivity of research fields in general areas (EOM, 2009). It determines that the number of authors that publishes n papers is equal to 1/n2 authors that publish only one article. Thus, the number of authors publishing two articles is equal to 1/4 of the authors that published one article, the number of authors who publish 3 articles is equal to 1/9 of that published one article, and so on (LEAL, OLIVEIRA ANS SOLURI, 2003). Chung and Cox (1990) than demonstrate that is possible to consider the number of authors with only one article as constant in 60,80%. Based then in this value is possible to calculate the proportion of authors that are supposed to publish a determinate amount of articles in accordance with the international pattern of Lotka's Low.

Hence, in order to compare, the table below presents the number of authors according to the quantity of articles published in the sample and the parameters established by Lotka.

Figure 30 - Productivity of the authors in LHC and the paramenters of the Lotka's Low.

Articles/Author	Nr of authors	% of the total	Lotka's Low parameters
1	388	89,20	60,80
2	35	8,05	15,20
3	8	1,84	6,76
4	2	0,46	3,80
5	1	0,23	2,43
6	0	0,00	1,69
7	0	0,00	1,24
8	1	0,23	0,95

Source: Elaborated by the author.

As presented in the table, the amount of authors that publishes only one article is 28,4% higher than the parameter established by Lotka, which indicates that the research in this area is comprised by a much larger portion of discontinued research than the expected in research fields. In consequence, the proportion of researchers that perform more than one study in the theme becomes greatly reduced.

Hence, the data indicate that in general do not exist continuity of the research efforts in the area and that the proportion of researchers who devote greater efforts to develop researches in the area is greatly reduced. Based in these data in turn is possible to infer that this discontinuity of the research efforts might be one of the cases to the limited use of research methods and substantial amount of theoretical/conceptual studies of weak contributions. Considering that a substantial amount of the papers studied are reports of applications of lean in a determinate setting, this data may also indicate that the implementation of Lean was not sustained or not expanded to other areas of the institution, once the absence of a second paper may be caused by the absence of results good enough to motivate a new publication tentative, suggesting also that in practice the Lean may be occurring as a passing fad in hospitals instead of a methodology that achieve its objectives through continuous and incremental process improvement.

4.3. PRACTICES AND PERFORMANCE GAINS OF LEAN IN HEALTHCARE

This sub-item is devoted to identify the main practices in Lean Healthcare based in a content analysis of eleven (11) papers. For the analysis, only articles from sources that was indexed in journal citation reports and obtained a score highest from three (3) points were selected. Results of the initiatives performed were also collect and classified. In the end of the chapter, the main practices and environment characteristics found were also discussed, pointing underused practices.

4.3.1. Main Practices

Many different practices were found in the articles reviewed. Among them, the classic lean tools and also complementary strategies such as parallel processing (Cima et al., 2011; McJoynt et al., 2009), benchmarking (Van Lent, Goedbloeda and Van Harten, 2009) and Six Sigma (Cima et al., 2011; Van Lent, Goedbloeda and Van Harten, 2009; Heitmiller et al., 2010).

Table 1 presents a summary of the interventions detected by the articles content. The table is organized around categories of similar practices (left column). In the right column are presented all the practices attributed to the intervention category accompanied in superscript of the reference of the paper where the practice was identified. The practices are ordered based on the frequency of appearance. The amount of articles in which at least one technique of the category was employed, can be checked in parentheses in the respective column.

Table 8 - Usual Lean Healthcare practices.

Category	*Practices Identified*
1. Mapping and analysis of current process (11 articles)	VSM [a04, a08, a09, a11]; Process mapping [a01, a02, a03, a05, a06, a07, a10];
2. Process redesign (11 articles)	Elaboration of new process or modifications in established ones [a01, a02, a03, a04, a05, a06, a07, a10, a08, a09,

	a11)
3. Incremental and continuous improvement techniques (11 articles)	Continuous actions to improve the processes (a02, a03, a04, a05, a06, a07, a08, a09, a10); PDCA (a01, a11);
4. Standardization (11 articles)	Codes (a01, a05, a09); templates (a02, a09, a11); Standard work (a01, a02, a03, a04, a05, a06, a07, a08, a09, a10, a11); Overall standardization (a04)
5. Training and communication (11 articles)	Systems to improve/facilitate communication (a01, a02, a04, a05, a06, a09, a10); Training and education (a01, a02, a04, a05, a06, a09); results feedback (a01, a04, a05, a06, a07, a08, a11); Periodical meetings (a01, a02, a03, a04, a05, a06, a07, a08, a09, a10, a11); Visual management (a01, a02, a04, a05, a08); clients training (a02, a11);
6. Performance management (11 articles)	Use of data (a01, a02, a03, a04, a05, a06, a07, a08, a09, a10); continuous management of results (a01, a03, a04, a06, a07, a08, a09, a10, a11; Rapid plant assessment a11;
7. Problem solving techniques (7 articles)	Root cause analysis a01, a02, a03, a04, a05, a07, a11; real time problem solving a04, a07; problem-solving sheet a04
8. Poka-yoke (5 articles)	Simplified systems and procedures to avoid bypass and errors a02, a05, a07, a09, a10; correlate medical experience and results to avoid false test results a10
9. Heijunka (5 articles)	Equalize work distribution a09; New schedule a04, a06, a08, a11
10. Six Sigma tools (3 articles)	DMAIC a05, a08, a09
11. One-piece-flow (2 articles)	1-by-1 process a10; One-piece-flow a02;
12. Parallel processing 2 articles)	Establishment of concurrent instead of sequencing processes a08, a09
13. First time quality (1 article)	Incentives and procedures to first time quality a09
14. Fist in, first out (1 article)	FIFO a09
15. Housekeeping techniques (3 articles)	5s a02; a04, a08
16. Go and see (2 articles)	Go to the Gemba a02, a11
17. Benchmarking (1 article)	Benchmarking a11
18. Just-in-time (1 article)	Just-in-time a04
19. Kanban(1 article)	Kanban a04

Source: Elaborated by the author.

As it may be observed in the table, six techniques predominate among the results: mapping and analysis of current processes; process redesign;

incremental and continuous improvement; standardization; training and communication; and performance management. All of them had one or more of its associated practices used in every analyzed article.

The first two topics are complementary (categories 1 and 2), both employed in order to perform improvements in the current process in an organization. As mapping techniques (category 1), can be understood practices that include descriptions and analysis of the current processes in order to identify points that need to be improved, Among them is the Lean technique of Value Stream Mapping (VSM), which details every aspect of a process pointing activities that do not add value from the customer perspective, these activities should be as far as possible removed from the process, increasing the proportion of value to the final client (LIKER, 2004). These techniques are somehow requested in order to enable to carry out redesigning or partial modifications in the current processes (category 2).

The category 3 makes reference to the way by which the modifications in the processes are usually performed. According to the information surveyed, the redesigning of a process often involves a series of small modifications, instead of an isolated improvement event, in a kind of incremental and continuous improvement process. Usually the project begins by some critical point and in the following the remaining problems are being addressed one by one. In general, the points to be improved and the respective countermeasures are determined by consensus of the improvement team in periodical meetings. These encounters can be held since in the form of brief meetings, until workshops, but always performed in relative short and regular periods of time. Based on the information collected from the articles, this technique may be considered as one of the key practices of the lean initiatives.

In this same line appear too diverse other practices designed to enhance the level of communication and knowledge in the organization (category 5). As mentioned before, it is likely that the correct use of tools designed to increase the level of communication is one of the most important characteristics of a successful Lean initiative. Considering the respective category of instruments (category 5), note that, instead of other categories, often more than one strategy to enhance communication is employed in the same initiative, aiming to cover different stakeholders (employees, clients, suppliers) and also areas of

knowledge (training about process details and lean behavior, awareness about performance results). Another interesting feature is the employment of strategies to facilitate and improve the communication. In 7 of the 11 articles, was used some kind of system or process strategically designed to address some difficulty in the communication, such as real time information systems and visual management.

The standardization is also a Lean practice very present in the initiatives. The instrument is most often used in processes, once the redesigning of a process is tight to the idea of standardization. But, the same concept can be extended also to the management of materials, codes, documents and various other areas, as demonstrated in various articles of the sample. According to Liker and Meier (2007) using this technique is possible to ensure more consistent performance and quality levels. It is also possible to point additional benefits such as prevent rework, misunderstandings and hand-offs between providers, mainly when they are from different departments. As the last technique of the most frequent group, appear the performance management practices (category 6). It is interesting to note that the control of data about the processes is not a technique directly linked to the concept of Lean Production; nevertheless it is very present in all the articles of the sample. The use of data is employed since before the beginning of the project to assist in the definition of improvement aspects, and follows with a plenty frequency along the project providing feedbacks about the actions taken and signalizing the need of countermeasures when necessary.

Following to the group of techniques with medium incidence, three practices appear: problem solving, poka-yoke and heijunka. Among the problem-solving techniques two characteristics are prominent: the approach of the problem in its root cause and the pursuit of resolution as quick as possible.

Then appear the Poka-yoke techniques, present in five of the eleven articles It is important to highlight that was considerate indicia of this instrument the employment of any kind of procedures or systems designed to avoid potential errors and defects. Nevertheless, if we consider as Poka-yoke systems that are able in fact to impede the error occurrence, no article of the sample presents this mechanism. Heijunka technique was also notable detected in the articles, five of them present some practice related to it. In four of the five occurrences,

the instrument was employed through alterations in the criteria and methods for scheduling procedures in the remaining occurrence, as measures to equalize the level of work among employees (MCJOYNT et al., 2009).

Ten other techniques were also detected in minor incidences: from one to three times. The entire group may be checked in the table (table 1). Among them stands out the presence of parallel processing in two articles. Parallel processing is also a non-traditional Lean tool, but present positive results in the initiatives that were employed.

4.3.2. Usual performance gains

Considering the analysis performed, the reviewed studies universally point the Lean initiatives in healthcare as successful in at least some aspect. A variety of improvements are presented, both in tangible and intangible aspects. A summary of the gains reported in the papers is presented in the table 2.

Table 9 - Usual performance gains in Lean Healthcare initiatives

Category	*Performance gains identified*
Stakeholders satisfaction (06 articles)	Staff satisfaction[a01, a02, a04, a06, a08, a11]; Patient satisfaction [a02, a04; a08];
Capacity and productivity (06 articles)	Increase in the number of attendances[a01, a02, a06, a11]; Staff productivity[a01, a03, a08, a11]
Times (5 articles)	Faster procedures[a01, a02, a03, a08, a09]; Less delays[a02, a08]; Waiting time [a01, a02, a08];
Exploitation of resources (05 articles)	Material wastage reduction[a02, a05]; Higher resources exploitation[a01, a08]; Better use of the physical space[a01];
Processes (4 articles)	More efficient processesa[02, a08, a10]; Reduction of unnecessary steps[a02, a06];
Costs (4 articles)	Less overtime[a08, a11]; Savings[a05]; financial gains[a03, a08]
Patient safety and Outcomes (3 articles)	Reduction in the rate of infections[a07]; Fewer complications[a04] Patient outcomes[a04]; Reduction of medico legal adverse events[a01]; Reduction of unplanned readmissions[a01];
Defects (2 articles)	Greater accuracy in test results[a10]; Less defects

	caused by procedures that were not followed[a02];
Variability (2 articles)	Lower variation in the times of procedures[a09]; More equalized workload[a02];

Source: Elaborated by the author.

The most common dimensions of improvement included stakeholder's satisfaction and the capacity and productivity increase. Considering the first category, six of the quotations make reference to staff satisfaction. According to the articles, this contentment is attributed to factors such as a perceived better work environment, more efficient processes and improved communication. The other aspect still in this same category is related to elevations in patient satisfaction. In the following, comes the gains regarding to levels of capacity and productivity, which are pointed in terms of elevation in the number of attendances and also directly as elevation in employees productivity.

Time-savings and timeliness of service are also frequently reported gains, which were detected in terms of reduction in the time required to perform procedures, less waiting time, and delays.

Still other aspects are also reported such as better resources utilization, this attributed to material wastage reduction, improved layout and other aspects, Better processes, through well designed processes and reduction of unnecessary steps and Cost reduction, reported as reduction in the need of overtime, savings and better financial performance.

In the seventieth position appears an important dimension to healthcare operations: the gains related to improvement in patient safety and satisfaction. Are reported reductions in the incidence of complications after medical procedures, reduced infection rates and others.

In the remaining positions are reduction in defects, incidence and less variability.

Although the quality was not pointed directly, note that several of the aspects are direct tight to the idea of quality improvement: Patient satisfaction, fast and punctual procedures, more efficient processes, least errors and mistakes, and most secure and accurate medical procedures, Cost is another aspect that is affected by some of the others improved dimensions: Improved capacity and productivity better resources utilization less defects and patient

safety problems.

A number of intermediate outputs were also reported. Most frequently mentioned outcomes in this set include increased communication and process awareness, which allow a more proactive position of the employees against problems, avoid mistakes and mainly handoffs among different providers.

4.3.3. Discussion

Based on the information obtained, healthcare can be understood as an environment where many different people with a high level of autonomy interact in complex and often unpredictable activities. These people characteristically possess different skills and specializations, resulting in different perspectives and often a lack of standardization in the procedures (McJoynt et al., 2009; Ben-Tovim et al., 2008; Culig et al., 2011). In general there seems to be a low level of understanding and adherence to procedures, suggesting that the internal processes are somehow undefined or excessively subjected to local decisions. Some articles point to factors such as fast technological development and complexity as causes or contributions to this problem (VAN LENT, GOEDBLOEDA AND VAN HARTEN, 2009; RAAB et al., 2006).

Additionally, these organizations seem to be overly segmented, generally operating as several independent silos, where it is difficult to engage in teamwork and collaboration (YIH, 2011; CANKOVIC et al., 2009). The communication tends to be weak or suffer breakdowns, causing frequent errors or low utilization due to an absence of correct and sufficient information (CIMA et al., 2011). The variability, which is already an inherent feature of healthcare, is intensified by frequent dependence on patient input and a lack of standardized procedures.

As a result of this interaction it is possible to observe in a considerable number of cases, excessive delays and losses in the links of the system (CIMA et al., 2011; MCJOYNT et al., 2009; CANKOVIC et al., 2009). The behaviors reported invariably also impact the ability to exploit resources causing a lot of waste throughout the processes. Safety also tends to be impacted, since poor design and the informality of procedures contributes to bypassing important activities resulting in errors.

Taking this background into account along with the best practices reported in the articles analyzed, it is possible to point out some aspects that are priorities for improving healthcare systems:

- *Attention to the practical aspects of the process (process redesign, techniques for improving flow and problem-solving):* Caused by culture and other factors, this perspective has hardly been considered, therefore, in general the processes are not designed with optimization in mind. According to Raab et al. (2006) often problems in the process are addressed through technological development instead of first paying attention to practical aspects, thus causing the issue to persist, generating unnecessary costs. As a result, characteristics such as potential for failure, excessive delays and variability are also observed. Thus, as much as possible, it is necessary to adopt a vision of care as a process, to then consider aspects such as efficiency, timeliness and the patient's perspective to the extent that it is possible. Ideally, the processes must be designed and continually improved upon focusing on execution and engagement, in order to ensure quality and efficiency.
- *Emphasis on communication and training (Follow-up meetings, training, techniques for improving the information flow and general awareness):* Several problems in healthcare are also caused by deficient communication and an insufficient understanding of the process and situations. An appropriate level of information enables more correct and prompt positioning, which is fundamental in a complex and variable environment like healthcare. Instead, in general employees have a low understanding of the steps involved in the processes performed by others, causing frequent delays and rework in the hand-offs. It is important to establish mechanisms for intensifying and facilitating communication such as regular meetings, visual management, and general instruments to make the necessary information available. Employees need to understand the process appropriately, along with the potential failures and performance levels, in order to correctly direct their efforts.
- *Efforts to minimize the sources of variability (Heijunka,*

client training): In many aspects the variability cannot be eliminated, but it can be reduced. The impact of wrong input from patients, for example, can be minimized through client training techniques. It is also possible to study the causes of variability in the processes and leverage and improve the schedule process based on potential failures; as was done by Laganga (2011). Intensifying standardization, both in procedures and materials is a necessary practice in order to improve this aspect.

- *Adopting a proactive position regarding healthcare characteristics:* It is often mentioned that as a result of proper characteristics in people and the environment, the implementation of changes in procedures in hospitals are very laborious (PAPADOPOULOS, RADNOR AND MERALI, 2011; BEN-TOVIM et al., 2008). It is common, for example to see an initial resistance to improvements, which is usually overcome after there is a better understanding of the project and the first positive results have been achieved (CANKOVIC et al., 2009; LA GANGA, 2011). This behavior is usually caused mainly by cultural issues that are contrary to the "manufacturing vision" in health and the perception of additional work with the new procedures. It is common to bypass steps and work around standard procedures, sometimes compromising patient and staff safety (RAAB et al., 2006). Therefore, an interesting strategy is to recognize these features and take a more pro-active approach. Some successful strategies have been: conducting initial meetings where employees receive training for the project, creating awareness about the problem in order to generate greater engagement. Also in terms of employee resistance, choosing the initial points for improvement is also an important decision. It is possible to consider, for example starting with administrative or operational processes such as the preparation of patients and the pre-analytical phase of laboratory exams, which are not directly involved in physician tasks. In order to avoid bypassing steps and ensuring patient safety, one can also consider simplifying the procedures as much as possible and developing mechanisms for facilitating correct execution. It is necessary to eliminate unnecessary procedures and include strategies for avoiding errors, such as poka-yoke.

Comparing the issues involved in the traditional Lean method it is possible to observe that some tools and practices are underused in healthcare organizations. As mentioned above, Just-in-time and Poka-yoke for example could contribute significantly to the solution of common problems in healthcare, but are still underexplored in this environment. SMED can also be quoted as one of these practices. Considering the insufficiency in healthcare systems in terms of the demand and high cost of equipment, it could also be interesting to devote some attention to machinery preparation, employing the lean technique to fast set-ups.

On the other hand, considering other practices such as the multi-skilled work force and cell arrange its employment does not seem to be so necessary or difficult to use. In this case, for example, assigning the majority of medical activities involves various regulatory issues and in general calls for long periods of education to legally acquire the new capability, thus the employment of this tool is limited to a set of activities and departments [06]. Another practice that does not seem to fit properly with hospitals is “autonomation”. Considering the intense labor involved in healthcare, attention to machinery and the practices related to it, end up in the background, at least when it is first implemented, where the problems associated with activities performed by people are so evident.

In the original Lean method, two pillars supported the philosophy: Just-in-time and “*autonomation*” (OHNO, 1988). Considering the manufacturing environment and the contextual features of the period when the method was developed, this assertion actually, seems to be quite relevant. Post-war Japan was marked by material and financial scarcity, obligating industries to find alternatives for survival; which for Toyota meant the total elimination of waste (OHNO, 1988). And in an industry, a considerable part of the waste occurs in terms of materials, justifying the emphasis on a tool like Just-in-time. *Autonomation* appears along the same lines, since the presence of machinery is intense in a manufacturing environment, and is responsible for a high proliferation of defects from simple problems, once again generating losses and rework (LIKER AND MEIER, 2007). Nevertheless, transposing this idea to health organizations, the concept does not fit perfectly.

Based on the material reviewed and several reports found in the literature, a philosophy seems to be able to provide significant improvements for health organizations. On the other hand, more careful observation reveals that the environment presents different characteristics and requirements. In hospital-like organizations different problems have more severe consequences, thus, logically in this environment different practices need to be emphasized in order to provide a more effective Lean approach. However, this question needs to be better addressed, as the literature offers very limited information on how to operationalize a lean intervention in healthcare and in general studies around a lean method that are more aligned with a contingency approach are restricted, with only a few exceptions remaining.

5. RESEARCH AGENDA AND OPPORTUNITIES FOR FUTURE

This section is devoted to identify over and unexplored research areas in the field of Lean in Healthcare and point out opportunities for future research. The results that will be presented, however, are based in a sample of the articles of the field, and so fourth they can not be taken as a complete representation of the research field.

The determination of the topics addressed was performed taking into consideration the main aspects observed along the researches performed in the previous chapters. The establishment of the recommended articles was made based firstly in the citations frequency. Nevertheless, once representative research may not appear due to a less frequency of citations caused by the reduced period of exposition of the article, this space was also used as opportunity to present relevant research that remain hidden in the anterior analysis.

5.1. CENTRAL ARTICLES AND PIONEER INITIATIVES

As well as in any research field, some articles in the Lean Healthcare are classics and compound a body of obligatory reading for those who are entering in the research field.

Table 10 - Central articles and Pioneer initiatives in Lean in Healthcare.

#	Paper	**Citations**
1	Spear, Steven J. Fixing healthcare from inside today (2005) *Harvard Business Review September*	**17**
2	King, D; Ben_Tovin, DI and Bassham, J. Redesigning Emergency department patient flows: Application of Lean Thinking to Healthcare 18, 391–397	**12**
3	Persoon, T; Zaleski, S and Frerichs, J. Improving preanalytic processes using the principles of lean production (Toyota Production System)(2006) *American Journal of Clinical Pathology 125:16-25*	**11**
4	Young, T and McClean, SI. (2008) A critical look at Lean Thinking in healthcare *Quality & Safety in Health Care/ BMJ Quality & Safety 17:382–386*	**10**
5	Kim et al.(2006) Lean health care: What can hospitals learn from a world-class automaker? *Journal of Hospital Medicine 1 (3) May/June*	**10**

6	Ben-Tovim et al (2007) Lean thinking across a hospital: redesigning care at the: Flinders Medical Centre. *Australian Health Review 31(1): 10-15*	**9**
7	Thompson, D; Wolf, G and Spear, S J (2002) Driving Improvement in Patient Care: Lessons from Toyota. *American Journal of Infection Control 33 (11), pp 585-595*	**9**
8	Dickson et al (2009). Application of Lean Manufacturing techniques in the emergency department. *Journal of Emergency Medicine Vo 37 (2) pp. 177–182*	**7**
9	Raab et al (2006). Effectiveness of Toyota process redesign in reducing thyroid gland fine-needle aspiration error. *American Journal of Clinical Pathology 126:585-592*	**7**
#	Jimmerson, Sobek and Weber (2005) Reducing waste and errors: Piloting Lean Principles at Intermountain Healthcare. *Joint Comission on Quality and Patient Safety 31 (5): 249-257*	**-**
#	Nelson-Peterson, D. and Leppa, C (2007). Creating an environment for caring using lean principles of the Virginia Mason production system. *Journal of Nursing Administration 37 (6), pp 287-294*	**5**
#	Grove at al. (2010). Lean implementation in primary care health visiting services in National Health Service UK. *Quality & Safety in Health Care/ BMJ Quality & Safety !9: e43*	**1**

Source Elaborated by the authors.

In Lean in healthcare, these body of literature is basically composed by two types of articles: simple conceptual/theoretical works explaining the basic concepts of Lean and calling the health organizations for improvement; and empirical researches that report methods and results of the pioneer initiatives.

Although those papers are not very rich in content, the classical articles are instrumental in understanding the early development of the fields and valuable in explicating the bases for the current theoretical perspectives of the disciplines (SOWER, MOTWANI AND SAVOIE, 1997).

Hence, the table below presents the classical articles in Lean in Healthcare ordered according to citations frequency. Here, was considerate as classical articles that are both are heavily cited and represent some importance in demonstrate the first steps of the Lean in healthcare operations.

As presented in the table, the article “Fixing Healthcare from inside, today” leads the ranking of citations. This article, as well as the “Driving Improvements in patient care: Lessons from Toyota” are linked to the Pittsburg Healthcare Initiative, where the concept of Lean in Healthcare was first developed with an explicit design drawn from the legacy and experience of

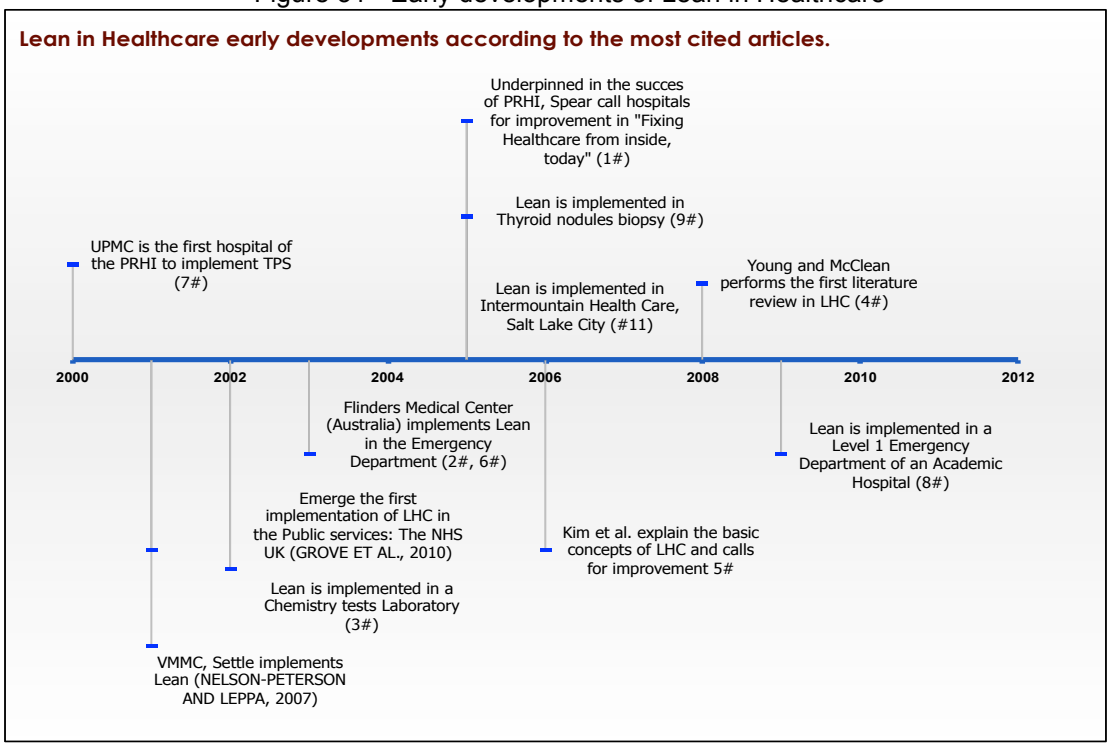
Toyota, Harvard Business School, and Alcoa (THOMSON, WOLF AND SPEAR, 2002).

The remaining articles are divided into simple conceptual/theoretical articles that explain basic concepts of Lean in Healthcare advertising its use (KIM ET AL., 2006), the fist literature review found in the field (YOUNG AND MCCLEAN, 2008), and empirical articles that describe the initiatives performed by the pioneers in the method implementation in the healthcare area. Among the empirical articles, are reported the initiatives of Flinders Medical Center, Australia (BEN-TOVIM, ET AL.,2006); the first implementation of Lean found in laboratory tests (PERSOON, FRERICHS AND ZALESKI, 2006); in thyroid nodule biopsy (RAAB ET AL., 2006); in an emergency department (DICKSON ET AL., 2009); and the first initiative conducted in Virginia Mason Medical Center, Seattle (NELSON-PETERSON AND LEPPA, 2007).

Based in the researcher experience, despite of the number of citations, the article that most specifically deal with the implementation of Lean in the NHS (GROVE AT AL., 2009) was also included, once this initiative is relevant in the literature and is the fist initiative of Lean in the Public Healthcare Service. The article “Reducing Waste and Errors: Piloting Lean Principles at Intermountain Healthcare” (JIMMERSON, SOBEK AND WEBER, 2005) was also included, once despite having been removed from of the second analysis, caused by the absence of impact factor by its publication Source, it was one of the most cited in the first citation analysis performed.

Once the articles mentioned tends to represent important facts in the early developments in Lean in Healthcare, the main events reported in each of them were disposed in a time line, providing an enhanced comprehension of the fist applications and publications (figure 31).

Figure 31 - Early developments of Lean in Healthcare



Source: Elaborated by the authors.

In order to comprehend the early developments and obtain a general perspective of Lean in Healthcare, two literature reviews provide a broad view of the field, such that can also assist is this task (Table 12).

Table 11 - Recommended literature reviews in Lean in Healthcare

Reference
De Souza, Luciano Brandão (2009). **Trends and Approaches in Lean Healthcare**. *Leadership in Health Services, v. 22, n.02, p. 121-139*
Poksinska, Bozena (2010). **The Current State of Lean implementation in Health care**. *Quality Management in Health care, v. 19, n.04, p. 319-329.*

Source: Elaborated by the authors.

5.2. APPLICATIONS OF LEAN IN HEALTHCARE OPERATIONS

The majority of the literature in Lean in Healthcare is formed by empirical studies. From these, a considerable part is devoted to report practices and tools utilized in implementing Lean in a determinate setting and the respective results.

In analyzing a broad set of these studies, the first characteristic that emerges is the limitation of the initiative to a determinate setting, being implementations in the whole organization much rare. Radnor (2010; 2011) and De Souza (2009) make similar findings and assert that projects in Lean in Healthcare tends to be small and enclosed, resulting in small-scale and localized productivity gains.

Additionally, is possible to observe that some areas of clinical practice are most often defined as a target for implementation than the others. Among them is possible to quote implementation in Laboratories (mainly Pathology departments) and Emergency departments. Therefore, research in these areas starting to create a volume, such that it is already possible to conduct researches in these specialized areas constructing upon the developments made. Papers focusing in the mentioned areas are pointed in the tables 13 and 14.

Table 12 – Recommended literature in Lean in Emergency Departments.

Reference
Mazzocato et al. (2012). **How does Lean work in the emergency care? A case study of a Lean-inspired intervention at the Astrid Lindgren Children's Hospital, Stockholm, Sweden**. *BMC Health Services Research, 12;28.*
Kelly et al. (2010). **Improving emergency department efficiency by patient streaming to outcomes-based teams**. *Australian Health Review, v. 31, n.01, p. 16 - 21.*
Dickson et al.; (2009). **Application of Lean Manufacturing techniques in the emergency department**. The *Journal of Emergency Medicine, v. 37, n.02, p. 177 - 182.*
King, D L; Ben-Tovim, David I; Bassham, Jane E; (2006). **Redesigning emergency department patient flows: Application of Lean Thinking to health care**. *Australian Health Review, v. 18, p. 391 - 397.*
Dickson et al.; (2009). **Use of Lean in the Emergency department: A case series of four hospitals**. *Annals of Emergency Medicine, v. 54, n.04, October, p. 504 - 510.*
Eller, Andrew.; (2009). **Rapid Assessment and disposition**. *Journal for Healthcare Quality, v. 31, n.03, p. 17 - 22.*

Source: Elaborated by the authors.

Table 13– Recommend literature in Lean applications in Laboratories

Reference
Raab et al. (2006). **Effectiveness of Toyota process redesign in reducing thyroid gland fine-needle aspiration error**. *American Journal of Clinical Pathology, v. 126, n.04, p. 585-592.*
Raab et al. (2006). **Improving Papanicolaou test quality and reducing medical errors by using Toyota production System methods**. *American Journal of Obstetrics and Gynecology, v. 194, n.01, p. 57-64.*
Persoon, T. J; Zaleski, Sue; Frerichs, J. (2006). **Improving Preanalytic processes using the principles of Lean Production (Toyota production System)**. *American Journal of Clinical Pathology, v. 125, n.01, p. 16-25.*
D'Angelo, Rita; Zarbo, R J (2007). **The Henry Ford Production System: Measures of process defects and waste in surgical pathology as a basis for quality improvement initiatives**. *American Journal of Clinical Pathology, v. 128, n.03, p. 423-429.*
Serrano et al. (2010). **Using Lean principles to improve quality, patient safety and workflow in Histology and Anatomic Pathology**. *Advances in Anatomic Pathology, v. 17, n.03, May, p. 215-221.*

Source: Elaborated by the authors.

Analyzing this situation in a macro level, another possibility of research could be the study of the motives behind this behind these choices. Conclusions about this common focus can for example determine ideal points of entry for the implementation of Lean in Healthcare organizations.

From a methodological point of view, some questions arose also from the empirical literature of the area. Most of them derived from the methodological and measure limitations observed in the vast majority of these studies (DE SOUZA, 2009; VEST AND GAMM, 2009; POKSINSKA, 2010; NICOLAY ET AL. 2011).

The first one is a concern regarding to the theories development in this research area. For theories be developed, is necessary to go through iterative cycles, where researchers build upon others work, starting from a descriptive stage (Carlile and Christensen, 2005), where is framed the current research in LHC. The following steps, however, includes synthesizing the observations made in form of frameworks. Nevertheless, as highlighted by Carlile and

Christensen (2005), the fidelity of the observations is fundamental in order to allow progress in the field.

Hence, two research topics derive from this issue. Firstly, in order to pull forward the research in the area is necessary to determine strategies to circumvent the limitations in the literature and synthesize the available information into implementation models. A possible strategy in this line could be the elaboration of initial constructs and posterior validation by other research methods such as case studies and survey. As highlighted by Papadopoulos, Radnor and Merali, 2011), the understanding of how to implement Lean in healthcare can be considerate a research gap, once despite of the vast number of studies, the comprehension of this practice remains limited.

In a second aspect, is questioned if is not necessary to conduct research that make clear the existence of such limitations, encouraging researchers to employ different methods and more valid approaches. The Operations Management field, when crossing by a similar situation around 1990, was subjected to alerts from several researchers such as Flynn (1990), who highlighted the issue motivating for change. In this line, authors such as Mazzocato et al (2010) and De Souza (2009) present the question; nevertheless without emphasize any need for change.

As efforts in order to synthesize practices in Lean in healthcare, some researches may already be pointed, which present analysis of groups of practices instead of isolated examples. Among them the work of Mazzocato (2010) stands out by the broad coverage of studies (33) and presents candidate mechanisms to improve the implementation strategies. Nevertheless, in this study any strategy is adopted in order to circumvent methodological limitations in the studies.

Table 14 - Recommended literature in Lean implementation models.

Reference
Mazzocato et al. (2010). **Lean Thinking in Healthcare: A Realistic Review of the Literature**. *Quality and Safety in Health Care, v. 19, p. 376-382.*
Burgess, Nicola; Radnor, Zoe (2013). **Evaluating Lean in Health care**. *International Journal of Health Care Quality Assurance, v. 26, n.03, p. 220-235.*
Radnor, Zoe; Howeg, Mathias; Waring, Justin (2012). **Lean in Healthcare: The Unfiled Promisse**. *Social Science and Medicine, v. 74, n.03, p. 364-371.*

Nicolay et al (2012). **Systematic Review of the application of quality improvement methodologies from the manufacturing industry to surgical healthcare**. *British Journal of Surgery, v. 99, n.03, p. 324-335.*

Source: Elaborated by the authors.

As a last topic that may be explored around the empirical studies in LHC, may be quoted studies around the sustainability of the initiatives in this organizational context. As mentioned in a previous chapter, with the exception of organizations such as UPMC, Flinders Medical Center, The Henry Ford Hospital and NHS that is no evidence that the high volume of initiatives undertaken in the area has persevere and continue to bring improvements. In this line, no study was found with the purpose of verifying the sustainability of existing projects over these 13 years.

5.3 Healthcare characteristics and its relation with the Lean tools and practices

According to the researches performed in the chapter five (5), six main characteristics are observed in healthcare organizations: Poorly designed processes, excessive segmentation inside of the organizations, high variability, differentiated social dynamics, fast and dynamic system and concerns around preventable medical errors.

The authors in the field already directly or indirectly recognize many of these characteristics, which is possible to visualize by papers that address these questions or apply Lean tools devoted to solve related problems.

The first and foremost characteristic is the differentiated social dynamics of the Healthcare organizations, which causes that the Lean implementation in these companies tends to be a highly contested process (WARING AND BISHOP, 2010). In this sense, some researchers have been recognizing these features and concentrating studies that demonstrate the influence of the relations of power in healthcare and provide strategies to overcame these barriers to implementation. This is a research topic that has been interestingly explored by some researchers, and seems to be promising in terms of future research.

Table 15 - Recomended literature in barriers to Lean in Healthcare

Reference
Papadopoulos, T; Radnor, Z; Merali, Y (2010). **The Role of actor associations in understanding the implementation of Lean Thinking in healthcare**. *International Journal of Operations & Production Management, v. 31, n. 02, p.167-191.*
Waring, J; Bishop, S (2010). **Lean Healthcare: Rhetoric, ritual and resistance.**. *Social Science & Medicine, v. 71, p. 1332-1340.*
De Souza, L B; Pidd, M (2011). **Exploring the barriers to Lean Healthcare implementation**. *Public Money and Management, v. 31, n.01, p. 59-66.*

Source: Elaborated by the author.

The high variability and poor structuration of the processes are also streaking features of healthcare organizations (MANS, 2011). Flexibility in Healthcare is a concept of major importance, once is not possible to accurately predict the state of health of patients, such that constant modifications are inherent to the processes in hospitals (MANS et al., 2006). Caused by this and the dependence of patients inputs (arrivals on time, adherence to protocols, etc), process in healthcare suffer by problems derived from high variability. Therefore, in order to contain this variability, several studies in the area involve the application of Lean in combination with Six Sigma, being many of these studies focused in Operating rooms schedule improvement.

Table 16 - Recommended literature in variability and Lean Six Sigma

Reference
La Ganga, Linda (2011). **Lean Service operations: Reflections and new directions for capacity expansion in outpatient clinics**. *Journal of Operations Management, v. 31, n. 02, p.167-191.*
Pandit, JJ; Pandit, M; Reynard, M (2010). **Understanding waiting lists as the matching of surgical capacity to demand: are we wasting enough surgical time**. *Anesthesia, v. 65, n. 06, p.625-640.*
Niemeijer et al. (2010). **Quality in trauma care: Improving the discharge process by means of Lean Six Sigma**. *The Journal of trauma, Injury and critical care, v. 69, n. 03, p.614 - 619.*
Parks et al. (2008). **Dissecting delays in trauma care using corporate Lean Six Sigma methodology**. *The Journal of trauma, Injury and critical care, v. 65,*

n. 05, p.1098 - 1104.

Cima et al. (2008). **Use of Lean and Six Sigma methodology to improve operating room efficiency in a high-volume Tertiary-care Academic Medical Center**. *Journal of the American College of Surgeons, v. 213, n. 01, p.83 - 92.*

Does et al. (2009). **Reducing start time delays in operating rooms**. *Journal of Quality technology, v. 41, n. 01, p.95 - 109.*

Heitmiller et al. (2010). **Blood wastage reduction using Lean Sigma methodology**. *Transfusion, v. 50, n. 09, p.1887-1896*

A last line of research emerges than from a view of Lean as a context dependent methodology. This perspective is grounded on works of authors James-Moore and Gibbons (1997) and Sohal and Egglestone (1994), which performed studies that indicate the existence of natural differences among the lean practices adopted in different companies and enforce the adaptation of the method according to the business requirements. As a more direct emphasis in this sense, may be quoted the work of Hines, Howeg and Rich (2004) which stated the Lean thinking as a limited method that is composed by a strategic (Values and principles) and an operational level (tools and practices), being the second one subject to adaptations and complements in order to allow the application of the method to different types of business and satisfy contrasting needs. As treated in the chapter three, Ohno (1988) itself make it clear that at Toyota the Lean tools was created with clear purposes and needs. Therefore, one research line to be explored could be the elaboration of implementation models for Lean in healthcare based in context requisites and characteristics, resulting in a methodology adapted to Healthcare organizations.

According to the preliminary studies in this perspective performed in the chapter 3, the results confirm the approaches of the authors mentioned above, which has taking into consideration the socio dynamics of the system and focusing efforts in control variability. Additionally, the development of Just-in-time and Poka-yoke could contribute significantly to the solution of common problems in healthcare, but still little explored in this environment. SMED can also be quoted as one of these practices. Considering the insufficiency of health systems against the demand and the high cost of equipment, could also be

interesting to devote some attention to the machinery preparation, employing the lean technique to fast set-ups.

Additionally, besides the incentive to explore underused tools, a research line that could be explored is the individual development of each technique that is appropriate to the healthcare environment. Although some techniques such as VSM and Kaizen events are already widespread in this area, research devoted to determine ideal approaches to conduct each of them are still not available in the current literature.

6. CONCLUSIONS

This study was devoted to mapping the characteristics of scientific research in Lean Healthcare identifying the main contributors to the field, the research areas and opportunities.

The analysis revealed that research in the field was carried out from 1998 to 2011, which is marked notably by three phases. An initial phase from 1998 to 2001, where a limited number of articles were produced (2), all of a conceptual/theoretical nature. Between 2002 and 2006, the first reports of the application of Lean philosophy in healthcare appeared, confirming the results from previous researchers (DE SOUZA, 2009). The following years, from 2006 to 2011 reveal a field that is rising exponentially, concentrating 79.34% of the papers produced, exceeding the combined total from the previous two periods.

The main characteristics of the research field may be posed in terms of three aspects. Firstly, in terms of the publication sources which demonstrate the inclination of authors publishing in Medical and Healthcare Management journals, an unexpected result when considering that Lean Thinking originally belongs to the manufacturing area. Dispersion was also a characteristic observed in the publication sources. The ten sources with the greatest number of articles accounted for only 25.62% of the total number of articles found, while the total number of sources containing only one article on the subject accounted for 39.67% of all the articles.

The analysis revealed that the United States was the main contributor in terms of countries (60.7%), followed by the United Kingdom (13.6%), the Netherlands (5.4%) and Canada (3.3%), for which the number of studies was much smaller. Other countries such as Denmark and Sweden also yielded results, but these were much less significant. Articles from a total of fourteen countries were found.

The last and most important characteristic relates to the methodology used in the documents. An analysis of the articles showed that the literature in the area suffers from limitations regarding the use of research methodologies as well as a lack of methodological rigor and appropriate measuring methods. In analyzing literature from the area, empirical articles predominate (67%), followed by conceptual/theoretical studies. In trying to classify the articles into

more specific categories, there was some difficulty classifying articles as case studies, since the vast majority is simply devoted to reporting improvements made in a given setting of a clinical practice, without demonstrating scientific research interests to analyze phenomena with impartiality and following research protocols. Similar difficulty was found by De Souza (2009), who also establishes an initial classification of the studies into basically empirical and conceptual, and goes on distributing these categories into more specific ones, involving areas of application where the more robust theoretical articles are separated from the "speculative".

Several doubts arose from the research characteristics identified in the first analysis, such that a second round was performed aiming to limit the presence of methodologically limited articles by restricting the analysis to articles published in sources indexed in Journal Citation Reports (JCR), which is a recognized method for evaluating a journal's quality. Complementary analysis performed based on the third of papers published by the most influential authors in the area demonstrated exactly similar research method patterns and a distribution of the publication papers in the main areas: Medicine (53%), Engineering/Management (27.7%) and Healthcare management (23.3%), thus confirming the predominance of journals from the medical area found in the first analysis. Aiming to determine the cause of the predominance of medical articles, a distribution of the publications according to subject area by year was also performed, revealing that the publications in the medical area have been rising at a more accelerated pace than Engineering/Management. Considering that the first publication analyzed was published in the "Journal of Physical Distribution and Logistics Management", the pattern observed does not explain the concentration of publications in medical-related areas. Considering that authors from Operations Management could be publishing in other areas, the set of 94 authors involved in the main third of publications in the area were classified according to subject area. The results point to researchers from the Medical areas as the main contributors, followed by Operations Management researchers. Professionals from hospitals and consultants that are not affiliated with any research institute were also included and classified as "Practitioners".

A quantitative analysis of the authorship of articles was also performed, revealing that the research in the field tends to be produced collaboratively.

From a total of 139 articles, 435 authors may be extracted, analyzing papers individually, this shows that 48% of the articles have between three (3) and five (5 authors) and 17% have between six (6) and twelve (12) authors.

Despite the high level of collaboration, in comparison to the individual productivity of these authors with the pattern established by Lotka's Law, the results show that in Lean in Healthcare the percentage of authors that publish only one (1) paper in this area during their careers is 28.4% higher than the (60.8%) determined, which indicates that research in this area is compromised by a much larger portion of discontinued research than is expected in research fields.

The Main contributors in terms of authors and documents in the research field were also determined, based on two different perspectives. The first one took into consideration an analysis of the whole set of documents cited by the articles analyzed, such that the results indicate the main references for the knowledge construction in this area. In performing this analysis, seminal authors from Lean Philosophy appear as the main source for knowledge construction, followed by precursors in the application of Lean and Lean Six Sigma in Healthcare and also authors that deal with general quality improvement in Healthcare. In performing a co-citation analysis of these citations, these three macro themes also appear to be dominant. Researchers focused on Lean in Healthcare, on the other hand, are found mixed with authors from overall quality improvement in Healthcare. Thus, a perspective that eliminates the authors that do not belong to the set under analysis and publish in journals indexed in JCR, reveals patterns that confirm the previous results, presenting additional authors in the area that replace the Lean seminal authors.

Combining these two perspectives it is then possible to determine that the central authors in the field are the precursors of the application of Lean in Healthcare and Lean Six Sigma. The most central author in the field is Spear, S.J., who contributes to the development of the lean system adapted to the Pittsburgh Regional Healthcare Initiative (PRHC) and the first implementation in the University of Pittsburgh Medical Center (UPMC). Spear is also responsible for the most cited article of the sample "Fixing Healthcare from the inside, today", which calls on healthcare companies to make improvements based on the success of PRHI. Among the first fifteen places, authors from other pioneer

initiatives also appear, among them, The Flinders Medical Center and Red Cross Hospital.

The analysis of the knowledge groups in the network restricted to Lean in Healthcare authors to determine research themes, on the other hand, does not produce very productive results. In order to determine the clusters, the k-cores algorithm was applied resulting in twenty-two (22) groups, which do not present representative affinity regarding the research themes treated. A pattern of themes could be recognized around three themes: Lean and Six Sigma and Variability; the use of Lean in Emergency departments and Laboratories, with Pathology Laboratories being the most predominant. These themes however are not focused on groups in the network, instead they are scattered throughout the network, showing that the groups are not yet properly formed and indicating that the authors could be having difficulties finding literature in their topics of interest, or do not consider it appropriate, despite its existence.

As the last topic in the analysis, the practices of Lean in Healthcare were analyzed showing that Lean is generally adopted in a limited format in healthcare organizations. Summarizing the information from the articles it was possible to observe an approach almost restricted to process redesign and problem solving through a limited exploration of the lean tools. Despite this fact, each of the reviewed studies concluded that the respective interventions were effective in at least some aspect. The main benefits include improved stakeholder satisfaction, increases in capacity, productivity and timeliness. An analysis of the articles' content showed yet a representative presence of common problems and characteristics that might be satisfactorily addressed by other Lean practices, suggesting that a look ahead could provide additional gains. On the other hand, some strategies enshrined in Manufacturing appear to conflict with inherent characteristics of these organizations. Therefore, despite its effectiveness, it was found that the employment of lean in healthcare operations tends to adopt a different format than in manufacturing. Contextual aspects made it more interesting to prioritize certain tools, while neglecting others and also seeking external combinations, such as Six Sigma, in order to fully meet the organizations' needs and increase the success of implementation.

Based on research performed throughout this study, it was then possible to create a research agenda and set the following directions for future studies in Lean in Healthcare in terms of potential research areas observed:

- The sustainability of Lean initiatives in healthcare;
- Ideal points of entry for Lean in Healthcare organizations based on the most frequent implementation areas;
- Socio-technical dynamics of Healthcare organizations and their relation to the Lean method implementation;
- Lean as a context-dependent methodology that should be adapted to satisfy healthcare requirements;
- Variability and Lean Six Sigma;
- Development of potentially interesting tools such as poka-yoke, just-in-time and SMED;
- Development of isolated tools and practices such as models for Kaizen Events implementation;

Therefore, the mapping of scientific research in Lean Healthcare revealed that the field is still underexplored in terms of research and not yet well structured in terms of themes and author relations. Despite the already substantial number of articles published, the general characteristics of the field demonstrate concerns excessively focused on practice, which can be observed by the articles' content, limited exploration of the research methods, and a strong presence in the medical area among authors and publication sources. Therefore, these limitations indicate that research in Lean in Healthcare is a fertile field for the development of research on several topics, presenting several opportunities for authors interested in the area.

6.1. CONCLUSIONS REGARDING TO LEAN IN HEALTHCARE PRACTICE

The studies performed indicate that Lean Thinking is a promising method for the healthcare industry. The literature for the most part reveals a rising number of successful implementation reports, demonstrating that the use of lean in this setting is increasingly considered an option in practice and that these initiatives have resulted in an overall high rate of satisfaction.

Despite the fact that some results among articles in the area were discredited due to characteristic limitations in methodological and measuring methods, for practical purposes, the observation of the numerous professionals involved is a valid and strong indication of success, since the articles demonstrate a general awareness that implementation positively achieves several different objectives.

On the other hand, a point that might be considered by practitioners is the absence of evidence attesting to the sustainability of these positive results and even their own initiatives, as they are currently being designed in an extended time horizon, since no studies were found specifically addressing this issue and it is rare to find distinct articles reporting initiatives in the same organization in different time periods.

Despite conclusions about the effectiveness of the method, the study showed that currently the information on how to implement Lean in Healthcare is rather limited. Regardless of the vast amount of studies reporting on implementation methods, the information available is not synthesized and often not clear, making it laborious to recognize the general conclusions about best practices for the method application. It is possible to observe a more representative trend around process redesign techniques, patronizing and incremental improvements as the main strategies. In the remaining articles, the pattern is variable and scattered, demonstrating a still limited exploration of the possibilities offered by the method.

The study shows further that in implementing the Lean method in Healthcare, contextual particularities arose that might be considered for improving the implementation process and the success of the method. Aspects such as initial resistance from medical professionals, complexity and highly variable routines suggest that an adapted method could enhance the suitability for these organizations.

Nevertheless, in summary the studies show that at this moment, there is still no single well-established manner to deal with the application of Lean thinking in health care settings. Taking into account the particularities of the environment it is clear that specific knowledge about the philosophical behavior in this particular context is helpful, since it would then be more likely to overcome the problems when they occur. Researchers have begun to address

this question, however many research efforts still need to be performed in order to make it possible for the practitioner to appropriately handle Lean implementations in healthcare.

6.2. CONCLUSIONS REGARDING TO THE OPERATIONS MANAGEMENT FIELD

Although throughout this research the application of Lean in Healthcare was addressed separately, the questions surrounding the method independent of the setting initially belongs to the Operations Management field, such that some conclusions from the research are also related to this macro area.

The first is a rise in the demand from Healthcare Operations for Industrial Engineering strategies demonstrated in the articles analyzed, which includes not just the Lean Method but a diversity of practices traditionally employed in industry. The healthcare companies, which before were fully subject to clinical decisions, are becoming more open to the introduction of rational methods for work design, causing this field to emerge as another fertile possibility for engineers both in terms of research and practice. As presented in the research, operations management professionals are acting in the area in very small numbers compared to the number of health professionals, who seem to be acting independently in Lean implementation in Healthcare and publishing about it.

Considering the practice, this question is mentioned several times in the articles analyzed and attributed to a perceived absence of capable professionals to act in this context. According to some articles, it is difficult to find professionals able to consider the particularities of the sector and act accordingly. In the research, special tracks in conferences and movements about the questions may be perceived, as well as a more effective participation of small groups in journal articles. Nevertheless, this participation still proves to be a poor representation of the evidence collected, indicating an opportunity to act in this area and bring the contributions already achieved into healthcare through the development of the application of Lean in other industries.

It seems it would be productive for Operations Management professionals to bring their experience with Lean in other industries to Healthcare Operations, likewise the demonstration of the existence of peculiarities in Healthcare and the need for adaptations in the original Lean model could be seen as an opportunity to consider the method as context-dependent and develop appropriate solutions, allowing Lean thinking to be used in unexplored business environments.

6.3. STUDY LIMITATIONS

In this section the main limitations of this research will be discussed. The topics will be treated separately in two sub-sections: the limitations of the research method itself and the limitations incumbent to the research as a result of the choices made by the researcher.

6.3.1. Limitations inherent to the analysis techniques

Literature reviews employing meta-searches characteristically involve a substantial number of references, however it is important to highlight that even so, the results presented have been developed based on a sample of articles in the field, and thus do not cover the totality of characteristics present in the literature. As a result of the large amounts of data handled during the research, it is necessary to also consider the possibility of failures in data gathering and quantification caused by limitations inherent to the manual process.

Limitations regarding the citation and co-citation analysis might also be mentioned. In terms of co-citations, the analysis is based on the affirmation that authors are frequently co-cited together due to an existent proximity among them based on co-authorship or affinity of themes. Nevertheless, in interpreting the data it is correct to assume that the opposite can also occur: authors may be frequently cited together because of their strikingly opposing viewpoints.

Along the same lines, citations were used to determine which authors are currently the most representative in the field, this is concluded based on how often an author is used as a reference for papers in the field. However, once more it is prudent to consider that an author may also be cited frequently due to a negative reputation in the field. Additionally, it is possible that the citations

were motivated by the prestige of the author in previous works or as an attempt to favor co-workers or a research institution for example.

6.3.2. Limitations regarding to the choices made along the research

In any research, the researcher must choose strategies for developing the study, which are believed to be the best option for achieving the set objectives. However, these choices naturally involve limitations and additionally, unexpected results may arise due to particularities of the context or the availability of resources. Thus, in this topic the main issues found in this paper will be presented as limitations of the choices made.

The first limitation to be mentioned is the impossibility of accessing all of the articles available in the literature. To perform the meta-searches, databases were selected for the acquisition of papers, in which availability depends on the level of access of the researcher or research institution, and in this case some papers were not available. This topic may be seen as a limitation for conducting the second analysis and getting results, since thirty (30) articles that fit with the search strategy could not be accessed and were excluded. This limitation might impact the productivity journal ranking, for example where a characteristic article may not appear because it was not available.

The second point is that the strategy chooses to determine a select group for more careful analysis. Based on the first phase of analysis, methodological and measuring limitations appear in a considerable number of papers selected and strategies are then employed to remove this material from subsequent analyses. The employment of the research filter according to JCR classification was then selected as the option; however, it appears that it may not be the most appropriate strategy for removing the undesired materials. After the filter, problems still persist and interesting studies were excluded.

The third and last main limitation resulted from the combination of techniques chosen for the analysis. This is because citation and co-citation analysis were chosen for a major part of the research performed, while content analysis was used for a small part. Since no studies indicating the main contributors to the research area were made in this field before, we believe that this was the correct position. Nevertheless, the results demonstrate that the

field is still immature, where the main contributors in terms of authors, documents and research institutions are not in fact well established, such that the investment in other techniques might provide improved results. The frequency of citations, for example, revealed articles that are important for the field, but are not so representative in terms of research development. On the other hand, much of the research that proves the development of the field was not revealed by the analysis proposed, such that the research agenda was the only topic where these studies could be presented. Taking into account that the main objective of a literature review is to present research that is relevant to the field and significant for knowledge construction, this is a weak point, since these studies were pointed out based on a subjective analysis in a systematic literature review that aims to be objective. On the other hand, the secondary position of the content analysis could occupy a more relevant position, as it is caused by the heterogeneity of the field, it is likely that an analysis based on the articles' content represents more interesting methods, allowing one to separate relevant materials from the rest based on a more detailed individual analysis.

6.4. LESSONS LEARNED IN PERFORMING A LITERATURE REVIEW

Conducting a systematic literature review is not as simple as it seems, it is laborious and painstaking work that requires time and rigorous organization. Hence, this section is devoted to passing on some lessons learned in performing this task in order to provide some guidance for students who aspire to engage in a similar project. Below is some simple advice according to the three main phases in conducting analogous projects: preparation, development and analysis.

- **Preparation:** In the first steps of a systematic literature review, creating a research protocol is probably the most important stage. It is important to devote some time to developing it in order to produce a project that is appropriate and, most important, viable in terms of time and operationalization. To achieve this aim, the first point to be followed is the acquisition of an appropriate theoretical background. Currently, several books and articles present

information about what to include or discard, what steps to follow and how. Some even provide models to be followed, which will increase the reliability of the review from the standpoint of the reader. As examples, we can quote Levy and Ellis (2006), Conforto et al (2011) and mainly the Cochrane Handbook (Higgins and Green, 2011), which provides complete guidance to authors for conducting the renowned Cochrane reviews. The second point may be posed in terms of time and tools. In planning the activities, it is not easy to consider everything that might occur throughout the process, such as limitations in the data sources and tools chosen, the absence of data or heterogeneity. These constraints have a direct impact on the time required to perform the review, causing rework if not properly added to the research protocol; considering the nature of the meta-searches, any rework is too much work. Hence, besides preparing a detailed plan, an interesting strategy to mitigate surprises during the process is to conduct small "pilot projects" of the intended research phases, in order to visualize the processes in practice and estimate appropriate times and methods for project development. In performing "pilot projects" it is also possible to evaluate if the results that will be obtained, considering the real condition of the data sources, are able to satisfy the requirements for achieving the proposed objective, thus allowing for any necessary changes in direction without major losses.

- **Data collection and treatment:** The data collection and treatment phase involves almost entirely mechanical processes. Once the research protocol has been properly developed, the researcher needs only to rigorously follow the established procedures to achieve the objective. Nevertheless, this phase is the most time-consuming part of the project and also the foundation for the entire analysis and results that will be obtained. Therefore, the data collected and organized must be precise, and for this objective the process must be performed exactly how it was designed to be: mechanical and according to the protocol. Thus, the aspects

highlighted for this phase are practical and might be summarized in terms of "explicitness" and organization. It is important to keep in mind that considering the large amount of work in this phase it is common that more than one researcher is involved in the project and tasks are performed in parallel; or that, if only one researcher is involved, the tasks will be performed on a long-term horizon, making it necessary to pay attention to the explicitness and organization of the data, avoiding doubts, rework and wasted time during the process. In other words, it is necessary to create rules about how to acquire materials and nomenclature. Material destinations, codes and data sources for each piece of information must be as clear and understandable as possible. It is useful for example, to keep links indicating the sources used for each piece of data, memos in spreadsheets and the like. It is important also to avoid separating data in different files, which is often done for the execution of tasks by different researchers. If it becomes necessary, it is important to develop strategies for easily joining data from different documents into a single document.

- **Analysis:** The analysis phase is much more particular for each author and might involve completely different procedures and logic. For this reason, the steps to be followed at this stage are determined by the researcher’s goals. Nevertheless, it is important to note that every review has the common objective of synthesizing the research from a field aiming to convey the reality in the best way possible to readers who will not go through the same process to find the answers. For this reason, an important and simple aspect is reflecting on the analysis and methods of the knowledge acquired, emphasizing the large amount of information obtained in the systematic literature review, the aspects that are in fact most important, allowing the reader to comprehend the main questions that emerge in the research field.

REFERENCES

TUCKER, Anita L; EDMONSON, Amy C; SPEAR, Steven J. When problem solving prevents organizational learning. **Journal of Organizational change Management, v.** 15, n. 2, p. 122-137, 2002.

AHUJA, Ravindra K; MAGNANTI, Thomas L; ORLIN, James B. **Network flows:** Theory, algorithms and applications. Upper Saddle River: Prentice Hall, 1993.

ABERNATHY, William J; CLARK, Kim B; KANTROW, Alan M. The New industrial competition. **Harvard Business Review**, v. 59, n. 05 (Sep-Oct), p. 68-81, 1981.

BAHENSKY,James A; ROE, Janet; AND BOLTON, Romy. Lean Sigma: Will it work for healthcare? **Journal of Healthcare information management,** v.19, n.1, p. 39-44, 2005.

BARDIN, Laurence. **Análise de conteúdo**. Lisboa, Portugal: Edições 70, 2011.

BARNES, Stuart J. Assessing the value of IS journals. **Communications of the ACM**, v. 48, n.1, p. 110-112, 2005.

BEN-TOVIM, David I et al. Redesigning care at the Flinders Medical Centre: clinical process redesign using "lean thinking". **Medical Journal of Australia**, v. 188, n. 6, p.S27-S31, 2006.

BEN-TOVIN, David I et al. Lean Thinking acoss a hospital: Redesigning care at Flinders Medical Centre. **Australian Health Review**, v. 31, n. 1, p. 10-05, 2007.

BEN-TOVIN, David I et al. Patient Journeys: The Process of Clinical redesign. **Medical Journal of Australia**, v. 17, n. 188 (6 sup), p. S14-S17.

BIOCHINI, Jorge Calmon de Almeida et al. Scientific research ontology to support systemmatic review in software engineering. **Advanced Engineering Informatics**, v. 21, n. 02, p. 133-151, 2007.

BJÖRNEBORN, Lennart; INGWERSEN, Peter. Toward a basic framework for webometrics. **Journal of the Americal Society for Information Science and Technology**, v. 55, n. 14, p. 1216-1227, 2004.

BORGATTI, Stephen P; LI, Xun. On Social Network analysis in a supply chain context. **Journal of Supply Chain Management**, v. 45 (April), n. 02, p. 5-22, 2009.

BOWEN, David E; YOUNGDAHL, William E. (1998). "Lean" service: in defense of a production-line approach. **International Journal of service industry and management** , v. 09, n. 3, p. 207-225.

BOYER, Kenneth K. An assessment of managerial commitment to lean

production. **International Journal of Operations and Production Management**, v.16, n. 09, p. 48-59, 1996.

BREYFOGLE, Forrest W; SALVEKAR, Arvind. **Lean Six Sigma in Sickness and in Health**. AUSTIN, TX: Smarter solutions, 2004.

BREYFOGLE, Forrest W. Implementing Six Sigma Smarter Solutions using statistical methods (2nd edition), New York: Wiley, 2003.

BURT, Ronald. **Structural roles:** the social structure of competition. Cambridge, MA: Harvard University, 1992.

CARLILE, Paul R; CHRISTENSEN, Clayton M. **The cycles of theory building in management research.** Retrieved 08 27, 2012, from Harvard Business School: http://www.hbs.edu/research/pdf/05-057.pdf

CASSEL, J; YOUNG, A. Why we should not seek individual informed consent for participation in health services research. **Journal of Medical Ethics**, v. 28 (Oct), 5, p. 313-317, 2002.

NAKANO, Davi Noboru. Métodos de Pesquisa Adotados na Engenharia de Produção e Gestão de Operações. In: MIGUEL, Paulo Augusto Cauchick (Org.). **Metodologia de Pesquisa em Engenharia de Produção e Gestão de Operações.** Rio de Janeiro, RJ: Elsevier.

CHASE, Richard B. Where does the costumer fit in a service operation? **Harvard Business review**, v. 56 (Nov/Dec), n. 6, p. 137-142, 1978.

CHOO, Vivien. Thin line between research and audit. **The Lancet**, v. 353 (Aug. 01), n. 9125, p. 337-338, 1998.

CIMA Robert R et al. Use of Lean and Six Sigma Methodology in improve operating room efficiency in a High-volume Tertary-Care Academic Medical Center. **Journal of the American College of Surgeons**, v. 213 (jul), n. 1, p. 83-92, 2011.

CONFORTO, Edivandro C; AMARAL, Daniel C; SILVA, Sérgio L da. Roteiro para revisão bibliográfica sistemática: Aplicação no desenvolvimento de produtos e gerenciamento de projetos. **In: 8 Congresso Brasileiro de Gestão de desenvolvimento de produto**. Porto Alegre, 2011.

COOK, Deborah J; MULROW, Cynthia D; HAYNES, Brian. Systematic reviews: Synthesis of the best evidence for clinical decisions. **Annals of Internal Medicine**, v. 126, n. 05, p. 376-380, 1997.

COONEY, Richard. Is "Lean" a universal production system? Batch production in the automotive industry. **International Journal of Operations and Production Management**, v. 22, n. 10, p. 1130-1147, 2002.

CRESWELL, John W; CLARK, Vicki L P. **Designing and conducting mixed**

method research. London: Sage, 2006.

Cusumano, Michael A. **The Japanese Automobile Industry: Technology and Management at Nissan and Toyota.** (Harvard East Asian Monographs, No. 122) Harvard University Press, Boston, 1985.

BERWICK, Donald M. Developing and testing changes in delivery of care. **Annals of Internal medicine**, v. 128, n. 8, p. 651-656, 1998.

BERWICK, Donald M. Controlling variation in healthcare: A consultation from Walter Shewhart. **Medical Care**, v. 29, n. 12, p. 126-133, 1991.

BERWICK, Donald M. Broadering the view of evidence-based medicine. **Quality and Safety in Healthcare**, v. 14 (Oct), n. 5, p. 315-6, 2005.

SOBEK, Durward K; JIMMERSON, Cindy. A3 Reports: Tool for process improvement in Healthcare. **In: Proceedings of the Industrial Engineering Conference**, Houston, 2004.

BLESER, LEENTJE DE et al. Defining Pathways. **Journal of Nursing management**, v. 14, n. 7, p. 553-63, 2006.

DE KONING, Henk; MAST, Jeroen. A Rational reconstruction of Six Sigma's breakthrough cookbook. **International Journal of Quality Reliability and Management**, v. 23, n. 7, p. 766-787.

DE KONING, Henk et al. Lean Six Sigma in Healthcare. **Journal for Healthcare quality**, v. 28, n. 2, p. 04-11, 2006.

DE MAST, Jeroen; DOES, Ronald.J.M.M; DE KONING, Henk. **Lean Six Sigma for Service and Healthcare**. The Netherlands: Alphen Aan den Rijn, 2006.

DE SOUZA, Luciano B. Trends and Approaches in Lean healthcare. **Leadership in Health services**, v. 22, n. 2, p. 121-139, 2009.

DEMING, Edwards W. **Out of the crisis**. Cambridge, MA: MIT Press, 1982.

DICKSON, Duncan; FORD, Robert C; LAVAL, Bruce. Top ten excuses for bad service (and how to avoid needing them). **Organisational Dynamics**, v. 34, n. 2, p. 168-204, 2005.

DICKSON, Eric W et al. Use of Lean in the Emergency Department: A Case Series of 4 Hospitals. **Annals of Emergency Medicine**, v. 54, n. 4 (Oct), p.504-510, 2009.

DOES, Ronald J M M et al. Comparing non manufacturing with traditional applications of six sigma. **Quality Engineering**, v. 15, n. 1, p. 177-182, 2002.

DOES, Ronald J M M et al. Reducing start time delays in operating rooms. **Journal of quality technology**, v. 41, n. 1, p. 95-109, 2009.

ARMSTRONG, E G; MACKEY, M; SPEAR, Steven J. Medical Education as a process management problem. **Academic medicine**, v. 79, n. 8, p. 721-728, 2004.

ENGELUND, Eva H; BREUM, Gitte; FRIIS, Alan. Optimisation of large-scale food production using lean manufacturing principles. **Journal of foodservice**, v, 20, n. 1 (Feb), p. 4-14, 2009.

EOM, Sean B. **Author cocitation analysis:** quantitative methods for mapping the intellectual structure of an academic discipline. Hershey: Information Science Reference, 2009.

FEINSTEIN, Karen W; GRUNDEN, Naida; HARRISON, Edward I. A Region adresses patient safety. **American Journal of infecction control**, v. 30, n. 4, p. 248-251, 2002.

FILLINGHAM, David. Can lean save lives? **Leadership in health services**, v. 20, n. 4, p. 231-241, 2007.

FLYNN, Barbara. Empirical research methods in operations Management. **Journal of Operations Management**, v. 9, n. 2, p. 250-284, 1990.

FREITAS, Henrique; JANISSEK, Raquel. **Técnicas complementares, sequenciais e decorrentes para a exploração de dados qualitativos**. Porto Alegre: Sphinx: Editora Sagra Luzzatto, 2000.

FREITAS, Henrique et al. O método de pesquisa survey. **Revista de Administração**, v. 35, n. 3 (Jul/Sep), p. 105-112, 2000.

FUJIMOTO, T. **Organizations for Effective Product Development—The Case of the Global Automobile Industry**. Unpublished D.B.A dissertation, Harvard University Graduate School of Business Administration, 1989.

GARFIELD, Eugene. **Citation indexing – Its theory and application in science, technology and humanities**. Institute of Scientific Information, ISI Press Philadelphia, 1997.

GRABAN, Mark. **Lean Hospitals: Improving quality, patient safety and employee satisfaction**. New York, NY: Productivity Press, 2009.

GRÖNROOS, Christian. Service management: A management focus for service competition. **International Journal of Service Industry Management**, v. 1, n. 1, p. 6-14, 1990.

GROVE, Amy L et al. UK health visiting: challenges faced during lean implementation. **Leadership in Health Services**, v. 23, n. 3, p. 204 - 218, 2010.

HANNEMAN, R A; RIDDLE, M; **Introduction to Social Network Methods**. Riverside: University of Califórnia, 2005. Available in: http://faculty.ucr.edu/~hanneman/nettext/index.html Acesso em 2 de setembro de 2013.

HART, Chris. **Doing a literature review: Releasing the social science research imagination**. London, UK: Sage Publications, 1998

HAYES, Robert H. Why Japanese factories work. **Harvard Business Review**, Jul-aug, p. 57-66, 1981.

HAYNES, Ray. M. Service typologies: A transaction modeling approach. **International Journal of service industry management**, v. 1, n. 1, p. 15-26, 1989.

HEINBUCH, Susan E. A case of successful technology transfer to healthcare: total quality materials management ns Just in time. **Journal of management in medicine**, v. 9, n. 2, p. 48-56, 1995.

HEITMILLER, Eugenie S et al. Blood Wastage reduction using Lean Sigma Methodology. **Transfusion**, v. 50, n. 9 (Sep), p. 1887-1896, 2010.

HINES, Peter; HOWEG, Matthias, RICH, Nick. Learning to evolve: a review of contemporary lean thinking. **International Journal of Operations and Production Management**, v. 24, n. 10, n. 994-1011, 2004.

HOWEG, Matthias. The Genealogy of Lean Production. **Journal of Operations Management** , v. 25, n. 02 (Mar) p. 420-437, 2006.

IOM. **Crossing in the Quality chasm: A new health system for the 21st century**. Washington, DC: National Academies Press, 2001.

JACOBS, S; PELFREY, S. Applying just-in-time philosophy to healthcare. **Journal of nursing administration**, v. 25, n. 1 (jan), p. 47-51, 1995.

JAMES-MOORE, S M; GIBBONS, A. Is lean manufacture universally relevant? An investigative methodology. **International Journal of operations and Production Management**, v. 17, n. 9, p. 899-911, 1997.

JIMMERSON, Cindy. **A3 Problem solving for healthcare: A Practical Method for Eliminating Waste**. New York: Healthcare Performance Press, 2007.

JIMMERSON, Cindy; WEBER, Dorothy; SOBEK, Durward. Reducing waste and errors. Piloting Lean Principles at intermountain Healthcare. **Joint Commission on Quality and Patient Safety**, v. 31, n. 5 (May), p. 249-57, 2005.

VANHAECHT, Kris; SERMEUS, Walter. The Leuven Clinical Patway compass. **Journal of integrated care patways**, v. 7, p. 2-7, 2003.

KARLSSON, Christer; AHLSTRÖM, Pär. Assessing changes towards Lean production. **International Journal of Operations and Production Management**, v. 16,n. 2, p. 24-41, 1996.

KIM, Christopher et al. The application of lean thinking to the care of patients with bone and brain metastasis with radiation therapy. **Journal of Oncology Practice**, v. 3, n. 4, p. 189-193, 2007.

L'HOMMEDIEU, Timothy; KAPPELER, Karl. Lean Methodology in i.v. Medication process in a children's hospital. **American Journal of Health-Systems Pharmacy**, v. 67, n. 24 (Dec), p. 2115-8, 2010.

LEE, W L; ALLWOOD, J. Lean Manufacturing in temperature dependent processes with interruptions. **International Journal of Operations and Production Management**, v. 23, n.11, p. 1377-1400, 2003.

LEVITT, Theodore. Production-line approach to service. **Harvard Business Review**, sep/Oct, p. 41-52, 1972.

LEVY, Yair; ELLIS, Timothy J. A Systems Approach to Conduct an Effective Literature Review in Support of Information Systems Research. **Informing Science Journal**, v. 9, p. 181-212, 2006.

LIKER, Jeffrey. **The Toyota way**: 14 Management principles from the world's greatest manufacturer. Madison: McGraw-Hill, 2004.

LIKER, Jeffrey; MEIER, David. **O Modelo Toyota**: Manual de Aplicação. Porto Alegre, RS: Bookman, 2007.

LOVELOCK, Christopher H. Classifying services to gain strategic marketing insights. **Journal of Marketing**, v. 47, n. 03 (Summer), p. 9-20, 1983.

GLOSH, Manimay; SOBEK, Durward K. A test of the designing rules in healthcare. In: **Proceedings of the Industrial Engineering research**, Orlando, 2006.

MALEYEFF, John. Exploration of internal service systems using lean principles. **Management Decision**, v. 44, n. 5, p. 674-689, 2006.

MANS, R et al. Process Mining in Health Care. In: L. Azevedo and A.R. Londral, (eds.). **International Conference on Health Informatics** (HEALTHINF'08), p. 118--125, Funchal, Maldeira, Portugal, January 28-31, 2008.

MANS, R. Workflow support for the health care domain. **Research School for operations management and logistics**. Eindhoven, 2011.

Mazzocato, Pamela et al. Lean thinking in healthcare: A realist review of the literature. **Quality & Safety in Health Care**, v. 19, n. 5, p.376-382, 2010.

MCGILL, M.E; SLOCUM, J.W. Unlearning the organisation. **Organisational**

Dynamics, v. 22, n. 2, p. 67-79, 1993.

MONDEN, Yasuhiro. Adaptable Kanban system helps Toyota maintain Just-in-time production. **Industrial Engineering**, v. 13, n. 5, p. 29-46, 1981.

MONDEN, Yasuhiro. How Toyota Shortened supply lot production time, waiting and conveyance time. **Industrial Engineering**, v. 13, n. 9, p. 22-31, 1981.

MONDEN, Yasuhiro. Smooted Production lets Toyota adapt to demand changes and reduce inventory. **Industrial Engineering**, v. 13, n. 8, p. 42-51, 1981.

MONDEN, Yasuhiro. **The Toyota production system**. Portland, OR: Productivity Press, 1983.

MULLANEY, Kathi. Improving the Process of supplying instruments to the operating room using lean rapid cycle improvement process. **Perioperative nursing clinics**, v. 5, n. 4, p. 479-487, 2010.

MULROW, Cynthia. D. Systematic Reviews: Rationale for systematic reviews. **British Medical Journal**, v. 309, n. 6954, p. 597-599, 1994.

NELSON-PETERSON, Dana L; LEPPA, Carol J. Creating an environment for caring using lean principles of the Virginia Mason production system. **Journal of Nursing Administration**, v. 37, n. 6, p.287-294, 2007.

NHS Choices (NHS Authorities and Trusts in England) **About the NHS, NHS authorities and trusts in England**. Available at: www.hesonline.nhs.uk/ease/servlet/contentserver?siteID1⁄41937&categoryID1⁄41168 (accessed 17 August 2009), 2009.

NICOLAY, C R et al. Systematic review of the application of quality improvement methodologies from the manufacturing industry to surgical healthcare. **British Journal of surgery**, v. 99, n. 3, p. 324-35, 2012.

NIEJMEIJER, Gerard C et al. Quality in trauma care: Improving the discharge Procedure of patients by means of Lean Six Sigma. **Journal of Trauma**, v. 69, n. 30, p. 614-618, 2010.

NOLAN, T.W et al. **Reducing Delays and waiting times throughout the healthcare system"**, Boston, MA: Institute for healthcare Improvement, 1996.

OHNO, Taichi. **Toyota Production System**: beyond large-scale production. Portland, OR: Productivity Press, 1988.

OTTE, E; ROUSSEAU, R. Social Network Analysis: A powerful strategy, also for the information sciences. **Journal of Information Science**, v. 28, n. 6, p. 441-453.

PAPADOPOULOS, Thanos; RADNOR, Zoe; MERALI, Yasmin. The Role of

actor associations in understanding the implementation of lean thinking in healthcare. **International Journal of Operations and Production Management**, v. 31 n. 2, p. 167-191, 2011.

PIERCY, N; RICH, N. Lean transformation in the pure service environment: the case of the call service centre. **International Journal of Operations and Production Management**, v. 29, n. 1, p. 54-76, 2009a

PIERCY, N; RICH, N. High quality and low cost: the lean service centre. **European Journal of Marketing**, v. 43, n. 11/12), p. 1477-1497, 2009b

PILKINGTON, A; LISTON-HEYES, C. Is production and operations management a discipline? A citation/co-citation study. **International Journal of Operations and Production Management**, v.19, n. 1, p. 7-20, 1999.

PILKINGTON, A., & MEREDITH, J. The evolution of intelectual structure of operations management 1980-2006. **Journal of Operations Management**, v. 27, n. 3, p. 185-202, 2009.

PLYTIUK, Crislayne et al. Lean Thinking in Health care: An overview of the research characteristics, themes and knowledge groups (1998-2011). Proceedings of the 2012 Industrial and Systems engineering Research conference. Orlando: IIE, 2012.

POKSINSKA, Bozena. The current state of Lean Implementation in Healthcare: a Literature review. **Quality Management in Healthcare**, v. 19, n. 4, p. 319-329, 2010.

PROTZMAN, C; MAYZELL, G; KERPCHAR, J. **Leveraging Lean in Healthcare: Transforming your enterprise into a high quality patient care delivery system**. New York, NY: Productivity Press, 2011.

QUINN, J., & GAGNON, C. Will services follow manufacturing into decline? **Harvard Business Review**, Nov/Dec, p. 95-103, 1986.

RAAB, Stephen et al. Effectiveness of Toyota process redesign in reducing thyroid gland fine-needle aspiration error. **American Journal of Clinical Pathology**, v. 126, n. 4, p.585-592, 2006

RADNOR, Zoe; HOWEG, Mathias; WARING, Justin. Lean in healthcare: The Unfiled promise? **Social Science & Medicine,** 74, n. 3, p.364-371, 2012.

RAVICHANDRA RAO, I K; **Quantitative methods for library and information Science**. New York: Wiley, 1983.

ROCHA, Décio; DEUSDARA, Bruno. Análise de conteúdo e análise de discurso: aproximações e afastamentos na (re) construção de uma trajetória. **Alea**, v. 07 n. 2, p. 305-322, 2005.

ROTHER, Mike et al. **Learning to see - Value Stream Mapping to create**

value and eliminate muda. Cambridge, MA: Lean Enterprise Institute, 2003.

SPEAR, Steven J; SCHMIDHOFER, Mike. Ambiguity and workarounds as contributors to medical error. **Annals of Internal Medicine**, v. 142, n. 8, p. 627-630, 2005.

SPEAR, Steven J. Fixing healthcare from inside: Teaching residents to heal broken delivery processes as they heal sick patients. **Academic Medicine**, v. 81 (10 sup) S144-9.

SPEAR, Steven J. Learning to Lead at Toyota," Harvard Business Review, May, 2004.

SPEAR, Steven J. **Chasing the rabbit** - How market leaders outdistance the competition and how great companhies can catch up and win", New York: McGraw-Hill, 2008.

SCHONBERGER, Richard J. Some observations on the advantages and implementation issues of just-in-time production systems. **Journal of Operations Management,** v. 3, n. 1, p. 1-12, 1982.

SCHONBERGER, Richard J. Japanese production Management: An evolution - With mixed success. **Journal of Operations Management,** v. 25, n. 2, p. 403-419, 2007.

SELLTIZ, W; WRIGHTSMAN, L S; COOK, S W. **Métodos de pesquisa nas relações sociais**. v. 1. Delineamentos de Pesquisa. 2.ed. São Paulo: EPU, 1987.

SHAH, Rachna; WARD, Peter T. Lean Manufacturing: Context, practice, bundles and performance. **Journal of Operations Management**, v. 21, n. 2, p. 129-149, 2003.

SHAW, Jonathan. A schema approach to the formal literature review in engineering theses. **System**, v. 23, n. 3, p. 325-335, 1995.

SHINGO, Shigeo. **A Study of the Toyota Production System from an industrial Engineering viewpoint**. Cambridge, MA: Productivity Press, 1981.

SILVESTRO, Rhian et al. Towards a classification of services processes. **International Journal of service Industry Management**, v. 3, n. 3, p. 62-75, 1992.

SMALL, Henry. Co-citation in the scientific literature: A new measure of the relationship between two documents. **Journal of the American Society for Information Science**, Jul/Ago, 1973.

SMEDS, Riitta. Managing changes towards Lean enterprises. **International Journal of Operations and Production Management**, v. 14, n. 3, p. 66-82, 1994.

SOHAL, Amrik & EGGLESTONE, Adrian. Lean Production: Experience among Australian Organizations. **International Journal of Operations and Production Management**, v. 14, n. 11, p. 35-51, 1994.

SPEAR, Steven J. Fixing Healthcare from inside, today. **Harvard Business Review**, v. 81 (Sept), n. 10, p. 1-15, 2005.

SPEAR, Steven; BOWEN, H Kent. Decoding the DNA of the Toyota Production System. **Harvard Business Review**, Sep/Oct, p. 96-106, 1999.

SQUIRES, David A. The U.S. Health System in Perspective: A Comparison of Twelve Industrialized Nations. Issues in International Health Policy. **Commonwealth Fund**, v. 16, pub. 1532. Available in: http://www.commonwealthfund.org/~/media/Files/Publications/Issue%20Brief/2011/Jul/1532_Squires_US_hlt_sys_comparison_12_nations_intl_brief_v2.pdf.

SUGIMORI, Y et al. Toyota Production System and Kanban System; materialization of just-in-time and respect-for-human system. **International Journal of Production Research**, v. 15, n. 6, p. 553-564, 1977.

SWANK, Cynthia K. The Lean Service Machine. **Harvard Business Review**, Oct, p. 123-129, 2003.

YOUNG, Terry; MCCLEAN, S I. A Critical look at Lean Thinking to Healthcare. **Quality and Safety in Healthcare**, v. 17, n. 05, p. 382-386.

YOUNG, Terry; MCCLEAN, S I. Some Challenges facing Lean in Healthcare. **International Journal for Quality in healthcare**, v. 21, n. 5, p. 309-310, 2009.

TAYLOR, Andrew; TAYLOR, Margaret. Operations Management research: contemporary themes, trends and potential future directions. **International Journal of Operations and Production Management**, v. 29, n. 12, p. 1316-1340, 2009.

PERSOON, Thomas J.; ZALESKI, Sue; FRERICHS, Janice. Improving preanalytic processes using the principles of lean production (Toyota Production System). **American Journal of Clinical Pathology**, v. 125, n. 1, p.16-25, 2006.

THOMPSON, Debra N; WOLF, Gail; SPEAR, Steven. Driving improvement in patient care: Lessons from Toyota. **Journal of Nursing administration**, v. 33, n. 11, p. 585-595, 2003.

THOMPSON, Paul. Disconnected capitalism: or why employers can't keep their side of the bargain. **Work, Employment & Society**, v. 17, n. 2, p. 359-78, 2003.

THOMPSON, P., WARHURSt, Chris; CALLAGHAN, George. Ignorant Theory and Knowledgeable Workers: Interrogating the Connections Between

Knowledge, Skills and Services. **Journal of Management Studies**, v. 38, n. 7, p. 923–42, 2001.

VAN DEN HEUVEL, Jaap et al. Six Sigma in a Dutch hospital: Does it work in the nursing department. **Quality and reliability engineering**, v. 20, n. 05, p. 419-426, 2004.

VAN DEN HEUVEL, Jaap et al. Implementing Six Sigma in The Netherlands. **Journal on Quality and Patient Safety**, v. 32, n. 7, p. 393-399, 2006.

VAN DEN HEUVEL, Jaap; DOES, Ronald J.M.M; DE KONING, Henk. Lean Six Sigma in a hospital. **International Journal of Six Sigma and Competitive advantage**, v. 2, n. 4, p. 377-388, 2006.

VAN DEN HEUVEL, Jaap; DOES, R J M M; BISGAARD, Soren. Dutch hospital implements Six Sigma. **Six Sigma Forum Magazine,** v. 4 (feb), p. 11-14, 2005.

VAN DEN HEUVEL, Jaap; DOES, R J M M; Verver, John P S. Six Sigma in Helthcare: Lessons Learned from a Hospital. **Journal of Six Sigma and competitive advantage**, v. 1, n. 4, p. 380-388, 2005.

VAN LENT, Wineke A M; GOEDBLOED, N; VAN HARTEN, W. Improving the efficiency of a chemotherapy day unit: Applying a business approach to oncology. **European Journal of Cancer**, v. 45, n. 5, p. 800-806, 2009.

VANHAECHT, K; SERMEUS W. Script for developing, implementing and evaluating a clinical patway: 30-step action plan of the clinical patway network. Acta hospitalia (in dutch), v. 42, p. 13-27, 2002.

VARKEY, Prathibha; RELLER, Katherine M; RESAR, Roger K. Basics of quality improvements in health care. **Mayo Clinic proceedings**, v. 82, n. 6, p. 735-9, 2007.

VENN-TREOLAR, Josephine. Nuchal translucency - Screening without consent. **British Medical Journal**, v. 316, n. 1026.3, 1998.

VEST, Joshua; GAMM, Larry A critical review of the research literature on Six Sigma, Lean and StuderGroup's Hardwing excellence in the United States: The need to demostrate and communicate the effectiveness of transformation strategies in healthcare. **Implementation Science**, v. 35, n. 4, p. art n. 35, 2009.

VOSS, Chris; TSIKRIKTSIS, Nikos; FROHLICH, Mark. Case research in operations management. **International Journal of Operations and production management**, v. 23, n. 2, p. 195-219, 2002.

WARING, Justin; BISHOP, Simon. Lean healthcare: Rhetoric, ritual and resistance. **Social Science & Medicine**, v. 71, n. 07, p.1332-1340, 2010.

WASSERMAN, Stanley; FAUST, Katherine. **Social Network analysis**: Methods and Applications. Cambridge: Cambridge University Press, 1994.

WEBSTERM, Jane; WATSON, Richard T. Analyzing the past to prepare for the future: Writing a literature review. **MIS Quarterly**, v. 26, n. 2, 13-23, 2002.

WHETHERELL, Charles; PLAKANS, Andrejs; WELLMAN, Barry. Social networks, kinship and community in Eastern Europe. **Journal of interdisciplinary history**, v. 24, n. 4, p. 639-663, 1994.

WHITE, Howard D; GRIFFITH, Belver C. Author Cocitation: A Literature measure of intellectual Structure. **Journal of the American Society for information Science**, v. 32, n. 03, p. 163-171,1981.

WHITSON, D. Applying just-in-time systems in health care. **IIE Solutions**, v. 29, n. 8, p. 32-7, 1997.

WOMACK, James P; JONES, Daniel. **A mentalidade enxuta nas empresas Lean Thinking**: Elimine o desperdício e crie riqueza. Rio de Janeiro, RJ: Elsevier, 1996.

WOMACK, James P; JONES, Daniel; ROOS, Daniel. **The Machine that changed the world**: The Story of Lean Production. New York, NY: Rawson Associates, 1990.

YIH, Yin. **Handbook of Healthcare delivery systems**. New York, NY: Productivity Press, 2011.

YOUSRI, Taher et al. Lean Thinking: Can it Improve the outcome of Fracture neck of femur patients in a district general hospital? **Injury,** v. 42, n. 11, p. 1234-1237, 2011.

ZEITHAML, V; PARASURAMAN, A; BERRY, L. Delivering Service Quality, The Free Press, New York, NY, 1990.

APENDIX 1 - TITLES ANALYZED ALONG THE SYSTEMATIC REVIEW

AAKRE, Kenneth T; VALLEY, Timothy B; O'KONNOR, Michael K. Improving Patient Flow for a Bone Densitometry Practice: Results from a Mayo Clinic Radiology Quality Initiative. **Radio Graphics**, v. 30, n. 2, p.309-315, 2010.

AASEBO, Ulf; STROM, Hans Henrik; POSTMYR, Merete. The Lean method as a clinical pathway facilitator in patients with lung cancer. **Clinical Respiratory journal**, v. 6, n. 3, p.169-174, 2012.

KANNE, A. The lean RIDE: Applying lean healthcare one process at a time. **Proceedings of the 2009 Society for Health Systems Conference and Expo**. Chicago, 2009.

AL-ARAIDAH, O; MOMANI, Amer; KHASAWNEH, Mohammad; MOMANI, Mohammed. Lead-Time Reduction Utilizing Lean Tools Applied to Healthcare: The Inpatient Pharmacy at a Local Hospital. **Journal for Healthcare Quality**, v. 32, n. 1, p.59-66, 2010.

ARONSSON, Hakan; ABRAHAMSSON, M; SPENS, K. Developing lean and agile health care supply chains. **Supply Chain Management**, v. 16, n. 3, p.176-183, 2011.

WOODWARD-HAGG, Heather; SUSKOVICH, Deanna; WORKMAN-GERMANN, Jamie; SCACHITTI, Susan. Development and implementation of a healthcare-based standardized economic impact evaluation methodology. **Proceedings of the 2008 American Society for Engineering Education Annual Conference and Exposition**. Honolulu, HI

MCCLEAN, S.; YOUNG, T. ; BUSTARD, D. ; MILLARD, P. ; BARTON, M. Discovery of value streams for lean healthcare. **4th International IEEE Conference Intelligent Systems**. Varna, Bulgaria, 2008.

ATKINSON, Paula; MUKAETOVA-LADINSKA, Elizabeta B. Nurse-led liaison mental health service for older adults: Service development using lean thinking methodology. **Journal of Psychosomatic research**, v. 72, n. 04, p. 328-331, 2012.

BEN-TOVIM, David I et al. Redesigning care at the Flinders Medical Centre: clinical process redesign using "lean thinking". **Medical Journal of Australia**, v. 188, n. 6, p. S27-31, 2008.

BEN-TOVIM, David I et al. Lean thinking across a hospital: redesigning care at the: Flinders Medical Centre. **Australian Health Review**, v. 31, n. 1, 200

BIELASZKA-DUVERNAY, C. Redesigning acute care processes in Wisconsin. **Health Affairs**, v. 30, n. 3, p.422-425, 2011.

BISGAARD, Soren; DOES, Ronald .J.M.M. Quality quandaries: Health care quality reducing the length of stay at a hospital. **Quality Engineering**, v. 21, n. 1, p.117-131, 2009.

BLACK, Jason. Transforming the patient care environment with Lean Six Sigma and realistic evaluation. **Journal for Healthcare Quality**, v. 31, n. 3, p.29-35, 2009.

DE SOUZA, L. B. Trends and Approaches in Lean Healthcare. **Leadership in Health Services**, v. 22, n. 2, p.121 - 139, 2009.

[No authors listed] Turning teamwork into quality care. **Quality Letter for Healthcare Leaders**, v.15, n. 12, p. 2-11, Dec. 2003.

GROVE, A. L et al. UK health visiting: challenges faced during lean implementation. **Leadership in Health Services**, v. 23, n. 3, p.204 - 218, 2010.

BRAATEN, J .S; BELLHOUSE, DOROTHY E. Improving Patient Care by Making Small Sustainable Changes: A Cardiac Telemetry Unit's Experience. **Nursing Economics,** v. 25, n. 3, p.162-173, 2007.

BRIDGES, JOHN F.P. Lean Systems Approaches to Health Technology Assessment: A Patient-Focused Alternative to Cost-Effectiveness Analysis. **Pharmaeconomics**, v. 24, n. 2, p.101-109, 2006.

BRIENT, K. Interdisciplinary Process Improvement for Enhancing Blood Transfusion Safety. **Journal for Healthcare Quality**, v. 32, n. 2, p.29-34, 2010.

BUESA, R J. Adapting lean to histology laboratories. **Annals of Diagnostic Pathology**, v. 13, n. 5, p.322-333, 2009.

DEBARBA, H; SMITH, J L; MYERS, M. Amid the nation's health-care crisis, Cancer Treatment Centers of America finds its own cure. **Global Business and Organizational Excellence**, v. 31, n. 1, p.6-19, 2011.

CANKOVIC, Milena et al. The Henry Ford Production System: LEAN Process Redesign Improves Service in the Molecular Diagnostic Laboratory: A Paper from the 2008 William Beaumont Hospital Symposium on Molecular Pathology. **The Journal of Molecular Diagnostics,** v. 11, n. 5, p.390-399, 2009.

CARBONEAU, C; BENGE, E; JACO, M.T; ROBINSON, M. A Lean Six Sigma Team Increases Hand Hygiene Compliance and Reduces Hospital-Acquired MRSA Infections by 51%. **Journal for Healthcare Quality**, v. 32, n. 4, p.61-70, 2010.

CARTER, Patrick M et al. Optimizing Clinical Operations as Part of a Global Emergency Medicine Initiative in Kumasi, Ghana: Application of Lean Manufacturing Principals to Low-resource Health Systems. **Academic Emergency Medicine**, v. 19, n. 3, p.338-347, 2012.

TSASIS, P.; BRUCE-BARRETT, C. Organizational change through Lean Thinking. **Health Services Management Research**, v. 21, n. 3, p. 192-8, Aug. 2008.

KAISER, D. PCAPI: Using lean concepts in a healthcare setting. **Proceedings of the 2004 IIE Annual Conference and Expo**. Houston, 2004.

KOLLENGODE, A. Power of Observation for Lean Six Sigma Initiatives in Health Care. **Proceedings of the 2008 Society for Health Systems Conference and Expo**, 2008.

VISICH, J. K.; WICKS, A. M.; ZALILA, F. Practitioner Perceptions of the A3 Method for Process Improvement in Health Care. **Decision Sciences Journal of Innovative Education**, v. 8, n. 1, p. 191–213, January 2010.

TYSON, P. Preparing for the new landscape of payment reform. **Healthcare Financial Management,** v. 64, n.12, p. 42-8, Dec. 2010.

CHASSIN, R. The six sigma initiative at Mount Sinai Medical Center. **Mount Sinai Journal of Medicine**, v. 75, n.1, p.45-52, 2008.

KULLAR, P et al. The use of Lean Thinking techniques in implementing the Department of Health, UK, 18-week waiting time directive for cochlear implantation. **Cochlear Implants International,** v. 11, n. 3, p. 133-45, Sep. 2010.

AHERNE, J. Think lean: Joe Aherne explains the advantages of educating healthcare staff in the principles and practices of lean thinking. **Nursing Management**, March 1, 2007.

CIMA, Robert R et al. Use of Lean and Six Sigma Methodology to Improve Operating Room Efficiency in a High-Volume Tertiary-Care Academic Medical Center. **Journal of the American College of Surgeons**, v. 213, n. 1, p.83-92, 2011.

CLARK, Clancy J et al. Template for Success: Using a Resident-Designed Sign-out Template in the Handover of Patient Care. **Journal of Surgical Education**, v. 68, n. 1, p.52-57, 2011.

COLLAR, Ryan M et al. Lean Management in Academic Surgery. **Journal of the American College of Surgeons,** v**.** 214, n. 6, p.928-936, 2012.

CULIG, Michael H et al. Improving Patient Care in Cardiac Surgery Using Toyota Production System Based Methodology. **Annals of Thoracic Surgery**, v. 91, n. 2, p.394-400, 2011.

D'ANGELO, R.; ZARBO, R J. The Henry Ford production system: Measures of process defects and waste in surgical pathology as a basis for quality improvement initiatives. **American Journal of Clinical Pathology**, v. 128, n. 3, p.426-429, 2007.

DAHLGAARD, Jens J; PETTERSEN, Jostein; DAHLGAARD-PARK, Su Mi. Quality and lean health care: a system for assessing and improving the health of healthcare organizations. **Total Quality Management & Business Excellence**, v. 22, n. 6, p.673-689, 2011.

MCCULLOCH, P et al. Effect of a “Lean” intervention to improve safety processes and outcomes on a surgical emergency unit. **British Medical Journal**, v. 341:c5469, 2010.

BOADEN, R. Quality improvement: theory and practice. **British Journal of Healthcare Management**, v. 15, n. 1, p. 12 - 16, 12 Jan 2009.

DAVIS, Jacqueline; ADAMS, John. The releasing time to care - the productive ward programme: participants perspectives. **Journal of Nursing Management**, v. 20, n. 3, p.354-360, 2012.

DE KONING, Henk et al. Lean Six Sigma in Healthcare. **Journal for Healthcare Quality**, v. 28, n. 2, p. 4–11, 2006.

VAN DEN HEUVEL, J.; DOES, R.J.M.M.; DE KONING, H. Lean Six Sigma in a hospital. **International Journal of Six Sigma and Competitive Advantage**, v. 2, n.4, p.377 - 388, 2006.

POCHA, C. Lean Six Sigma in health care and the challenge of implementation of Six Sigma methodologies at a Veterans Affairs Medical Center. **Quality Management in Health Care**, v.19, n. 4, p. 312-8, Oct-Dec 2010.

ESIMAI, G. Lean six sigma reduces medication errors. **Quality Progress**, April 2005, p. 51- 57.

DE MAST, Jeroen et al. Process improvement in healthcare: overall resource efficiency. **Quality and reliability engineering international**, v. 27, n. 8, p.1095-1106, 2011.

DE SOUZA, Luciano Brandão; PIDD, Michael. Exploring the Barriers to Lean healthcare implementation. **Public Money and Management,** v. 31, n. 1, 2011.

LEES, L Exploring the principles of best practice discharge to ensure patient involvement. **Nursing Times**, v. 06, n. 25, p. 10-14, 2010.

DICKSON, Eric W et al. Use of Lean in the Emergency Department: A Case Series of 4 Hospitals. **Annals of Emergency Medicine**, v. 54, n. 4, p.504-510, 2009.

DAVIES, J. Use of Lean Production to Reduce Waste When Compounding Sterile Pharmaceutical Products. **Hospital Pharmacy**, v. 44, n. 11, p. 974–977.

PANNING, R. Using data to make decisions and drive results: a LEAN implementation strategy. **Clinical Leadership and Management Review**, v. 19, n. 2, E4, Mar 28, 2005.

DICKSON, Eric W et al. Application of Lean Manufacturing techniques in the emergency department. **Journal of Emergency Medicine,** v. 37, n. 2, p.177-182.

DUNDAS, Nicola E et al. A Lean Laboratory: Operational Simplicity and Cost Effectiveness of the Luminex xTAG™ Respiratory Viral Panel. **The Journal of Molecular Diagnostics**, v. 13, n. 2, p.175-179, 2011.

ECKEL, S.F. Analyzing methods for improved management of workflow in an outpatient pharmacy setting. **American Journal of Health-System Pharmacy**, v. 16, n. 11, p.966-971, 2012.

ELLER, A. Rapid Assessment and Disposition: Applying LEAN in the Emergency Department. **Journal for Healthcare Quality**, v. 31, n. 3, p.17-22, 2009.

OLDFIELD, P et al. Red light-green light: from kids' game to discharge tool. **Healthcare quarterly**, v. 14, n. 1, p. 77-81, 2011.

EVANS, P.C; LEE, H. Medication reconciliation in the emergency department: opportunities for workflow redesign. **Quality & Safety in Health Care**, v. 19, n. 6, p.531-535, 2010.

GOUT, J. R; TOUSSAINT, J. S. Mistake-proofing healthcare: Why stopping processes may be a good start. **Business Horizons**, v. 53, n. 2, p. 149–156, March–April 2010.

CROMPTON, P. Modernizing medical photography, part 2. **Journal of Visual Communication in Medicine**, v. 28, n. 1, p. 6-12, Mar. 2005.
FEINSTEIN, Karen Wolk; GRUNDEN, Naida; HARRISON, Edward I. A region addresses patient safety. **International Journal of Physical distribution and logistics Management**, v. 28, n. 9-10, p.741-772, 1998.

MAY D, PRICE I. A revised approach to performance measurement for health-care estates. **Health Services Management Research**, v. 22, n. 4, p. 151-7, 2009.

FRATINO, L M et al. Evaluation of quality improvement initiative in pediatric oncology: Implementation of aggressive hydration protocol. **Journal of Nursing Care Quality**, v. 24, n. 2, p.153-159, 2009.

GOIN, K H et al. The impact of a lean rounding process in a pediatric intensive care unit. **Critical Care Medicine**, v. 40, n. 2, p.608-617, 2012.

GOIN, K.H.B, FORTENBERRY, J.D.A. Lean analysis of a pediatric intensive care unit physician group rounding process to identify inefficiencies and opportunities for improvement. **Pediatric Critical Care Medicine**, v. 12, n. 4, p.415-421, 2011.

JIJU, A. Lean and Six Sigma methodologies in NHS Scotland: Some observations and key findings from a Pilot Survey. In: **Proceedings of the 2008 IIE Annual Conference and Expo**. Cancún, 2008.

BALLÉ, M.; RÉGNIER, A. Lean as a learning system in a hospital ward. **Leadership in Health Services**, v. 20, n. 01, p.33 - 41, 2007.

SINGH, S.; BAHENSKY, J.; DICKSON, E. W. Lean changes the culture of patient care in an academic medical center. In: **Proceedings of the 2008 IIE Annual Conference and Expo**. Cancún, 2008.

GROVE, A L et al. Lean implementation in primary care health visiting services in National Health Service UK. **Quality & Safety in Health Care**, v. 19, n. 5, p.1-5.

GRUVER, R. Lean in the Laboratory and Radiology: A Patient Throughput Imperative. In: **Proceedings of the 2009 Society for Health Systems Conference and Expo**. Chicago, 2009.

KIMSEY, D. B. Lean Methodology in Health care. **AORN Journal**, v. 92, n. 1, p.53-60, Jul. 2010.

GUNSOLUS, R. L.; BUDAUS, M.; Improving the health care experience by maximizing efficiency. **Health facilities management**, mar, 2010. Available: http://www.hfmmagazine.com/hfmmagazine/jsp/articledisplay.jsp?dcrpath=HFMMAGAZINE/Article/data/03MAR2010/1003HFM_FEA_AD. kulAcessed in: 09/19/2013.

TSENG, S.-H.A, SWANSON, K.B, MCCLAY, M.A. Improving the hospital discharge process with six sigma methods. Quality Engineering, v. 22, n. 1, p.13-20, 2010.

MULLANEY, K. Improving the Process of Supplying Instruments to the Operating Room Using the Lean Rapid Cycle Improvement Process. **Perioperative Nursing Clinics**, v. 5, n. 4, p. 479-487, December 2010.

COOKSON, D et al. Improving the quality of Emergency Department care by removing waste using Lean Value Stream mapping. **The International Journal of Clinical Leadership**, v. 17, n. 1, p. 25-30, March 2011.

DECKARD, G. J et al. Improving timeliness and efficiency in the referral process for safety net providers: application of the Lean Six Sigma methodology. **Journal of Ambulatory Care Management**, v. 33, n. 2, p.124-30, Apr-Jun 2010.

MARI, J et al. Deployment of Lean Manufacturing Principles in Healthcare Delivery Processes. In: **Proceedings of the 2008 Society for Health Systems Conference and Expo**. Orlando, 2008.

GWYNETH, W. Implementation of releasing time to care – the productive ward. **Journal of Nursing Management**, v. 17, n. 5, p.647-654, 2009.

LAING K, B. K. Implementing "lean" principles to improve the efficiency of the endoscopy department of a community hospital: a case study. Gastroenterology Nursing, v. 28, n. 3, p. 210-5, May-Jun, 2005.

SAACS, A. A.; HELLENBERG, D. A. Implementing a structured triage system at a community health centre using Kaizen. **South African Family Practice**, v. 51, n. 6,

p. 496-501, 2009.

WIJMA, J.; TRIP, A.; DOES, R. J. M. M.; BISGAARD, S. Quality Quandaries - Efficiency Improvement in a Nursing Department. **Quality Engineering**, v. 21, n. 02, p. 222-228, Apri. 2009.

WORKMAN-GERMANN- J., WOODWARD-HAGG, H. Implementing Lean Six Sigma Methodologies in the Radiology Department of a Hospital Healthcare System. **Proceedings of the 2006 American Society for Engineering Education Annual Conference**, Chicago, IL, June 2006.

HALWACHS-BAUMANN, GABRIELE. Concepts for Lean laboratory organization. **Journal of Medical Biochemistry**, v. 29, n. 4, p.330-338, 2010.

KOVACH, JAMI; DE LA TORRE, LUIS; WALKER, DAVID. Continuous improvement efforts in healthcare: a case study exploring the motivation, involvement and support necessary for success. **International Journal of Six Sigma and Competitive Advantage**, v. 4, n. 3, p. 254-269, 2008.

DAHL, O J. Cost and efficiency lead to increased value for the patient and bottom line for the practice. **Journal of Medical Practice Management**, v. 25, n. 2, p. 87-9, 2009.

HEITMILLER, Eugenie S et al. Blood wastage reduction using Lean Sigma methodology. **Transfusion**, v. 50, n. 9, p.1887-1896, 2010.

SEARS, DOUGLAS H. Bon Secours Health System integrates Lean Six Sigma and Knowledge Transfer to drive clinical and operational excellence. **Global Business and Organizational Excellence**, v. 28, n. 6, p. 31–45, 2009.

HIRZALLAH, M.A et al. Building a protocol expressway the case of mayo clinic cancer center. **Journal of Clinical Oncology,** v. 27, n. 23, p.3855-3860, 2009.

HOLDEN, RICHARD J. Lean Thinking in Emergency Departments: A Critical Review. **Annals of Emergency Medicine,** v. 57, n. 3, p.265-278, 2011.

HUGGINS, E. J. Lean methodology: supporting battlefield medical fitness by cutting process waste. **Journal for Healthcare Quality**, v. 32, n.4, p.39-49, 2010.

HUMMER, JANE; DACCARETT, CRISTINA. Improvement in prescription renewal handling by application of the lean process. **Nursing Economics**, v. 27, n. 3, p.197-201, 2009.

KAHN N, DANIEL C. Improving access to lab services through the implementation of lean principles. **Clinical Leadership and Management Review**, v. 21, n. 4, 2007.

TRILLING, L et al. Improving care efficiency in a radiotherapy center using Lean philosophy: A case study of the proton therapy center of Institut Curie — Orsay. In: **Proceedings of the 2010 IEEE Workshop on Health Care Management**. Venice,

2010.

YAMAMOTO, J.; ABRAHAM, D.; MALATESTINIC, B. Improving Insulin Distribution and Administration Safety Using Lean Six Sigma Methodologies. **Hospital Pharmacy**, v. 45, n. 03, p. 212-224, mar. 2010.

HYDES, Theresa; HANSI, Navjyot; TREBBLE, Timothy M. Lean thinking transformation of the unsedated upper gastrointestinal endoscopy pathway improves efficiency and is associated with high levels of patient satisfaction. **Quality & Safety in Health Care**, v. 21, n.1, p.63-69, 2012.

IANNETTONI, Mark D et al. Kaizen Method for Esophagectomy Patients: Improved Quality Control, Outcomes, and Decreased Costs. **The Annals of Thoracic Surgery,** v. 91, n. 4, p.1011-1018, 2011.

ISAAC-RENTON, Judith L et al. Use of lean response to improve pandemic influenza surge in public health laboratories. **Emerging Infectious Diseases**, v. 18, n.1, p.57-62.

JACOBSON, Gregory H et al. Kaizen: A Method of Process Improvement in the Emergency Department. **Academic Emergency Medicine,** v.16, n.12, p.1341-1349, 2009.

RANGACHARI, P. Knowledge sharing and organizational learning in the context of hospital infection prevention. **Quality Management in Health Care**, v.19, n.1, p. 34-46, Jan-Mar. 2010.

HANSEN, GEIR K.; OLSSON, N. O. E. Layered Project–Layered Process: Lean Thinking and Flexible Solutions. **Architectural Engineering and Design Management**, v. 7, n. 02, 2011.

STUBBS, James R.; JONES, Gayle. Integrating Quality, Education, Lean, and Performance Management into a culture of continuous improvement. **Transfusion,** v**.** 51, n.07, p.1598-1603, 2011.

JARRETT, P. GARY. Logistics in the health care industry. **Journal of Nursing Administration,** v. 33, n. 11, p.585-595, 2003.

SILVESTER, L. A. Major trauma: A Lean approach to process design. **British Journal of Healthcare Management**, v. 17, n. 10, p 486 - 495, 10 Oct 2011.

GUIDO, K. Making an ED fast track exactly that--fast and efficient. **Journal of Medical Practice Management**, v. 23, n. 3, p.197-8, Nov-Dec 2007.

WINCH, S.; HENDERSON, A. J. Making cars and making health care: a critical review. **Medical Journal of Australia**, v. 191, n. 1, p. 28-9. Jul 6, 2009.

JOHNSON, C; ALLEN, R; WEDGEWOOD, I. Attacking waste and variation hospital-wide: a comprehensive lean-sigma deployment". **Proceedings of the 2007 Society for Health Systems Conference**, New Orleans, LA, 2007.

VILLA, DAVIDE. Automation, lean, six sigma: Synergies for improving laboratory efficiency. **Journal of Medical Biochemistry**, v. 29, n.4, p.334-348, 2010.

RAVN, HENRIETTE; PETERSEN, LARS ODD. Balancing the surgical capacity in a hospital. **International Journal of Healthcare Technology and Management**, v. 8, n. 6, p. 603-624, 2007.

JOHNSON, C. Daniel et al. Process improvement: what is it, why it is important, and how it is done? **American Journal of Roentgenology,** v. 194, n.2, p.461-468, 2010.

JOHNSON, MARY E.; JACOBSON, JAMES M. Lean and Six Sigma: Not for Amateurs (First in a 2-part series). **Labmedicine**, v. 37, n. 3, p.140-145, 2006.

HERRING L. Lean experience in primary care. **Quality in Primary Care**, v. 17, n. 04, p. 271-5, August 2009.

JOOSTEN, TOM; BONGERS, INGE; JANSSEN, RICHARD. Application of lean thinking to health care: Issues and observations. **International Journal for Quality in Health Care**, v. 21, n. 5, p.341-347, 2009.

KELLY, Anne-Maree et al. Improving emergency department efficiency by patient streaming to outcomes-based teams. **Australian Health Review**, v. 31, n. 1, p.16-21.

KEMPER, Benjamin P.H; KOOPMANS, Mariel; DOES, Ronald, J.M.M. Quality quandaries: The availability of infusion pumps in a hospital. **Quality Engineering**, v. 21, n.4, p.471-477, 2009.

KIM, Christopher S et al. Teaching Internal Medicine Residents Quality Improvement and Patient Safety: A Lean Thinking Approach. **American Journal of Medical Quality,** v. 25, n.3, p.211-217, 2010.

CAMPBELL, R. J.; GANTT, L.; CONGDON, T. Teaching Workflow Analysis and Lean Thinking via Simulation: A Formative Evaluation. **Perspectives in health information management**, v. 9, 2009.

KIM, Christopher S et al. Lean health care: What can hospitals learn from a world-class automaker? **Journal of Hospital Medicine**, v. 1, n.3, p.192-199, 2006.

WEINSTOCK, D. Lean Healthcare. **Journal of Medical Practice Management**, May/june, p. 339-341, 2008.

KING, Diane L; BEN-TOVIN, David I; BASSHAM, Jane E. Redesigning Emergency department patient flows: Application of Lean Thinking to Healthcare. **Emergency Medicine Australasia**, v. 18, n. 4, p. 391-7, Aug. 2006.

KRUSKAL, Jonathan B et al. Quality initiatives: Lean approach to improving performance and efficiency in a radiology department. **Radio Graphics,** v. 32, n.2, p.573-587, 2012.

KULLBERG, ANNA; LARSEN, JOACIM; SHARP, LENA. Why is there another person's name on my infusion bag?' Patient safety in chemotherapy care: a review of the literature. **European Journal of Oncology Nursing**. Article in Press, 2012.

KUMAR, Sammer; DE GROOT, Rebecca A; CHOE, Daewon. Rx for smart hospital purchasing decisions: The impact of package design within US hospital supply chain. **International Journal of Physical distribution and logistics Management** v. 38, n. 8, p.601-615, 2008.

KAPLAN, G. S.; PATTERSON, S. H. Seeking perfection in healthcare. A case study in adopting Toyota Production System methods. **Healthcare Executive**, v. 23, n. 3, p. 16-8, 20-1, May-Jun, 2008.

KHURMA, N.; BACIOIU, G. M; PASEK, Z. W. Simulation-based verification of lean improvement for emergency room process. **Proceedings of the 2008 Winter Simulation Conference**. Austin, 2008.

L'HOMMEDIEU, Timothy; KAPPELER, Karl. Lean methodology in i.v. medication processes in a children's hospital. **American Journal of Health System Pharmacy,** v. 67, n.24, p.2115-2118, 2010.

LAGANGA, Linda R. Lean service operations: Reflections and new directions for capacity expansion in outpatient clinics. **Journal of Operations Management,** v. 29, n.5, p.422-433, 2011.

Going Lean in Health Care. IHI Innovation Series white paper. Cambridge, MA: **Institute for Healthcare Improvement**, 2005. Available on www.IHI.org. Accessed in 09/20/2013.

BAHENSKY, J. A.; ROE, J.; BOLTON, R. Lean sigma--will it work for healthcare? **Journal of Healthcare Information Management**, v. 19, n. 1, p. 39-44, Winter, 2005.

LERACI, Susan et al. Streaming by case complexity: Evaluation of a model for emergency department fast track. **Emergency Medicine Australasia**, v. 20, n. 03, p. 241-249, 2008

LINDBERG, K. Curing a meagre health care system by lean methods - translating 'chains of care' in the Swedish health care sector. **Annals of Thoracic Surgery**, v. 68, n.2, p.353-358, 1999.

PRINTEZIS A, GOPALAKRISHNAN M. Current pulse: can a production system reduce medical errors in health care? **Quality Management in Health Care**, v. 16, n.3, p. 226-38, 2007.

BISHU, Ram R; JONES, Erick C; THUMMALAPALLI, Rama. DEAPS- An alternative to DMAIC? - A case study. **International Journal of Industrial Engineering: theory, applications and practice**, v. 16, n. 3, p. n/a, 2009.

HERZER, Kurt R et al. Designing and Implementing a Comprehensive Quality and Patient Safety Management Model: A Paradigm for Perioperative Improvement. **Journal of Patient Safety,** v. 4, n. 2, p. 84-92, 2008.

LUMMUS, Rhonda R; VOLURKA, R J; RODEGHIERO, B. Improving quality through value stream mapping: A case study of a physician's clinic. **Total Quality Management & Business Excellence**, v. 17, n.8, p.1063-1075, 2006.

MAGHADASIAN, Mahdy. Supply chain leagility in professiona; services: How to apply decoupling point concept in healthcare delivery system. **Supply Chain Management**, v. 15, n.1, p.80-91, 2010.

MAZUR, Lukasz M; CHEN, Shi-Jie (Gary). An empirical study for medication delivery improvement based on healthcare professionals' perceptions of medication delivery system. **Health Care Management Science,** v.12, n.1, p.56-66, 2009.

MAZZOCATO, Pamela et al. How does lean work in emergency care? A case study of a lean-inspired intervention at the Astrid Lindgren Children's hospital, Stockholm, Sweden. **Quality & Safety in Health Care**, v. 12, n. 1, article nr 28, 2012.

MAZZOCATO, Pamela et al. Lean thinking in healthcare: A realist review of the literature. **Quality & Safety in Health Care**, v. 19, n.5, p.376-382, 2010.

CASTLE, A. Lean thinking on the wards. **Nursing Standard**, v. 22, n. 8, p. 16-8, Oct 31-Nov 6, 2007.

MCCREERY, J.; ROTHENBERG, L. Facilitating lean learning and behaviors in hospitals during the early stages of lean implementation. **EMJ - Engineering Management Journal**, v. 24, n.1, p.11-22, 2012.

BRYANT, P M; GULLING, R D. Faster, better, cheaper: lean labs are the key to future survival. **Clinical leadership & management review**, v. 20, n. 2, E2, Mar. 2006.

[No authors listed]. Five principles can encourage organizations to 'think lean'. Performance **Improvement Advisor,** v. 8, n. 8, p. 94-5, aug. 2004.

MEIER, Frederick A; VARNEY, Ruan C; ZARBO, Richard J. Study of amended reports to evaluate and improve surgical pathology processes. **Advances in Anatomic Pathology**, v. 18, n.5, p.406-413, 2011.

EL HARIT, J. Sustaining VAP bundle compliance in the ICU: A model of CQI. **Proceedings of the 2009 Society for Health Systems Conference and Expo**. Chicago, 2009.

POST, N. M. Sutter Health Unlocks the Door to A New Process. **Engineering News-Record.** Available on http://enr.construction.com/features/bizLabor/archives/071121a-2.asp Accessed in 09/20/2013.

MELANSON, Stacy E.F et al. Applying lean/Toyota production system principles to improve phlebotomy patient satisfaction and workflow. **American Journal of Clinical Pathology,** v. 132, n.6, p.914-919, 2009.

MUDER, R. R et al. Implementation of an Industrial Systems-Engineering Approach to Reduce the Incidence of Methicillin-Resistant Staphylococcus aureus Infection. **Infection Control & Hospital Epidemiology**, v. 29, n. 8, p.702-708, 2008.

LANGABEER, J. R.; DELLIFRAINE, J. L.; HEINEKE, J.; ABBASS, I. Implementation of Lean and Six Sigma quality initiatives in hospitals: A goal theoretic perspective. **Operations Management Research**, v. 2, n. 1-4, p. 13-27, Dec. 2009.
NELSON-PETERSON, Dana L; LEPPA, Carol J. Creating an environment for caring using lean principles of the Virginia Mason production system. **Journal of Nursing Administration**, v. 37, n.6, p.287-294, 2007.

KIM, Christopher S; SPAHLINGER, David A; BILLI, John E. Creating Value in Health Care: The Case for Lean Thinking. **Journal of Clinical Outcomes Management**, v.16, n. 12, p. 557-562, 2009.

NEWELL, Terry.L.; STEINMETZ-MALATO, Laura L.; VAN DYKE, Deborah L. Applying Toyota production system techniques for medication delivery: improving hospital safety and efficiency. **Journal for Healthcare Quality**, v. 33, n.2, p.15-22, 2011.

NEWHOUSE, R.P. The intersection of evidence-based practice with 5 quality improvement methodologies. **Journal of Nursing Administration**, v. 42, n.6, p.299-304, 2012.

STANKOVIC, A. K. The laboratory is a key partner in assuring patient safety. **Clinics in Laboratory Medicine**, v. 24, n. 4, p. 1023-35, Dec. 2004.

NG, David; VAIL, Gord, THOMAS, Sophia, SCHMIDT, Nicki. Applying the Lean principles of the Toyota Production System to reduce wait times in the emergency department. **Canadian Journal of Emergency Medicine**, v. 12, n. 1, p.50-57, 2010.

FURMAN, C; CAPLAN, R. Applying the Toyota Production System: using a patient safety alert system to reduce error. **Joint Commission Journal on Quality and Patient Safety,** v. 33, n.7, p. 376-86, 2007.

NICOLAY, C R et al. Systematic review of the application of quality improvements methodologies from the manufacturing industry to surgical healthcare. **British journal of surgery**, v. 99, n. 3, p.324-335.

NIEMEIJER, Gerard C et al. Quality in Trauma Care: Improving the Discharge Procedure of Patients by Means of Lean Six Sigma. **Journal of Trauma Injury Infection & Critical Care**, v.69, n.3, p.614-619, 2006.

PANDIT, J. J; PANDIT, M; REYNARD, M. Understanding waiting lists as the matching of surgical capacity to demand: are we wasting enough surgical time? **Anesthesia**, v. 65, n.6, p.625-640, 2010.

PAPADOPOULOS, THANOS. Public-private partnerships from a systems perspective: A case in the english national health service. **Systems Research and Behavioral Science**, v. 29, n.4, p.420-435, 2012.

PAPADOPOULOS, Thanos; RADNOR, Zoe; MERALI, Yasmin. The Role of actor associations in understanding the implementation of Lean Thinking in heathcare. **International Journal of Operations and Production Management**, v.31, n.2, pp.167-191, 2010.

PARK, Kyung W; DICKERSON, Cheryl. Can efficient supply management in the operating room save millions? **Current opinion in anesthesiology**, v. 22, n.2, pp.242-248, 2009.

FILLINGHAM, D. Can lean save lives? **Leadership in Health Services**, v. 20, n.4, pp. 231-41, 2007.

DART, RC. Can Lean Thinking transform American health care? **Annals of Emergency Medicine**, v. 57, n.3, p. 279-81, 2011.

PARKS, Jennifer K et al. Dissecting delays in trauma care using corporate Lean Six Sigma Methodology. **Journal of Trauma Injury Infection & Critical Care**, v.65, n.5, p.1098-1104, 2008.

PIGGOTT, Zoe et al. Application of lean principles to improve early cardiac care in the emergency department. **Canadian Journal of Emergency Medicine**, v.13, n.5, p.325-332, 2011.

ALDARRAB, Ayad et al. Application of Lean Six Sigma for Patients Presenting with ST-Elevation Myocardial Infarction: The Hamilton Health Sciences Experience. **Healthcare Quarterly**, v. 9, n.1, p. 56-61, 2006.

MOZAMMEL, Afsheen; MAPA, Lash B; SCACHITTI, Susan. Application of Lean

Six Sigma in healthcare - A graduate level directed project experience. **ASEE Annual Conference and Exposition**, Vancouver, Canada, 2011.

PINDER, J.B; WYTON, P.G. Operationalizing lean health assets. **Health Environments Research and Design Journal**, v. 3, n. 2, p.13-29, 2010.

RAAB, Stephen S et al. Improving Papanicolaou test quality and reducing medical errors by using Toyota production system methods. **American Journal of Obstetrics and Gynecology**, v.194, n. 1, p.57-64, 2006.

RAAB, Stephen S et al. Dissemination of lean methods to improve pap testing quality and patient safety. **Journal of Lower Genital Tract Disease**, v. 12, n. 2, p.103-110, 2008.

RAAB, STEPHEN ET AL. Effectiveness of Toyota process redesign in reducing thyroid gland fine-needle aspiration error. **American Journal of Clinical Pathology**, v.126, n. 4, p.585-592, 2006.

RADNOR, Zoe; HOWEG, Mathias; WARING, Justin. Lean in healthcare: The Unfiled promise? **Social Science & Medicine**, v. 74, n.3, p.364-371, 2012.

RASCHE, C.B, VON REINERSDORFF, A.B. The First View Concept: Introduction of industrial flow techniques into emergency medicine organization. **European Journal of Emergency Medicine**, v. 19, n. 3, p.136-139, 2012.

CAREY, Raymond G. Measuring for Improvement: From Toyota to Thoracic Surgery. **International Journal of Health Planning and Management**, v. 19, n. 4, p.383-398, 2004.

KOLLBERG, B.; DAHLGAARD, J. J.; BREHMER, P. Measuring lean initiatives in health care services: issues and findings. **International Journal of Productivity and Performance Management**, v. 56, n.1, p.7 - 24, 2007.

RECHEL, B ET AL. Hospital capacity planning: from measuring stocks to modeling flows. **Bulletin of the World Health Organization** 88632-636, pp.632-636, 2010.

KIM, Christopher s et al. Hospitalist time usage and cyclicality: opportunities to improve efficiency. **Journal of Hospital Medicine,** v. 5, n. 6, p. 329-34, Jul-Aug. 2010.

RELLER, Katherine; RESAR, Roger K. Basics of Quality Improvement in Health Care. **Mayo Clinic Proceedings**, v. 82, n. 6, p.735-739, 2007.

COONS, Jason A. Beginning the Lean improvement journey in the Clinical Laboratory. **Proceedings of the 2009 Society for Health Systems Conference**, 2007.

RILEY, William et al. Using lean techniques to define the platelet (PLT) transfusion process and cost-effectiveness to evaluate PLT dose transfusion strategies. **Transfusion**, v. 52, n. 9, p.1957-1967, 2012.

CASEY, J. T.; BRINTON, T. S.; GONZALEZ, C. M. Utilization of lean management principles in the ambulatory clinic setting. **Nature Clinical Practice Urology,** v. 6, n. 3, p. 146-53, Mar 2009.

HAGAN, P. Waste not, want not: Leading the lean health-care journey at Seattle Children's Hospital. **Global Business and Organizational Excellence**, v. 30, n. 3, p. 25–31, March/April 2011.

ROBERT, G.B, MCCARTHY, G.C, EAGAR, K. The Clinical Services Redesign Program in New South Wales: Perceptions of senior health managers. **Australian Health Review**, v. 34, n.3, p.352-359, 2010.

ROBINSON, Stewart et al. SimLean: Utilising simulation in the implementation of lean in healthcare. **European Journal of Operational research**, v. 219, n. (n/a), p.188-197, 2012.

VIAU, M.; SOUTHERN, B. Six Sigma and Lean concepts, a case study: patient centered care model for a mammography center. **Radiology Management**, v. 29, n. 5, p.19-28, Sep-Oct. 2007.

PAPADOPOULOS, T.; MERALI, Y. Stakeholder Network Dynamics and Emergent Trajectories of Lean Implementation Projects: A Study in the UK National Health Service. **Public Money and Management**, v. 28, n. 1, p. 41-48, February 2008.

ROSE, William N; DAYTON, Paula J; RAIFE, Thomas J. An analysis of mobile whole blood collection labor efficiency. **Transfusion**, v. 51(7 part 2), p.1609-1612, 2011.

RUTLEDGE, Joe; XU, Min; SIMPSON, Joanne. Application of the Toyota Production System Improves Core Laboratory Operations. **American Journal of Clinical Pathology**, v. 133, n. 1, p.24-31, 2010.

SCHWARZ, Patrick et al. Lean processes for optimizing OR capacity utilization: prospective analisys before and after. **Langenbeck's Archives of Surgery**, v. 369, n. 7, p.1047-1053, 2011.

SCHWEIKHART, Sharon.A.; DEMBE, Allard.E. The Applicability of Lean and Six Sigma Techniques to Clinical and Translational Research. **Journal of Investigative Medicine**, v. 57, n. 7, p.748-755, 2009.

SEREMBUS, Joanne F; MELOY, Faye; POSMONTIER, Bobbie. Learning from Business Incorporating the Toyota Production System into Nursing Curricula. **Journal of Psychosomatic research**, v. 72, n.4, p.328-331, 2012.

BOWEN, D. E.; YOUNGDAHL, W. E. "Lean" service: in defense of a production-

line approach". International **Journal of Service Industry Management**, v. 9, n. 3, p.207 - 225, 1998.

BIFFL, W. L. et al. "Leaning" the process of venous thromboembolism prophylaxis. **Joint Commission Journal on Quality and Patient Safety**, v. 37, n. 3, p. 99-109, March 2011.

SPEAR, Steven J. Learning to lead at Toyota. **Harvard Business Review**, May 2004. Available on http://clinicalmicrosystem.org/toolkits/getting_started/LearningToLeadAtToyota.pdf Accessed in 09/20/13.

JOHNSON, C et al. A. Linking lean healthcare to six sigma: An emergency department case study. **Proceedings of the 2004 IIE Annual Conference and Expo**. Reno, 2004.

ALLEN, D.; BLAYLOCK, W.; MIECZKOWSKI, S. Local implementation of the crisis model: the Buckinghamshire community acute service. **Psychiatric Bulletin**, v. 33, p. 252-254, 2009.

SERRANO, Leo et al. Using LEAN Principles to Improve Quality, Patient Safety, and Workflow in Histology and Anatomic Pathology. **Advances in Anatomic Pathology**, v. 17, n. 3, p.215-221, 2010.

SHAH, Rachna et al. Explaining Anomalous High Performance in a Health Care **Supply Chain.Decision Sciences**, v. 39, n.4, p.759-789, 2008.

SIEBERT, JOSEPH R. Increasing the efficiency of autopsy reporting. **Archives of Pathology and Laboratory Medicine**, v. 133, n. 12, p.1932-1937, 2009.

KUO, M. H et al. Integrating A3 reports and the House of Quality: improving workflow in the recovery room using information technology. **Studies in Health Technology and Informatics**, v. 150, p. 416-20, 2009.

RILEY, W. Interaction of Quality and Finance in the Intensive Care Unit. **Clinical Pulmonary Medicine**, v. 17, n. 01, p. 20-27, 2010.

LAROCCO, M.; BRIENT, K. Interdisciplinary process improvement for enhancing blood transfusion safety. **Journal for Healthcare Quality**, v. 32, n. 2, p. 29-34, Mar-Apr. 2010.

VAN LENT, W. A. M.; DE BEER, R. D.; VAN HARTEN, W. H. International benchmarking of specialty hospitals. A series of case studies on comprehensive cancer centres. **BMC Health Services Research**, v. 10:253, 2010.

SNYDER, Kimberlee D; MCDERMOTT, Maggie. A Rural Hospital Takes on Lean. Journal for Healthcare Quality, v. 31, n. 3, p.23-28, 2009.

SOBEK, Durwal; JIMMERSON, Cindy. A3 reports: Tool for process improvement". **Proceedings of the 2004 Industrial Engineering Research Conference**,

Houston, TX, 2004.

SOUTH, Susan F. Achieving Breakthrough Improvements with the Application of Lean Six Sigma Tools and Principles Within Process Excellence. **Labmedicine**, v. 36, n.4, p.240-242, 2005.

WEI, J C. Adapting lean practices to services. **Proceedings of the Fifth International Conference on Information and Management Sciences** 5: 1-7, 2006.

SPEAR, Steven. J. Fixing healthcare from inside, today. **Harvard Business Review** v. 83, n. 9, p.78-91, 2005.

SPEAR, S. J. Fixing healthcare from the inside: teaching residents to heal broken delivery processes as they heal sick patients. **Academic Medicine,** v. 81(10 Suppl): S144-9, Oct. 2006.

[No authors listed]. Florida hospital saves 5.3 M dollars by adopting principles of lean manufacturing. **Performance Improvement Advisor**, v. 9, n. 1, p. 10-11, Jan. 2005.

TOWILL, DR. Frank Gilbreth and health care delivery method study driven learning. **International Journal of Health Care Quality Assurance,** v. 22, n. 4, p.417-40, 2009.

NIEMEIJER, G C et al. Generic project definitions for improvement of health care delivery: a case-based approach. **Quality Management in Health Care**, v. 20, n. 2, p.152-64, Apr-Jun. 2011.

BROWN, T.; DUTHE, R. Getting 'Lean': hardwiring process excellence into Northeast Health. **Journal of healthcare information management**, v. 23, n. 1, p.34-8, Winter, 2009.

GLASGOW, J. M.; SCOTT-CAZIEWELL, J. R.; KABOLI, P. J. Guiding inpatient quality improvement: a systematic review of Lean and Six Sigma. **Joint Commission Journal on Quality and Patient Safety**, v. 36, n. 12, p. 533-40, Dec. 2010.

LODGE, A.; BAMFORD, D. Health service improvement through diagnostic waiting list management. **Leadership in Health Services**, v. 20, n. 4, p.254-65, 2007.

LONG, J. C. Healthcare Lean. **Michigan health & hospitals**, v. 39, n. 4, p. 54-5, Jul-Aug. 2003.

STANKOVIK, ANA K. Developing a Lean consciousness for the clinical laboratory. **Journal of Medical Biochemistry**, v. 27, n.3, p.354-359, 2008.

NAPOLES L, Quintana M. Developing a lean culture in the laboratory. **Clinical Leadership Management Review**, v. 20, n. 4: E4, 2006.

STAPLETON, F Bruder et al. Modifying the Toyota Production System for Continuous Performance Improvement in an Academic Children's Hospital. **Pediatric Clinics of North America**, v. 56, n.4, p.799-813.

LODGE, A.; BAMFORD, D. New Development: Using Lean Techniques to Reduce Radiology Waiting Times. **Public Money & Management**, V. 28, N. 1, p. 49-52, February 2008.

ZILM, F.; CRANE, J.; ROCHE, K. T. New directions in emergency service operations and planning. **Journal of Ambulatory Care Management**, v. 33, n. 4, p. 296-306, Oct-Dec. 2010.

STICHLER, Jaynelle F. Where is the value in value engineering? **Journal of Nursing Administration**, v. 39, n.6, p.255-259, 2009.

SWIICK, Maureen et al. Application of Simulation Technology to Enhance the Role of the Professional Nurse. **Journal of Nursing Administration**, v. 42, n. 2, p.95-102, 2012.

TEICHGRÄBER, Ulf K; DE BUCOURT, Maximilian. Applying value stream mapping techniques to eliminate non-value-added waste for the procurement of endovascular stents. **European Journal of Radiology**, v. 81, n. 1, p.e47-e52, 2011.

PERSOON, Thomas J.; ZALESKI, Sue; FRERICHS, Janice. Improving preanalytic processes using the principles of lean production (Toyota Production System). **American Journal of Clinical Pathology**, v.125, n. 1, p.16-25, 2006.

THOMSON, Debra; WOLF, Gail; SPEAR, Steven J. Driving Improvement in Patient Care: Lessons from Toyota. **American Journal of Infection Control**, v. 30, n. 4, p.248-251, 2002.

[No authors listed] (2008). ED becomes 'lean' and cuts LBTC, LOS times. **ED Management**, v. 20, n. 4, p. 44-5.

MCCULLOCH, Peter et al. Effect of a “Lean” intervention to improve safety processes and outcomes on a surgical emergency unit. **British Medical Journal**, 341:c5469, 2010.

HINTZEN, BL et al. Effect of lean process improvement techniques on a university hospital inpatient pharmacy. **American Journal of Health System Pharmacy** v. 66, n. 22, p. 2042-7, 2009.

POWELL, Alison; RUSHMER, Rosemary; DAVIES, Huw. Effective quality improvement: Conclusions. **British Journal of Healthcare Management,** v**.** 15, n. 8, p. 374 - 379, 2009.

TOUSSAINT, John. Writing the new playbook for U.S. health care: Lessons from Wisconsin. **Health Affairs**, v. 25, n.5, p.1343-1350, 2009.

HEINBUCH, S. E A case of successful technology transfer to health care: Total quality materials management and just-in-time. **Journal of Management in Medicine**, v. 9, n. 2, p.48 - 56, 1995.

BUCCI, R. V.; MUSITANO, A. A Lean Six Sigma journey in radiology. **Radiology Management**, v. 33, n. 3, p. 27-33, May-Jun 2011.

YASIN, M. M et al. An empirical investigation of the effectiveness of contemporary managerial philosophies in a hospital operational setting. **International Journal of Health Care Quality Assurance**, v. 15, n. 6, p.268 - 276, 2002.

MAZUR, L. M.; CHEN, S. J.; An empirical study for medication delivery improvement based on healthcare professionals' perceptions of medication delivery system. **Health Care Management Science**, v. 12, n. 1, p. 56-66, Mar 2009.

TOWILL, D.R.; CHRISTOPHER, M. An evolutionary approach to the architecture of effective healthcare delivery systems. **Journal of Health Organization and Management**, v. 19, n. 2, p.130 - 147, 2005.

DELLIFRAINE; J. L.; LANGABEER II, J. R. An institutional perspective on quality initiatives: evidence beyond manufacturing. **International Journal of Information Systems and Change Management**, v. 4, n. 1, p. 3-14.

MANDAHAWI, N.; AL-ARAIDAH, O.; BORAN, A.; KHASAWNEH, M. Application of Lean Six Sigma tools to minimise length of stay for ophthalmology day case surgery. **International Journal of Six Sigma and Competitive Advantage**, v. 6, n.3, p.156 - 172, 2011.

ROSEN, L. Applying industrial engineering practices to radiology. **Radiology Management**, v. 26, n. 6, p. 32-5, Nov-Dec 2004.

MEREDITH, J. O et al.. Are we operating effectively? A lean analysis of operating theatre changeovers. **Operations Management Research**, v. 4, n. 3-4, p 89-98, 2011.

PARK KW, DICKERSON C. Can efficient supply management in the operating room save millions? **Current Opinion in Anesthesiology**, v. 22, n. 2, p. 242-8, Apr 2009.

CHAN, A. P. C.; LINDA, FAN, L. C. N.; YU, A. T. W. Construction process reengineering: a case study. **Logistics Information Management**, v. 12, n. 6, p.467 - 476, 1999.

PAPADOPOULOS, T. Continuous improvement and dynamic actor associations: A study of lean thinking implementation in the UK National Health Service. **Leadership in Health Services**, Vol. 24 Iss: 3, pp.207 - 227, 2011.

VAN LEEUWEN, KIM C; DOES, RONALD J. M. M. Quality quandaries: Lean nursing. **Quality Engineering**, v. 23, n.1, p.94-99, 2011.

VAN LENT, WINEKEE A M; GOEDBLOEDA, N; VAN HARTEN, W H. Improving the efficiency of a chemotherapy day unit: Applying a business approach to oncology. **European Journal of Cancer**, v. 45, n. 5, p.800-806, 2009.

VAN VLIET, Ellen J et al. Exploring the relation between process design and efficiency in high-volume cataract pathways from a lean thinking perspective. **International Journal for Quality in Health Care**, v. 23, n. 1, p.83-93, 2011.

GANDHI, T.; BOSIRE, J. Delivering Faster Lab Turnaround Through Lean. In: **Proceedings of the Society for Health Systems Conference and Expo**. Chicago, 2009. A partir daqui as refs estao de acordo com a PUC.

VAN VLIET, Ellen J et al. Efficacy and efficiency of a lean cataract pathway: a comparative study. **Quality & Safety in Health Care**, v. 19, n.13, p.1-6, 2010.

JENKINS J. Eliminating common PACU delays. **Journal of healthcare information management**, v. 21, n. 2, p. 53-8, 2007.

MIJITA, RUSSEL et al. Emergency Department Overcrowding: Developing Emergency Department Capacity Through Process Improvement. **Clinical Pediatric Emergency Medicine**, v.12, n. 2, p. 141-150, 2011.

SOKALSKI, Joseph M; RUNFOLA, Salvatore F; RUNFOLA, Gina. Engaging production-floor employees for rapid improvements at Test Technology, Inc. Global **Business and Organizational Excellence**, v. 30, n. 1, p. 17–28, 2010.

GRABAN, Mark. Engaging staff in Lean improvements for patient care settings. **Proceedings of the 2009 Society for Health Systems Conference and Expo**. Chicago, IL, 2009.

ZHANG, L et al. Enhancing same-day access to magnetic resonance imaging. **Journal of the American College of Radiology**, v. 8, n. 9, p. 649-56, 2011.

VARKEY, Prathibha; KOLLENGODE, A. A framework for healthcare quality improvement in India: The time is here and now! **Journal of Postgraduate Medicine**, v. 57, n. 3, p.237-241, 2011.

SOBEK, Durward; GHOSH, M. A Framework for Quality Improvement Programs, ***Proceedings of the 2007 Industrial Engineering Research Conference***, Nashville, TN, 2007.

KUO, Alex Mu-Hsing et al. A Healthcare Lean Six Sigma System for Postanesthesia Care Unit Workflow Improvement. **Quality Management in Health Care**, v. 20, n. 1, p. 4–14, 2011.

VERMAAT, T.M et al. Reducing start time delays in operating rooms. **Journal of Quality Technology**, v. 41, n. 1, p.95-109, 2009.

JIMMERSON, C.; WEBER, D.; SOBEK, D. K.; Reducing waste and errors: piloting lean principles at Intermountain Healthcare. **Joint Commission Journal on Quality and Patient Safety**, v. 31, n. 5, p. 249-57, May 2005.

STONEMETZ, J et al. Reduction of regulated medical waste using lean sigma results in financial gains for hospital. **Anesthesiology Clinics**, v. 29, n. 1, p. 145-52, Mar. 2011.

VEST, Joshua R; GAMM, Larry D. A critical review of the literature on six sigma, lean and studerGroup's hardwiring excellence in the united states: the need to demonstrate and communicate the effectiveness of effectiveness of transformation strategies in healthcare. **Implementation Science**, v. 4, n. 1, p.1-9, 2009.

WALDHAUSEN, John H.T et al. Application of lean methods improves surgical clinic experience. **Journal of Pediatric Surgery**, v. 45, n. 7, p.1420-1425, 2010.

WARING, Justin; BISHOP, Simon. Lean healthcare: Rhetoric, ritual and resistance. **Social Science & Medicine**, v. 71, n. (n/a), p.1332-1340, 2010.

JONES, D. T.; FILOCHOWSKI, J. Lean healthcare. Think yourself thin. **The Health Service Journal**, v. 116 (6000): suppl 6-7, Apr. 2006.

CASTLE, A.; HARVEY, R. Lean information management: the use of observational data in health care. **International Journal of Productivity and Performance Management**, v. 58, n. 3, p.280 - 299, 2009.

WIJMA, Jeanet et al Quality Quandaries: Efficiency Improvement in a Nursing Department. **Quality Engineering**, v. 21, n. 2, p.222-228, 2009.

WOJTYS, Edward M et al. Applying lean techniques to improve the patient scheduling process. **Journal for Healthcare Quality**, v. 21, n. 3, p.10-16, 2009.

MURRELL, Karen L.; OFFERMAN, Steven R.; KAUFFMAN, Mark B. Applying Lean: Implementation of a rapid triage and treatment system. **Western Journal of Emergency Medicine**, v.12, n. 2, p. 184-191, 2011.

FISCHMAN, D. Applying Lean Six Sigma methodologies to improve efficiency, timeliness of care, and quality of care in an internal medicine residency clinic. **Quality Management in Health Care**, v. 19, n.3, p. 201-10, 2010.

WOOD, S., BEAUVAIS, B. Thinking lean: implementing DMAIC methods to improve efficiency within a cystic fibrosis clinic. **Journal for Healthcare Quality**, v. 33, n.2, p.37-46, 2011.

MORRISSETTE, M. Time Release Fix: 5S is the little big secret for improving health care. **Industrial Engineer**, v. 41, n. 8, p. 34-38, 2009.

LEE, T. S.; KUO, M. H. Toyota A3 report: a tool for process improvement in healthcare. **Studies in Health Technologies and Informatics**, v. 143, p. 235-40, 2009.

BURKITT, K. H et al. Toyota production system quality improvement initiative improves perioperative antibiotic therapy. **American Journal of Managed Care**, v. 15, n. 9, p. 633-42, Sep 2009.

[No authors listed] Toyota's tips drive dramatic ED improvements. **ED Management,** v. 14, n. 11, p. 125-6, Nov 2002.

YOUNG, Terry. An Agenda for Healthcare and Information Simulation. **Health Care Management Science**, v. 8, pp 189–196, 2005.

YOUNG, Terry et al. Using industrial process to improve patient care. **British Medical Journal**, v. 328, n. 7432, p.162-164.

YOUNG, Terry; MCCLEAN, SI. A critical look at Lean Thinking in healthcare. **Quality & Safety in Health Care**, v.17, n.5, p.382-386, 2008.

YOUSRI, T.A et al. Lean thinking: Can it improve the outcome of fracture neck of femur patients in a district general hospital? **Injury**, v. 41, n. (n/a), p.1234-1237, 2011.

GANTI, A. R.; GANTI, A. G. Lean: Rx for hospitals. **Proceedings of the 2004 Annual Lean Management Solutions Conference**. Los Angeles, 2004.

ZARBO, Richard J et al. The Henry Ford production system: reduction of surgical pathology in- process misidentification defects by bar-code specified process standardization. **American Journal of Clinical Pathology**, v.131, n.6, p.975-976.

ZARBO, Richard; D'ANGELO, Rita. The Henry Ford production system - Effective reduction of process defects and waste in surgical pathology. **American Journal of Clinical Pathology**, v. 128, n. 6, p.1015-1022, 2007.

APENDIX 2 - TITLES EMPLOYED IN THE CONTENT ANALYSIS

A01. Ben-Tovim, D. I., Bassham, J. E., Bennett, D. M., Dougherty, M. L., Martin, M. A., O'Neill, S. J., Sincock, J. L. and Szwarcbord, M. (2008). "Redesigning care at the Flinders Medical Centre: clinicalprocess redesign using lean thinking", Medical Journal Australasia 188 (17), pp. S27-S31.

A02. Cankovic, M., Varney, R. C., Whiteley, L., Brown, R., D'Angelo, R., Chitale, D. and Zarbo R. J. (2009).
"The Henry Ford Production System: LEAN Process Redesign Improves Service in the Molecular Diagnostic Laboratory", Journal of Molecular Diagnostics 11 (05), pp. 390-399.

A03. Collar, R. M., Shuman, A. G., Feiner, S., McGonegal, A. K., Heidel, N., Duck, M., McLean, S. A., Billi, J. E., Healy, D. W. and Bradford, C. R. (2012). "Lean Management in Academic Surgery", Journal of the American College of Surgeons 214 (06) pp. 928-936.

A04. Culig, M. H., Kunkle, R. F., Frndak, D. C., Grunden, N., Thomas D. Maher, J. and George J. Magovern,
J. (2011). "Improving Patient Care in Cardiac Surgery Using Toyota Production System Based Methodology", The Annals of Thoracic Surgery 91, pp. 394–400.

A05. Heitmiller, E. S., Hill, R. B., Marshall, C. E., Parsons, B. J., Berkow, L. C., Barrasso, C. A., Zink, E. K. and Ness, P. M. (2010). "Blood wastage reduction using Lean Sigma methodology". Transfusion 50, pp.1887-1896.

A06. LaGanga, L. R. (2011). "Lean service operations: Reflections and new directions for capacity expansion in outpatient clinics", Journal of Operations Management 29, pp. 422–433.

A07. Muder, R. R., Cunningham, C., McCray, E., Squier, C., Perreiah, P., Jain, R., Sinkowitz-Cochran, R. L. and Jernigan, J. A. (2008). "Implementation of an Industrial Systems-Engineering Approach to Reduce the Incidence of Methicillin-Resistant Staphylococcus aureus Infection", Infection control and hospital epidemiology 29 (08), pp. 702-708.

A08. Cima, R. R., Brown, M. J., Hebl, J. R., Moore, R., Rogers, J. C., Kollengode, A., Gwendolyn J Amstutz, G. J., Weisbrod, C. A., Narr, B. J. and Deschamps, C. (2011). "Use of Lean and Six Sigma Methodology to Improve Operating Room Efficiency in a High-Volume Tertiary-Care Academic Medical Center",Journal of the American College Surgeons 213 (01), pp. 83-92

A09. McJoynt, T. A., Hirzallah, M. A., Satele, D. V., Pitzen, J. H., Alberts, S. R. and Rajkumar, S. V. (2009)."Building a Protocol Expressway: The Case of Mayo Clinic Cancer Center", Journal of Clinical Oncology 27 (23), pp. 3855-3860.

A10. Raab, S. S., Andrew-JaJa, C., Condel, J. L., & Dabbs, D. J. (2006).

“Improving Papanicolaou test quality
and reducing medical errors by using Toyota production system methods”, American Journal of Obstetrics and Gynecology 194, pp. 57–64.

A11. Van Lent, W. A., Goedbloeda, N. and Hartena, W. (2009). “Improving the efficiency of a chemotherapy day unit: Applying a business approach to oncology”, European Journal of Cancer 45, pp. 800–806.

APENDIX 3 - GROUPS ESTABLISHED BY THE K-CORES ALGORITHMUM - ANALYSIS 2 - CO-CITATIONS

Grupo 1
N. Ref K-core: 54
Anguelov, Z;
Bassham, Jane E;
Ben-Tovim, David I;
Bennet, Denise M;
Black, J;
Bolch, Denise;
Bongers, I;
Cheung, Dickson S;
Dann, Linda;
De Koning, Henk;
DelBeccaro, Mark;
Dickson, E W;
Digiusto, E;
Does, Ronald J M M;
Dougherty, Melissa;
Eller, Andrew;
Fox, Debra;
Frankel, Heidi L;
Friese, Randall S;
Gamm, L D;
Hendricks, J;
Jacobson, Gregory H;
Jansen, R;
Joosten, T;
Kin, J M;
Klein, Jorie;
Leppa, C J;
Leraci, S;
Lescallette, Richard;
Martin, Margaret A;
McClean, S I;
McCoin, Nicole S;
Nelson-Peterson, D L;
Ng, David;
Nugent, Andrew S;
O'Neil, Susan;
Parks, Jennifer K;
Russ, Stephan;
Schmidt, Nicki;
Shafi, Shahid;
Sincock, Jackie L;
Singh, S;
Slovis, Corey;
Sonntag, P;
Spear, S J;
Stapleton, F B;
Szwarcbord, Michael;
Thomas, Sophia;
Toussaint, J;
Vail, Gord;
Van Den Heuvel, Jaap;
Vest, J L;
Vetterick, D;
Wyatt, Cristopher C;
Young, Terry P;

Grupo 2
N. Ref K-core: 45
Andrew-JaJa, Carey;
Balassanian, R;
Bellhouse, D E;
Billi, John E;
Braaten, J S;
Bryant, M;
Condel, Jennifer L;
Cox, L;
D'Angelo, R;
Dabbs, David J;
Feinstein, K W;
Frerichs, J;
Grunden, N;
Grzybicki, D M;
Harrison, Eduard I;
Janosky, J E;
Jolley, Damien;
Kelly, Anne-Marie;
Kim, C S ;
King, D;
Lummus, R R;
Persoon, T;
Raab, S S;
Rodeghiero, B;
Spahlinger, D A;
Sudilovsky, D;
Thompson, D N;
Vokurka, R J;
Vrbin, CM;
Wolf, G A;
Zaleski, S;
Zarbo, R J;

Grupo 3
N. Ref K-core: 35
Aakre, K T;
Angelis, J;
Baum, Jonathan M;
Goonan, E M;
Grove, A L;
Hagan, P;
Hegge, P;
Lobo, M M;
Macintyre, M;
Melanson, S E;
Meredith, J O;
Neailey, K;
O'Connor, M K;
Paredes, Jose D;
Richmond, B;
Rutledge, Joe;
Santos, Katherine S;
Sato, B;
Serrano, L;
Siebert, J R;
Simpson, Joanne;
Stahnke, L;
Valley, T B;
Xu, Min;

Grupo 4
N. Ref K-core: 33
Blaser, Sandra M;
Chesin, Carole M;
Fisch, John M;
Soomer, Deborah L;

Grupo 5
N. Ref K-core: 30
Connel, C;

Grupo 6
N. Ref K-core: 28
Aronsson, H;
Bisgaard, Soren;
Brommels, M;
Mazzocato, P;
Savage, C;
Sermeus, Walter;
Sol, Johannes C A;
Thor, Johan;
Van Harten, Wim H;
Van Vliet, Ellen J;

Grupo 7
N. Ref K-core: 24
Brailsford, S;
Davies, Ruth;
Harper, Paul;
Klein, Jonathan H;
Reller, M K;
Resar, R K;
Varkey, Prathibha;
Verver, John P S;

Grupo 8
N. Ref K-core: 22
Alberts, S R;
Hirzallah, M A;
McJoynt, T A;
Pitzen, J H;
Rajkumar, S V;
Satele, D V;

Grupo 9
N. Ref K-core: 21
Ahaus, K T B;
Avansino, J R;
Cunningham, Candace;
Jain, Rajiv;
Jernigan, John A;
McCray, Ellesha;
Muder, Robert R;
Niemeijer, G C;
Perreiah, Peter;
Sawin, R S;
Sinkowitz-Cochran, Ronda L;
Squier, Cheryl;
Trip, A;
Van Gaalen, C M;
Vermaat, T M B;
Vissers, Jan M H;
Waldhausen, J H;
Wendt, K W;

Grupo 10
N. Ref K-core: 19
Bredenhoff, Eelço;
Kop, Lucas M;

Grupo 11
N. Ref K-core: 18
Mahar, B;
Neuman, C;
Ormsby, A;
Tuthill, J M;
Varney, R;

Grupo 12
N. Ref K-core: 17
Jacobson, J M
Johnson, Mari E

Grupo 13
N. Ref K-core: 16
De Bucourt, M;
Teichgraber, U K;
WILSON, GWYNETH ;

Grupo 14
N. Ref K-core: 15
Gustafson, Michael L;
Jarret, P;
Tanasijevic, Milenko J;

Grupo 15
N. Ref K-core: 14
Culig, Michael H;
Frndak, Diane C;
Kunkle, Richard F;
Magovern, George J Jr;
Maher, Thomas D Jr;
Newel, D L;
Steinmetz-Malato, L L;
Van Dyke, D L;

Grupo 16
N. Ref K-core: 13
Goedbloed, N;
Van Lent, Winekee A M;

Grupo 17
N. Ref K-core: 10
Brown, R;
Cankovic, M;
Chitale, D;
Hiteley, L;

Grupo 18
N. Ref K-core: 9
Amstutz, Gwendolyn J;
Brown, Michael J;
Cima, Robert R;
Deschamps, Claude;
Hebl, James R;
Howeg, Mathias
Kollengode, Anantha;
Moore, Robin;
Narr, Bradly J;
Radnor, Zoe;
Rogers, James C;
Waring, Justin;
Weisbrod, Cheryl A;

Grupo 19
N. Ref K-core: 7
Lindberg, K;
Tragardh, B;

Grupo 20
N. Ref K-core: 4
Goldstain, SM;
Halwachs-Baumann, Gabriele;
Henry, T D;
Shah, R;
Unger, B T;

Grupo 21
N. Ref K-core: 3
Agbabian, J;
Overgaard, K A;
Schley, L;
Wojtys, E M;

Grupo 22
N. Ref K-core: 0
De Souza, L B;
Libby, A;
Pidd, Michael

APENDIX 4 - KEYWORDS CONSIDERATED FOR GROUPS IDENTIFICATION IN CLUSTER ANALYSIS - ANALYSIS 2

#	Group name	Keywords	Interpretation
4	Light gray (2 articles)	Laboratory tests (1); timeliness (1); supply chain management (1); case study (1);	Lean in laboratory and supply chain (2)
0	Isolates - not presented (2 articles)	Quality of medical visits (1); high volume surgery clinics (1); Case Study (1); NHS UK (1); Barriers for implementation (1);	Implementation barriers and quality of medical visits (2)
3	Variability in the appointments (1 article)	Variability (1); Schedule process (1)	Reduce variability in the schedule of appointments
7	Implementation models	Implementation models(1), Lean model interpretation(1).	Study of the different interpretation of Lean made by seven companies
9	NHS UK	NHS UK (3); Empirical research (2); Social dimensions (1); Application (1) Operating room suites (1), Lean and Six Sigma (2); implementation models (1); PDSA (1), Applicability (1); Socio-technical dimensions (1); Actor network theory (1); Simulation (1),	Research more focused in the NHS UK that analysis simulation in HC, lean as context dependent and Socio-technical dimensions of lean;
10	Lean in Pathology laboratory (1)	Laboratory tests (1); Pathology (1)	Application in Pathology laboratory.
13	Lean in Chemotherapy (1)	Chemotherapy (1), PDSA (1).	Application of Lean in a Chemotherapy day unit.
14	Lean in medication delivery and cardiac surgery (2)	Medication delivery system (1), Just-in-time (1); Cardiac surgery (1),	Applications in Medication delivery and cardiac surgery.
15	Supply chain and laboratory applications (2)	Supply chain (1); just-in-time (1); literature review (1); Application (1); laboratory (1); phlebotomy (1), blood draw (1).	Application in laboratory tests and supply chain review.
16	NHS (UK) implementation model and Lean in supply chain (2);	NHS UK (1); implementation models (1); Supply chain (1), endovascular stents (1);	NHS implementation model and application of Lean in the supply chain of endovascular stents.
17	Basic concepts of Lean Six Sigma (1).	Conceptual paper (1), Lean Six Sigma (1)	Basic concepts of Lean Six Sigma.
18	Lean in Pathology Laboratories (3).	Evaluate Lean results (1), surgical pathology laboratory (2), amended reports (1); Pathology laboratory (1);	Lean in Pathology laboratories.
19	Implementation models in cataract surgery (1).	Case study (1), implementation models (1), Lean model interpretation (1), comparation (1), cataract surgery (1).	Comparation of Lean implementation models in cataract surgery.
21	Reduction of variability and Six Sigma (6)	Cataract surgery (1); Lean Six Sigma (3); Trauma care (1); discharge procedure (1); Protocol for infection prevention (1); reduce variability (1); Medical visits in high volume	Reduction of variability and Six Sigma in diverse settings.

		surgery clinics (1), Operating rooms (1)	
22	Lean Six Sigma in protocols development (1)	Lean Six Sigma (1), protocol development unit (1);	Application of Lean Six Sigma in a cancer protocol development unit
24	Basic concepts of Lean Six Sigma and quality improvement methodologies (5)	Lean Six Sigma (4); constraints theory (1); Quality improvement methodologies (2); Lean (1); Six sigma (1); Operating rooms (1); PDSA (1); Discuss the applicability (1)	Basic concepts of Lean Six Sigma and quality improvement methodologies.
28	Lean and Lean Sigma in supply chain, Emergency department and others.	Lean Six Sigma (4); Literature review (2); implementation methods (2); Cataract surgery (1); Chemotherapy (1); PDSA (1); Operating rooms (1); chronic pulmonary disease (1); Lean production (1), Agile production (1), supply chain management (1); Case study, emergency department (1)	Lean and Lean Sigma in supply chain, Emergency department and others.
30	Basics of Quality improvement methodologies (1)	Quality improvement methodologies (1), Lean (1), Six sigma (1).	Basics of Quality improvement methodologies
33	Lean in Pathology Laboratory (1)	Papanicolau test (1); Pathology Laboratory (1)	Application of Lean in Pathology laboratory.
35	Lean in Laboratories (7)	Laboratory (1); phlebotomy (1), blood draw (1); Lean six sigma (1); radiology (2); NHS (1); Pathology laboratory (2); autopsy (1); implementation methods (1);	Application of Lean in laboratories.
45	Lean in Pathology Laboratory and Emergency Department (18)	Implementation methods (1), Thyroid gland fine-needle aspiration (1); Pathology laboratory (7); Emergency department (2); Implementation Models (1); Nursing unity (1); Cardiac surgery (1); patient flow in a medical clinic (1); Teach lean in residency programs (1); Evaluate Lean results (1); ameded reports (1); otolaryngology (1) operating room (1);	Lean in Pathology Laboratory and Emergency Department
54	Lean, Lean Six Sigma and Emergency departments (31)	Implementation models (4); Emergency department (9); Lean Six Sigma (9); constraints theory (2); Literature review (3); evidence of effectiveness (1); Six Sigma (1), Studer's Hardwiring Excellence (1); Trauma care (1), discharge procedure (1); lean capabilities (1); Trauma resuscitation unity (1); Pediatric unit (2) Operating rooms (1); chronic obstructive pulmonary disease (1); socio technical dynamics (1), simulation modeling (1); Supply chain (1); operating rooms (1); infusion pumps (1)	Lean, Lean Six Sigma and Emergency departments.