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Lean Healthcare: Barriers and Enablers in the Colombian Context

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***Abstract*—**Lean philosophy has evolved over time and has been implemented both in manufacturing and services, more recently lean has been integrated in the companies of the health sector. Currently it is important to understand the successful way to implement this philosophy and try to identify barriers and enablers to the sustainability of lean healthcare. The main purpose of this research is to identify the barriers and enablers in the implementation of Lean Healthcare based on case studies of Colombian healthcare centers. In order to do so, we conducted semi-structured interviews based on a maturity model. The main results indicate that the success of Lean implementation depends on its adaptation to contextual factors. In addition, in the Colombian context were identified new factors such as organizational culture, management models, integration of the care and administrative departments and triple helix relationship.

***Keywords*—**Barriers, enablers, implementation, lean healthcare, sustainability.

I. Introduction

IT is widely known that lean manufacturing principles can be applied effectively to many different types of organizations and industries, it's principles have universal applicability [1]. Under this paradigm, [2] and [3] state that lean is a management strategy that is applicable to all organizations, because it is related to process improvement. In the line of this thinking, it must be emphasized that many problems in the industry, such as safety, quality, capacity constraints, low levels of efficiency and motivation, are similar problems arising in the health sector; therefore, the scientific literature has analysed how to improve a process through new trends in production management systems (i.e. lean), in order to reduce costs in the sector, improve processes, enhance response times and quality of care provided to patients and increase staff satisfaction [4]-[8].

The literature on the lean philosophy has analyzed how the factors of organizational context influence the implementation and sustainability of lean in organizations, that is, to identify barriers and facilitators is essential for the development of the field of lean. Many investigations have been carried out on the successful implementation of lean tools in enterprises [9], likewise, there have been developed models to identify barriers and facilitators to lean implementation. [3], [9]-[14]. However, the literature is scarce in studies that had established the key factor for successful implementation of Lean in the Colombian health system. This gap is largely due to the absence of qualitative empirical studies that take into account the true complexity and context of lean [9] implementation [15]-[18].

The aim of this study is to contribute to the understanding of the lean implementation and sustainability in the Colombian healthcare centers, specifically, to evaluate their maturity level, as well as to identify those barriers that obstruct the implementation and sustainability of this philosophy and the enablers that can overcome these barriers. To achieve this objective, we conducted semi-structured interviews with Quality Coordinators in healthcare centers located in the Metropolitan Area of Bucaramanga (Colombia), in order to validate and supplement the existing theory about barriers and enablers to enable implementation and sustainability of lean healthcare, and find the organizations mechanisms to overcome these barriers and to empower enablers.

The paper is organized as follows: The first section shows theoretical framework of lean healthcare. Subsequently, the methodological design used in the research is detailed. Finally, the results are discussed including recommendations for possible future research based on the implications of this study.

II. Background of Lean Healthcare

A. Lean Healthcare

The first publications related to the use of methods of manufacturing in the health sector can be found in [19], [20]; based on a preliminary literature review, it is shown that the use of lean in health services appears for the first time in a work published by the Agency for the Modernization of British NHS Health [21], notwithstanding the application of lean healthcare has been increasingly documented in the literature by different authors [22]-[24], everyone agrees that the lean philosophy can be adapted and developed to improve the health of patients. Other studies [10], [13], [19], [21] show the rising importance that Lean Healthcare has had in the recent years reflected in the increase of both academic and empirical research.

Lean Healthcare applications in specific departments of hospitals and clinics are shown in other research articles, for example, the adaptation of Lean philosophy to improve the processes of emergency services [25]-[27], surgical units [28], [29] and laboratories [30]-[32]. However Lean Healthcare is in an early stage of development, and appears to be far from reaching a high level of excellence compared to Lean Manufacturing applications [33].

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The first empirical studies of Lean Healthcare were published in 2002 [21], which were mainly case studies of the implementation of a tool or principle of Lean in a department of a hospital or clinic, lacking a vision of Lean as a systematic philosophy [34], [35]. Although Lean requires changes to be adapted to the peculiarities of this sector [36], different institutions have proved the benefits of implementing Lean in Healthcare, for example the case of ThedaCare Improvement System (TIS) of ThedaCare Inc., which reports a decrease in waste and an increase in productivity [13], [36]. Another successful report in the application of Lean as an operational strategy is in the Virginia Mason Medical Center (VMMC) [37]. Since the introduction of Lean, they have demonstrated they can save capital, use staff more efficiently, reduce inventories, improve productivity, save space and improve quality. Improvements have resulted in tens of millions of dollars in savings. Moreover, the case of Bolton NHS Trust in UK is reported, standing out the main results obtained in more than two years of practice such as the improvement of service performance, quality and safety [38]. Furthermore, some international organizations have developed guidelines of Lean Healthcare [4], [39], [40], which show the results of its application in institutions such as the NHS Institute for Innovation and Improvement, the IHI- Institute for Healthcare Improvement and the Lean Enterprise Institute. These case studies disseminate Lean Healthcare initiatives as well as show that this philosophy can reduce waste in the health sector similarly to the manufacturing industries.

Nowadays, the accreditation requirements of the health sector as well as the rising needs and expectations of patients demand continuous improvement of health care quality while lower costs are achieved [41]. Thus, the improvement of the efficiency and effectiveness of health processes represents an opportunity to reduce costs, improve the processes and the quality of care, and increase staff satisfaction [3], [43], [44]. Lean has also been identified as an alternative approach that seeks to solve the quality problems in a hospital or clinic [8], [45]. Therefore, the purpose of Lean Healthcare is to create value for the patients, which it is fulfilled with the elimination of process waste in order to offer them a proper diagnosis and treatment [24], [38], [46], [47]. According to the literature, some outcomes of applying Lean Healthcare are: better patient care, better quality service processes, better process design, greater financial performance, greater value for patients, and higher productivity and timely provision of services. These results are got by reducing the time waiting, errors, incidents, inadequate procedures and costs [3], [22], [24], [48]-[53].

B. Barriers and Enablers

The barriers are organizational characteristics that may limit or prevent the implementation of Lean and also can compromise the efficiency and effectiveness of the processes, meanwhile, the enablers serve as catalysts which promote the success and long-term sustainability of this philosophy [23].

Empirical studies on Lean Healthcare have started to abroad the contextual factors that influence its implementation. The main factors identified in the literature are: The top management commitment and support, the organizational structure, the multidisciplinary collaboration, the resources and financial capacity, the leadership, the teamwork, the training and education, the communication and exchange of information, [3], [4], [23], [34], [45], [54]-[57]. These studies state that the implementation of Lean is not a homogeneous or invariable process instead of that, it is dependent on contextual factors [34] However, there is still a gap in the understanding of barriers and their relationships due to the lack of qualitative empirical studies that abroad the true complexity of Lean [15].

III. Methodology

A qualitative research approach was selected in order to validate the existing theory about barriers and enablers, and also to identify new contextual factors which can be useful to Lean implementation [58].

The multiple case study as research methodology allows to compare, analyze and validate the same phenomenon in different scenarios in order to predict similar results and allow the expansion of theories [59], [60].

The data was compiled from the semi-structured interviews which was conducted with Quality or Medical Management coordinators in ten healthcare centers in Bucaramanga (Colombia) in order to obtain information relevant to the identification of the organization level of maturity and the Lean facilitators and barriers. The selection of this population was made considering that the interviewee's position could provide empirical knowledge related to the continuous improvement of activities in healthcare centers. According to [61], the purpose of the interview is to generate new information and confirm the information known. This qualitative instrument is useful to research strategic phenomena where interviewees should reflect on daily practices, and it is flexible because it allows researchers to adapt the questions to the context of interviewees.

The semi-structured interviews were carried out using the model developed by [62]. For information analysis, the stages stated by [63] were used as follows: (1) **The description** where the interviews were recorded and transcribed; (2) **The analysis** where initial categories were defined based on the maturity model to encode the information using the software NVivo®, and (3) **The interpretation** of data based on the contextual factors as recommended [63].

IV. Discussion

A. Maturity Level

In order to identify and determine the level of maturity of the studied clinics and hospitals which are named for confidentiality reasons as A, B, C, D, E, F, G, H, I, semi-structured interviews were carried out according to the model developed by [62], which assessed through 34 items (Appendix 1) the maturity level of the institution according to the following factors: lean implementation enablers, lean practices and operational performance of organizations. The characteristics of each level are:

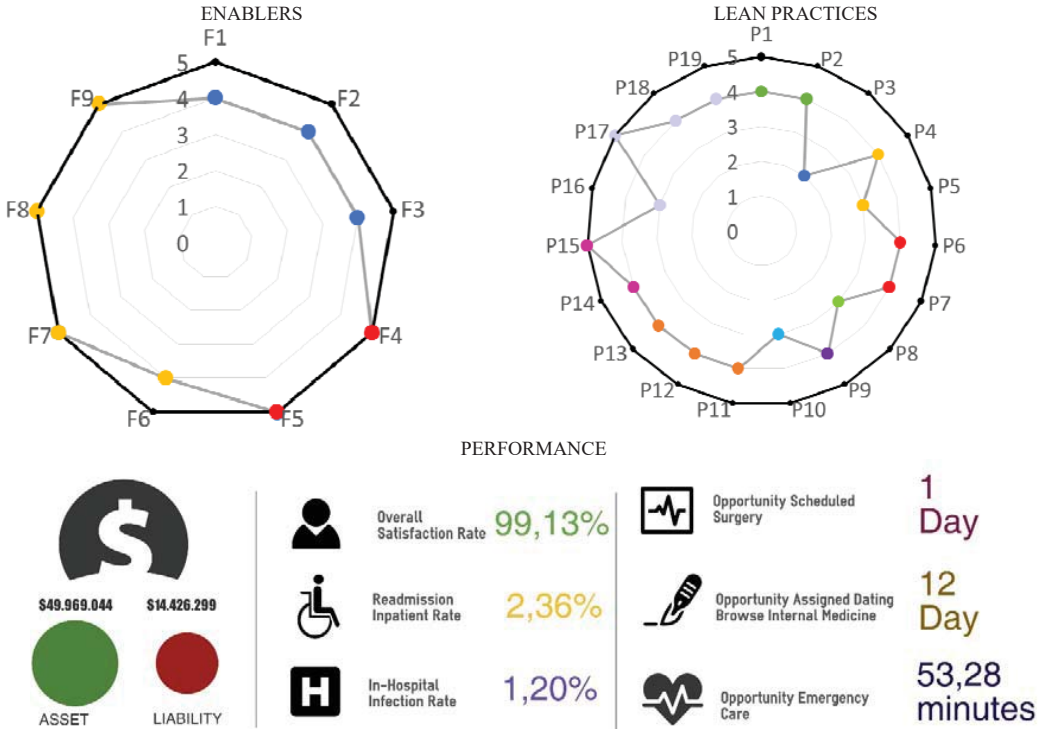
– **Level 1: No adoption**, where the problems are usually

explicit and the solutions often focus on symptoms rather than causes.

- **Level 2: General awareness**, where the search for appropriate tools and methods is started, the problem solving is increasingly structured, and there is an informal approach in some areas with varying degrees of efficacy.
- **Level 3: Systematic approach**, where most of the organization areas are involved but at different stages. These institutions use more tools and methods to monitor work metrics.
- **Level 4: On-going refinement**, where all areas are involved but at different stages. There are sustainable continuous improvement strategies.
- **Level 5: Exceptional, well-defined, innovative approach**, where all areas are involved at an advanced level. The results of the improvements are sustained and there is an innovative approach to solving problems.

The analysis of the results are presented in Table I, where the first row shows the maturity level of the healthcare centers according to the lean implementation enablers, lean practices and operational performance of organizations (Appendix I). In the last row, the results of this evaluation are presented in financial, quality, safety and patient opportunity terms.

TABLE I
MATURITY LEVEL EVALUATION



Based on the results of the application of this instrument, Fig. 1 shows the maturity of enablers and organizational practices in relation to the four zones of progress defined by [62], which are:

1. **Progress zone** when both the implementation practices and the enablers to Lean sustainability are met significantly within the organization.
2. **Start zone** when the enablers are used more than the implementation practices within the organization.
3. **Confusion zone** when the implementation practices are used more than the enablers within the organization.
4. **Critical zone:** when both the implementation practices and the enablers to Lean sustainability are met insignificantly within the organization.

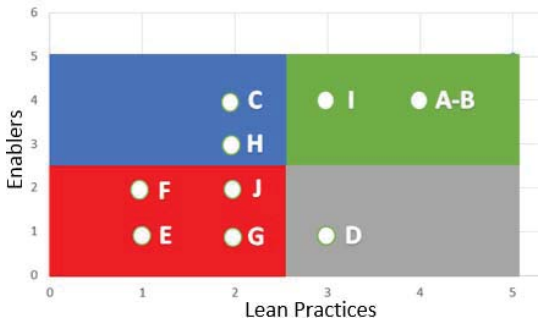


Fig. 1 Progress zones to Lean sustainability

The healthcare centers A, B and I are located in the Progress Area where the lean implementation reach a sustainable level considering that enablers and practices are

met significantly within the organization. However, healthcare organizations in the other zones have not got sustainable levels of lean implementation and present varying degrees of risk.

The healthcare centers C and H, which are located in the Start Area, are organizations that have less risk compared to other zones. This is due to its high level of enablers' development which have a significant effect on the maintenance of the improvements achieved through the Lean implementation. However, the low level of practices' adoption reduces the efficacy of the continuous improvement strategies carried out within these organizations. In order to move towards the Progress Zone, these organizations need to have a good command of lean tools and activities through training and practice.

With respect of the health institution D, which have a high level of Lean practices adoption, its efforts are insufficient and inefficient due to the lack of enablers' adoption that enable the sustainable implementation of Lean. Such organizations suffer from high levels of frustration caused by the efforts in the implementation of improvement activities while not reach satisfactory levels of performance. If enablers are missing, the Lean philosophy does not function correctly because its Lean practices are likely to fail. So, the risk likelihood to fail in these organizations is higher than those in the Start Zone and lower than those in the Critical Zone.

Since organizations in the critical zone (E, F, J and G) have low levels of adoption of both Lean enablers and practices, they need great efforts to move towards the Progress Zone.

B. Barriers and Enablers

This section lists the different organizational factors that act as barriers and enablers in the implementation and sustainability of Lean Healthcare. A summary of the main organizational factors that were identified in both the maturity model and the case studies are shown in Table II. The second column shows whether those factors are confirmed by interviewees or are new additions (included) to the existing literature, taking into account the Colombian healthcare centers context.

TABLE II
ORGANIZATIONAL FACTORS: BARRIERS AND ENABLERS

Factor	
Employee training	Confirmed
Employee engagement	Confirmed
Employee understanding	Confirmed
Management commitment	Confirmed
Management understanding	Confirmed
Time for improvement work	Confirmed
Resources for improvement work	Confirmed
Change agent	Confirmed
Bi-directional vertical information flow	Confirmed
Organizational culture	Included
Management models	Included
Integration of the care and administrative departments	Included
Triple Helix relationship	Included

Each organizational factor is described as follows*:*

1. *Employee Training* is established by the interviewees as a key element for the implementation and sustainability of the lean philosophy because they feel that the employee involvement promotes successful outcomes. Moreover, the transfer of knowledge from experts is considered essential as employees feel part of the process.
2. *Employee Engagement:* The successful implementation of Lean requires commitment from employees of all areas to achieve sustainability of the improvements, then, the lack of multidisciplinary collaboration is considered a barrier to lean adoption. Some participants of the interviews stated that is important to show staff the importance of their functions along the value chain. To enhance the commitment of the employees, one of the strategies used by the healthcare centers interviewed is to make them leaders of improvement projects in their work areas. Also, courses or seminars on communication, teamwork and leadership are taught in order to strengthen employee engagement with the institution.
3. *Employee Understanding:* The interviewees stated that it is important to know the concept and purpose of Lean philosophy so that they can develop new ideas to the process improvement. All employees must be respected and their skills should be enhanced to increase the customer value.
4. *Management Commitment:* All of the interviewees agree that a total commitment of top management is required because their support can favor the implementation of other factors needed to the initiation and sustainability of Lean philosophy. Regarding to this factor, a participant said: "the fact that the chief work together with me, gives me confidence and enthusiasm to continue working towards service quality". The close relationship between long-term plans and improvement strategies, allows management to set up systems, procedures and policies which benefit the implementation and sustainability of Lean projects.
5. *Management Understanding:* According to the participants of this study, the Lean adoption goals should be disseminated in all organizational areas. In order to be effective, it is necessary that top management knows very well the Lean concept, its objectives and methods, and are able to explain and teach them to the staff. Moreover, the interviewees agreed that the lack of integration of Lean strategy with the overall strategy of the health institution is one of the main obstacles.
6. *Time for Improvement Work*: The interviewees consider that the time to carry out Lean projects is a critical factor. Most of them noted that the lack of established schedules for these projects make these improvements unsustainable. One interviewee said: "the main barrier is the time, because we get training, but we do not have time to plan and implement improvements".
7. *Resources for Improvement Work*: Although the implementation of lean techniques is considered low-cost investment, interviewees consider that it is necessary that

a part of the annual budget must be allocated for the development of improvement activities. However, financial resources are not only considering but also resources related to materials, physical space and staff. Besides, there is a close relationship between the resources allocation and the management commitment and the employee involvement. As noted before, the lack of resources is one of the common problems in implementing and sustaining Lean.

8. *Change Agent:* According to the interviewees, the presence of a leader who has the ability to motivate workers in achieving improvement objectives, has had a positive impact on the sustainability of Lean achievements. In the line of this thinking the agent of change must participate before and during the Lean implementation.
9. *Bi-directional Vertical Information Flow:* Different communication strategies are used by the healthcare centers in order to exchange the information related to the planning and development of improvement activities. The use of intranet as well as formal or informal committees are outlined. These communication strategies are used to report the progress and to formulate new improvement jobs.
10. *Organizational Culture*: Regarding to this factor, barriers such as change resistance and staff turnover appear. The former barrier is associated with the diversity of profiles and professional approaches. The participants of this study indicated that change resistance deserves special attention in the initial phase of Lean implementation. Meanwhile, a characteristic of the Colombian health sector is the high staff turnover rates, which makes the commitment of workers and the strengthening of the organizational culture more difficult.
11. *Management Models:* Some interviewees stated that an important facilitator for lean sustainability is the proper use of management models that contribute to the spread of lean best practices to all levels of the organization. The systematic integration of these models such as ISO certifications and the Joint Commission has provided key tools for improvement work. As one of the interviewees affirm: "the long-term sustainability of the improvement activities has been achieved through a continuous commitment to get international certifications".
12. *Integration of the Care and Administrative Departments:* The relationship between these two departments is a fundamental factor. Most interviewees perceived that the care workers see lean projects as a barrier. A quality coordinator said: "doctors must decide whether to use part of their time in the patient care or use it to fill out forms". Hence, there is a need to conform cross-functional teams with employees from the two departments in order to implement improvement works. The multidisciplinary nature of the teams, that are usually made up of industrial engineers, systems engineers, business managers, nurses and doctors, should be used to enable the generation of new ideas and the development of new improvement works.
13. *Triple Helix Relationship:* The participation of government and universities on improvement projects within healthcare centers is highlighted. This factor has allowed to ensure the necessary resources to implement improvements as well as to get advice on methodologies that contribute to improvements sustainability. As one interviewee stated: "our healthcare center encourages our postgraduate training through collaboration agreements with universities in order to implement new trends and methodologies in our clinic". Another interviewee said: "we have participated in research calls offered by Colciencias and worked together with university research groups". Based on this triple helix participation, improvements of work have increased with successful implementation and sustainability.

V. Conclusion

Nowadays, the accreditation requirements of the health sector as well as the rising needs and expectations of patients demand continuous improvement of health care quality while lower costs are achieved [42]. In this line of thinking, implementation of Lean Healthcare provides the transformation of the organizational processes. Based on the multiple case study methodology, we found the contextual factors that influence the implementation and sustainability of Lean Healthcare. The main contribution of this study was the identification of new organizational factors that were not presented in the Lean maturity model developed by [25], which are: organizational culture, management models, integration of care and administrative departments and triple helix relationship.

The results of this research allow healthcare centers to know the key factors to implement and sustain Lean improvement works. Furthermore, the enablers presented in the article allow healthcare centers to strengthen their improvement programs, to implement Lean strategies at all levels of the organization and to identify the potential barriers that could avoid the successful improvement of Lean works. Moreover, it was found that the successful implementation of Lean Healthcare requires employee training and understanding, management understanding, allocation of time and resources to improvement works, organizational culture, and triple helix relationships. On the other hand, the factors that influence the Lean philosophy sustainability are: management commitment, change agent, bi-directional vertical flow of information, management models and relationships between care and administrative departments. In addition, the multiple case study provide strong empirical evidence of how organizational context influence the factors, that is, depending on the context the factors could act as barriers or enablers in the implementation and sustainability of Lean Healthcare.

The limitations of this research are derived from the reduced number of healthcare centers studied. Future research could be addressed the validating of the maturity model of

Lean including each of the organizational factors identified in this paper in order to set up a framework that guides healthcare centers to the successful implementation and sustainability of Lean Healthcare.

APPENDIX I

TABLE III
LEAN SERVICE ASSESSMENT INSTRUMENT

Items	
Employee training	F1
Employee engagement	F2
Employee understanding	F3
Management commitment	F4
Management understanding	F5
Time for improvement work	F6
Resources for improvement work	F7
Change agent	F8
Bi-directional information flow	P1
Identification of customer value	P2
Customer involvement	P3
Value stream mapping	P4
Workplace design for flow	P5
Connecting the process	P6
Standardized tasks	P7
Formalization of work standards	P8
Proactive planning	P9
Built-in quality	P10
Pull system	P11
Visual signals	P12
Visualization of information	P13
Visualization of improvements	P14
Employees measure and follow up work	P15
Multifunctional teams	P16
Employee participation in improvement work	P17
Focus of improvement work	P18
Structured problem solving	P19
Sustaining improvements	P20

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REFERENCES

[1] G. Kundu and B. Manohar. "Critical success factors for implementing lean practices in it support services." *International Journal for Quality Research*, (Online). Vol 6. No. 4. pp 301–312. 2012

[2] A. Esain. S. Williams. And L. Massey. "Combining planned and emergent change in a healthcare lean transformation." *Public Money and Management: Integrating Theory and Practice in Public Management*, Vol 28. No. 1, pp 21–26. 2008

[3] M. Diane. J. Womack. A.P. Byrne. O.J. Flume. G.S. Kaplan. And J. Toussaint. "Going lean in health care". *Innovation Series*, pp 1–20. 2005

[4] N. Westwood. M.J. Moore and M. Cooke. *Going lean in the NHS*. Reino Unido: NHS Institute of Innovation and Improvement. p 154. 2007

[5] L. Cuatrecasas. "Design of a rapid response and high efficiency service by lean production principles: Methodology and evaluation of variability of performance." *International Journal of Production Economics*, 80(2), 169–183. doi:10.1016/S0925-5273(02)00316-X, 2002.

[6] J.K. Liker and J.M. Morgan. "The Toyota Way in Services: The Case of Lean Product Development". *Academy of Management Perspectives*, 20, pp 5–20. doi:10.5465/AMP.2006.20591002, 2006.

[7] T. Young. S. Brailsford. C. Connell. R. Davies. P. Harper and J.H. Klein. "Using industrial processes to improve patient care". *BMJ. Clinical Research Ed.* vol. 328 (7432) pp. 162-164. 2004

[8] C.S. Kim. D.A. Spahlinger. J.M. Kin. R.J. Coffey and J.E. Billi, "Implementation of lean thinking: One health system's journey." *Joint Commission Journal on Quality and Patient Safety*, Vol. 35(8), pp 406–413. 2009.

[9] U. Apte, C. Goh, "Applying lean manufacturing principles to information intensive services," *International Journal of Services Technology and Management*. Vol. 5, p 488, 2004.

[10] L. Cuatrecasas, "A lean management implementation method in service operations," *International Journal of Services Technology and Management*. Vol. 5. p 532, 2004.

[11] B. Kollberg. J.J. Dahlgaard and P. Brehmer. "Measuring lean initiatives in health care services: issues and findings." *International Journal of Productivity and Performance Management,* Vol. 56(1), pp 7–24. 2004

[12] A. Sanchez, M. Perez, "The use of lean indicators for operations management in services," *International Journal of Services Technology and Management.* Vol. 5; p. 465, 2004.

[13] K. Aij, F. Simons, G. Widdershoven, M. Visse, "Experiences of leaders in the implementation of Lean in a teaching hospital--barriers and facilitators in clinical practices: a qualitative study," *BMJ Open*. Vol. 3. No. 10. p 0365, 2013.

[14] Z. Radnor, P. Walley, A. Stephens, G. Bucci. "Evaluation of the lean approach to business management and its use in the public sector," *Scotland: Scottish Executive*. 2006. 138 p

[15] A. Taylor, M. Taylor, A. Mcsweeney, "Towards greater understanding of success and survival of lean systems," *International Journal of Production Research*. Vol. 51. No. 22; p 6607-6630, 2013.

[16] T.A Saurin, J. Rooke, L. Koskela, and S. Kremmer, "Guidelines for the management of complex socio-technical systems: an exploratory study of a refurbishment project". *IGLC* 21, Fortaleza, 13-22.2013.

[17] A. Lewis, "Lean production and sustainable competitive advantage", *International Journal of Operations & Production Management*, Vol. 20 Iss: 8, pp.959 – 978, 2000.

[18] J. Moyano-Fuentes, M. Sacristán-Díaz, "Learning on lean: a review of thinking and research", *International Journal of Operations & Production Management*, Vol. 32 Iss: 5, pp.551 – 582, 2012.

[19] S. Jacobs and S. Pelfrey. "Applying just-in-time philosophy to healthcare." *The Journal of Nursing Administration*, Vol. 25(1), pp 47–51. 199hi

[20] D. Whitson. "Applying just-in-time systems in health care." *IIE Solutions*, Vol. 29(8), pp 32–77. 1997

[21] L.B. Souza. "Trends and approaches in lean healthcare." *Leadership in Health Services.* Vol. 22(2), pp 121–139. 2009 doi:10.1108/17511870910953788

[22] P. Mazzocato. C. Savage. M. Brommels. H. Aronsson and J. Thor. "Lean thinking in healthcare: a realist review of the literature." *Quality & Safety in Health Care*, Vol. 19(5), pp 376–82. 2010. doi:10.1136/qshc.2009.037986

[23] B. Poksinska. "The current state of Lean implementation in health care: literature review." *Quality Management in Health Care*, Vol. 19(4), pp 319–29. 2010. doi:10.1097/QMH.0b013e3181fa07bb

[24] T.P. Young and S.I Mcclean. "A critical look at Lean Thinking in healthcare." *Quality & Safety in Health Care*, Vol. 17(5), pp 382–6. 2008

[25] G. Loor. A. Vivacqua. J.F. Sabik. L. Li. E.D. Hixson. E.H. Blackstone and C.G. Koch. "Process improvement in cardiac surgery: development and implementation of a reoperation for bleeding checklist." *The Journal of Thoracic and Cardiovascular Surgery,* Vol. 146(5), pp 1028–32. 2013. doi:10.1016/j.jtcvs.2013.05.043

[26] S. A. Waits. B. N. Reames. R. W. Krell. B. Bryner. T. Shih. A.T. Obi. And S.L. Wong. "Development of Team Action Projects in Surgery (TAPS): a multilevel team-based approach to teaching quality improvement." *Journal of Surgical Education*, Vol. *71*(2), pp 166–8. 2014. doi:10.1016/j.jsurg.2014.01.015

[27] C. J. Warner. D.B. Walsh, B. A.J. Horvath. T.R. Walsh. D.P. Herrick. S.J. Prentiss. And R.J. Powell. "Lean principles optimize on-time vascular surgery operating room starts and decrease resident work hours." *Journal of Vascular Surgery*, Vol. *58*(5), pp 1417–22. 2013. doi:10.1016/j.jvs.2013.05.007

[28] P. Hwang. D. Hwang and P. Hong. "Lean practices for quality results: a case illustration." *International Journal of Health Care Quality Assurance*, Vol. 27(8), pp 729–741. 2014. doi:10.1108/IJHCQA-03-2014-0024

[29] P. Mcculloch. S. Kreckler. Y. Sheena. A. Handa AND k. Catchpole. "Effect of a "Lean" intervention to improve safety processes and outcomes on a surgical emergency unit." BMJ. *Clinical Research Ed.* 2010. doi:http://dx.doi.org/10.1136/bmj.c5469
[30] R. Stuart and E. Sweet. "A systems approach to an institutional laboratory ventilation management plan." *Journal of Chemical Health and Safety,* Vol. 20(4), pp 31–37. 2013. doi:10.1016/j.jchas.2013.03.491
[31] B. A. White. J. Baron. Y. Chang, Y. C.A.C. Jr and D.F.M. Brown. "Applying Lean Methodologies Reduces Emergency Department Laboratory Turnaround Times." *Annals of Emergency Medicine*, Vol. 64(4), S9. 2014. doi:10.1016/j.annemergmed.2014.07.046
[32] L. Samuel, L and S. Novak-Weekley. "The Role of the Clinical Laboratory in the Future of Health Care: Lean Microbiology." *Journal of Clinical Microbiology*, Vol. *52*(6), pp 18212–1817. 2014
[33] D.M. Berwick. A. Kabcenell and T. Nolan. "No Toyota yet, but a start." *Modern Healthcare*, Vol. 35(5), pp 18–20. 2005.
[34] Z. Radnor. P. Walley. A. Stephens and G. Bucci. (2006). Evaluation of the lean approach to business management and its use in the public sector,Edinburgh: Social Research. pp 1–145 2006. doi:ISBN 0 7559 6056 4
[35] F. Badurdeen. K. Wijekoon and P. Marksberry. "An analytical hierarchy process-based tool to evaluate value systems for lean transformations." *Journal of Manufacturing Technology Management,* Vol. 22(1), pp 46–65. 2011.
[36] Z. Radnor and P. Walley. "Learning to Walk Before We Try to Run: Adapting Lean for the Public Sector." *Public Money & Management*, Vol. 28(1), pp 13–20. 2008. doi:10.1111/j.1467-9302.2008.00613.x
[37] K. Barnas. "ThedaCare's business performance system: sustaining continuous daily improvement through hospital management in a lean environment." *Joint Commission Journal on Quality and Patient Safety / Joint Commission Resources*, Vol. 37(9), pp 387–99. 2011.
[38] D. Fillingham. "Can lean save lives?". *Leadership in Health Services* Vol. 20, pp 231–241. 2007. doi:10.1108/17511870710829346
[39] D. Jones. "Design lean healthcare systems". *Lean Enteprise Academy website.*Avaible at http://www.leanuk.org/article-pages/sector/healthcare.aspx
[40] D. Jones, A. Mitchell. "Lean thiking for the NHS". *NHS Confederation.* 2006
[41] M. Cretikos. M. Parr. K. Hillman. G. Bishop. D. Brown. K. Daffurn and L. Young. "Guidelines for the uniform reporting of data for Medical Emergency Teams." *Resuscitation*, Vol. 68(1), pp 11–25. 2006. doi:10.1016/j.resuscitation.2005.06.009
[42] J.R. Black and D. Miller. *The Toyota way to healthcare excellence: increase efficiency and improve quality with Lean*. New York: Health Administration Press. May 12, 2008
[43] R. Chalice. Improving Healthcare Using Toyota Lean Production Methods: 46 steps for improvement. USA: *ASQ Quality Press*. p. 62. 2007
[44] N. Burgess and Z. Radnor. "Evaluating Lean in healthcare." *International Journal of Health Care Quality Assurance*, Vol. 26(3), pp 220–35. 2013 doi:10.1108/09526861311311418
[45] D.L. King, D. I. Ben-tovim and J. Bassham. "Redesigning emergency department patient flows: Application of Lean Thinking to health care". *EMA - Emergency Medicine Australasia*, Vol. 18, pp 391–397. 2006. doi:10.1111/j.1742-6723.2006.00872.x
[46] E.W. Dickson. S, Singh. D.S. Cheung. C.C. Wyatt and A.S. Nugent. "Application of lean manufacturing techniques in the Emergency Department." *The Journal of Emergency Medicine*, Vol. 37(2), pp 177–82. 2009. doi:10.1016/j.jemermed.2007.11.108
[47] C. Jimmerson. D. Weber and D.K. Sobek. "Reducing waste and errors: piloting lean principles at Intermountain Healthcare". *Joint Commission Journal on Quality and Patient Safety / Joint Commission Resources*, Vol. 31(5), pp 249–57.2005.
[48] D. Folinas and T. Faruna. "Implementing lean thinking paradigm practices in medical set up." *Business Management Dynamics*, Vol. 1(2), pp 61–78. 2011.
[49] M. Graban. *Lean Hospitals: Improving Quality, Patient Safety, and Employee Engagement*, (2 nd). USA: Taylor & Francis Group. 2011.
[50] H. Koning. J.P.S. Verver. J. Heuvel. S. Bisgaard, S and R.J.M.M Does. "Lean Six Sigma in Healthcare." *Journal for Healthcare Quality*, Vol. 28(2), pp 4–11. 2006. doi:10.1111/j.1945-1474.2006.tb00596.x
[51] C.R. Nicolay. S. Purkayastha. A. Greenhalgh. J. Benn. S. Chaturvedi. N. Phillips and A. Darzi. "Systematic review of the application of quality improvement methodologies from the manufacturing industry to surgical healthcare." *British Journal of Surgery*, Vol. 99(3), pp 324–335. 2012. doi:10.1002/bjs.7803
[52] T. Papadopoulos. "Continuous improvement and dynamic actor associations." *Leadership in Health Services*, Vol. 24(3), pp 207–227. 2011. doi:10.1108/17511871111151117
[53] Z.J. Radnor. M. Holweg and J. Waring. "Lean in healthcare: the unfilled promise?." *Social Science & Medicine*. Vol. 74(3), pp 364–71. 2012. doi:10.1016/j.socscimed.2011.02.011
[54] K.H. Aij. F.E. Simons. G.A.M. Widdershoven and M. Visse. "Experiences of leaders in the implementation of Lean in a teaching hospital--barriers and facilitators in clinical practices: a qualitative study." *BMJ Open*, Vol. 3, pp e003605. 2013. doi:10.1136/bmjopen-2013-003605
[55] M. Ballé. A. Régnier. "Lean as a learning system in a hospital ward." *Leadership in Health Services*, Vol. 20(1), pp 33–41. 2007. doi:10.1108/17511870710721471
[56] H.L. Farley. K.M. Baumlin. A.G. Hamedani. D.S. Cheung. M. R. Edwards. D.C. Fuller and J.M Pines. "Quality and safety implications of emergency department information systems." *Emergency Medicine*, Vol. 62(4), pp 399–407. 2013. doi:10.1016/j.annemergmed.2013.05.019
[57] R. Sousa and C. Voss. "Contingency research in operations management practices." *Journal of Operations Management*, Vol. 26(6), pp 697–713. 2008. doi:10.1016/j.jom.2008.06.001
[58] J.W. Creswell, "Qualitative inquiry and research de sign: Choosing among five traditions," *Thousand Oaks,* CA, EEUU: Sage. 1998.
[59] R.K. Yin, "Case study research: Design and methods" (2nd ed.). *Newbury Park, CA: Sage Publications.* 1994
[60] K.M Eisenhardt, and M.E. Graebner, "Theory building from case studies: Opportunities and challenges," *Academy of Management Journal*, 50(1), 25-32, 2007.
[61] M. Brod, L.E. Tesler, T.L Christiansen, "Qualitative research and content validity: Developing best practices based on science and experience," *Quality of Life Research*, 18(9), 1263-1278. doi:10.1007/s11136-009-954, 2009.
[62] M. Malmbrandt and P. Åhlström. "An instrument for assessing lean service adoption." *International Journal of Operations & Production Management,* Vol. 33(9), pp 1131–1165. 2013. doi:10.1108/IJOPM-05-2011-0175
[63] H.F. Wolcott, "Writing Up Qualitative Research". (3 ed.) *Sage, Thousand Oaks*, CA, 2009.
[64] H. Bahaitham, A. Elshennawy, S. Furterer, "Assessment and Implementation of Lean Sustainability in Healthcare Organizations," *institute of Industrial Engineers*. 2013; p 52.

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