



Provided by the author(s) and University of Galway in accordance with publisher policies. Please cite the published version when available.

Title	Analysis of the relationship between knowledge management and lean tools during lean implementation in hospitals
Author(s)	Rosa, Angelo; Marolla, Giuliano; McDermott, Olivia
Publication Date	2023-02-12
Publication Information	Rosa, A., Marolla, G., McDermott, O. (2023). Analysis of the Relationship Between Knowledge Management and Lean Tools During Lean Implementation in Hospitals. In: McDermott, O., Rosa, A., Sá, J.C., Toner, A. (eds) Lean, Green and Sustainability. ELEC 2022. IFIP Advances in Information and Communication Technology, vol 668. Springer, Cham. https://doi.org/10.1007/978-3-031-25741-4_7
Publisher	Springer, Cham
Link to publisher's version	https://doi.org/10.1007/978-3-031-25741-4_7
Item record	http://hdl.handle.net/10379/17822
DOI	http://dx.doi.org/10.1007/978-3-031-25741-4_7

Downloaded 2024-04-29T10:58:25Z

Some rights reserved. For more information, please see the item record link above.



Analysis of the relationship between knowledge management and lean tools during lean implementation in hospitals.

Angelo Rosa¹, Giuliano Marolla¹ and Olivia McDermott²

¹ LUM University, Department of Management, Finance and Technology

² College of Science & Engineering, National University of Ireland, Galway, Ireland

Rosa@ibsc.it

Abstract

During the last two decades, lean healthcare has received increasing attention from both researchers and practitioners because it plays an imperative role in quality and safety clinical process improvement. Although there is much evidence of the positive results of the paradigm implementation at the micro level, only in few cases the methodology is implemented at meso level or improvements are observed at organizational level. Among the main factors leading to the failure of meso implementation is the lack of widespread knowledge of lean tools and concepts within the organization. The lean implementation process at the meso level require high efforts to manage the transfer, sharing, integration, and transformation of lean knowledge within the organization. Thus, many researchers have positively assumed knowledge management (KM) as a critical success factor of lean sustainability and meso implementation. Although, the relationship of KM and lean sustainability have gradually become a hot topic, few scholars have investigated this issue in healthcare sector. Based on literature review focusing on the key characteristics of the lean healthcare implementation process, this article aims to bring out the relationships between lean tools, KM and lean sustainability in hospital setting. Results provide some relevant insights for hospitals applying the lean paradigm namely: KM is a critical success factor in disseminating and sustaining lean methodology and lean knowledge degree is strongly influenced by the use of lean tools.

Keywords: Lean healthcare; Lean tools; Knowledge management;

1. Introduction

Lean is a managerial paradigm that integrates principles, methods and techniques aimed at optimizing organizational processes. Its main purpose is to increase the value provided to end customers by systematically reducing waste [1]. Over the last two decades, the adoption of lean in healthcare has received increasing attention from both researchers and practitioners, as most scientific articles and direct testimonials highlight the effective application of the methodology results in increased value for both internal and external stakeholders of organizations and in operational cost reduction [2,3]. The adoption of lean tools in healthcare processes improve clinical pathways lead times and quality performances, reduces transport and movement waste, as well as clinical risk, and simplifies communication and coordination practices [4]. These findings have led to a common consensus that lean tools are key drivers of lean implementation.

In the past, many researchers have argued that the lean philosophy is particularly suitable for healthcare organisations because its principles are intuitive and convincing and because doctors and technicians can easily master the main tools and methodologies [5]. However, in recent years, researchers have highlighted that the promise of an easy, pitfall-free implementation process and the existence of a tangible relationship between lean implementation and improved organizational performance is an oversimplification [5, 6]. In more detail, recent studies have shown that although healthcare organisations are successful in introducing

lean into both single clinical and support processes they fail in the dissemination process of the methodologies at systemic level [7,8]. This affects lean sustainability and consequently systemic (meso) implementation. Many researchers suggest that this phenomenon is due to the lack of or inability to use tools aimed at learning, knowledge dissemination and knowledge application [6]. Thus, the role of knowledge management (KM) in the successful deployment of lean in healthcare organizations is emerging as a prominent issue [6, 8].

Although the role of KM on lean sustainability is discussed through research in other sectors, it is not in healthcare. The study focuses on the themes of LM on Lean sustainability in healthcare.

The research questions (RQ's) are to ascertain:

RQ1; The effect of application of lean tools on lean sustainability

RQ2: The effect of application of lean tools on Knowledge acquisition, Knowledge integration and on Knowledge application.

RQ3: the effect of Knowledge acquisition on knowledge integration and of Knowledge integration on knowledge adoption.

RQ4: The effect of knowledge acquisition, knowledge integration and knowledge adoption has on lean sustainability

The paper is structured as follows: the following section shows the research methodology, in section 3 the results and the theorized model are discussed; finally, section 4 presents the discussion and the conclusion.

2. Methodology - Literature Review

A literature review was carried out in relation to the relationship between Knowledge Management and Lean sustainability with a specific focus on Healthcare. A systematic literature review (SLR) was utilized. Articles published between 2000 and 2021, using the full academic databases Web of Science and Scopus were searched. The search strategy followed the approach in Tranfield et al. [9] which seeks to create a reliable knowledge stock by synthesizing the relevant body of literature [9,10]. The following search string was applied to search all the databases mentioned above: "Lean" AND "Knowledge Managment", "Lean" AND "Knowledge acquisition" and "Lean" AND "Knowledge integration", "Lean" AND "Knowledge adoption" as well as "Lean Healthcare" AND "knowledge management". Table 1 provides a detailed listing of the inclusion/exclusion criteria. The references of the selected studies were manually checked to identify additional relevant studies that were missed in the database search. Grey literature (conference papers, magazine-related articles, workshops, books, editorials, prefaces) were excluded.

Table 1. Inclusion & Exclusion criteria for the SLR

Inclusion criteria	Exclusion criteria
Academic peer-reviewed journal articles books, magazine-related articles, etc.) related to Lean sustainability and Knowledge Management from a Healthcare viewpoint and other sectors	Grey literature (conference proceedings, dissertations, text
Articles published in high quality relevant journals	Articles published in languages otherthan English and Italian
Articles published from 2000 to 2021	Articles published before 2000
	Articles published in non-refereed journals

The initial search identified 213 articles after which duplicates articles found were firstly removed,

and the full text was retained if the abstracts stated that the study was related to Lean, Knowledge management and had a healthcare context. The four authors reviewed and independently assessed the eligibility for inclusion of the retrieved studies based on the search criteria Parameswaran et al [11]. Inclusion agreement was solved by discussions and consensus among reviewers. This process yielded 50 studies for final inclusion at this stage of the review.

The analysis was conducted based on several observations in response to the research questions - Lean and Knowledge Management (knowledge acquisition, integration and adoption) and sustainability and the emerging themes in relation to the aforementioned topics were reviewed. Thus, for example, content analysis was used to comprehend the elements to be included in the factors under examination. In addition, the panel of four researchers discussed frequently to assess the interpretation of concepts as reported in the selected articles.

3.0 Results and theoretical model

The themes related to Lean tools, knowledge acquisition, integration and sustainability. Table 2 shows the factors and elements derived from literature review and the debate among researchers.

Table 2: List of Themes arising from the literature review

<i>Construct</i>	<i>Items</i>	<i>References</i>	<i>Final Items</i>
Lean tools	Value Stream Map	Antony <i>et al.</i> (2018)	<i>Mapping tools</i>
	5S	[18]; Antony <i>et al.</i>	5s
	Root Cause Analysis	(2019)[5]; Basu	Root Cause Analysis
	Failure mode and effect analysis (FMEA)	(2004)[13], Henrique and Godinho Filho	<i>Total quality management tools</i>
	SMED tools	(2020)[4]; Marolla	SMED tools
	Kanban	<i>et al.</i>	Kanban
	Assessment tools	(2021)[8]; Parkhi,	Assessment tools
	Rapid improvement	2019[14]	<i>Kaizen blitz</i>
Knowledge acquisition	Strategic tools		<i>Hoshin Kanri</i>
	Visual management tools		Visual management tools
	Training course	Al Khamisi <i>et al.</i>	<i>Internal training courses</i>
	Sharing of lean knowledge	(2019) [15]; Arumugam <i>et al.</i>	Sharing of lean knowledge
	Kata coaching	(2013) [16]; Basu	Kata coaching
	Brainstorming	(2004) [13]; Moreno- Luzon	Brainstorming
	Employment of an external consultant or experts	and Lloria (2008)[17]	<i>External training courses</i>
	Knowledge integration	Lean tool promotion- related materials	Arumugam <i>et al.</i> (2013) [16];
Lean assessment		Basu	Lean assessment
Implementation of standard templates for project submissions (e.g., Report A3)		(2004)[13]; Grant (1996)[18]; Kaplan <i>et al.</i>	Implementation of standard templates for project submissions (e.g., Report A3)
Managing lean tools		(2012) [19]; Moreno-Luzon and Lloria (2008) [17]; McFadden <i>et al.</i> (2014)[20]	<i>Common language</i>
Knowledge application		Decision-making models based on data from lean tools	Al Khamisi <i>et al.</i> (2019) [15]; Arumugam <i>et al.</i> (2013) [16];
	Building a lean authority system	Arumugam <i>et al.</i> (2016)[21]; Basu (2004)	Building a lean authority system
	Problem solving capability		Problem solving capability

	Groups of Lean experts acting horizontally across the organization	[13]	Groups of Lean experts acting horizontally across the organization
Lean sustainability	Employee involvement level	Al-Balushi <i>et al.</i> (2014)[22];	Employee involvement level
	Management sponsorship	Assarlind <i>et al.</i> (2013)[23];	Management sponsorship
	Management involvement	Henrique and Godinho Filho (2020)[4];	Management involvement
	Degree of spreading the culture of continuous improvement	Papadopoulos <i>et al.</i> (2011)[24];	Degree of spreading the culture of continuous improvement
	Processes improvements	Kaplan <i>et al.</i> (2012)[19]	Processes improvements

Researchers who have studied the lean transformation process of healthcare organizations have defined some specific steps in the implementation of the paradigm [18]. Each of these stages is characterized by several enabling factors and critical failure and success factors. Brandao de Souza and Pidd (2011) defined micro implementation as the condition in which a limited number of employees implements lean at the level of a single process at discrete times, while meso implementation is where the paradigm is implemented at the strategic level and the culture of continuous improvement spreads spontaneously within the organization[25]. As extensively demonstrated in the literature, the introduction and dissemination phases - belonging to micro implementation - are key factors in the implementation process as they largely affect the level of lean sustainability [6]. Sustainability refers to the widespread organisational consensus towards lean practices and tools and the employee commitment to embrace the culture of continuous improvement [22,24]. The role of KM is to drive effectively the processes of knowledge acquisition, integration and application of the tool and lean concepts within the organization [26, 27, 28, 29, 30]. Effective management of these steps results in increased confidence in the method and reduced organizational resistance to change. In addition, based on organisational characteristics, these phases allow the organization to assess the potential improvements achievable and designing the most effective processes for systematically adopting the paradigm [6, 18].

3.1 Lean tools, sustainability and knowledge management

During the introduction phase, running pilot projects is crucial to ensure that trainees gain experience using lean methodologies and tools and fully understand the fundamental concepts of the paradigm [25]. Many case studies show that the successful lean introduction is largely determined by the ability of the pilot projects teams to effectively apply lean tools [2,14]. Successful pilot projects and their celebration motivate the organization to undertake additional improvement projects using lean tools. Moreover, the implementation of lean tools in the healthcare organizations has been shown to result in positive clinical and organizational outcomes [4,18].

RQ: Hypothesis 1: The application of lean tools has a positive impact on lean sustainability.

Knowledge and maturity in using lean tools is a pre-requisite before proceeding with the other implementation phases [5,6]. KM trigger with acquiring knowledge about the opportunities provided by lean tools, so an organization can interpret and assess that knowledge. Many authors discuss the role of the introduction phase as an organizational stimulus to acquire knowledge [19, 25]. In particular, the successful implementation of the tools during the pilot phases prompts organizations to foster knowledge exchange and provide internal training (in many cases by means peer teaching training courses) [19]. Discussions between the pilot projects participants and sharing experiences with other colleagues are other means of knowledge acquisition [6]. In the dissemination phase, the process of monitoring the appropriateness and effectiveness of the use of lean tools prompts organizations to set up kata coaching initiatives aimed at stimulating and fostering the transmission of tacit knowledge between employees [16, 21].

RQ: Hypothesis 2a: The application of lean tools has a positive impact on Knowledge acquisition.

Lean tools play an important role during the paradigm dissemination process by providing a common language and standard practices for improvement initiatives [8,13]. The creation of a common knowledge base and the use of standard tools serves as a coordination mechanism in which organizations can more effectively utilize the valuable knowledge resources derived through improvement projects [31,32]. Thus, the use of lean tools fosters the integration of lean knowledge within the organization.

RQ: Hypothesis 2b: The application of lean tools has a positive impact on Knowledge integration.

The implementation of lean tools not only offers a common approach to undertake improvement projects, but also produces a plethora of data allowing organisational weaknesses in process management to be exposed[31]. The data obtained and the evidence that emerges through the application of the tools can foster the establishment of decision-making models based on lean methodology and increase problem solving capacity within the organization [8, 16, 22]. When the dissemination phase is advanced and successful, healthcare organizations understanding the potential of lean tools and practices establish internal expert groups to support the methodology and/or embed a responsible "authority" in the organizational structure to support the paradigm over time [19]. As a result, the ability to apply lean knowledge increases.

RQ: Hypothesis 2c: The application of lean tools has a positive impact on Knowledge application.

3.2 Interaction among knowledge management dimensions

The effective dissemination process requires that lean knowledge is acquired, integrated, and applied within the organization. These three dimensions of knowledge are closely interrelated and mutually permeate each other [33]. Lean knowledge acquisition is the process of seeking, evaluating, and understanding the conceptual pillars and operational tools of the lean paradigm. The acquired knowledge represents the raw material through which the knowledge integration process can be activated [33]. Lean requires the application of sets of standard procedures, common thinking and language, and behaviours and culture oriented towards change and sharing. These elements are not typical of healthcare organisations; therefore, integration requires the creation of a common knowledge base through the acquisition of knowledge [19].

Hypothesis 3a: Knowledge acquisition has a positive impact on knowledge integration.

Knowledge integration has a significant influence on knowledge creation, allowing information to be incorporated and transformed into useful knowledge at every level of the organization [18, 23]. Thus, knowledge integration impacts the organization's capability to fully understand the value of lean and to act by effectively applying the concepts and tools of the methodology [15]. Antony et al. [12] explain that implementing lean-based decision- making models requires a deep focus on project management and lean evaluation systems; these practices require high levels of knowledge integration. Similarly, creating lean teams to support improvement projects without first encouraging the use of lean tools will result in a failure to adopt the methodology [6,8].

Hypothesis 3b: Knowledge integration has a positive impact on knowledge adoption.

3.3 Knowledge Management and sustainability

The role of knowledge is considered crucial during organizational transformation activities, whether they are oriented towards product, process or business innovation. Although there are many empirical studies assessing the impact of KM on performance goals of improvement practices or organizational models, there are very few studies discussing the role of KM on lean sustainability, particularly in healthcare. The most recent research evaluating the impact of KM on lean sustainability is by Zhang et al. (2020) who show the mediating role of KM between lean tools and lean sustainability, focusing on companies in Beijing, Tianjin and Weifang [27]. The authors considered the same three dimensions of knowledge adopted in this research and revealed that each dimension has a direct impact on the lean sustainability. Arumugam et al.[16] through the lens of goal theory and sociotechnical systems theory, show the mediating role of KM between the variables “challenging goal setting” and “adherence to the lean Six Sigma method” and the variable “success of Six Sigma projects”. The authors specifically describe the elements of knowledge acquisition and adoption, while the processes of knowledge integration are assumed from a social rather than technical perspective. In previous research, Arumugan et al. [16] demonstrate the mediating role of the “learning behaviour” and “knowledge creation” variables among “Six Sigma resources (technical)” and “team

psychological safety (social)” antecedent variables and the variable “success of Six Sigma process improvement projects”. Reich et al. [34] demonstrate the effect of KM and Knowledge Alignment on achieving project management goals and business value in IT-enabled projects. In their research, the concept of Knowledge Alignment is reflective of knowledge integration concept.

From the results of these articles, the additional three hypotheses are formulated:

Hypothesis 4a: knowledge acquisition has a positive impact on lean sustainability;

Hypothesis 4b: knowledge integration has a positive impact on lean sustainability;

Hypothesis 4c: knowledge adoption has a positive impact on lean sustainability.

Figure 1 represents the theoretical model derived from the literature review.

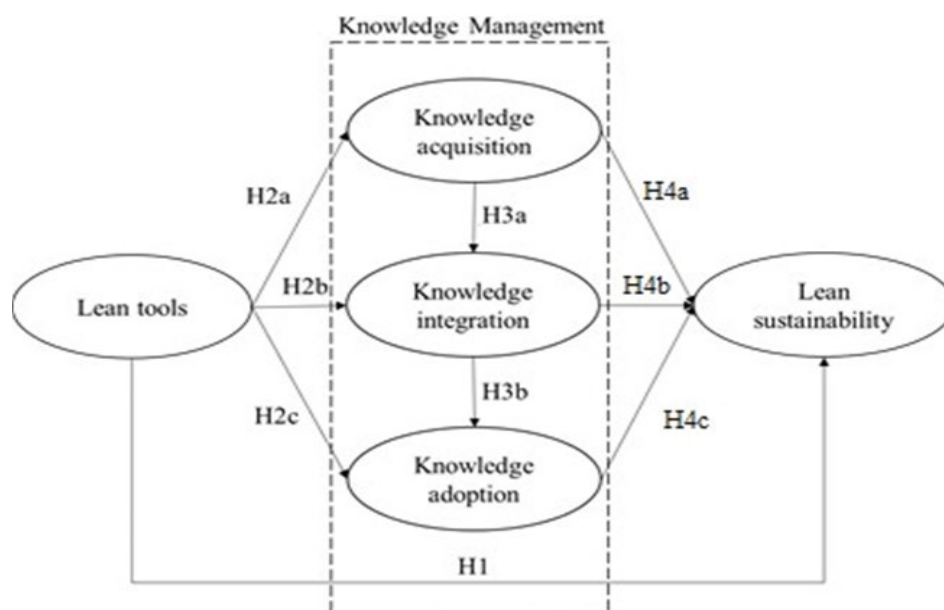


Figure 1: Theoretical Model

4.0 Discussion & Conclusion

The sustainability of lean plays a key role in the successful adoption of the paradigm within hospitals. High sustainability reduces the barriers to implementation and drives the spontaneous orientation of the organization to continuous improvement. The widespread application of lean tools within the organization has always been considered an enabler of sustainability, however, some researchers suggest that it happens because the tools stimulate and promote knowledge of the methodology. Thus, knowledge is considered a mediating variable between lean tools and sustainability. Based on this theory, a model has been hypothesized. The findings confirm the mediating role of KM between the tools and the sustainability of lean methodology. Moreover, the analysis clearly highlights the different importance of the stages of knowledge acquisition, integration, and application. In particular, widespread knowledge of lean tools encourages the adoption of project management systems, models for evaluating organizational capabilities and standardized procedures for improvement projects (e.g. Report A3, PDCA cycle, Kaizen Blitz, etc.). Although the hypothesis that knowledge integration positively influences system-wide adoption of knowledge is confirmed further analysis will test this.

The results of this study can provide policy makers and decision makers with some suggestions with respect to lean implementation. First, lean tools should be considered not only as best practices for conducting improvement projects but also, and more importantly, as a medium for creating, integrating, and applying knowledge. In addition, the importance of KM should be formally recognized and therefore driven within the organization. In order for knowledge integration to translate into an effective system of knowledge adoption, managers must be actively involved in this process and facilitate it by making decisions based on lean concepts, leveraging enabling factors such as the creation of a lean management authority or favouring the creation of cross-functional lean teams that act as operation managers.

The research study is characterized by a number of limitations, the first of which is that it is a model and requires testing. In light of these limitations, however, the study offers many insights for future research.

References

1. Womack, J.P. and Jones, D.T.: *Banish Waste and Create Wealth in Your Corporation*. Free Press, NY (2003).
2. Bossone, E., Majolo, M., D'Ambrosio, S., Raiola, E., Sparano, M., Russo, G., Longo, G., Triassi, M., Rosa, A. Lean Management Approach for Reengineering the Hospital Cardiology Consultation Process: A Report from AORN "A. Cardarelli" of Naples. *Int. J. Environ. Res. Public Health*. 19, 4475 (2022). <https://doi.org/10.3390/ijerph19084475>
3. D'Andreamatteo, A., Iannia, L., Lega, F. and Sargiacomo, M.: Lean in healthcare: a comprehensive review. *Health Policy*, Vol. 119 No. 9, pp. 1197–209 (2015).
4. Henrique, D.B. and Godinho Filho, M.: A systematic literature review of empirical research in Lean and Six Sigma in healthcare. *Total Quality Management & Business Excellence*. Vol. 31 No. 3-4, pp.429-449 (2020).
5. Antony, J., Sreedharan, R., Chakraborty, A. and Gunasekaran, A.: A systematic review of Lean in healthcare: a global prospective, *International journal of quality & reliability management*. Vol. 36 No. 8, pp. 1370-1391 (2019).
6. Rosa, A., Marolla, G., Lega, F. and Manfredi, F.; Lean adoption in hospitals: the role of contextual factors and introduction strategy, *BMC health services research*. Vol. 21 No. 1, pp. 1-18 (2021).
7. Glasgow, J.M., Caziewell, S., Jill, R. and Kaboli, P.J.: Guiding inpatient quality improvement: a systematic review of Lean and Six Sigma. *Joint Commission Journal on Quality and Patient Safety*, Vol. 36 No. 12, pp. 533-540 (2010).
8. Marolla, G., Rosa, A. and Giuliani, F.: Addressing critical failure factors and barriers in implementing Lean Six Sigma in Italian public hospitals. *International Journal of Six Sigma*. Vol. ahead-of-print No. ahead-of-print (2012).
9. Tranfield, D., Denyer, D., Smart, P.: Towards a Methodology for Developing Evidence-Informed Management Knowledge by Means of Systematic Review. *British Journal of Management*. 14, 207–222 (2003). <https://doi.org/10.1111/1467-8551.00375>.
10. Yang, E.C.L., Khoo-Lattimore, C., Arcodia, C.: A systematic literature review of risk and gender research in tourism. *Tourism Management*. 58, 89–100 (2017).
11. Parameswaran, U.D., Ozawa-Kirk, J.L., Latendresse, G.: To live (code) or to not: A new method for

- coding in qualitative research. *Qualitative Social Work*. 19, 630–644 (2020).
<https://doi.org/10.1177/1473325019840394>.
12. Antony, J., Palsuk, P., Gupta, S., Mishra, D. and Barach, P.: Six Sigma in Healthcare: A Systematic Review of the Literature. *International Journal of Quality & Reliability Management*. Vol. 35 No. 5, pp. 1075-1092 (2018).
 13. Basu, R.; Six Sigma to operational excellence: role of tools and techniques. *International Journal of Six Sigma and Competitive Advantage*. Vol. 1 No. 1, pp.44-64 (2004).
 14. Parkhi, SS.: Lean management practices in healthcare sector: a literature review. *Benchmarking*. Vol. 26 No. 4, pp. 1275–89 (2019).
 15. Al Khamisi, Y.N., Khan, M.K. and Munive-Hernandez, J.E.; Knowledge-based lean six sigma system for enhancing quality management performance in healthcare environment. *International Journal of Lean Six Sigma*. Vol. 10 No. 1, pp. 211-233 (2019).
 16. Arumugam, V., Antony, J. and Kumar, M.; Linking learning and knowledge creation to project success in Six Sigma projects: An empirical investigation. *International Journal of Production Economics*. Vol. 141 No 1, pp. 388-402 (2013).
 17. Moreno-Luzon, M.D. and Lloria, M.B: The role of non-structural and informal mechanisms of integration and coordination as forces in knowledge creation. *British Journal of Management*. Vol. 19, pp.250–276 (2008).
 18. Grant, R.M.: Prospering in dynamically-competitive environments: organisational capability as knowledge integration. *Organisation Science*. Vol. 7 No. 4, pp.375–387 (1996).
 19. Kaplan, H.C., Provost, L.P., Froehle, C.M. and Margolis, P.A.: The model for understanding success in quality (MUSIQ): building a theory of context in healthcare quality improvement. *BMJ Quality & Safety*. Vol. 21 No. 1, pp. 13–20 (2012).
 20. McFadden, K., Lee, J., Gowen, C. and Sharp, B.: Linking Quality Improvement Practices to Knowledge Management Capabilities. *Quality Management Journal*. Vol. 21 No. 1, pp. 34-55 (2014).
 21. Arumugam, V., Jiju, A. and Linderman, K.: The influence of challenging goals and structured method on Six Sigma project performance: A mediated moderation analysis. *European Journal of Operational Research*. Elsevier, vol. 254(1), pages 202-213 (2016).
 22. Al-Balushi, S., Sohal, A.S., Singh, P.J., Al Hajri, A., Al Farsi, Y.M. and Al Abri, R.: Readiness factors for lean implementation in healthcare settings – a literature review. *Journal of Health Organization and Management*. Vol. 28 No. 2, pp. 135-153 (2014).
 23. Assarlind, M., Gremyr, I. and Bäckman, K., : Multi-faceted views on a Lean Six Sigma application. *International Journal of Quality and Reliability Management*. Vol. 30 No. 4, pp. 387-402 (2013).
 24. Papadopoulos, T., Radnor, Z. and Merali, Y.: The role of actor associations in understanding the implementation of Lean thinking in healthcare. *International Journal of Operations & Production Management*. Vol. 31 No. 2, pp. 167-191 (2011).
 25. Brandao De Souza, L., and Pidd, M.: Exploring the barriers to lean health care implementation. *Public Money Management*. Vol. 31 No. 1, pp. 59-66 (2011).
 26. Davenport, T. H. and Prusak, L.: *Working knowledge: How organizations manage what they know*, Harvard Business School Press, Boston (1998) .
 27. Zhang, B., Niu, Z. and Liu, C.: Lean tools, knowledge management, and lean sustainability: The moderating effects of study conventions. *Sustainability*. Vol. 12 No. 3, 956 (2020).
 28. Barney, J.B.. *Firm Resources and Sustained Competitive Advantage*. *Journal of Management*, Vol. 17 No. 1, pp. 99-120 (1991).
 29. Nonaka, I.:A dynamic theory of organizational knowledge creation. *Organization Science*. Vol.5 No.1, pp. 1:14–37 (1994).
 30. Marr, B. and Schiuma, G.: *Measuring and Managing Intellectual Capital and Knowledge Assets in New Economy Organisations*. *Handbook of Performance Measurement*, ed. M. Bourne, Gee, London (2001).
 31. McFadden, K., Lee, J., Gowen, C. and Sharp, B.: Linking Quality Improvement Practices to Knowledge Management Capabilities. *Quality Management Journal*. Vol. 21 No. 1, pp. 34-55 (2014).
 32. Zahra, S.A., and George, G.: Absorptive capacity: A review, reconceptualization, and extension. *The Academy of Management Review*. Vol. 27 No. 2, pp.185–203 (2002).
 33. Nonaka, I., von Krogh, G. and Voelpel, S.: Organisational knowledge creation theory: evolutionary paths and future advances. *Organisation Studies*. Vol. 27, No. 8, pp.1179–1208 (2006).
 34. Reich, B. H., Gemino, A., & Sauer, C.: How knowledge management impacts performance in projects: An empirical study. *International Journal of Project Management*, 32(4), 590-602 (2014).

