

Lean Healthcare In Reducing HAI An Integrative Literature Review

Laryssa Carvalho de Amaral¹[0000-0003-2320-4383], Robisom Damasceno Calado¹[0000-0003-3349-0344], Luiza Werner Heringer Vieira¹[0000-0003-0955-298X], and Sandra Maria do Amaral Chaves¹[0000-0002-2985-1410]

Universidade Federal Fluminense, Rio das Ostras, Brasil
{laryssaamaral,robisomcalado,sandrachaves}@id.uff.br,
luizawheringer@gmail.com

Abstract. The aim of this study was to analyze the contributions of the Lean Healthcare approach through the use of methods and tools to reduce Healthcare-Associated Infections (HAI). The guiding question of the study was to investigate how can the Lean Healthcare approach contribute to the implementation of actions to mitigate the risk of HealthCare-Associated Infections? Articles were collected from 2010 to February 2021, in the Web of Science, Scopus, Emerald databases. An analysis form was created. Of the 21 articles collected, 09 were selected, according to the PRISMA®. As for Lean Healthcare methods and tools, the use of standardized work, CTQ and SIPOC was identified as the most used to mitigate the risk of HAI. The high LOS of patients in the hospital increases the risk of HAI, with Lean Six Sigma results in the reduction of hospital costs and lower rates of LOS, with the reduction of the number of complications and infections. Standardized work has reduced the rates of HAI, which reinforces the idea of the need to implement the Lean Healthcare approach, with a focus on respect for people and consequently on the valorization of teamwork, which leads to change in the organizational culture.

Keywords: Healthcare-Associated Infections · Lean · Lean Healthcare

1 Introduction

Healthcare-Associated Infections (HAI), as well as the increased resistance of microorganisms to antimicrobials compromise the delivery of safe care to the patient, being responsible for the greatest number of adverse events associated with health care, with high morbidity and mortality. In view of this scenario, the World Health Organization - WHO launched the first Global Challenge for patient safety with the aim of awakening the world's view to the importance of thinking about management models for reducing HAI as a vital element for the delivering safe care to the patient. Therefore, one of the strategic goals established by WHO is to promote hand hygiene [1, 3, 9, 11].

HAI are infections that can be caused by exogenous or endogenous agents [7]. In relation to exogenous causes, there is a need for a control of the hospital environment, to ensure the safety of patients in preventing infections, which can be due to several causes, such as the lack of standardized procedures, the prolonged use of invasive devices, antibiotics and environmental hygiene, which can contribute to the spread of microorganisms [1, 7].

When we think about the health care field, the Lean Healthcare approach, together with its tools, has been shown to be efficient to reduce the length of stay of patients in hospitals, seeking mechanisms for the rational use of resources, which can promote a better quality of life. and reduce costs [4].

HAI are the most common adverse events that affect millions of patients annually worldwide. The reduction in HAI is considered an indicator of the quality of health care provided [7]. Thus, the standardization of work consists of the execution of successive and defined activities for each professional, properly structured to be carried out efficiently. With the Lean Healthcare approach, standardized work is defined as one of its foundations [10].

There is a vast literature on the implementation of the Lean approach in the health area, with the presentation of several methods and techniques that can ensure the improvement of health care.

Just like SIPOC (i.e. Suppliers, Input, Process, Outputs and Customers) which enables the analysis of the client, the output and the data, to clarify the main characteristics of the process, providing visibility for the whole team in relation to the process, with the control and prevention of risks, contributing to the reduction of HAI [8].

Little is discussed about the context in which health professionals work, their conditions and workload, which can increase the chances of adverse events, which is one of the causes of HAI [12].

Therefore, the guiding question of this study is to investigate: How can the Lean Healthcare approach contribute to the implementation of actions to mitigate the risk of HealthCare-Associated Infections?

The objective of this article was to analyze the contributions of the Lean Healthcare approach through the use of methods and tools in reducing Healthcare-Associated Infections (HAI).

2 Method

The method used was the Integrative Literature Review. Three questions were elaborated, in order to reach the proposed objective: (1) What are the main problems for reducing HAI with the application of the Lean Healthcare? (2) How does the Lean Healthcare approach contribute to the identification of risks in cases of HAI? In the first stage, the keywords “Healthcare-Associated Infections”, “Lean” and “Lean Healthcare” were defined, the filters for the selection of articles were applied, in the English language and in the period from 2010 to February 2021 and the databases were chosen: Web of Science, Scopus, Emerald and the strategy of identifying duplicates was used in the manager of Mendeley

references from the collected records. In the second stage, after reading the titles and abstracts, records that do not answer the study questions and systematic reviews, letter to the editor, conference papers were excluded, and those that meet the scope of this study were included, and records collected from other sources through the snowball method. The gray literature records were excluded, and the articles were analyzed using a form indicating: references, actions to mitigate the risk of HAI, Lean Healthcare methods and tools and results obtained. The collected data were analyzed for presentation.

3 Results

Of the 21 articles collected, 9 were selected, according to three stages represented in the PRISMA® flowchart. It was verified through the List of Predatory Journals (<https://predatoryjournals.com/journals/>) that none of the selected articles appear in the gray literature (Figure 1).

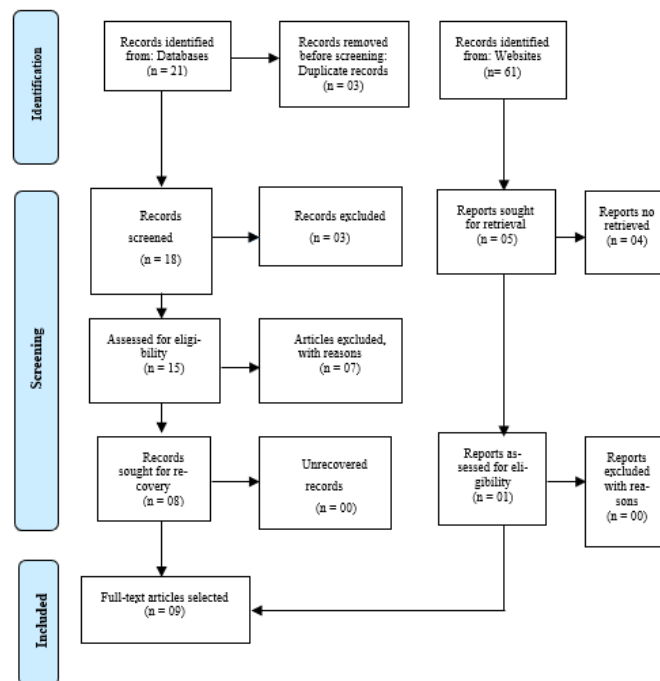


Fig. 1. Flowchart of the PRISMA 2020

The analysis of the articles through the form created for this systematic review enabled the construction of Table 1 and Table 2. In the analyzed articles, it was found that in its objectives, the prevalence of HAI in hospitalized patients

was the focus of the studies [2, 8], with the use of the Lean Healthcare methodology in order to carry out the improvement procedures. Lean Six Sigma has been recognized as a method for improving processes and reducing HAI as noted in some articles [6–8, 13, 11].

The application of tool methods to mitigate risks, it was verified in the studies, through the Lean Six Sigma, it was possible to identify statistical data that evidence causes of HAI risks and even so, they had corrective actions reducing the prevalence of HAI and improvement in the processes of health [7, 8].

With regard to actions to mitigate HAI, there was the application of Lean engineering techniques to develop a standard process that included physical steps and also standard communication elements from the provider for patients and family members and the creation of a physical environment to give support for changes [14]. In addition to creating programs to apply the tools of the Lean Healthcare approach, two articles [2, 5], and the participation of a multidisciplinary team were described [1].

The length of stay of patients in the hospital increases the risk of HAI, therefore the reduction of the LOS indicator (ie, Length of Stay) with the Lean Six Sigma method, resulted in the lowest number of complications and infections, in addition to contributing to the reduction of costs in the hospitalization of patients [11].

Statistical tests were performed on the groups of patients and presented in graphs to provide a visualization of the decrease in the length of stay, from 13.14 days reduced to 9.21 days, that is, a reduction of 29.9%. The general population was also divided into subgroups according to six variables that potentially influence the length of stay [13].

Regarding the methods and tools of the Lean Healthcare approach, the use of standardized work, CTQ (Critical to Quality) and SIPOC was observed as the most used Lean tools to mitigate the risk of HAI. As seen in the studies: The rate of urinary tract infection was 25.4% to 6.5% with the use of standardized work [1]. The percentage of colonized patients was reduced from 0.36 to 0.19% [9] and reduced the number of hospitalizations by 20%, which generated the lowest number of HAI [8].

The Length of Stay with a reduction of 29.9% [13]. On average, the county's HAI had been reduced from 12.8% to 9.8 % during the year [5].

The participation of patients in critical practices throughout their journey allowed the adoption of innovative management, centered on the patient, for example, clinical protocols based on lines of care, with the application of standardized work tools, Lean and 3 P techniques (i.e., Production, Preparation and Process) [14].

The use of Strategic Management tools, such as Balanced Scorecard (BSC), associated with Lean and Six Sigma tools, such as PDSA and also TQM (i.e Total Quality Management), contributed to the reduction of the hospital rate of HAI that was below the national average and consequently reduced the mortality rate [6].

Table 1. Objectives and actions to mitigate HAI risks related to Lean Healthcare methods (Source: Authors).

Ref.	Study objectives	Actions to mitigate the risk of HAI
[2]	Determine the prevalence of HAI and associated risk factors, distribution of systemic AMU and AMR trend in Ferrara University Hospital (FUH), comparing prevalence data recorded in 2016 and 2018.	By the Lean Healthcare Management program that was carried out in FUH in 2018, establishing improvement actions in Rehabilitation and Surgical departments and the update of FUH standard operating procedure for prevention of catheter-associated urinary tract infection according to the latest available evidence-based guidelines. UTI significantly decreased in 2018 (from 25.4% to 6.5%), dropping behind gastrointestinal system infections and surgical site infections
[7]	Lean Six Sigma (LSS) has been recognized as an effective management tool for improving healthcare performance. Here, LSS was adopted to reduce the risk of healthcare-associated infections (HAI), a critical quality parameter in the healthcare sector.	Lean Six Sigma proved to be a useful tool for identifying variables affecting the risk of HAI and implementing corrective actions to improve the performance of the care process. Finally, corrective measures to prevent HAI were implemented and monitored for 1 year after implementation.
[8]	In this article, we report on the application of the Lean Six Sigma (LSS) methodology to reduce the number of patients affected by sentinel bacterial infections who are at risk of HAI.	The LSS methodology was applied in the general surgery department by using a multidisciplinary team. The pre-intervention (January 2011 to December 2012) and post-intervention (January 2013 to December 2014) phases were compared to analyze the effects of the methodology implemented. The methodology allowed the identification of variables that influenced the risk of HAI and the implementation of corrective actions to improve the care process, thereby reducing the percentage of infected patients.
[14]	Our aim was to develop a standard process for room entry in the intensive care unit that improved compliance with hand hygiene and allowed for maximum efficiency.	We recognized that hand hygiene is a single step in a substantially more complicated process of room entry. We applied Lean engineering techniques to develop a standard process that included both physical steps and also standard communication elements from provider to patients and families and created a physical environment to support this.
[11]	Postoperative length of hospital stays (LOS) will be the main indicator to assess the improvements brought by the new antibiotic quantitatively	Antibiotic prophylactic protocol
[13]	The aim of this paper is to analyze the introduction of DTAP, employing Lean Thinking and Six Sigma methodology based on the DMAIC cycle	The adoption of a DTAP for patients with femur fracture is the resulting consequence of the improvement process regarding quality of care, introduced of this hospital with the goal of optimizing human resources and materials.
[5]	The purpose, therefore, was to investigate processes and impact related to implementing two concurrent quality initiatives in a Swedish hospital.	Programs called the Dynamic and Viable Organization (DVO) and a national initiative on stopping healthcare associated and hospital acquired infections (SHAI).
[6]	The purpose of this paper is to study critical practices for adopting improvement knowledge as a management innovation in a professional organization.	Identifying the patient as the guiding principle and encouraging involvement and local change initiatives. Identifies critical practices for adopting a management innovation.
[1]	To prevent environmental transmission of pathogens, hospital rooms housing patients on transmission based precautions are cleaned extensively and disinfected with ultraviolet (UV) light. We sought to improve room turnover efficiency to allow for UV disinfection.	A multidisciplinary healthcare team participated in a 60 day before-and-after trial that followed the Toyota Production System Lean methodology. We used value-stream mapping and manual time studies to identify areas for improvement.

Table 2. Tools and results obtained distributed by the articles (Source: Authors).

Ref.	Tools	Resulted
[2]	Standardized work	Results of this study contribute to reinforces the statement that HAI and AMR remain a high burden for healthcare systems, undermining patient safety in hospitals and causing high rates of morbidity, mortality and costs
[7]	DMAIC, SIPOC, CTQ, Ishikawa, cause-effect diagram, brainstorming sessions	The implementation of an LSS approach could significantly decrease the percentage of patients with HAI.
[8]	DMAIC, SIPOC, CTQ, Ishikawa, cause-effect diagram, brainstorming sessions	The LSS is a helpful strategy that ensures a significant decrease in the number of HAI in patients undergoing surgical interventions. The implementation of this intervention in the general surgery departments resulted in a significant reduction in both the number of hospitalization days and the number of patients affected by HAI
[14]	Standardized work, Lean techniques and 3P (Production Preparation Process)	We observed meaningful improvement in the performance of the new standard as well as time savings for clinical providers with each room entry. We also observed an increase in room entries that included verbal communication and an explanation of what the clinician was entering the room to do.
[11]	Lean Six Sigma: DMAIC, SIPOC, CTQ and box-plot	The results show that the LOS of patients treated with Ceftriaxone is lower than those who were treated with the association of Cefazolin plus Clindamycin, the difference is about 41%. Moreover, a lower number of complications and infections was found in patients who received Ceftriaxone.
[13]	Lean Six Sigma: DMAIC, Critical to quality (CTQ), SIPOC, VSM, Ishikawa fishbone (root cause) diagram, Standardized Work and Box – plot	Statistical tests were performed on the groups and graphics were provided to visualize the decrease of LOS (29.9%). The overall population was also divided in subgroups according to six variables potentially influencing LOS
[5]	PDSA	Even though both initiatives shared the same improvement approach, there was no strong indication that they were strategically combined to benefit each other. The initiatives existed side by side with some coordination and some conflict.
[6]	Lean Six Sigma: PDSA; TQM	The hospital rate of Healthcare-Associated Infections (HAI) is below the national mean (7.1% mean at SkaS, 9.4% mean in Sweden).
[1]	Kaizen, 5S, VSM	We decreased room turnover time by half in 60 days by decreasing times between and during routine tasks. Utilizing Lean methodology and manual time study can help teams understand and improve hospital processes and systems.

Legend: DMAIC - Define,

Measure, Analyze, Improve and Control; CTQ - Critical to Quality;
 SIPOC - Suppliers, Input, Process, Outputs and Customers; 3P -
 Production, Preparation and Process; VSM - Value Stream Mapping; PDSA
 - Plan, Do, Study and Act; TQM - Total Quality Management; A3 - A3
 Report; 5S - Sort, Set in order, Shine, Standardize and Sustain; WHO
 - World Health Organization; DTAP - Diagnostic - Therapeutic
 Assistance Pathway.

4 Discussion

Based on the results obtained, it was founded that the Lean approach contributes to reduce the risks of HAI, difficulties were pointed out in studied articles to obtain data for statistical analysis.

One of the main problems for reducing HAI with the application of Lean Healthcare is the difficulty of obtaining data to plan the actions necessary to mitigate the risk of HAI in hospitals. In the analyzed articles, the scarcity of data for statistical analysis and the use of Lean Six Sigma tools, such as the Pareto Graph and the use of tests to assess the correlations between HAI and specific parameters on the type of intervention, comorbidities, allergies and among other factors that can also increase the risk of HAI.

Another problem is related to the low adherence of health professionals to the use of clinical protocols, caused by work overload, as activities are carried out that do not add value to the patient, thus making adherence to the protocols difficult. Despite knowledge about the protocols and the risks of contamination, health professionals are not sensitive to the need to comply with the protocols, compromising patient safety and the risk of HAI. Standardized work reduces HAI, as found in the analysis of the articles with the results found.

Standardized work consists of a Lean tool that reduces HAI, as verified in the analysis of the articles, which point to the need for planning to implement actions that reduce the risk of HAI. Prevention actions were carried out based on the identification of risks in different sectors of hospitals, leading to a reorganization of patient-centered actions, which is corroborated by the Lean Healthcare approach.

Actions contribute to the development of a sustainable safety culture, responsibilities and actions, whose focus is on providing the best result and experience for patients, are based on the Lean Healthcare approach through the application of tools and methods that ensure the realization of its principles.

As verified in the articles, the applications of Lean methods and tools, such as the standardized work and SIPOC, corroborate the importance of the Lean approach in mitigating the risks of HAI and also the application of quality tools, such as the CTQ (Critical to Quality).

It was founded in the studies that the risk of HAI is increased due to the increase in the length of stay of patients in the hospital environment, as verified in the statistics presented in the studies through the LOS indicator and percentage of patients with HAI, thus showing the importance of the Lean approach that contributes to reducing the average length of stay of hospitalized patients.

Organizational culture and leadership are essential facilitators for patient involvement as a member of the healthcare team. Through culture it is possible to develop a favorable environment for the identification of improvements, inclusion of patients as members of the health team, determination of responsibilities, negotiation, teamwork and open and frequent communication. In this environment, on the other hand, visible leadership is needed, which is an example in the development of an environment that favors continuous learning, character-

ized by transparency in relationships, constant concern with failures promoting continuous improvement and reliability of care processes.

5 Conclusion

Through this systematic review of the literature, the authors of the present study concluded that the Lean Healthcare approach contributes to the reduction of HAI rates. The methods and tools of the Lean Healthcare approach are essential to redirect the actions that will mitigate the risk of HAI, particularly the standardized work, which despite the low adherence of health professionals, when implemented, resulted in a decrease in the length of stay of patients and therefore reduced HAI rates.

Considering that adherence to clinical protocols was one of the problems discussed in the analyzed articles, we saw that this reinforces the idea of the need to implement the Lean Healthcare approach that focuses on respect for people and, consequently, the valorization of teamwork and professionals of health, which leads to a change in the organizational culture.

It is noteworthy that there are still few studies in the literature on the Lean Healthcare approach aimed at the problem of HAI, which was evidenced by the scarcity in the literature, which reinforces the need to expand future studies, particularly related to the application of HFMEA, for being a tool that provides risk analysis, which we recommend for future research.

6 Limitations

The scarce literature on HAI with the application of the Lean approach became the main limitation in carrying out this study, particularly with a focus on the issue of patient safety in the face of HAI risks.

7 Acknowledgements

The authors would like to thank the Brazilian Ministry of Health, Fluminense Federal University and Euclides da Cunha Foundation. This Research is part of a "Lean Project in UPAs 24h" that has been funded by the Brazilian Ministry of Health (TED 125/2019, number: 25000191682201908).

References

1. Ankrum, A.L., Neogi, S., Morckel, M.A., Wilhite, A.W., Li, Z., Schaffzin, J.K.: Reduced isolation room turnover time using lean methodology. *Infection Control & Hospital Epidemiology* **40**(10), 1151–1156 (2019)
2. Antonioli, P., Bolognesi, N., Valpiani, G., Morotti, C., Bernardini, D., Bravi, F., Di Ruscio, E., Stefanati, A., Gabutti, G.: A 2-year point-prevalence surveillance of healthcare-associated infections and antimicrobial use in ferrara university hospital, italy. *BMC infectious diseases* **20**(1), 1–8 (2020)

3. Anvisa: Programa nacional de prevenção e controle de infecções relacionadas à assistência à saúde. https://www.gov.br/anvisa/pt-br/centraisdeconteudo/publicacoes/servicosdesaude/publicacoes/pnpciras_2021_2025.pdf
4. Backman, C., Hebert, P.C., Jennings, A., Neilipovitz, D., Choudhri, O., Iyengar, A., Rigal, R., Forster, A.J.: Implementation of a multimodal patient safety improvement program “safetyleap” in intensive care units: A cross-case study analysis. *International journal of health care quality assurance* (2018)
5. Ernst, J., Schleiter, A.J.: Standardization for patient safety in a hospital department: killing butterflies with a musket? *Qualitative Research in Organizations and Management: An International Journal* (2018)
6. Hellström, A., Lifvergren, S., Gustavsson, S., Gremyr, I.: Adopting a management innovation in a professional organization: the case of improvement knowledge in healthcare. *Business Process Management Journal* (2015)
7. Improta, G., Cesarelli, M., Montuori, P., Santillo, L.C., Triassi, M.: Reducing the risk of healthcare-associated infections through lean six sigma: The case of the medicine areas at the federico ii university hospital in naples (italy). *Journal of evaluation in clinical practice* **24**(2), 338–346 (2018)
8. Montella, E., Di Cicco, M.V., Ferraro, A., Centobelli, P., Raiola, E., Triassi, M., Improta, G.: The application of lean six sigma methodology to reduce the risk of healthcare-associated infections in surgery departments. *Journal of evaluation in clinical practice* **23**(3), 530–539 (2017)
9. Nyström, M.E., Garvare, R., Westerlund, A., Weinehall, L.: Concurrent implementation of quality improvement programs: coordination or conflict? *International journal of health care quality assurance* (2014)
10. O’Reilly, K., Ruokis, S., Russell, K., Teves, T., DiLiberio, J., Yassa, D., Berry, H., Howell, M.D.: Standard work for room entry: Linking lean, hand hygiene, and patient-centeredness. In: *Healthcare*. vol. 4, pp. 45–51. Elsevier (2016)
11. Organization, W.H., et al.: Report on the burden of endemic health care-associated infection worldwide (2011)
12. Ricciardi, C., Fiorillo, A., Valente, A.S., Borrelli, A., Verdoliva, C., Triassi, M., Improta, G.: Lean six sigma approach to reduce los through a diagnostic-therapeutic-assistance path at aorna cardarelli. *The TQM Journal* (2019)
13. Ricciardi, C., Sorrentino, A., Improta, G., Abbate, V., Latessa, I., Perrone, A., Triassi, M., Orabona, G.D.: A health technology assessment between two pharmacological therapies through six sigma: the case study of bone cancer. *The TQM Journal* (2020)
14. Team, P.E.A.: Engaging patients in patient safety-a canadian guide. *Canadian Patient Safety Institute* (2017)