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► **To cite this version:**

Milena Reis, Luis Valdiviezo Viera, Laryssa Amaral, José Farias Filho, Adriana Teixeira, et al.. Motivators to Application of DMAIC in Patient Care Processes. IFIP International Conference on Advances in Production Management Systems (APMS), Sep 2021, Nantes, France. pp.269-279, 10.1007/978-3-030-85902-2_29. hal-04117690

HAL Id: hal-04117690

<https://inria.hal.science/hal-04117690v1>

Submitted on 5 Jun 2023

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Motivators to application of DMAIC in patient care processes

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Abstract. Six Sigma comprises DMAIC which is a methodology that has attracted the attention of researchers in the field of Healthcare. This study aims to understand the motivators to apply DMAIC in process in the context of Six Sigma and Lean Six Sigma to be implemented in processes focused on direct patient care. The article covers literature on DMAIC from 1997 to October 2020. For such a purpose, a systematic literature review has been carried out based on empirical studies in Hospitals and Emergency units. A total of 21 articles were reviewed, and the topic Motivators were addressed in this article with the aim of performing DMAIC through Six Sigma/Lean Six Sigma. Based on the analyzed articles, the most frequent motivator to implement Six Sigma/Lean Six Sigma DMAIC in organizations lies in reducing process time (such as length of stay) and improving the quality of service. It was also noticed that DMAIC has been used in several health services, such as patient discharge and surgeries (femur surgeries, for instance. An application of DMAIC in 50 emergency care units (UPAs) corroborated the main motivators indicated in the literature.

Keywords: Lean Six Sigma · DMAIC · motivators · Healthcare

1 Introduction

Healthcare is a field which has made remarkable advances in technology and treatment, but it is often overwhelmed by inefficiencies, errors, resource constraints and other problems that hinder accessibility and safe patient care [35]. Emergency departments have become increasingly overcrowded due to growing demand, among other factors, which adversely affects the performance of health services [1].

This article analyzes the use of the DMAIC cycle aimed to implement Lean Six Sigma Improvement Projects grounded in the Motivators. The present study

seeks to understand the motivations and objectives of implementing the Lean Six Sigma DMAIC cycle in Hospitals and Emergency Units. The Research question of the present study is “What were the motivations for implementing the Improvement Projects?”

2 Lean, Six Sigma, Lean Six Sigma

The Six Sigma methodology is grounded in the work of Motorola and General Electric [13]. It is an improvement methodology [18, 33]. It is an approach that aims “to improve an organization’s products, services and processes by continually reducing defects in organizations” [24]. By defect it is understood “anything that does not meet customer requirements” [27]. It aims to “make the process 99.99996% defect free” [13].

The purpose of using Six Sigma lies in “process improvement”; while a Lean approach “focuses on flow and speed up of processing by reducing or eliminating” waste [28]. Lean focuses on reducing inefficiency, cost [10], waste [10, 25]. Lean manufacturing Lean Manufacturing comes from Toyota Production System [25]. Six Sigma and Lean methodologies are complementary, as both use “data collection and analysis to improve performance” and “focus on eliminating waste and redundancy in operational processes” [15]. When used together, they are called Lean Six Sigma (LSS). In literature, it is also referred to as Lean Sigma, Lean Six Sigma DMAIC and LSS DMAIC.

DMAIC refers to the 5 stages of the Lean Six Sigma methodology and it is similar in many to the steps to the PDCA (Plan-Do-Check-Act) cycle [22]. The term DMAIC is an acronym for “Define, Measure, Analyze, Improve and Control” (Define, Measure, Analyze, Improve and Control). DMAIC incorporates a clear problem-solving framework into a Six Sigma approach [17] to be used in order to reduce process variability based on statistics [15, 36]. DMAIC can be considered as a continuous improvement method [12], and “a core methodology used in Six Sigma projects”, used for improving, optimizing and reorganizing processes” [19].

3 Motivators

Motivators are crucial for designing the implementation and achieving results. The motivating factors for implementing Lean Six sigma in Indian SMEs are, namely, reducing cycle time, increasing customer satisfaction, improving process efficiency, increasing production capacity, reducing costs and continuous improvement [34]. It should be noted that there seems to be a gap in studies on motivational factors for Lean Six Sigma applications in Healthcare units.

As regards Lean process implementation, Antony et al. [6] conducted a systematic literature review on healthcare services and stated the following motivational factors: 1) improving consumer services; 2) increasing patient satisfaction; 3) surpassing others and gaining competitive advantage; 4) improving the process and operational efficiency; 5) improving the quality of service; 6) transforming

organizational culture; 7) standardizing and streamlining the process; 8) reducing delays and operational time; 9) eliminating waste; 10) eliminating tasks that do not add value; 11) minimizing staff and administrative inefficiencies.

4 Materials and Methods

This article sought to answer research questions by selecting articles and performing their subsequent analysis. The analysis of articles corresponded to a systematic literature review.

4.1 Systematic review

In this article, a systematic review was carried out so as to achieve its objective. Therefore, the sequence of stages presented by Moher et al. [26] was selected for its research design Figure 1 shows a flowchart of the systematic review.

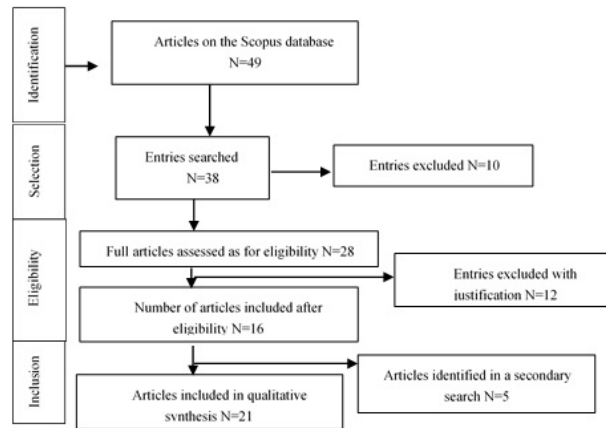


Fig. 1. Systematic Review: Manuscript Selection Flowchart

The present research was carried out between August and October 2020. Scopus was the database selected for the present research due to the fact that it contains the largest database of peer-reviewed abstracts and citations reviewed.

This article is focused on DMAIC implementations in hospital and emergency health environments. For such a purpose, in the stage of Identification, a simulation of keywords with variations of terms linked to DMAIC was carried out. The term “DMAIC” and its variants were combined and as well as the terms “hospital” or “emergency”. For this article, a combination of the following keywords will be used: dmaic OR ”define measure analyze improve control” AND hospital OR emergency AND application OR implementation AND patient. As a result, 49 entries were found.

Table 1 shows details about the search carried out on the Scopus Platform regarding search filters. In the Screening Stage, as a result of using search filters through the entries found in the previous stage, only articles published in journals in English were considered. The “year” search filter was not considered; therefore the search covered an analysis of all years, which resulted in an analysis ranging from 1997 to 2020 (10/12/2020). By inserting the search filters, 38 articles remained, of which 10 were excluded (unavailability, poster and abstract reading). Thus, 28 articles were selected for the stage of eligibility.

Table 1. Search filters

Search filters	Search entries	Documents
Document Type, Type source and language	TITLE-ABS-KEY (dmaic OR "define measure analyze improve control") AND TITLE-ABS-KEY (hospital OR emergency) AND TITLE-ABS-KEY (application OR implementation) AND TITLE-ABS-KEY (patient) AND DOCTYPE ("ar") AND SRCTYPE(j) AND LANGUAGE (english)	38

In the stage of eligibility, full articles were considered with detailed intervention through the DMAIC stages based on an empirical research method carried out in a clinical environment that focused on direct patient care. The 28 articles were examined based on the criteria shown in Table 2. Twelve out of the 28 articles were excluded, and 16 articles remained. In addition, in a secondary search based on the criteria shown in Table 2, 5 articles were identified in the reference sections of selected articles (secondary search) that started to comprise the list of articles that would be used. Thus, the research to be carried out in the next stages was based on 21 articles.

Table 2. Inclusion criteria

Database: Scopus	Focus on patient care in a clinical setting
Published in peer-reviewed journals	Clear focus on implementing DMAIC Six Sigma
Language: English	Detailed in-process intervention through DMAIC
Research method: empirical - case study (single/multiple)/action research	Exposure of pre-implementation and post-implementation measures
Articles published before October 2020	Articles with an empirical approach

5 Improvement Project Motivators

In this section, the results of the systematic literature review will be presented. The analyses related to the following aspects will be presented: motivators.

5.1 Problems and Project Motivators

The analyzed articles have DMAIC implementations through Sigma/Lean Six Sigma applications in hospital wards to solve/minimize a large variety of prob-

lems, such as patient dissatisfaction with the service, long waiting time in the process and a negative impact on the patient safety. Table 3 shows the problems to be solved and/or minimized for carrying out the Improvement Project. Regarding the need to reduce the length of stay, in addition to the patient's risks, Singh et al. [32] consider that an increase in length of stay generates "higher treatment costs for patients and a reduction in bed turnover rate".

Table 3. Problems

Authors	Problems
[5]	Patient dissatisfaction with the discharge process.
[3]	Multiple patient falls leading to high dissatisfaction rate
[4]	Failure to use the PHQ-2/9 depression screening tool in primary care
[7]	Long patient discharge time (on average 215.7 minutes).
[9]	Need to reduce average cycle time of an outpatient department service process (Outpatient Department), waiting time and average queue time. Decreased productivity in the organization affecting quality and patient care.
[8]	The fact of not charging for the service increased the number of patients with a consequent longer length of service and waiting time, which compromised functioning of the services, in addition to crowding within and outside the Hospital.
[11]	Long patient length of stay has led to long patient waits and delays and, thus staff was unable to meet growing demands for performing patients musculoskeletal procedures, especially in outpatient procedures.
[14]	Patient safety
[16]	Inadequate patient waiting time
[21]	Unduly prolonged hospital stays of patients undergoing hip prosthesis surgery.
[22]	Inappropriate length of stay at the Hospital
[20]	Inappropriate length of stay of patients undergoing hip replacement surgery
[23]	Inappropriate waiting time of patients needing femur fracture operation
[2]	Frequent occurrence of medication errors in the pharmacy which leads to re-work and increased waiting time for patients.
[30]	Need for a path that streamlines the process of femur surgery.
[29]	Inappropriate length of stay of patients undergoing knee replacement surgery
[31]	Inadequate patient transfer time
[32]	Delays in administering medications that could create problems such as increased length of stay, recovery time as a result of compromising patient safety
[37]	High incidence of human errors impacting patient safety in hospitals and the potential for errors with the use of insulins in the hospital setting
[38]	In addition to the hospital's mission to be patient-centered, the results of the voice of the customer (complaints from previous patient periods, feedback form and patient satisfaction survey record) which indicated the time of patient discharge as factoring in dissatisfaction.
[39]	Impact on patient safety from possible errors in the hospital environment with regard to insulin dispensing and administration process (improper use of medication can cause serious problems to the patient)

A total of 15 motivators for implementing Six Sigma/Lean Six Sigma using the structure of the DMAIC methodology could be obtained (Table 4). A compilation was carried out by considering the problem at times and the objectives of works shown in Table 3 and at other times based on the term "limitation" or the terms "limitations" or "challenges" in analyzed articles. It is worth mentioning that Al Kuwaiti and Subbarayalu [3] were the only ones to highlight the safety and satisfaction of employees as important factors for carrying out the improve-

ment project. The motivator "reducing time" can be cited as the most widely considered towards the improvement projects under analysis, followed by "improving the quality of service" and "improving the process", "reducing errors"; while "reducing rework, improving employee satisfaction" were less mentioned.

Table 4. Improvement Projects Motivators

Motivators	Authors
Improving patient satisfaction	[3, 5, 32]
Improving employee satisfaction	[3]
Reducing errors	[2, 4, 5, 37, 39]
Improving the quality of service	[5, 8, 9, 14, 21, 22]
Reducing risk	[3, 14]
Improving patient safety	[3, 14, 32, 39]
Improving staff safety	[3]
Process improvement (simplification/efficiency/effectiveness/productivity/reliability)	[4, 9, 11, 21, 39]
Reducing time (waiting time, length of stay)	[2, 7–9, 11, 16, 20–23, 29–32, 38]
Improving patient services	[9, 14, 23]
Reducing delays	[11, 32]
Increasing service capacity	[11, 23]
Standardizing and streamlining the process	[20, 21, 23]
Reducing costs	[20, 23, 29, 39]
Reducing rework	[2]

As regards the 11 motivators cited by Antony et al. [6], 7 were found in the present work: improving services for consumers, increasing patient satisfaction, improving the process operational efficiency, improving the quality of services, standardizing, and streamlining the process, reducing delays and operational time and eliminating tasks that do not add value. As for those cited by Sodhi et al. [34], among others, the factors "increasing production capacity" and "reducing costs" were also considered.

6 Application of DMAIC Methodology in patient care processes: the Lean Project Emergency Care Units (UPAs) 24h

The Lean project in UPAs 24h is a partnership between the Ministry of Health and the Fluminense Federal University with the objective of implementing the restructuring project - Humanization of Patient Care Flow in the UPAs – 24 h urgency and emergency network. The project team is composed of 30 professors and students and 20 specialists, working in management, research, training and advising the 50 UPAs distributed in 8 states and the Federal District. The methodology benefited about 13 million users of the country's public health network. More than 28,300 hours of training were carried out for the 548 employees of the UPAs between the months of April and November/2020.

The methodology of the Lean Project in UPAs 24h developed is integrated and oriented to the principles of the Lean Healthcare approach, to improve patient care processes. The implementation is guided by action research, using the DMAIC method (Define, Measure, Analyze, Improve and Control) to improve communication and the quality of the service offered. The use of continuous improvement and quality tools with servers and employees of the 50 UPAs is highlighted. The main motivators for the development of the project were improved service to SUS users in UPAS, reducing the length of stay of users as well as overcrowding in UPAS, in addition to a focus on patient safety and an increase in user and team satisfaction. In this controlled project, the appropriate indicators are monitored to assess and reduce overcrowding in UPAs. Indicators such as average length of stay were evaluated and monitored.

The project had assistance (in person) to identify potential opportunities for flow and process improvement, aiming at a more efficient management of resources. The project has the following main features: a) support for the development of organizational skills by planning face-to-face technical visits to the 50 UPAs in different states of Brazil; initial assessment of services and environment; involvement of the entire UPA network to impact culture change and reorganization; b) support in the use of DMAIC tools and in leading teams to change and reorganize processes; review of instruments, tools and construction of driving diagrams according to the DMAIC method; elaboration of educational and support materials related to intervention/change processes; monitoring activities and technical visits, as well as controlling the actions of each improvement implementation project; c) Monitoring and Presentation of Results: Develop the control methodology and perform remote monitoring of UPAs indicators; presentation of the results of the services and the project as a whole.

The methodology of the Lean project in UPAs generated qualitative and quantitative results. Even with difficulties especially related to the fact that the project takes place during the Covid-19 pandemic, the project had the benefits of greater humanization of treatment from patient reception to discharge, improvement in the organization of the environment and safety, greater flexibility and service capacity to patients during and after the Covid-19 period, increased user and team satisfaction and reduced waiting time for care. In 43 of the 50 UPAs – 24h there was a 39.5% reduction in the patients' average length of stay in the establishments and at the end of the 6 months of remote monitoring for monitoring the indicators. The main motivators for the development of the project were improved service to SUS users in UPAS, reducing the length of stay of users as well as overcrowding in UPAS, in addition to a focus on patient safety and an increase in user and team satisfaction.

7 Discussion and Conclusions

This section outlines the main results of the systematic literature review and indicates directions for further research. The present work comprised the analysis of 21 articles through the Scopus database. Firstly, the review results have been

discussed, which are: Motivators. Most factors cited by Antony et al. [6] as motivators could be found in the present review and some motivators cited by Sodhi et al. [34] have also been highlighted. “Reducing process time” was the most commonly cited motivator in literature review articles, followed by “improving the quality of service”. Discharge of femur, knee and hip prosthesis surgeries were the most recurrent processes in the analysis of the articles.

This article was limited to revising articles that contained the terms “dmaic” and “define measure analyze improve control” as keywords in their title and abstract, but it is known that there are several articles that contain these terms in other parts of the manuscript with applications or implementations that have not been included. In addition, the research that supported the present research was limited to the Scopus database. These limitations can be further explored in later studies. In line with Antony et al. [6], the Lean Journey in the articles of the systematic literature review does not usually contemplate a long period. This translates into a research opportunity for further studies. The study made it possible to present, through articles selected from literature, results of the development of Six Sigma/Lean Six Sigma improvement projects based on the DMAIC cycle in different healthcare processes. Different motivators mentioned in the literature were considered in the action research presented regarding the 24-hour UPAs, such as improving user satisfaction, improving employee satisfaction, improving the quality of service, improving patient safety, reducing length of stay. It can be seen from the action research presented that among the various benefits obtained, the reduction in permanence time was a substantial reduction in most of the UPAs analyzed, which indicates that the DMAIC methodology can be successfully used in emergency units with a view to the continuous improvement.

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. Ahsan, K.B., Alam, M., Morel, D.G., Karim, M.: Emergency department resource optimisation for improved performance: a review. *Journal of Industrial Engineering International* **15**(1), 253–266 (2019)
2. Al Kuwaiti, A.: Application of six sigma methodology to reduce medication errors in the outpatient pharmacy unit: A case study from the king fahd university hospital, saudi arabia. *International Journal for Quality Research* **10**(2) (2016)
3. Al Kuwaiti, A., Subbarayalu, A.V.: Reducing patients’ falls rate in an academic medical center (amc) using six sigma “dmaic” approach. *International journal of health care quality assurance* (2017)
4. Aleem, S., Torrey, W.C., Duncan, M.S., Hort, S.J., Mecchella, J.N.: Depression screening optimization in an academic rural setting. *International journal of health care quality assurance* (2015)

5. Allen, T.T., Tseng, S.H., Swanson, K., McClay, M.A.: Improving the hospital discharge process with six sigma methods. *Quality Engineering* **22**(1), 13–20 (2009)
6. Antony, J., Sreedharan, R., Chakraborty, A., Gunasekaran, A., et al.: A systematic review of lean in healthcare: a global prospective. *International Journal of Quality & Reliability Management* (2019)
7. Arafeh, M., Barghash, M.A., Haddad, N., Musharbash, N., Nashawati, D., Al-Bashir, A., Assaf, F.: Using six sigma dmaic methodology and discrete event simulation to reduce patient discharge time in king hussein cancer center. *Journal of healthcare engineering* **2018** (2018)
8. Bhat, S., Gijo, E., Jnanesh, N.: Application of lean six sigma methodology in the registration process of a hospital. *International Journal of Productivity and Performance Management* (2014)
9. Bhat, S., Jnanesh, N.: Application of lean six sigma methodology to reduce the cycle time of out-patient department service in a rural hospital. *International Journal of Healthcare Technology and Management* **14**(3), 222–237 (2014)
10. Black, J.: Transforming the patient care environment with lean six sigma and realistic evaluation. *Journal for Healthcare Quality* **31**(3), 29–35 (2009)
11. Cheung, Y.Y., Goodman, E.M., Osunkoya, T.O.: No more waits and delays: Streamlining workflow to decrease patient time of stay for image-guided musculoskeletal procedures. *RadioGraphics* **36**(3), 856–871 (2016)
12. Chiarini, A.: From total quality control to lean six sigma: evolution of the most important management systems for the excellence (2012)
13. Coughlin, K., Posencheg, M.A.: Quality improvement methods—part ii. *Journal of Perinatology* **39**(7), 1000–1007 (2019)
14. Dang, A., Gjolaj, L.N., Whitman, M., Fernandez, G.: Using process improvement tools to improve the care of patients with neutropenic fever in the emergency room. *Journal of oncology practice* **14**(1), e73–e81 (2018)
15. DelliFraine, J.L., Langabeer, J.R., Nembhard, I.M., et al.: Assessing the evidence of six sigma and lean in the health care industry. *Quality Management in Healthcare* **19**(3), 211–225 (2010)
16. Gijo, E., Antony, J., Hernandez, J., Scaria, J.: Reducing patient waiting time in a pathology department using the six sigma methodology. *Leadership in Health Services* (2013)
17. Goh, T.N., Tang, L.C., Lam, S.W., Gao, Y.F.: Six sigma: a swot analysis. *International Journal of Six Sigma and Competitive Advantage* **2**(3), 233–242 (2006)
18. Goh, T., Xie, M.: Statistical control of a six sigma process. *Quality Engineering* **15**(4), 587–592 (2003)
19. Henrique, D.B., Godinho Filho, M.: A systematic literature review of empirical research in lean and six sigma in healthcare. *Total Quality Management & Business Excellence* **31**(3-4), 429–449 (2020)
20. Improta, G., Balato, G., Ricciardi, C., Russo, M.A., Santalucia, I., Triassi, M., Cesarelli, M.: Lean six sigma in healthcare: fast track surgery for patients undergoing prosthetic hip replacement surgery. *The TQM Journal* (2019)
21. Improta, G., Balato, G., Romano, M., Carpentieri, F., Bifulco, P., Alessandro Russo, M., Rosa, D., Triassi, M., Cesarelli, M.: L ean s ix s igma: a new approach to the management of patients undergoing prosthetic hip replacement surgery. *Journal of evaluation in clinical practice* **21**(4), 662–672 (2015)
22. Improta, G., Balato, G., Romano, M., Ponsiglione, A.M., Raiola, E., Russo, M.A., Cuccaro, P., Santillo, L.C., Cesarelli, M.: Improving performances of the knee replacement surgery process by applying dmaic principles. *Journal of evaluation in clinical practice* **23**(6), 1401–1407 (2017)

23. Improta, G., Ricciardi, C., Borrelli, A., D'alessandro, A., Verdoliva, C., Cesarelli, M.: The application of six sigma to reduce the pre-operative length of hospital stay at the hospital antonio cardarelli. *International Journal of Lean Six Sigma* (2019)
24. Kwak, Y.H., Anbari, F.T.: Benefits, obstacles, and future of six sigma approach. *Technovation* **26**(5-6), 708–715 (2006)
25. Lobo, C.V.F., Calado, R.D., da Conceicao, R.D.P.: Evaluation of value stream mapping (vsm) applicability to the oil and gas chain processes. *International Journal of Lean Six Sigma* (2018)
26. Moher, D., Liberati, A., Tetzlaff, J., Altman, D.G., Group, P.: Preferred reporting items for systematic reviews and meta-analyses: the prisma statement. *PLoS medicine* **6**(7), e1000097 (2009)
27. Pande, P., Neuman, R., Cavanagh, R.: *The Six Sigma way team fieldbook: An implementation guide for process improvement teams*. McGraw Hill Professional (2001)
28. Raval, S.J., Kant, R., Shankar, R.: Revealing research trends and themes in lean six sigma: from 2000 to 2016. *International Journal of Lean Six Sigma* (2018)
29. Ricciardi, C., Balato, G., Romano, M., Santalucia, I., Cesarelli, M., Improta, G.: Fast track surgery for knee replacement surgery: a lean six sigma approach. *The TQM Journal* (2020)
30. 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)
31. Silich, S.J., Wetz, R.V., Riebling, N., Coleman, C., Khoueiry, G., Abi Rafah, N., Bagon, E., Szerszen, A.: Using six sigma methodology to reduce patient transfer times from floor to critical-care beds. *Journal for Healthcare Quality* **34**(1), 44–54 (2012)
32. Singh, A., Pradhan, S., Ravi, P., Dhale, S.: Application of six sigma and 5 s to improve medication turnaround time. *International Journal of Healthcare Management* pp. 1–9 (2020)
33. Snee, R.D.: Lean six sigma—getting better all the time. *International Journal of Lean Six Sigma* (2010)
34. Sodhi, H.S., Singh, D., Singh, B.J.: An empirical analysis of critical success factors of lean six sigma in indian smes. *International Journal of Six Sigma and Competitive Advantage* **11**(4), 227–252 (2019)
35. Taner, M.T., Sezen, B., Antony, J.: An overview of six sigma applications in health-care industry. *International Journal of health care quality assurance* (2007)
36. Tlapa, D., Zepeda-Lugo, C.A., Tortorella, G.L., Baez-Lopez, Y.A., Limon-Romero, J., Alvarado-Iniesta, A., Rodriguez-Borbon, M.I.: Effects of lean healthcare on patient flow: a systematic review. *Value in Health* **23**(2), 260–273 (2020)
37. Trakulsunti, Y., Antony, J., Dempsey, M., Brennan, A.: Reducing medication errors using lean six sigma methodology in a thai hospital: an action research study. *International Journal of Quality & Reliability Management* (2020)
38. Vijay, S.A.: Reducing and optimizing the cycle time of patients discharge process in a hospital using six sigma dmaic approach. *International Journal for Quality Research* **8**(2) (2014)
39. Yamamoto, J., Abraham, D., Malatestinic, B.: Improving insulin distribution and administration safety using lean six sigma methodologies. *Hospital Pharmacy* **45**(3), 212–224 (2010)