Article

The impact of lean six sigma program on the performance standards of pre-hospital emergency: A semi-experimental study

Ehsan Koshki[1], Mohammad Zarezadeh[2], Khadijeh Nasiriani[1*]

[*1]Department of Nursing, Nursing and Midwifery Care Research Center, Non-Communicable Diseases Research Institute, Shahid Sadougi University of Medical Sciences, Yazd, Iran
[2]Department of Health Management and ecomomics, School of Public Health, Shahid Sadoughi University of Medical Sciences, Yazd, Iran

Article Info

Article history:
Received: 7 May 2024
Accepted: 5 Sep 2024

Keywords:
Total quality management, Emergency medical services, Institutional practice

***Corresponding author:**
Nursing and Midwifery College, Boali St, Safaeyeh, Yazd, Iran

Email: nasiriani@ssu.ac.ir

Abstract

Background: Emergency medical services (EMSs) organize care provided to patients in out-of-hospital settings, playing a crucial role in minimizing physical and psychological harm resulting from diseases and emergencies. Consequently, pre-hospital emergency is an integral component of healthcare systems, requiring performance standards to improve outcomes for injuries and other illnesses. Thus, the effective utilization of modern management methodologies is essential in this context.
Objectives: The current study aimed to determine the impact of the Lean Six Sigma (LSS) program on performance standards of pre-hospital emergency.
Methods: This single-group quasi-experimental study with a pretest-posttest design was conducted on 50 pre-hospital emergency personnel in Koohdasht County in 2023 using a census method. The research tool included a performance standard measurement checklist, completed through observation before and after implementing the LSS method. Data were analyzed using the paired t-test in SPSS v.18 software.
Results: The findings revealed that the majority of participants held bachelor's degrees (54%), were contractual employees (56%), and were all male. There was a statistically significant difference in the mean score of the performance standards in the personnel ($p=0.001$), equipment ($p<0.001$), and overall ($p<0.001$) dimensions before and after the intervention.
Conclusion: Based on the findings, the implementation of the LSS program was able to enhance the performance standards of pre-hospital emergency in the personnel and equipment dimensions, and overall. Hence, the use of this method is recommended in other centers and other dimensions affecting the performance standards of pre-hospital emergency.

Implications of this paper in nursing and midwifery preventive care:

- The current study demonstrates that the implementation of the Lean Six Sigma was able to enhance the performance standards of pre-hospital emergency. Thus, it is recommended the Lean Six Sigma program and other quality development programs in improving the status of human resources and medical equipment in pre-hospital emergency.

Introduction

Emergency medical services (EMSs) are defined as a system that organizes all aspects of care provided to patients in out-of-hospital settings [1] and serves as an influential and efficient system for minimizing casualties resulting from diseases and emergencies [2]. EMSs are an integral component of healthcare systems requiring performance standards to improve injuries and other illnesses [3] since poor pre-hospital care is a key factor in the development of complications and mortality among critically ill and injured patients [4].

Providing high-quality services in the emergency department is of paramount importance due to the unique nature of emergency. This is particularly true in Iran, where numerous natural and man-made disasters result in significant loss of life, necessitating increased attention to emergency preparedness [5]. Consequently, a thorough understanding of personnel performance, adequate preparedness for EMSs, and the competence of pre-hospital emergency managers are crucial for saving lives and providing care to the injured [6]. Key variables influencing optimal pre-hospital EMSs include the adequate preparedness of personnel and the availability of adequate and standardized equipment. In this regard, in a qualitative study on the challenges faced by pre-hospital emergency personnel in the Sistan & Baluchestan region, Mohammadi et al. found that pre-hospital emergency personnel

encountered numerous difficulties in carrying out their missions. To elevate the quality of pre-hospital EMSs, it is necessary to provide the required facilities, equipment, and personnel [7]. Organizations must conduct thorough and efficient assessments to achieve their goals; these assessments require standards for quantitative and qualitative comparisons to determine the current state and address any issues [8]. If performance does not meet the standards, Lean Six Sigma (LSS) is an effective approach to improve performance standards [9]. In recent decades, LSS has emerged as a potent and systematic approach for elevate healthcare quality, controlling costs, ensuring patient safety, increasing resource efficiency, and overcoming challenges [10].

LSS aims to bridge the gap between the current state and the desired state [11]. This approach enables a comprehensive analysis of healthcare processes, thereby improving quality, patient management, patient satisfaction, and healthcare system operational processes, while mitigating medical errors [12]. The LSS approach underscores the reduction of non-value-added activities in a process and, by seriously focusing on measuring organizational performance indicators, provides a better opportunity to achieve desired results [13]. Furthermore, this approach encompasses numerous techniques, methods, and skills that are all essential for organizational growth and success, and the LSS implementation is not restricted to a specific part of the organization or even to a particular organization. Therefore, it is obvious that its implementation method is also flexible [14,15]. LSS projects are based on the Define, Measure, Analyze, Improve, and Control (DMAIC) cycle, a results-oriented approach that is an all-embracing approach to process improvement and consists of 5 phases, each of which is logically related to both the previous and the following phase. 1- The "Define" phase: In this phase, the principal problem is identified and its aspects and components are specified. 2- The "Measure" phase: In this phase, the desired and current states are determined, input/output variables of the process are defined, and measurement systems are examined. 3- The "Analyze" phase: In this phase, the most important input and in-process factors affecting the process outputs are identified using data. 4- The "Improve" phase: In this phase, activities and improvements that culminate in the optimization of process outputs and the elimination/reduction of deviations in the process are identified. 5- The "Control" phase: In this phase, the results of the improvements made are documented and monitored, and those responsible for following up on these findings are determined [16,17]. According to evidence, over the past few decades, LSS has attracted increasing attention from researchers and practitioners in healthcare [18]. Healthcare organizations implement the LSS method to improve performance in terms of cost reduction, quality improvement, organizational culture enhancement, and efficiency [19,20]. However, very little attention has been paid to the factors that lead to implementation failure and the causal relationships between them, with implementation methods varying between organizations [19]. Evidence shows that studies in the field of pre-hospital EMS quality improvement are limited, and no studies have been found to explore the impact of LSS. Therefore, this study aimed to determine the impact of the LSS program on the level of compliance with performance standards in urban and road pre-hospital emergency bases.

Methods

The current research is a single-group quasi-experimental study with a pretest-posttest design. Data were collected and compared before and after the implementation of the LSS program in urban and road pre-hospital emergency bases in Koohdasht County in 2023. The sample size comprised 50 individuals, who were included in the study using a census method.

After the research proposal was approved by the Research Council of the International Campus of Shahid Sadoughi University of Medical Sciences, Yazd, Iran, an ethics code was obtained. The researcher then visited the pre-hospital emergency in Koohdasht County and, after explaining the study to the center's officials and obtaining their consent and cooperation, invited all personnel (n=50) working in 3 urban and 8 road emergency bases to participate in the study using a census method. This study was conducted from August 22 to January 19, 2023. Subsequently, the researcher sent a demographic information form to each of the personnel.

In order to conduct the study, in accordance with LSS projects based on the DMAIC cycle, in the "Define" phase, the objective, which was to increase the performance standards of pre-hospital EMSs in Koohdasht County, was determined, the two personnel and equipment dimensions were selected, and the indicator items were identified. In the second step, data from the performance standard checklist were collected. Therefore, the researcher, using the performance checklist, observed performance in the personnel and equipment dimensions for at least three shifts for each individual. The initial observations took one month. Observations were conducted at various working hours, including the time of arrival at the base, the time of operation announcement, or the end and return to the base. In the third step, the performance of personnel was analyzed according to the performance standard checklist, and items with unsatisfactory performance were identified and extracted. In the fourth step, items requiring improvement to comply with performance standards in pre-hospital EMSs were analyzed based on an expert panel. The most common deficiencies were related to portable oxygen from the equipment dimension; medical thermometer from the equipment dimension; special labels from the personnel dimension; penlight from the equipment dimension; cervical collar from the equipment dimension; equipment disinfection from the personnel dimension; daily ambulance handover in each shift from the personnel dimension; keeping the ambulance clean from the personnel dimension; taking at least a basic technician training course from the personnel dimension; the condition of black, lace-less shoes from the personnel dimension; the technical condition and radio of the ambulance from the equipment dimension; ambu bag with mask and airways from the equipment dimension; and oral airway mask with oxygen inlet from the equipment dimension, respectively. In the next stage, the results along with the original questionnaire were provided to an expert panel (consisting of 10 people, including nursing professors; experts working in the field of research with a mastery over the research topic; the official in charge of the prehospital emergency of the county; the head of emergency training of the prehospital county; and several experienced personnel with postgraduate degrees in the field of emergency working at the base). The expert panel proposed the necessary solutions to address the deficiencies.

The proposed solutions comprised sending a written list of deficiencies and the importance of eliminating equipment deficiencies to senior managers, conducting re-training and new training courses on ambulance technical matters, preparing and emphasizing the importance of proper equipment disinfection, informing personnel of deficiencies in performance standards in both personnel and equipment dimensions, increased monitoring and control and considering a equipment handover checklist, suggesting the purchase and replacement of equipment, and taking legal action such as incentives and penalties. Training sessions were provided to personnel by the researcher in groups during three shifts over five courses based on a list of the most common deficiencies extracted. In the fifth step, the researcher monitored the personnel performance, equipment, and pre-hospital emergency management in Koohdasht County for one month to assess the impact of all improvement stages. At the end of this period, the performance of all personnel in the personnel and equipment dimensions was observed indirectly by the researcher using a performance checklist during three shifts. Ultimately, the collected data from the second and fifth stages were analyzed and compared (Figure 1).

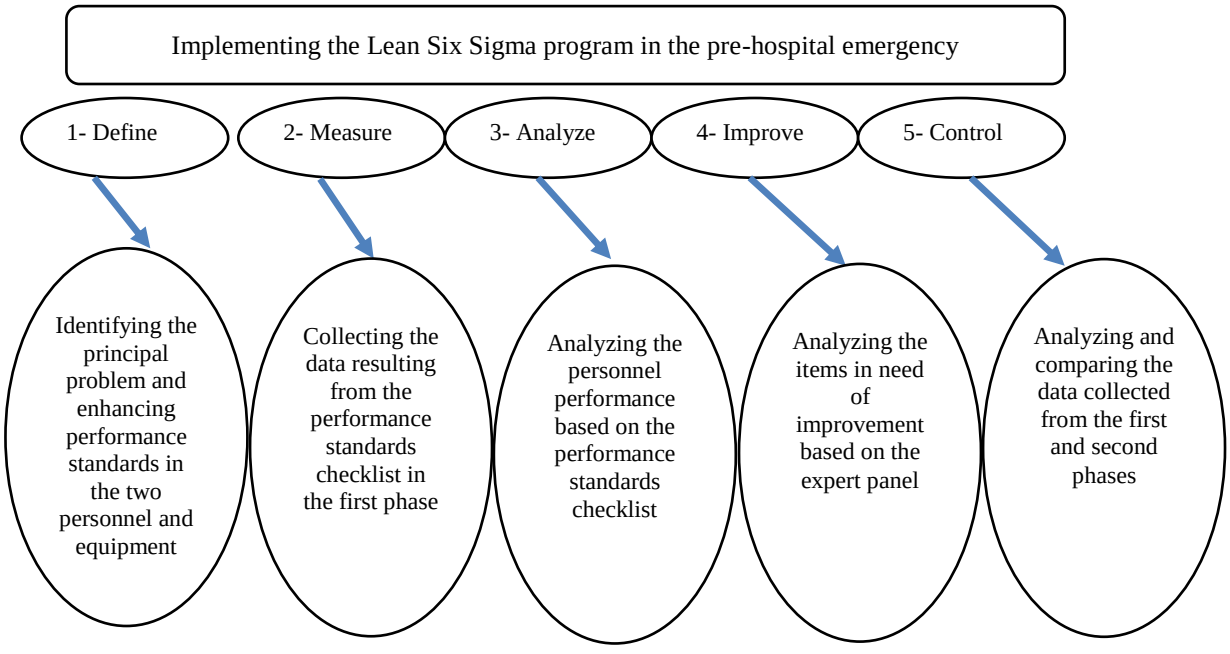

Figure 1: The Lean Six Sigma program implementation method in pre-hospital emergency

For data collection, the performance of pre-hospital emergency personnel was assessed by the researcher using a checklist during their shifts through observation. The checklist was derived from ambulance equipment (patient transfer and transport equipment, ventilation and respiratory equipment, diagnostic equipment, injection equipment, and life-saving treatment management equipment) based on the requirements of the standard license 4374 of 2011/second revision. Additionally, the standard questions in the personnel checklist were taken from the regulations of the inclusive coverage organization of pre-hospital EMSs, approved by the Cabinet of Ministers on 16/12/2007. This researcher-developed checklist consisted of 10 questions in the personnel dimension and 15 questions in the equipment dimension, with a score of two for a complete answer, one for an incomplete answer, and zero for the absence of an answer. The mean scores for each item, dimension, and the total score were calculated. In the personnel dimension, the minimum score for this dimension is zero and the maximum score is 20. Based on the classification of the mean questionnaire score in the personnel dimension, it was divided into four levels: Poor (0-5), moderate (5.1-10), good (10.1-15), and excellent (15.1-20). In the equipment dimension, the minimum score is zero and the maximum score is 30. Based on the classification of the mean questionnaire score in the equipment dimension, it was divided into four levels: Poor (0-7.5), moderate (7.6-15), good (15.1-22.5), and excellent (22.6-30). For the overall checklist, the minimum total score is zero and the maximum total score is 50. Based on the classification of the mean total score of questionnaire in both the personnel and equipment dimensions, it was divided into four levels: Poor (0-12.5), moderate (12.6-25), good (25.1-37.5), and excellent (37.6-50). In order to confirm content validity, the checklist was provided to five experts in the field of pre-hospital emergency, and the qualitative validity was approved. The checklist reliability was confirmed by completing it for 10 people at a two-week interval using a test-retest method (r=0.81). Data were collected in two stages: Before and after the LSS implementation.

In this study, SPSS version 18 was employed for data analysis. Descriptive statistics including frequency, percentage, mean, and standard deviation (SD) were used. Data normality was assessed using the Kolmogorov-Smirnov test, and the comparison of pre-intervention and post-

intervention data was conducted using the paired t-test.

Results

Based on the findings, the most frequent education level among the participants included 27 individuals (54%) with a bachelor's degree, and the most common employment type was contractual, with 28 individuals (56%). In addition, all participants were male. Details and other demographic characteristics are presented in Table 1.

Table 1: Demographic characteristics of research units

Variable	Subgroup	N (%)
Education level	Associate	20(40%)
	Bachelor	27(54%)
	Master	3(6%)
Employment type	Permanent	9(18%)
	Contractual	28(56%)
	Corporate	13(26%)
Total		50(100%)
Variable	Mean (SD)	
Age	36.30(7.76)	
Work experience	12.24(6)	

SD: Standard deviation; Number (percent)

The paired t-test results revealed a significant increase in the mean and standard deviation (SD) scores of the performance standards both in both personnel and equipment dimensions, as well as the total score, after the implementation of the LSS program ($p<0.001$) (Table 2).

Table 2: Comparison of the mean pre-hospital emergency performance standard scores before and after the implementation of Lean Six Sigma program

Pre-Hospital Emergency Performance Standards	N	Score	Before Proram Implementation	After Proram Implementation	P
		Min-Max score of the questionnaire	Mean (SD)	Mean (SD)	
Personnel dimension	50	0-20	11.78(2.93)	18.42(2.26)	0.001
Equipment dimension	50	0-30	20.94(1.22)	26.88(1.41)	0.001
Total score	50	0-50	32.72(2.62)	2.66(45.30)	0.001

*Paired t-test
SD: Standard deviation

Discussion

The findings regarding the performance standards of pre-hospital emergency before the implementation of the LSS program demonstrated that the mean performance standard scores in the personnel, equipment, and overall performance standard dimensions were evaluated as good before the implementation of the LSS program. In line with the study results, Abbaspour et al. (2016) suggested that the current status of emergency bases at Torbat-e-Heydariyeh University of Medical Sciences is at a relatively good level according to the Ministry of Health standards; however, the shortage of equipment in prehospital emergency bases will reduce the efficiency of pre-hospital EMSs. Sufficient attention to achieve the standards seems to be really necessary [21]. Heydari and Shahbazi (2015) showed that the majority of pre-hospital emergency personnel in Isfahan province had a

satisfactory performance regarding the principles and equipment used in patient transfer in prehospital emergency centers [22]. However, contrary to the study results, Sabouri et al. (2014) found that none of the pre-hospital emergency bases in the city of Birjand had sufficient personnel, and none of the ambulances at the emergency bases had all the necessary equipment [23]. Moradi et al. (2021) report that the status of the equipment available in pre-hospital emergency ambulances in the city of Khorramabad is far from the standards of the Iranian Ministry of Health and that more attention needs to be paid to controlling the status of equipment in pre-hospital emergency ambulances [24]. In addition, Kazemnezhad et al. (2014) indicated in a study that the equipment of pre-hospital EMS vehicles in the city of Rasht had a significant difference compared to the standards of the Iranian Ministry of Health and the Iranian National Standard Organization [25]. The difference in results could be attributed to the year of the study and the updating of guidelines, which, over time and with changes in guidelines, pre-hospital emergencies have improved their equipment.

Other findings revealed that implementing the LSS program increased the mean performance standard score in both the personnel and equipment dimensions, although there is still some distance to reach the maximum score. Based on a literature review, no evidence of the application of the LSS program in pre-hospital emergency was found. However, evidence of the application of the LSS program in other healthcare sectors has been indicative of improvements in organizational and personnel performance. In this regard, Karimi et al. (2015) reported that after implementing LSS, the medical equipment dysfunction decreased in an operating room in a hospital in Isfahan, the mean cost of equipment repairs decreased considerably, and the mean performance score of users of operating room equipment increased remarkably [26]. Improta et al. (2019) showed that LSS was effective in shortening the length of pre-operative stay for patients in a hospital in Italy [27]. Gheysari et al. (2014) demonstrated that by implementing LSS, the number of canceled surgeries at Ayatollah Kashani Hospital in Isfahan decreased [28]. In a study aimed at the impact of LSS and workforce management on the qualitative performance of Malaysian hospitals, Ahmad et al. (2018) suggestd that the LSS approach was one of the problem-solving tools that, when used correctly, can effectively contribute to resolving problems and improving the organization's status [29]. According to Mahmoudirad and Estaki's (2012) research, after implementing the LSS model, the quantity and quality of patient training in the vardiac care unit (CCU) ward of Vali-e-Asr Hospital in the city of Birjand increased [30]. The results of Scala et al.'s (2021) study revealed that the LSS approach shortened the mean length of stay for patients with femoral fractures in a university hospital in Italy to 3.5 days [31]. According to Hossein et al.'s (2017) research, LSS can mitigate overcrowding in emergency departments in Egypt [32]. Therefore, based on the results of this study and the studies mentioned above, it can be inferred that the LSS program is one of the problem-solving tools that, when used correctly, can effectively contribute to eliminating problems and improving the performance standard status. LSS provides a systematic approach to improving working processes based on customer needs and the actual analysis of ongoing processes in any organization.

The current study faced several limitations. There are also other items, such as reviewing and reforming the organizational structure, administrative rules and regulations, training courses, information and communication technology, management, and reforming the personnel monitoring and evaluation system, which could be considered to enhance pre-hospital emergency. However, due to the conditions and available resources, only two items were examined. Data were collected through observation, and the limitations of the observational data collection method should be taken into account. Moreover, this research was conducted in a single county, which must be taken into consideration when generalizing the data. It is suggested that in future studies, while eliminating the limitations of the present research, the effect of implementing the LSS program on other pre-hospital emergency standards, such as training courses, information and communication technology, and management, be explored, and be

compared with other quality improvement programs.

Conclusion

Based on the findings, the implementation of the LSS program improved in both personnel and equipment dimensions, as well as overall performance standards in pre-hospital emergency. Hence, according to the effectiveness of the LSS program in promoting performance standards in pre-hospital emergency, it is recommended that pre-hospital emergency managers and personnel, while periodically evaluating standards, utilize the program to improve performance standards in pre-hospital emergency in both personnel and equipment dimensions. Additionally, this program should be included in management training courses and incorporated into the curricula of students or as re-training courses, particularly for personnel. Furthermore, it is recommended that other pre-hospital emergency centers and healthcare facilities adopt to the LSS program to enhance performance standards.

Ethical Consideration

To ensure ethical considerations, ethical approval (IR.SSU.REC.1402.043) was obtained from the Ethics Committee of Shahid Sadoughi University of Medical Sciences, Yazd. Informed consent was obtained from all participants, and the anonymity of the questionnaires and confidentiality of the information were observed. The ethical principles outlined in the Declaration of Helsinki were adhered to in this study.

Acknowledgments

The researchers would like to thank the pre-hospital emergency personnel for their participation in this study.

Conflict of interest

Not applicable.

Funding

Not applicable.

Authors' contributions

All authors contributed to the conceptualization, methodology, data interpretation, and preparation and approval of the manuscript.

References

1. Mehmood A, Rowther AA, Kobusingye O, Hyder AA. Assessment of pre-hospital emergency medical services in low-income settings using a health systems approach. International journal of emergency medicine. 2018;11(53):1-10. https://doi.org/10.1186/s12245-018-0207-6.
2. Carvalho A, Captivo M, Marques I. Integrating the ambulance dispatching and relocation problems to maximize system's preparedness. European Journal of Operational Research. 2020; 283(3) :1064-1080. https://doi.org/10.1016/j.ejor.2019.11.056
3. Jansson J, Larsson M, Nilsson J. Advanced paramedics and nurses can deliver safe and effective pre-hospital and in-hospital emergency care: An integrative review. Nursing Open. 2021; 8(5):2385-405. https://doi.org/10.1002/nop2.866
4. Butler MW, Adefuye AO. Assessing the knowledge of emergency medical care personnel in the Free State, South Africa, on aspects of paediatric pre-hospital emergency care. Pan African Medical Journal. 2019; 32 (1): 1-13. https://DOI: 10.11604/pamj.2019.32.98.17718
5. Lawn S, Roberts L, Willis E, Couzner L, Mohammadi L, Goble E. The effects of emergency medical service work on the psychological, physical, and social well-being of ambulance personnel :a systematic review of qualitative research. BMC psychiatry.2020; 20: 1-16. https://DOI: 10.1186/s12888-020-02752-4
6. Amiresmaili M, Talebian A, Miraki S. Pre-hospital emergency response to terrorist attacks: A scoping review. Hong Kong Journal of Emergency Medicine. 2022;29(1):-56 .62. https://doi.org/10.1177/1024907920941620
7. Mohammadi M, Firouzkouhi M, Abdollahimohammad A, Shivanpour M. The challenges of pre-hospital emergency personnel in Sistan area: a qualitative study. Journal of Qualitative Research in Health Sciences. 2019;8(3):.32-221. https://jqr1.kmu.ac.ir/article_90977.html [in persian]
8. Akbarisari A, Habibi F, Khosravi B ,Hamouzadeh P, Yousefvand M. Designed questionnaire to evaluate the performance of hospital emergency. Hospital. 2020;19(1):-44 . .51. URL: http://jhosp.tums.ac.ir/article-1-6274-en.html [In Persian]
9. Null G, Cross JA, Brandon C. Effects of lean six sigma in program management. Journal of Manufacturing Technology Management. 2020;31(3):.98-572. https://doi.org/10.1108/JMTM-04-2019-0139
10. Atashga K, Khosravi B. Quality improvement and cost reduction using six sigma approach: focused on Taleghani hospital. Health Information Management. 2015;11(7):-840 .50 https://doi.org/10.22122/him.v11i7.1137. [In Persian]
11. Vaishnavi V, Suresh M. Modelling of readiness factors for the implementation of lean six sigma in healthcare organizations. International Journal of Lean Six Sigma. 2020;11(4):.633-597. https://doi.org/10.1108/IJLSS-12-2017-0146
12. Persis DJ, Sunder M V, Sreedharan VR, Saikouk T. Improving patient care at a multi-speciality hospital using lean six sigma. Production Planning & Control. 2022;33(12):.54-1135. https://doi.org/10.1108/IJQRM-03-2023-0099
13. Pranata A. Optimizing health service delivery: addressing non-value added activities through lean six sigma. Indonesia Accounting Research Journal. 2024;11(3): 173–183.

https://journals.iarn.or.id/index.php/Accounting/article/view/255
14. Patel AS, Patel KM. Critical review of literature on lean six sigma methodology. International Journal of Lean Six Sigma. 2021;12(3):.74-627. https://doi.org/10.1108/IJLSS-04-2020-0043 ·
15. Rathi R, Vakharia A, Shadab M. Lean six sigma in the healthcare sector: a systematic literature review. Materials Today: Proceedings.81-50:773;2022 . https://doi.org/10.1016/j.matpr.2021.05.534.
16. Koushki A, Larti N, Fakhri M, Fatahi S. Investigating the effect of Lean six sigma method on the observance of performance standards in the central sterilization unit of the operating room. Perioperative Care and Operating Room Management. 2022;.28:100269. https://doi.org/10.1016/j.pcorm.2022.100269
17. Tampubolon S, Purba H. Lean six sigma implementation, a systematic literature review. International Journal of Production Management and Engineering. 2021;9(2):-125 .39. https://doi.org/10.4995/ijpme.2021.14561
18. Marolla G, Rosa A, Giuliani F. Addressing critical failure factors and barriers in implementing lean six sigma in Italian public hospitals. International Journal of Lean Six Sigma. 2022;13(3):.64-733. https://doi.org/10.1108/IJLSS-01-2021-0018.
19. Samanta AK, Gurumurthy A. Implementing lean six sigma in health care: a review of case studies. International Journal of Lean Six Sigma. 2023;14(1):.89-158. https://doi.org/10.1108/IJLSS-08-2021-0133
20. Noronha A, Bhat S, Gijo E, Antony J, Laureani A, Laux C. Performance and service quality enhancement in a healthcare setting through lean six sigma strategy. International Journal of Quality & Reliability Management. 2023;40(2):.90-365 https://doi.org/10.61919/jhrr.v4i1.451
21. Abbaspour S, Sabbaghi MR, Tatari M. The assessment of clinical equipment of emergency medical services in Torbat Heydariyeh university of medical sciences in 2016. Iranian Journal of Emergency Care. .8-1:(2)1;2017. URL: http://ijec.ir/article-1-42-en.html [In Persian]
22. Heidari M, Shahbazi S. Assessment of Emergency Medical Services (EMS) Staff's knowledge and practice about principles and equipment used for patient handling in EMS centres of Isfahan province. Journal of Research Development in Nursing and Midwifery. 2015;12(1):.7-111. URL: http://nmj.goums.ac.ir/article-1-719-en.html [In Persian]
23. Sabouri E, Naderi Moghadam M, Saburie M O, Mohammadi Y, Tavakkoli F. The evaluation of prehospital emergency performance indicators in Birjand, 2015. Iranian Journal of Emergency Care. 2017;1(1):.8-61. URL: http://ijec.ir/article-1-29-en.html [In Persian]
24. Moradi B, Yarahmadi S, Valipour M, Javadi N, Galehdar N. Assessing the status of pre-hospital emergency ambulance equipment in khorramabad city based on the standard of Iranian ministry of health in 2021Iranian Journal of Emergency Medicine. 2022;9(1):e.24. https://doi.org/10.22037/ijem.v9i1.39183 . [In Persian]
25. Kazem Nejad E, Poursheikhian M, Vatankhah S, Jahangiri K. Pre-hospital emergency medical services: Situation analysis of ambulance medical equipments in Rasht city. Quarterly Scientific Journal of Rescue and Relief. 2014;6(1):1-6. URL: http://jorar.ir/article-1-175-en.html [In Persian]
26. Karimi A, Mojdeh S, Mehraban MA. The effect of six sigma program on improving medical equipment management of operating rooms in one of the hospitals in Isfahan in 2016. Pharmacophore. 2017;8(6):e-1173225. https://www.researchgate.net/publication/335881137_The_effect_of_six_sigma_program_on_improving_medical_equipment_management_of_operating_rooms_in_one_of_the_hospitals_in_isfahan_in_2016_Ashkan_Karimi_et_al_201.[In Persian]
27. 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. 2020;11(3):.76-555. https://doi.org/10.1108/IJLSS-02-2019-0014
28. Gheysari E, Yousefi H, Soleymani H, Mojdeh S. Effect of six sigma program on the number of surgeries cancellation. Iranian journal of nursing and midwifery research. 2016;21(2):191. https://doi: 10.4103/1735-9066.178247..
29. Ahmed S, Abd Manaf NH, Islam R. Effect of lean six sigma on quality performance in malaysian hospitals. International journal of health care quality assurance. 2018;31(8):.87-973. https://doi.org/10.1108/IJHCQA-07-2017-0138.
30. Mahmoudirad G, Esteki R. Investigating the effects of six sigma method on the quantity and effectiveness of patient education in the CCU of Birjand Valiasr hospital in 2012. Modern Care Journal. 2014;.(2)11. https://www.magiran.com/p1323948. [In Persian]
31. Scala A, Ponsiglione AM, Loperto I, Della Vecchia A, Borrelli A, Russo G, et al. Lean six sigma approach for reducing length of hospital stay for patients with femur fracture in a university hospital. International Journal of Environmental Research and Public Health. 2021;18(6): 2843. https://doi.org/10.3390/ijerph18062843.
32. Hussein NA, Abdelmaguid TF, Tawfik BS, Ahmed NG. Mitigating overcrowding in emergency departments using Six Sigma and simulation: a case study in Egypt. Operations Research for Health Care. 2017;.12-15:1. https://doi.org/10.1016/j.orhc.2017.06.003