Readiness of Health Care Organization for Lean Six Sigma Implementation: An Empirical Study

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Abstract
Background: Lean Six Sigma (LSS) is a tool designed to address issues and enhance the efficiency and effectiveness of healthcare agencies by reducing variation and eliminating waste. To ensure the sustainable implementation of LSS, hospitals must be adequately ready to adopt this approach. **Aim**: assess health care organizations for lean six sigma implementation. **Design**: in this study, a descriptive research design was adopted. **Setting**: study conducted at a private hospital in Cairo. **Subjects**: a convenient sample of nurses (158) working in the forementioned study setting. **Data collection**: there were two tools used as, 1st tool. nurses' knowledge questionnaire and 2nd tool: Healthcare readiness questionnaire toward lean six sigma implementation. **Results**: less than half of nurses have a low level of knowledge while 23.4% have a high level of knowledge regarding lean six sigma. More than half of nurses perceived a low level of readiness while 22% perceived a high level of readiness. **Conclusion**: there was a statistically positive significant correlation between knowledge and healthcare organizational readiness at r= 0.45 p=< 0.0001. **Recommendations:** establish ongoing training and education sessions focused on Lean Six Sigma principles, methodologies, and practical applications. Further studies to evaluate the effectiveness of various training and educational interventions designed to improve Lean Six Sigma knowledge and readiness among healthcare staff.

Keywords: Healthcare organization, Lean Six Sigma, Nurses & Readiness

Introduction

With the day-to-day increase in healthcare costs, rapidly evolving medical knowledge and technology, and decreasing reimbursement rates, hospitals face significant challenges. To ensure operational efficiency, high-quality patient care, and employee engagement while still meeting financial goals, many in the global healthcare sector have adopted Lean Six Sigma (LSS) methodology. LSS is favored for its zero-tolerance approach, which helps minimize medical procedural errors **(Rathi et al., 2022)**.

Lean is a management approach, a methodology and a philosophy that can assist healthcare professions in providing preferable patient care. Initially expanded for car manufacturing and used in engineering and production operations, Lean's benefits were soon recognized by other industries. Today, it is applied in pharmaceutical, electronic, and healthcare settings, leading to significant improvements in process flow. In healthcare, Lean helps reduce patient wait times from entry to exit by eliminating Non-Value Add (NVA) time and activities for both patients and staff **(Teeling et al., 2023).**

Six Sigma is a data-driven methodology designed to enhance process capability and improve the quality of process outputs. It is a multi-dimensional, structured approach aimed at improving processes, reducing defects and process variability, lowering costs, increasing patient satisfaction, and boosting profits. Six Sigma focuses on eliminating waste and inefficiency, thereby increasing patient satisfaction by delivering what the patient expects **(McDermott et al., 2022)**.

Lean is oftentimes used in wedding with Six Sigma, another widely recognized improvement methodology developed by Motorola aiming to optimize industrial way by lowering variability through the rigorous collection and statistical analysis of process metrics **(Kam et al., 2021)**.

Lately, LSS has become one of the most widely applied mechanism in organizations. This mechanism integrate Lean and Six Sigma approaches to enhance serving quality by minimizing costs and waste, yielding significant results in healthcare advancement **(Costa et al., 2023)**.

In healthcare system, Lean in most cases usually used to free up time for patient care, while, Six Sigma focuses on lowering undesirable difference in day-to-day work operations. When used together, they significantly affect on health results, steps and quality of care, budgetary performance, and patient and staff contentment **(Henrique & Godinho-Filho, 2020)**.

For process enhancement, LSS generally use the DMAIC (Define, Measure, Analyze, Improve, Control) paradigm. Healthcare organizations may detect issues, assess performance, determine the

underlying reasons, make improvements, and sustain the benefits with the aid of this methodical approach **(Monday, 2022).**

Health care organization readiness refers to the extent to which a health care institution is prepared to effectively adopt and implement new initiatives, methodologies, or changes. Organizational readiness is essential in developing LSS which include several dimensions as, leadership commitment, workforce capability, process management maturity, and the cultural aspect involves the alignment of the organization's values and behaviors with Lean Six Sigma principles **(Dewi et al., 2024).**

Moreover, implementing Lean Six Sigma (LSS) in healthcare encounters distinct challenges not typically seen in other sectors. These obstacles encompass capacity spikes caused by seasonal fluctuations or pandemics, such as the flu and COVID-19, as well as the growing number of elderly patients. Additionally, the diverse professional backgrounds within the healthcare field contribute to the perception that certain manufacturing industry practices do not align well with healthcare settings **(Trakulsunti et al., 2022).**

Significance of the study

In order to increase quality and efficiency at the same time, healthcare organizations are putting more and more emphasis on operational excellence and employing operations management models. LSS is more than just a method or a set of tools for improvement; it embodies a mindset and psychology geared towards enacting change. Given that healthcare is a people-intensive and process-driven métier, it is an ideal setting for LSS. Globally, LSS is being implemented across diversified service and manufacturing organizations. However, the healthcare sector, particularly in developing countries like Egypt, India, Pakistan, and Sri Lanka, is still not fully aware of the sustainable advantages of the LSS strategy **(Rathi et al., 2022)**.

So, it is necessity to assess readiness of health care organization for lean six sigma implementation.

Aim of the study

The present study aimed to assess readiness of health care organization for lean six sigma implementation through the following objectives:

1. Assess nurses' level of knowledge regarding lean six sigma.
2. Determine healthcare organizational readiness level regarding lean six sigma implementation as perceived by nurses.

Research questions:

This study was answered the following questions: -

1. What is nurses' level of knowledge regarding lean six sigma?

What is healthcare organizational readiness level regarding lean six sigma implementation as perceived by nurses .

Subjects and Methods

Research Design:

In this study, a descriptive research design was followed.

Study setting:

This study was carried out in private hospital in Cairo. It provides holistic healthcare services for patients in different medical and surgical specialties. These departments are (Medical intensive care unit, oncology intensive care unit, neonatal intensive care unit, dialysis unit, cardiac Cath lab unit, hematology unit, diabetes unit, immunity unit, neurological unit, medical unit and chest unit). Its total capacity is (250) beds.

Study Subjects:

A convenience sample of nursing professionals as: staff nurse, charge nurse, head nurse, and supervisor (158) working in the forementioned study setting were incorporated into the current study during the time of data collection from the beginning of January 2024 to the end of March 2024.

Tools of Data Collection

Two tools were used for data collection through the following - :

The first tool: Nurses' Knowledge Questionnaire: The tool in question was created by a researcher based on review of the related literatures **(Ali, 2023; Costa et al., 2023; Fathi et al., 2022).** Also, is consisted of two parts as the following:

Part 1: Personal characteristics data: It was focused on personal characteristics of nurse such as (age, gender, educational qualifications, years of experience, & current position).

Part 2: Nurses' Knowledge Regarding Lean Six Sigma Questionnaire: It was focused on assessment of nurse's knowledge level regarding lean six sigma. It was composed of 60 questions divided into 6 key areas of knowledge: a) basic concepts of lean 10 questions; b) basic concepts of six sigma 10 questions; c) DMAIC process understanding 10 questions; d) tools and techniques 10 questions; e) application in healthcare 10 questions; f) Change management 10 questions.

Scoring system :

This part's overall score was 60 grades, One point was awarded for a correct response, and zero for an incorrect response. These scores were summed up and were converted into a percentage score. Those respondents who obtained score above 45 were considered as high level, while the scores between 30 and 45 were considered as medium level. The score below 30 was considered as low level.

The second tool: Healthcare Organizational Readiness Regarding Lean Six Sigma Implementation Questionnaire: It was created by the researcher based on review of the related literature **(Fathi et al., 2022; Pittman et al., 2021; Vaishnavi & Suresh, 2020).** It measured healthcare organizational readiness regarding lean six sigma implementation as perceived by nurses. It consisted of 30 items. It was divided into 6 parts: a) leadership commitment (5 items); b) cultural readiness (5 items); c) resources and infrastructure (5 items); d) training and education (5 items); e) communication and collaboration (5 items); f) current processes and systems (5 items).

Scoring system:
It was measured by five points Likert scale. The total score was 150. Those respondents who obtained scores above 113 were considered as high level, while the scores between 75 and 113 were considered as medium level. The score below 75 was considered as low level.

Validity and reliability
In the study, content validity was established through jury opinions regarding the format, layout, and clarity of the questionnaire. Content validity ensured that each item included in the questionnaire was appropriate for its intended purpose. The Content Validity for the overall questionnaire was 0.89, indicating good content validity.

Reliability of the tools was assessed using Cronbach's alpha coefficient, which measures the internal consistency of the questionnaire items. For the knowledge questionnaire, Cronbach's alpha was 0.824, indicating good reliability. The readiness questionnaire had a Cronbach's alpha of 0.865, also demonstrating good internal consistency. Additionally, internal consistency reliability was evaluated using the Spearman-Brown Prophecy Formula $(r1=2(r)/1+r)$ to estimate the reliability of the entire test based on the correlation coefficient computed from split halves of the data. Based on the jury's feedback the questionnaires were slightly altered to increase their relevance and clarity.

Pilot Study
In the pilot study, which involved 10% (16) of the total study sample size and aimed to decided clarity, applicability of the tools and to estimate the time required for complete the questionnaire sheets. The total time required to complete the knowledge tool ranged between (45-60) minutes and readiness tool (20-30) minutes. The primary study sample comprised those who took part in the pilot study. The final version was ready to be distributed to the nurses who took part in the study after minor revisions were made based on the findings of the pilot study.

Fieldwork
After securing the official approvals for conducting the study, the researcher interviews with nurses under study to identify the goal of the study and obtain their approval to join in the study before to any data collection. Data collection was collected by the researcher and completed within three months from the beginning of January 2024 to the end of march 2024. The researcher collects data three days / week in day shift from all departments.

Ethical considerations
Before starting the study, ethical approval was obtained from the scientific ethical committee of the Helwan University faculty of nursing. Before any data was collected, each participant's written consent was also obtained. They received assurances that their responses would only be used for study purposes, that their privacy and confidentiality would be protected, and that they could leave the study at any moment without suffering any consequences.

Statistical analysis
Statistical analysis was done by using the computer software program (SPSS) version 26 for data entry and statistical analysis. Descriptive statistics were used to portray the data as frequencies and percentages for the qualitative variables. For quantitative variables, mean and standard deviation are used. If a normal distribution of the data could not be assumed, the Shapiro-Wilk and Kolmogorov-Smirnov tests were performed to ascertain whether a variable follows a normal distribution. The Cronbach alpha coefficient was computed in order to evaluate the internal consistency of the scales employed in order to determine their reliability. The study variables were correlated using Pearson correlation analysis. At p-value <0.001 and <0.05, statistical significance was taken into consideration

Results

Table (1): Number and percentage distribution of the studied nurses of healthcare organizational readiness according to their personal data (N=158)

| Personal data	No.	%
Age (years)		
20-29	34	21.5%
30-39	77	48.8%
40-49	41	25.9%
> 50	6	3.8%
Gender		
Male	66	41.8%
Female	92	58.2%
Educational qualification		
Diploma in nursing science	38	24.05%
Bachelor's degree in nursing science	110	69.62%
Master's degree in nursing science	8	5.1%
Doctorate degree in nursing science	2	1.26%
Years of Experience		
1-5	48	30.4%
6-10	68	43.03%
11-15	32	20.3%
> 15	10	6.3%
Current position		
Staff nurse	107	67.72%
Charge nurse	28	17.73%
Head nurse	16	10.12%
Supervisor	7	4.43%
Previous training		
Yes	12	7.6%
No	146	92.4%
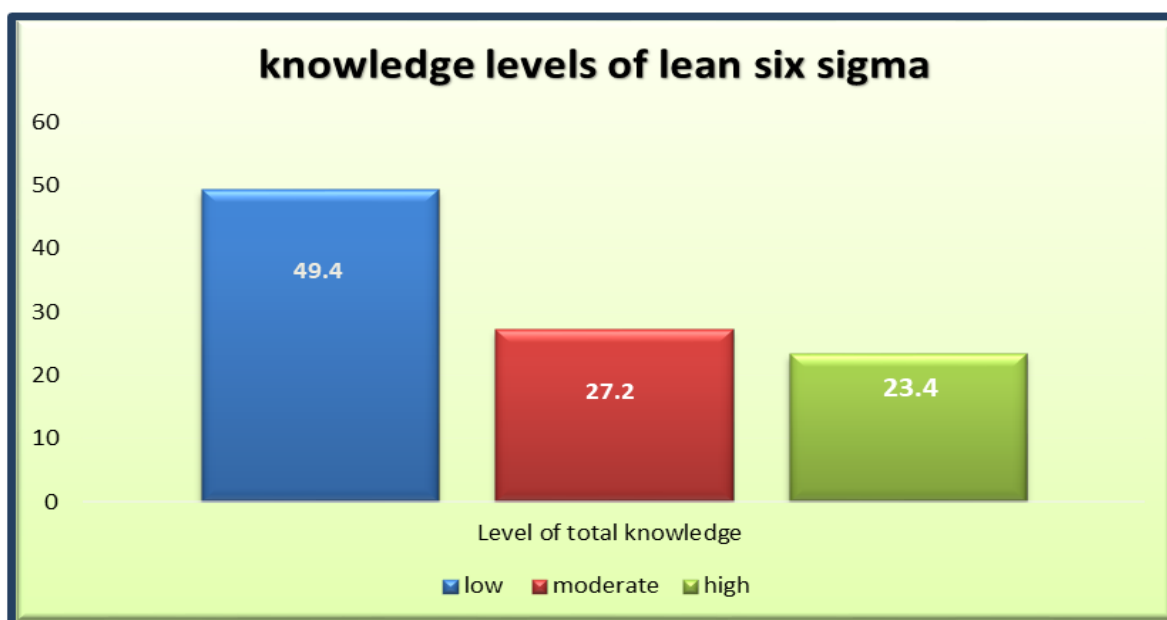
Figure (1): Percentage distribution of the studied nurses' levels of knowledge regarding lean six sigma in healthcare organization

Table (2): Mean, SD, Minimum, Maximum, and Cronbach's α of the studied nurses key area of knowledge regarding lean six sigma in healthcare organization (N=158).

Key Area of Knowledge	Mean (M)±SD	Mini	Max	Cronbach's α
Basic Concepts of Lean	7.2±1.3	4	10	0.82
Basic Concepts of Six Sigma	6.8±1.5	3	10	0.85
DMAIC Process Understanding	7.5±1.2	4	10	0.88
Tools and Techniques	6.7±1.6	3	10	0.81
Application in Healthcare	7.0±1.3	4	10	0.84
Change management	6.9±1.4	4	10	0.83
Total Knowledge Score	41.1±6.8	4	10	0.82

Figure (2): Percentage distribution of the studied nurses regarding healthcare organizational readiness levels of lean six sigma implementation

Table (3): Mean, SD, Minimum, Maximum, and Cronbach's α of the studied nurses of healthcare organizational readiness dimensions regarding lean six sigma implementation in healthcare organization (N=158).

Dimensions of readiness	Mean (M)±SD	Min	Max	Cronbach's α
Leadership Commitment	15.0±3.0	8	20	0.83
Cultural Readiness	16.0±3.2	9	22	0.85
Resources and Infrastructure	15.5±3.1	8	21	0.84
Training and Education	14.8±3.0	7	20	0.82
Communication and Collaboration	15.3±3.2	8	22	0.86
Current Processes and Systems	16.2±3.3	9	23	0.87
Total Readiness Score	92.8±18.8	49	128	0.91

Table (4): Correlation between personnel data and knowledge and readiness

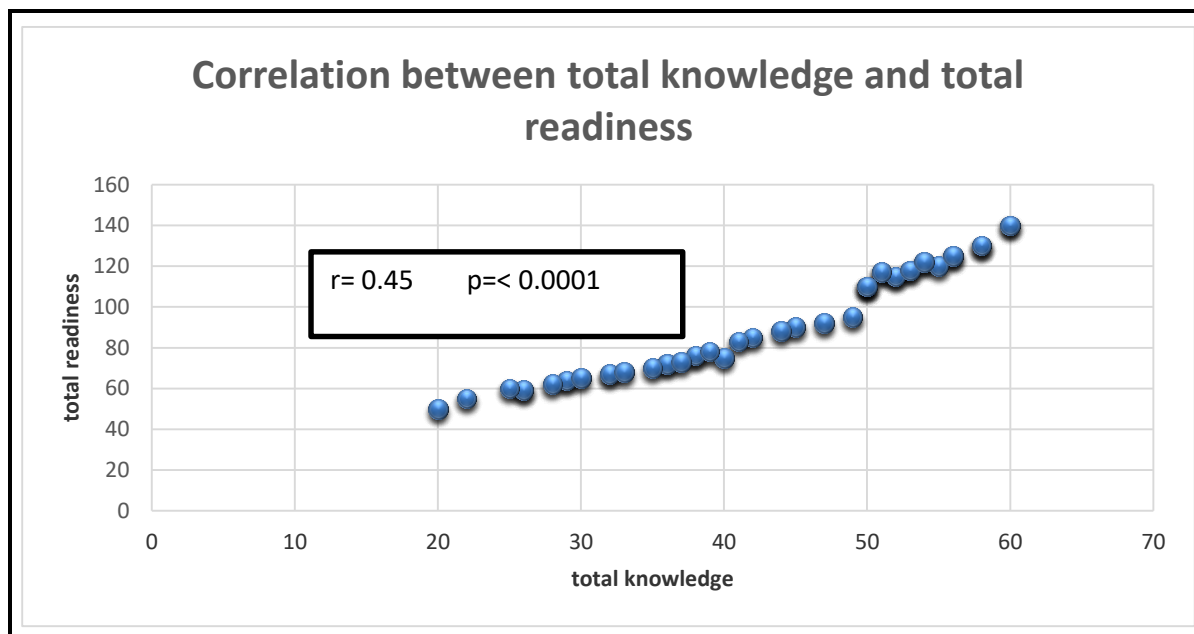| Sociodemographic Variable	Knowledge (r)	Knowledge (p-value)	Readiness (r)	Readiness (p-value)
Age Group	0.34	0.0001**	0.33	0.0002*
Gender	0.15	0.065	0.12	0.115
Educational Qualifications	0.30	0.0005*	0.32	0.0002*
Experience (Years)	0.32	0.0002*	0.35	0.0001*
Position in Hospital	0.29	0.0008*	0.31	0.0003*
Previous training	0.36	0.001*	0.28	0.003*

* Significant p <0.05

Figure (3): Correlation between total knowledge and total readiness regarding lean six sigma in healthcare organization

Table (1): Shows that near to half of nurses (48.8%) aged from 30-39 years. According to gender, more than half of them (58.2%) were females. Regarding educational qualifications, more than two thirds (69. 62%) have a bachelor's degree in nursing science . In relation to years of experience, (43.03%) have from 6-10 years of experience while (5.3%) have more than 15 years of experience. More than two thirds of them (67.72%) were staff nurses.

Figure (1): Reveals levels of knowledge regarding lean six sigma in healthcare organizations. Near to half of nurses (49.4%) had low knowledge level while (23.4%) had high level of knowledge.

Table (2): Depicts the higher mean score in keys areas of knowledge about lean six sigma was related to DMAIC Process understanding (7.5±1.2) while lower mean score was related to tools and techniques (6.7±1.6).

Figure (2): Displays readiness levels of LSS implementation in healthcare organizations. Above half of nurses (51%) perceived low readiness level while (22%) perceived a high level of readiness.

Table (3): Defines that the higher mean score in dimensions of healthcare organizational readiness about lean six sigma was related to current processes and systems (16.2±3.3) while lower mean score was related to training and education (14.8±3.0)

Table (4): Clarifies the correlation between personnel data and knowledge and healthcare organizational readiness. There was a statistically significant correlation between all personnel data and knowledge and healthcare organizational readiness at $p < 0.05$ except

gender, it has no correlation with knowledge and healthcare organizational readiness.

Figure (3): Displays the correlation between total knowledge and total readiness regarding lean six sigma in healthcare organization. There was a statistically positive significant correlation between knowledge regarding lean six sigma in healthcare organization and healthcare organizational readiness at r= 0.45 p=< 0.00.

Discussion:

Lean Six Sigma is a powerful approach for healthcare organizations aiming to improve quality, efficiency, and patient satisfaction. By combining the strengths of LSS, healthcare providers can address complex challenges, reduce waste, minimize variability, and continuously enhance their processes and outcomes. Implementing LSS in a healthcare organization requires high level of readiness to ensure successful adoption and sustainability.

The current study aimed to assess readiness of health care organization for lean six sigma implementation. Also, the researcher questions of the current study were formulated as the following: what is nurses' level of knowledge regarding lean six sigma? and what is healthcare organizational readiness level regarding lean six sigma implementation as perceived by nurses.

Concerning knowledge regarding lean six sigma in healthcare organization among the studied nurses, the present study revealed that, less than half of nurses have low level of knowledge while, less than one quarter of them have high level of knowledge. This result might be due to healthcare organizations do not provide sufficient

training or education on Lean Six Sigma methodologies. Also, ongoing professional development among nurses often prioritizes clinical skills and patient care over process improvement methodologies like Lean Six Sigma. This imbalance can lead to lower levels of knowledge in these areas.

The study findings were in the same line with the study by **Sethi & Joshi, (2020)** who conducted the study in India and studied "Knowledge and Attitude of Nurses Toward the Implementation of Quality Management Systems with Special Reference to Six Sigma". Further, who illustrated that, when compared to government organizations, almost one-third of private sector healthcare personnel scored poorly on knowledge assessments. Furthermore, compared to government organizations, under one quarter of healthcare professionals working in the private sector had high knowledge scores.

Regarding readiness levels of lean six sigma implementation in healthcare organizations, the present findings were stated that, more than half of nurses perceived a low level of readiness while, less than one quarter of them perceived a high level of readiness. This result could be related to insufficient support from management and leadership. Also, nurses often have high workloads and face significant stress in their roles. Adding the responsibility of implementing a new system may feel overwhelming, contributing to a perception of low readiness.

The present study results were in harmony utilizing the research by **Fathi et al., (2022)** who conducted the study in Egypt and studied " Nursing Staff Readiness regarding Utilization of Six Sigma of Quality Management in Critical Care Units", and who reveals that, above half of staff nurses had low level of readiness of six sigma of quality management, while under one quarter of participants had high level of readiness.

There was disagreement with the study's findings as the study by **Sreedharan & Sunder, (2018)** who conducted a study in India entitled "A novel approach to lean six sigma project management: a conceptual framework and empirical application, Production Planning & Control. They revealed that a sizable portion of employees stated that six sigma had stressed the significance of readiness assessment and assessed their level of preparedness for the implementation of LSS.

Additionally, these results were mismatched with the results of the investigation carried out by **Costa et al., (2023)** who conducted the study in New Zealand, entitled " Readiness Level Assessment for Lean Six Sigma Implementation in the Healthcare sector" and who stated that, "Average Ready" is the most often cited level among the nine institutions surveyed.

Concerning on correlation between personnel data and knowledge and healthcare organizational readiness, this particular study findings reported that there was no

correlation between gender and knowledge and healthcare organizational readiness. This result might be due to knowledge and readiness might be more closely tied to specific roles or positions within the organization rather than gender.

The present study findings were in agreement with the study by **Ciasullo et al., (2024)** who conducted the study in Italy entitled " Lean Six Sigma and quality performance in Italian public and private hospitals: a gender perspective", and who observed that the study subjects' perceptions of LSS and quality performance were not significantly impacted by their gender alone.

As regarding correlation between total knowledge and total readiness of lean six sigma in healthcare organization, the current study results were stated that, there was a statistically positive significant correlation between knowledge and healthcare organizational readiness at r= 0.45 p=< 0.000. the present study findings could be due to low level of knowledge and healthcare organizational readiness among the studied nurses which reflect the fact of low awareness and understanding of Lean Six Sigma principles could have contributed to a more negative attitude and readiness among healthcare professionals.

The current study's findings concurred with that of the investigation by **Mohamed et al., (2020)** who conducted the study in Egypt, who studied "Literature review about nursing personal readiness toward using lean management at selected hospitals", and who demonstrated that, among head nurses at two hospitals, there was a significantly substantial positive association between their overall knowledge and readiness items regarding lean management.

In addition, the findings of the current study were supported by **Abou hashish & Abdel aal, (2019)** who conducted the study in Egypt, who studied " Starting the lean journey: The effect of lean awareness on nurses' knowledge and readiness for lean transformation in the hospital", and who found that, after completing the training, there was a significant increase in the positive association between the nurses' overall knowledge of Lean and their preparedness for Lean transformation (r = 0.697, p <.001).

Conversely, the current study outcomes were opposed to the study by **Fathi et al., (2022)** who conducted the study in Egypt and studied "Nursing Staff Readiness regarding Utilization of Six Sigma of Quality Management in Critical Care Units", and who found no statistically significant correlation between preparedness and understanding regarding the six sigma of quality management.

Conclusion:
Based on the findings of the study, it was concluded that less than half of nurses have a low level of knowledge regarding lean six sigma and more than half of nurses

perceived a low level of readiness. Accordingly, there was a statistically positive significant correlation between knowledge regarding lean six sigma and healthcare organizational readiness regarding lean six sigma implementation at r= 0.45 p=< 0.0001.

Recommendations:

In light of the current study's findings, it was suggested that,

- Establish ongoing training and education sessions focused on LSS principles, methodologies, and practical applications.
- Integrate LSS principles and methodologies into the nursing and healthcare management curriculum.
- Create platforms for knowledge sharing and discussion among healthcare professionals, such as forums, webinars, and conferences, to facilitate the exchange of experiences and best practices in LSS.
- Ensure strong leadership commitment to Lean Six Sigma implementation.
- Implement robust performance monitoring and evaluation systems to track the progress and impact of LSS initiatives.
- Develop a clear communication strategy to keep all staff informed about LSS goals, initiatives, and successes.
- Further studies to evaluate the effectiveness of various training and educational interventions designed to improve Lean Six Sigma knowledge and readiness among healthcare staff.
- Investigate specific barriers and facilitators to LSS implementation in different healthcare settings.

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