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EFFECTIVENESS OF NURSE-INITIATED SONO TRIAGE TRAINING ON KNOWLEDGE, SKILL ACQUISITION AND LEARNING CURVE AMONG EMERGENCY NURSES: A QUASI-EXPERIMENTAL STUDY

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Abstract
Background: Timely trauma triage is essential for improving patient outcomes in emergency departments. Nurse-Initiated Sono Triage (NISt), integrating the Trauma Triage Protocol (TTP) with point-of-care ultrasound using the extended Focused Assessment with Sonography for Trauma (e-FAST), has the potential to enhance nurses' competency in early trauma assessment.
Objective: To evaluate the effectiveness of a Nurse-Initiated Sono Triage educational programme on emergency nurses' knowledge, skill acquisition, and learning curve.
Methods: A quasi-experimental one-group pre-test–post-test study was conducted among 30 emergency nurses at a tertiary care hospital in New Delhi between April and July 2024. Participants received a structured educational programme followed by simulation-based and supervised clinical training in NISt. Knowledge was assessed using a structured questionnaire, while competency was evaluated using standardized observation checklists. Each nurse performed 20 supervised Sono Triage assessments. Pre- and post-intervention scores were compared using paired *t*-tests, and competency progression was analysed using Linear Mixed Models.
Results: Significant improvements were observed in both knowledge and practical competency following the intervention. The mean Sono Triage knowledge score increased from 10.60 ± 3.21 to 18.53 ± 1.42 ($p < 0.001$). Trauma Triage Protocol skill scores improved significantly (4.966 ± 0.034 vs. 4.992 ± 0.010; $p < 0.001$). All Sono Triage skill domains, including probe handling, cardiac, right upper quadrant, left upper quadrant, pelvic, and e-FAST assessment, demonstrated statistically significant improvements ($p < 0.001$). The time required to complete Sono Triage assessments decreased significantly across repeated patient encounters, demonstrating progressive competency acquisition and an improved learning curve.
Conclusion: The Nurse-Initiated Sono Triage educational programme significantly enhanced emergency nurses' knowledge, technical skills, and efficiency in performing trauma ultrasound assessments. The findings support the integration of competency-based Sono Triage training into emergency nursing practice to strengthen early trauma assessment, facilitate timely clinical decision-making, and improve the quality of emergency care.

KEYWORDS: Nurse-Initiated Sono Triage; Emergency Nursing; Trauma Triage Protocol; e-FAST; Point-of-Care Ultrasound (POCUS); Skill Acquisition; Knowledge Assessment; Learning Curve; Emergency Department; Quasi-Experimental Study.

INTRODUCTION

Emergency departments worldwide are experiencing increasing patient overcrowding, resulting in delays in trauma recognition and timely intervention. The Trauma Triage Protocol (TTP) used in the study was used from the AIIMS Triage Protocol, which was developed and validated by experts working at AIIMS, Delhi (Singh et al., 2022). Nurse-Initiated Sono triage (NISt) was developed by the researcher by integrating the principles of point-of-care ultrasound (POCUS), e-FAST examination, and existing trauma triage practices used in emergency care settings. In emergency care, the concept of the “Golden Hour” stresses the importance of early identification and prompt management within the first hour following injury (Almutawa et al., 2025; Yaqoob et al., 2025). More than 30 years, triage systems have been developed to assist healthcare professionals in making rapid and appropriate decisions by prioritizing patients according to illness severity, particularly in emergency and trauma settings (Pontisidis et al., 2024). Effective trauma care depends largely on timely clinical decision-making and accurate triaging based on the patient’s condition and severity (Dagur et al., 2023).
Some literature findings emphasised that quality of emergency care, reduce delays that contribute to better patient outcomes by the use of the structured triage educational training (Shawah'en et al., 2024). The triage nurses must possess

adequate knowledge and practical competency to accurately determine patient acuity and prioritize treatment (Culley & Svendsen, 2014; Emergency Nurses Association [ENA], 2019). It is critical to ensure that for appropriate triage decisions and safe patient management the nurses must possess knowledge and triage skills (Phukubye et al., 2021). The quality of emergency nursing care is deeply shaped by how competent nurses are and how familiar they remain with established emergency protocols (Kerie et al., 2018). Previous studies have consistently highlighted a strong positive link between nurses' knowledge, their practice, and the overall standard of triage-related emergency care (Rippey & Royse, 2009).

In recent years, the Extended Focused Assessment with Sonography for Trauma (e-FAST) has gained recognition as a rapid bedside diagnostic tool in trauma care, offering a valuable complement to conventional imaging methods (Mumoli et al., 2026). While ultrasound has traditionally been the domain of physicians, task-shifting approaches have shown that trained nurses can safely and effectively carry out protocol-based ultrasound examinations. Nurse-led triage systems are already helping streamline patient flow, and similarly, nurse-performed ultrasound has the potential to support clinicians by improving diagnostic accuracy and optimizing resource use—particularly during peak hours or when routine imaging is unavailable (Bella et al., 2025).

The broader impact of ultrasound on treatment decisions, hospital stays, and patient survival remains less clearly defined, however there are reports in some instances where diagnoses were quicker. Challenges such as poor image acquisition, misinterpretation, or weak integration into clinical decision-making can limit its effectiveness. In India, despite global progress, nurse-performed e-FAST is still rarely implemented, largely due to the absence of structured training programmes and limited evidence on feasibility. This underscores the need for well-designed training to ensure safe and effective clinical use (Abrokwa et al., 2022).

Point-of-care ultrasound (POCUS) is now being used by a wide range of healthcare professionals across different systems and practice models. Evidence suggests that accurate interpretation of POCUS plays a crucial role in enhancing patient management and ultimately contributes to better clinical outcomes (Thomas et al., 1997).

Integration of the Sono triage into nursing practice is not intended to replace the physician- led diagnosis or the conventional method of triaging. Instead, it offers an additional source of relevant clinical information about trauma patients and leads to prompt management. The present article focuses on the nurse's knowledge and skill acquisition after the intervention the Nurse-initiated Sonotriage Educational programme and supervised hand-held assistance for performing the Sono triage. A preliminary pilot study conducted at the same institution demonstrated the feasibility of the educational programme, which also revealed improvements in nurses' knowledge, practical skills, and triage competency. The pilot study was not intended to assess competency growth during repeated clinical practice or to thoroughly investigate learning progression using longitudinal analytical techniques, even if those results showed proof of concept. By assessing the educational program in a larger cohort of emergency nurses and looking at competency development through repeated supervised patient evaluations assessed using Linear Mixed Models, the current inquiry serves as the primary study and expands on previous work.

The results of this study should add to the increasing body of data in favour of competency-based educational interventions in emergency nursing and could offer a useful framework for various institutions.

MATERIAL AND METHODS

Study Design and Setting

This study used a quasi-experimental one-group pre-test–post-test design and was conducted in the Emergency Department of a tertiary care hospital in New Delhi. It represents the main phase of a larger research project on Nurse-Initiated Sono Triage (NISt) and builds on a previously published pilot study conducted in the same setting. The pilot study provided initial evidence regarding the feasibility and potential effectiveness of the intervention. The present study was undertaken with a different group of participants and a larger sample to further examine and strengthen the earlier findings.

The findings presented in this manuscript are drawn from the main study evaluating the effectiveness of Nurse-Initiated Sono Triage (NISt) among emergency nurses. Although the overall study included several outcomes, this paper focuses specifically on nurses' knowledge, skill development and learning progression following the training programme. The results reported here are distinct from those presented in the pilot study and provide additional evidence on the effectiveness of the intervention in a larger sample.

The objectives of the present study were:

1. To prepare a module on Nurse-Initiated Sono triage (NISt)supported by educational programme
2. To assess the pre- and post-intervention knowledge of the nurses regarding NISt and the Trauma Triage Protocol (TTP).
3. To assess the pre- and post-intervention skills of the nurses regarding NISt and the Trauma Triage Protocol (TTP).

Secondary objective

4. To determine the learning curve and proficiency attainment of nurses performing Nurse-Initiated Sono Triage during clinical practice.

Study Population and Sampling

In the present study, the target population comprised patients and Nurses of the Emergency department of a Tertiary Care Hospital, New Delhi. The accessible population among patients was those triaged to the yellow area, and for nurses, those posted in the yellow area.
For Nurses, the sampling technique used was Total Enumeration. For patients, it was consecutive sampling technique was used to select the patients admitted in the yellow area after triaging in the emergency department who met the inclusion criteria.
For the sample size estimation of the nurses it was drawn from the pilot study findings, the knowledge scores improved from a pretest mean of 16.3 (SD = 2.9) to a post-test mean of 20.9 (SD = 2.0), resulting in a large intervention effect size. Furthermore, an equivalent point-of-care ultrasound education research among nursing practitioners indicated that a minimum of 32 subjects was needed based on alpha 0.05, power of 80%, and medium effect size. During this period, there were only 30 eligible emergency nurses and hence all eligible nurses available during the study period were surveyed (total enumeration).
For the patient level outcomes, the sample size was determined by the Under-triage rates. The pilot Sono triage study showed an under-triage rate of 3% after the intervention, while previous emergency triage literature suggested under-triage rates of about 8%. The minimum necessary sample size was calculated to be roughly 325 patient contacts per phase, assuming a decrease in under-triage from 8% to 3%, a two-sided significance level of 0.05, and statistical power of 80%. With 600 patient interactions in the pretest phase and 600 in the post-test phase (a total of 1,200 patient encounters), the current study met the projected minimum criterion and had sufficient power to assess improvements in triage performance.

For Sono triage Practice Exposure
Based on expert recommendations of the Emergency medicine dept, and previous literature findings by Bhoi et al. (2013), 20 supervised positive and negative e-FAST scans for free fluid for the patients per participant was required to achieve competency in the procedure. Accordingly, each nurse performed trauma triage protocol and e-FAST (Sonotriage) assessments on 20 patients. With 30 nurses included, the total sample comprised 600 patient observations (30 × 20), selected using a consecutive sampling technique.
$30 \times 20 = 600$

Development Of Nurse-Initiated Sono Triage Module
A module on Nurse-Initiated Sono triage was developed through an extensive literature review, expert consultation, and emergency ultrasound guidelines. It included the details of the e-FAST machine, machine knobology, probe handling, image acquisition, interpretation of findings, and different views. i.e., cardiac view, right upper quadrant view, left upper quadrant view, pelvic view and e-FAST. The module was also validated by the experts and the CVI was found to be 0.90. This was done by the researcher by delivering an education programme with the help of a powerpoint focusing on trauma triage principles, SonoTriage concepts, ultrasound physics, image optimization, anatomical landmarks, interpretation of sonographic findings, and clinical decision support.
This was followed by a skill-based training of the nurses on the standardized patient, allowing them to practice probe handling, image acquisition, standard scanning protocols, and interpretation of images.
Supervised clinical practice after the demonstration of the skill. In this, the nurse performed Nurse-Initiated Sono Triage examinations on trauma patients under the supervision of the researcher receiving immediate feedback to reinforce learning and improve performance.
Competency assessment was also done using structured observational checklists to evaluate knowledge application, technical performance, image acquisition, interpretation, communication, and procedural consistency throughout the programme.

Data Collection Tools
Four instruments were used for data collection. The first instrument was a structured questionnaire to capture the demographic profile of patients and Nurses, including age, gender, academic qualifications, years of experience and any previous training on e-FAST. For patients, the same information was asked along with their profession, area of residence, chief complaints, and triage category as per the Trauma triage protocol and Nurse-initiated Sono triage.
The second instrument was a Structured Knowledge questionnaire of the nurses developed by the researcher. It comprised 30 multiple-choice questions on triage and Sono triage. 10 items are related to triage, and 20 items are related to Sono triage. It took around 15-20 minutes to complete the questionnaire. The scoring of the knowledge was based on Bloom's cut-off points, which were followed to categorize the overall scores of knowledge and skill items as good (80-100%), fair (60-79%), and low (≤59.0%), respectively.
The third instrument was the Observation Checklist for Trauma Triage Protocol to assess the nurses' skill competency on performing triaging as per the Trauma triage protocol. The trauma triage protocol comprises 2 categories, including 17 items related to the clinical profile of the patients: Date, time, clinical history, clinical indication, vital signs, triage area and reason for triaging in a particular area. The other portion consisted of questionnaire related to trauma triaging: able to independently assess the patient, able to identify the physiological parameters (red, yellow, green), able to identify anatomical injuries, able to identify the mechanism of injury, able to categories the patient to red, yellow and green correctly, re-evaluates the patient (if necessary), able to re-triage the patient (if needed), mentions injuries identified, able to do CCT. These items were assessed using a 2-point scale where "No" was denoted as 0, and " Yes " as 1.
The fourth instrument was an Observation checklist for nurse-initiated Sono triage. It was a self-developed structured checklist, divided into 6 domains, to assess nurses' skills in performing Sono triaging. It is a checklist that has an evaluation

scale ranging from 1 to 5 where 1=not able to identify, 2=identified with unsatisfactory technique, 3=identified with satisfactory technique, 4= identifies with good technique, 5=identified with very good technique. The level of skill scoring for Sono triage was based on Bloom's Taxonomy, with Excellent (90-100%), Very Good (75-89%), Good (60-74%), Fair (40-59%), Poor (<40%).

These tools were developed through an extensive literature review, expert guidance, and the researcher's experience. Content validity was established using Lawshe's Content Validity Ratio (CVR) method, with eleven experts rating each item as "essential" or "not essential." Items scoring below the CVR threshold of 0.78 were revised or excluded. The Content Validity Index (CVI) was 0.82 for the demographic proforma, 0.80 for the knowledge questionnaire, 0.85 for the structured observation checklists, and 0.85 for the acceptability questionnaire, indicating acceptable to good content validity.

A pilot study was conducted on 15 nurses and 150 patients, to ensure reliability of the tool and the feasibility of the study in the month of October to November 2023. The sample of pilot study was nurses from AIIMS Jammu who were posted in AIIMS, Delhi for a 6-month duration.

Educational Intervention: Nurses finished the baseline knowledge assessments and skill assessment before the intervention. The organized curriculum was then followed in the delivery of the educational program. After completing simulation-based training and theoretical instruction, nurses moved on to the supervised clinical phase, where each nurse conducted Nurse-Initiated Sono Triage assessments on twenty trauma patients under the supervision of the researcher

After every supervised examination, immediate formative input was given to boost clinical decision-making, improve picture interpretation, and reinforce proper scanning practices. After completing the training, the nurses were evaluated utilising standardized competency assessment techniques and the same knowledge questionnaire.

Outcome measures

Changes in knowledge and skill proficiency after completing the educational program were the main results. While skill competency was assessed using structured observational checklists that evaluated preparation, probe handling, scanning technique, image acquisition, interpretation of sonographic findings, and communication of examination results, knowledge was measured using a knowledge questionnaire developed by the researcher.

Acquiring competencies through repeated supervised clinical practice was the secondary goal. Each nurse's performance on 20 supervised patient assessments was analyzed to determine competency progression.

Data Collection Procedure

Data collection was conducted between March and August 2024 in the Emergency Department of a Tertiary Care Hospital, New Delhi. The Ethical permission to conduct the study was obtained from the Institutional Ethics Committee of AIIMS, New Delhi, Ref No.IEC-994/13.01.2023, RP-37/2023, OP-3/16.05.2023. The researcher underwent comprehensive training in performing Ultrasonography and e-FAST. The ultrasound machines used in this study were Ultrasound Model M Turbo with curvilinear C5-1 and linear L12-3 MHz transducers during the training phase and during data collection. The research also got a competency certificate for the same.

Before the administration of the intervention, permission was obtained from the Head of the Emergency Dept, the Nursing Superintendent and the Nursing Supervisor of the Emergency Dept. Duty rosters were obtained, and shift-wise duty allocation was discussed with the Nursing Supervisor. The study subjects, i.e., nurses and the patients fulfilling the sampling criteria were identified for the study. They were informed about the purpose of the study and the potential benefits of the Sono triage on nurses' knowledge, skills. The study subjects were informed about their right to autonomy to leave the study at any point in time, and about ensuring the confidentiality of information. The study subjects, i.e., nurses working in the yellow area of the emergency dept were contacted, and they were informed about the research study and its objectives. The written consent for participation was taken from them. The nurses were then oriented about the knowledge questionnaire and module, followed by the pre-knowledge assessment, that is, the number of items in it, details of each item, and instructions regarding information to be filled in the questionnaire. Pretest knowledge assessment was done on Day 1. The nurses were divided into 3 groups with each group having 5 nurses from the morning shift and 5 nurses from the evening shift. It took 15-20 minutes to fill the knowledge questionnaire.

This content was delivered in the form of a lecture to the nurses divided as per group. The session was delivered for 1 hour with the help of a PowerPoint presentation, followed by discussion and doubt clarification. They were also provided with the printed copies of the module after the session.

The Ultrasound machine was calibrated, and the machines used in this study were Ultrasound Model M Turbo with curvilinear C5-1 and linear L12-3 MHz transducers. From morning shift, 5 nurses and evening shift 5 nurses were taken for the pre intervention skill assessment. These nurses had to take 10 patients each for the assessment for both triaging and Sono triaging three alternate days in a week.

Patients fulfilling the sampling criteria were identified for the study. Patients were informed about the purpose of the study and the potential benefits of the Sono triage on nurses' knowledge, skills and patients' outcomes. Patients were informed about their right to autonomy to leave the study at any point in time, and about ensuring the confidentiality of information. Patients coming to the emergency was directed to the triage counter for categorization according to severity of illness. Patients were triaged at the Triage counter using the Trauma Triage Protocol by the nurse. The same patient is tracked in the yellow area after 10 mins of admission for performing an ultrasound (Sono triage). If the patient is FAST positive, he/she is immediately re-triaged into Red Category or Red area for prompt intervention. The patient was triaged as per the Trauma Triage Protocol. The nurses were asked to perform supervised positive and negative e-FAST scans for free fluid in a patient. They were observed while performing the procedure with the help of an observation checklist for both

trauma triaging and Sono triaging. The pre-intervention skill assessment took about 10 minutes for each nurse. The triaging of the patient by the nurse was done by the Trauma triage Protocol and was assessed in the Triage counter by the researcher with the help of an observation checklist. Same patient was reassessed by the nurse after 10 minutes of admission in the yellow area. The nurses performing Sono triaging were observed with the help of an observation checklist. The pre-intervention skill assessment took about 10-12 minutes for each nurse for both triaging and Sono triaging

For the Skill training on Triage and Sono triage, the nurses were divided into morning shift and evening shift with 5 nurses from each shift with 10 patients each. These nurses had to perform return demonstration of Sono triaging/ e-FAST followed by the procedure demonstration by the researcher. On a standardized patient, the researcher demonstrated the steps of performing the e-FAST. It took around 15-20 minutes to demonstrate the machine, including machine knobology, probe handling, image acquisition, interpretation of findings, and different views. i.e., cardiac view, right upper quadrant view, left upper quadrant view, pelvic view and e-FAST. The nurses performed the return demonstration on the patient's bedside. Following the pre-test knowledge and skills assessment, the nurses simultaneously had to practice performing Sono triaging to gain competency and skill acquisition.

The nurses had to practice Sono triaging for 20 patients as per the recommendation from previous literature findings (Bhoi et al. 2013). The researcher supervised and observed a minimum of 5 patients for each nurse in a day and clarified their query. Each nurse took about 10-15 minutes while practice session to perform the Sono triaging for Positive or Negative free fluid extended Focused Assessment for Sonography in Trauma (e-FAST scans). Since triaging according to the Trauma Triage Protocol was a routine activity in the emergency department at JPNATC, AIIMS, the nurses continued to perform it.

The post-intervention knowledge assessment was initiated from Day 14 onwards. The nurses were again assessed for their skills related to Trauma triage protocol and Nurse Initiated Sono triage using the same structured tools used during the pre-intervention skill assessment. The assessment for the nurses was done as per the group allotment of the nurses. The nurses gave the post-test knowledge on Day 14. The nurses took around 15-20 minutes to complete the questionnaire.

For the observation of post-intervention skill assessment, 5 nurses from morning shift and 5 nurses from evening shift had to take 10 patients during their shift. They had to do both post-skill assessment in front of the researcher. The day of the assessment was considered as Day 14 for their assessment. 1 nurse performs the procedure for 10 patients each. The triaging of the patient by the nurse was assessed in the Triage counter by the researcher with the help of an observation checklist. After the admission of the patient in the yellow area, after 10 minutes the nurses reassess the patient by performing e-FAST. Each nurse performs supervised positive and negative e-FAST scans for free fluid for patients in each shift in the presence of the researcher and is assessed by an Observation checklist. The researcher was not blinded during the post-intervention assessment, as there was uncertainty regarding the criteria employed by the assessors to evaluate skill performance. This lack of blinding may have introduced potential bias in the outcome assessment.

Ethical Consideration

Ethical permission was obtained from the Institute Ethics Committee, All India Institute of Medical Sciences (AIIMS), New Delhi, India with reference number IEC-994/13.01.2023, RP-37/2023, OP-3/16.05.2023, on 18th May 2023.

RESULTS

Descriptive statistics were used to summarize nurses and patient's sociodemographic profile. Continuous variables were expressed as mean ± standard deviation, while categorical variables were presented as frequencies and percentages.

The normality of continuous data was assessed before inferential analysis. Pre- and post-intervention knowledge and competency scores were compared using the paired t-test. Changes in competency across repeated supervised clinical assessments were examined using descriptive trend analysis and graphical representation.

To account for the repeated measurements obtained from individual participants and the correlation between observations, competency progression was further analyzed using a Linear Mixed Model (LMM). The model included assessment sequence as a fixed effect and participant as a random effect, allowing estimation of the overall learning trajectory while accounting for between-participant variability. A two-sided p-value of <0.05 was considered statistically significant.

The study assessed the characteristics of the nurses and the patients. Table 1 represents the following demographic characteristics of the nurses.

Table 1: Sociodemographic profile of the nurses (N = 30).

Sl. No	Demographic	Frequency	Percentage
1	Age in years		
	20-25	8	26.7
	26-30	14	46.7
	31-35	6	20.0
	35-40	2	6.7
	>40 years and above	0	0.0
	Mean ± SD	28.2 ± 4.6	
2	Gender		
	Male	9	30.0
	Female	21	70.0

3	Educational qualifications		
	Post graduate and above	3	10.0
	B.Sc. Nursing	21	70.0
	Post basic B.Sc. Nursing	2	6.7
	Diploma nursing	4	13.3
4	No. of years working in emergency Department		
	1-5 years	26	86.7
	6-10 years	2	6.7
	11-20 years	2	6.7
	>21 years $ above	0	0.0
	Mean ± SD	4.2 ± 3.5	
5	Have you received any training in performing e-FAST?		
	Yes	3	10.0
	No	27	90.0

A total of 30 nurses were included in the study. The mean age of the nurses was 28.2 ± 4.6 (Mean ± SD). Most of the nurses were female (70%) and were graduates. (86.7%) had 1–5 years of experience in the emergency department. The average years of experience of the nurses were 4.2 ± 3.5 (Mean ± SD). Only 10.0% of the nurses reported having undergone such training.

Table 2: Sociodemographic characteristics of patients pre- and post-intervention (skill) N=600

Sl. No.	Demographic Variable	Category	Pre-test f (%)	Post-test f (%)	χ^2	p-value
1	Age (years)	25	117 (20)	127 (21)	0.42	0.98
		26–30	96 (16)	93 (15.5)		
		31–35	73 (12)	70 (12)		
		36–40	114 (19)	111 (18.5)		
		>40	200 (33)	199 (33)		
		Mean ± SD	34.8 ± 6.7	34.6 ± 7.1		
2	Gender	Male	481 (80.6)	484 (80.3)	0.02	0.89
		Female	116 (19.4)	119 (19.7)		
3	Marital Status	Single	117 (19.5)	122 (20.3)	6.8	0.033*
		Married	471 (78.5)	473 (78.8)		
		Divorced/Separated	12 (2.0)	5 (0.8)		
4	Educational Qualification	Postgraduate & above	32 (5.3)	32 (5.3)	4.2	0.52
		Diploma & Graduate	93 (15.5)	96 (16)		
		High school	119 (19.8)	116 (19.3)		
		Middle school	187 (31.2)	187 (31.2)		
		Primary school	47 (7.8)	47 (7.8)		
		Illiterate	27 (4.5)	26 (4.3)		
5	Profession	Government service	36 (6.0)	38 (6.3)	1.9	0.59
		Private service	286 (47.7)	285 (47.5)		
		Self-employed	129 (21.5)	130 (21.7)		
		Unemployed	149 (24.8)	147 (24.5)		
6	Area of Residence	Urban	523 (87.2)	524 (87.3)	0.01	0.92
		Rural	77 (12.8)	76 (12.7)		

S: significant at p < 0.05; NS: not significant at p < 0.05.

As seen in Table 2, the demographic characteristics of the patients were largely comparable in the pre-test and post-test groups. Age distribution was balanced with most of them falling over the 40 years of age, and the mean age of 34.8 ± 6.7 and 34.6 ± 7.1 years respectively, showing no significant difference (χ^2=0.42, p=0.98). The gender composition had a stable proportion in pre and posttest with predominantly male (≈80%, χ^2=0.02, p=0.89). Marital status showed a statistically significant difference (χ^2=6.8, p=0.033) as the divorced/separated patients declined in the posttest from 2.0% to 0.8%. The educational qualification showed no variation (χ^2=4.2, p=0.52). Almost half of the participants were working in the private sector (~48%) followed by unemployed (~25%), self-employed (~22%) and working in a government sector with no significant difference (χ^2=1.9, p=0.59). most of the patients were from the urban area (~87%) and consistent across the groups (χ^2=0.01, p=0.92). Overall, the demographic variables showed homogeneity except for marital status.

Table 3: Comparison of mean triage knowledge scores in pre-test and post-test N=30

Knowledge Test	Mean	Standard Deviation (SD)	Mean Difference	t value	p value
Pre-test	7.87	1.01	1.86	9.52	<0.001* (S)
Post-test	9.73	0.45			

Table 3 indicates a clear improvement in triage knowledge after the intervention. The average score was higher in the post-test than in the pre-test, and the low p-value shows that this change was unlikely to be due to chance. In simple terms, the intervention had a positive effect on the participants' knowledge.

Table 4: Mean, Standard deviation, mean difference & paired t-test of pre-test & post-test Sono triage knowledge among the nurses. N=30

Knowledge Test	Mean	SD	Mean Difference	t value	p value
Pre-test	10.60	3.21	7.93	14.16	<0.001* (S)
Post-test	18.53	1.42			

Table 4 presents the comparison of the Sono triage knowledge scores before and after the intervention among the nurses. The mean pre-test knowledge score was 10.60 ± 3.21, indicating a moderate level of baseline knowledge with relatively higher variability among the nurses. Following the intervention, the mean post-test score increased substantially to 18.53 ± 1.42, reflecting not only an improvement in knowledge but also a more consistent performance, as evidenced by the reduced standard deviation.

The mean difference of 7.93 highlights a considerable gain in knowledge after the intervention. This improvement was found to be statistically highly significant, with a t-value of 14.16 and a p-value < 0.001. These results indicate that the observed increase in knowledge scores is unlikely to have occurred by chance.

Overall, the findings suggest that the intervention was highly effective in enhancing the knowledge level of the nurses. The reduction in variability in post-test scores further implies that the intervention helped standardize understanding across the group.

Table 5 Mean, Standard deviation, mean difference and paired t-test of the pre and post intervention Trauma Triage protocol Skill Scores (TTP) among Nurses N=30

Assessment Phase	Mean	SD	Mean Difference	t-value	p-value
Pre-intervention (Triage)	4.966	0.034	+0.026	4.82	<0.001* (S)
Post-intervention (Triage)	4.992	0.010			

S: significant at p < 0.05; NS: not significant at p < 0.05.

Table 5 shows a significant increase in the triaging skills after the intervention. There was an increase in the mean score from 4.966 (SD = 0.034) to 4.992 (SD = 0.010). The t value of 4.82 (p < 0.001) suggests that the improvement was highly significant. The reduction in the standard deviation indicates that the nurses had greater consistency showing that the intervention enhanced their performance and standardized the skill levels.

Table 6: Linear Mixed-Effects Model of Trauma Triage protocol (TTP) skill scores pre- and post-intervention among nurses N=30

Domain	Pre-test (Mean ± SD)	Post-test (Mean ± SD)	Fixed Effect β (Post–Pre)	SE	z value	95% CI	p value
Triage Skill	4.966 ± 0.034	4.992 ± 0.010	+0.026	0.005	4.82	0.015 to 0.037	<0.001* (S)

S: significant at p < 0.05; NS: not significant at p < 0.05.

As shown in Table 6, a linear mixed-effects model (LMM) was used to assess the repeated measures for the nurses, pre and post intervention of the Trauma Triage Protocol (TTP). The repeated measures created a correlated observations within individuals for the same group of nurses at multiple time points. The mean score increased from 4.966 ± 0.034 to 4.992 ± 0.010 which indicated improved triage performance. The fixed-effect estimate (β = +0.026, SE = 0.005, z = 4.82) confirmed a statistically robust positive effect, with a 95% confidence interval of 0.015–0.037 and p < 0.001. There was ceiling effect as the change was small, however the modest increase shows an improvement. Therefore, the LMM analysis reflected an improvement in the TTP skills after the intervention.

Table 7: Mean, Standard deviation and paired t-test of Pre- and Post-Intervention Sono triage Skill Assessment Scores Across Domains among nurses N=30

Domain	Pre-test (Mean ± SD)	Post-test (Mean ± SD)	Mean Difference	t value	p value
Probe Skill	13.01 ± 0.66	26.17 ± 2.05	+13.17	32.82	<0.001*
Cardiac Skill	6.36 ± 1.40	15.54 ± 1.89	+9.18	17.03	<0.001*
Right Upper Quadrant Skill	10.93 ± 2.41	24.15 ± 1.91	+13.21	22.36	<0.001*
Left Upper Quadrant Skill	4.90 ± 0.72	15.98 ± 1.06	+11.08	20.62	<0.001*
Pelvic Skill	2.29 ± 1.42	8.04 ± 0.76	+5.75	19.59	<0.001*
EFAST Skill	4.18 ± 0.95	10.79 ± 1.00	+6.61	23.58	<0.001*

S: Significant at p < 0.05; NS: not significant at p < 0.05.

Table 7 depict the domain wise comparison of the Sono triaging skill scores pre and post intervention. It can be seen that there was a consistent and significant improvement in almost all the domains. In the probe skill domain, the mean score increased from 13.0±0.66 to 26.17± 2.05, with a mean difference of 13.17 (t=32.82, p<0.001). There was an improvement in the cardiac skills from 6.36 ± 1.40 to 15.5 ± 1.89 (mean difference = 9.18, t = 17.03, p < 0.001), an increase in the skills related to the right upper quadrant from 10.9 ± 2.41 to 24.15 ± 1.91 with a mean difference 13.21, t = 22.36, p < 0.001. The left upper quadrant skills also showed a notable rise from 4.90 ± 0.72 to 15.98 ± 1.06 with a mean difference of 11.08, t=20.62, p<0.001. The pelvic skills showed an increase form 2.29 ± 1.42 to 8.04 ± 0.76 with a mean difference of 5.75, t = 19.59, p < 0.001. The e-FAST skills rose from 4.18 ± 0.95 to 10.8 ± 1.00 with a mean difference of mean difference = 6.61, t =23.58, p < 0.001

It can be seen that the nurses were good in all the domains and showed a significant improvement after the intervention. It clearly depicted the development of the nursing skill competency in performing the Sono triaging. Based on Bloom's Taxonomy, nurses' Sono-triage competency levels before and after the intervention were interpreted as Excellent (90–100%), Very Good (75–89%), Good (60–74%), Fair (40-59%) and Poor (<40%)

Table 8: Linear mixed-effects model comparing pre-test and post-test scores of Sono-triage skills and time across different domains among nurses. N=30

Domain	Fixed Effect β (Post–Pre)	SE	z value	95% CI	p value
Probe Skill	+13.17	0.39	34.02	12.41 to 13.92	<0.001*
Cardiac Skill	+9.18	0.42	21.72	8.35 to 10.00	<0.001*
Right Upper Quadrant Skill	+13.21	0.55	23.92	12.13 to 14.30	<0.001*
Left Upper Quadrant Skill	+8.78	0.43	20.62	7.94 to 9.61	<0.001*
Pelvic Skill	+5.75	0.29	19.93	5.19 to 6.32	<0.001*

EFAST Skill	+6.61	0.25	26.72	6.13 to 7.09	<0.001*
Cardiac Time	−3.47	0.13	−27.44	−3.72 to −3.22	<0.001*
Right Upper Quadrant Time	−3.61	0.14	−25.79	−3.88 to −3.34	<0.001*
Left Upper Quadrant Time	−3.77	0.13	−28.81	−4.03 to −3.52	<0.001*
Pelvic Time	−3.82	0.13	−29.42	−4.07 to −3.56	<0.001*
Total Time	−16.04	0.53	−30.45	−17.07 to −15.00	<0.001*

significant at p < 0.05; NS: not significant at p < 0.05.

Table 8 presents the findings of the Sono triage skill and time scores across different assessment domains using the linear mixed-effects model, pre-test and post-test. Following the skill training intervention, a significant improvement was seen in all of the skill domains. For probe handling, there was a rapid increase (β=+13.17, z=34.02, p<0.001). For Cardiac, and abdominal skills are improved markedly (Cardiac β=+9.18, RUQ β=+13.21, LUQ β=+8.78, all p<0.001). pelvic assessment and e-FAST skills also showed strong improvements (β=+5.75 and β=+6.61 respectively, both p<0.001). All of these findings indicated a positive effect of the intervention on the skill acquisition and competency with a statistically significant improvement of (p < 0.01). The precision and reliability of the estimates could be observed by the relatively narrow confidence interval, reflecting the improved competency among the nurses.

With the regard to time performance, there was a substantial reduction in the time to complete the Sono triaging. For Cardiac time, it decreased by 3.47 units (z=−27.44, p<0.001), RUQ time by 3.61 units (z=−25.79, p<0.001), LUQ time by 3.77 units (z=−28.81, p<0.001), and pelvic time by 3.82 units (z=−29.42, p<0.001). Most notably, total time dropped by 16.04 units (z=−30.45, p<0.001). The negative β coefficients indicate that the time taken to complete each component of the Sono triage assessment significantly decreased after the intervention.

Overall, the above findings are suggestive of significant improvement in both skills and time following the intervention. The nurses were able to correctly assess and identify the free fluid presence or absence during the ultrasonographic assessment.

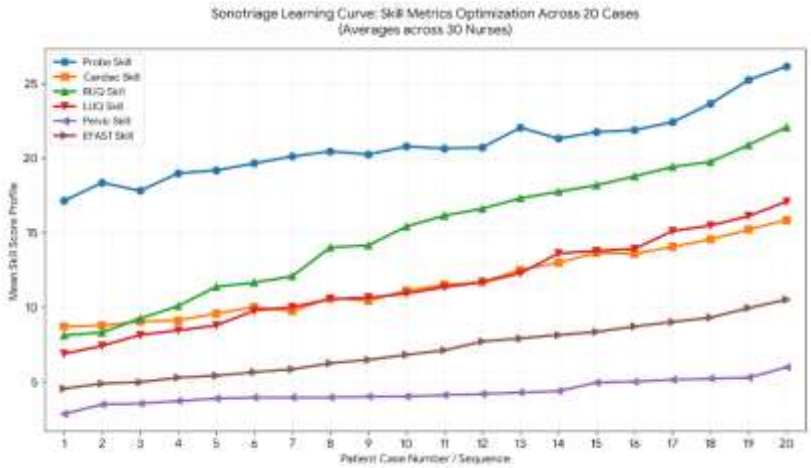

Figure 1: Mean skill score progression across 20 patient cases for probe, cardiac, RUQ, LUQ, pelvic, and EFAST domains (n = 30 nurses).

Figure 1 illustrates the of nurses' Sono triage skills learning curve across 20 patient assessments. Following the skill training intervention, a significant improvement was seen in all of the skill domains. For probe handling, there was a rapid increase from 13.0 ± 0.66 to 26.2 ± 2.05, with a mean gain of 13.20 points. For Cardiac, the skill improvement was noted as +9.18, likewise in right upper quadrant it was +13.22, left upper quadrant assessment +8.78, pelvic assessment +5.75, and overall e-FAST performance +6.61. All of these findings indicated a positive effect of the intervention on the skill acquisition and competency with a statistically significant improvement of (p < 0.01).

The learning curve generally follows the typical pattern of skill acquisition, with rapid improvement in the early stages of training, and gradual refinement of skills as experience increases. These findings suggest that Nurse-Initiated Sono triage can be effectively learned and implemented by emergency nurses through formal hands-on training and repeated clinical practice.

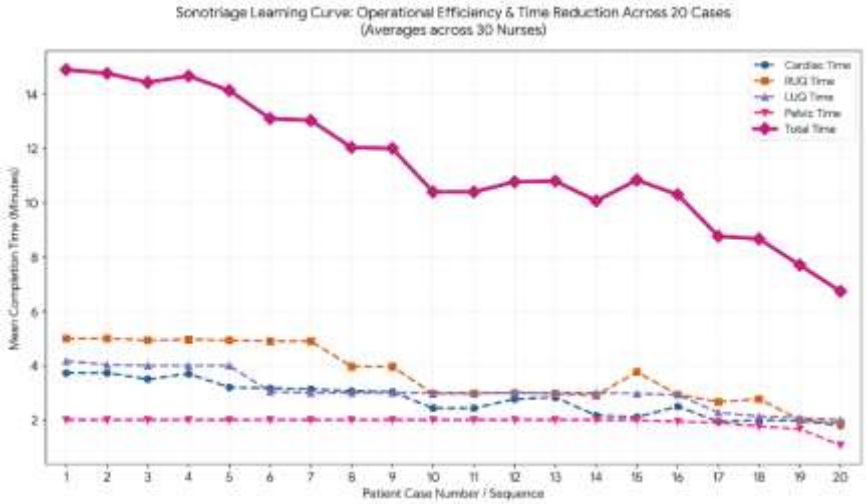

Figure 2: Sonotriage learning curve depicting mean completion time across 20 patient cases for cardiac, RUQ, LUQ, pelvic, and total scanning domains (n = 30 nurses)

Figure 2 shows the total completion time, which was consistently reduced from approximately 15 minutes in the first case to about 7 minutes in the twentieth case, demonstrating evident efficiency improvements with increasing experience of nurses. RUQ scanning was consistently longest, and pelvic shortest. Cardiac and LUQ times decreased slightly but were relatively stable compared to the total time curve. Overall, the figure depicts an efficiency learning curve where repeated practice enabled nurses to perform Sono triage assessments with increasing speed, reflecting streamlined workflow and increasing confidence at the bedside.

DISCUSSION

The present study aimed to evaluate the effectiveness of Nurse-Initiated Sono Triage (NISt) in improving the nurses' knowledge and skills in trauma triage and ultrasound-based assessment. Results showed statistically significant improvements in both domains post intervention, indicating the value of NISt as a practical and clinically relevant training strategy for emergency nurses.

The marked improvement in knowledge scores suggests that the structured educational module was effective in improving the participants' understanding of the principles of trauma triage and e-FAST assessment. The higher post-test scores and the decreased variance among the participants suggest not only increased learning but increased consistency in learning among the group as a whole. These findings are in support of previous studies showing that structured educational interventions are effective in improving triage knowledge, clinical reasoning and decision making of emergency nurses and enhancing the accuracy of triage (Butler et al., 2023; Varndell et al., 2018). Comparable findings have been reported in studies where nurses with minimal to no prior experience in e-FAST were able to accurately acquire and interpret ultrasound images following targeted educational programmes (Ariffin et al., 2023; Khalaf Awwad et al., 2022).

The positive outcomes may also be due to the demographic characteristics of the participants. The majority of the nurses in the current study were relatively young (mean age 28.2 years) and had only a few years of experience in the emergency department. New nurses are often more open to learning new technologies and clinical skills, especially hands-on skills such as point-of-care ultrasound. The willingness to learn and adapt could have contributed to the significant gains observed post intervention. Similar findings have been reported in studies of nurses with similar demographic profiles where participants in the younger age group showed significant gains following structured educational interventions (Bhoi et al., 2013; Douglas et al., 2019).

FAST is a quick, non-invasive, and repeatable ultrasound examination conducted at the bedside to detect free fluid in the peritoneal and pericardial areas, while e-FAST expands this evaluation to cover the thoracic region (Tay et al., 2026). By integrating Sono Triage into standard trauma evaluations, nurses are no longer exclusively reliant on subjective clinical assessments and patient histories. Rather, they now have access to objective, real-time data that can aid in early clinical decision-making. A noteworthy finding in the current study was that only 10% of participants had prior training in e-FAST, indicating a significant lack of formal ultrasound education for emergency nurses. As a result, most participants entered the study with minimal knowledge and practical experience in ultrasound. This highlights the significance of the observed improvements, as the intervention successfully elevated competency in a relatively brief timeframe. Comparable results have been documented in research indicating that structured ultrasound training has enhanced skills in image acquisition, scanning techniques, and overall confidence among healthcare providers (Adhikari et al., 2015; Ali et al., 2023). Similarly, Tirwa and Koul (2026) found considerable advancements among participants who lacked formal training in point-of-care ultrasound prior to the study.

In the present study, it was observed that the nurses were proficient and skill acquainted to do the Sono triaging in terms of performing it across various domains. The domains included probe handling, cardiac assessment, right upper quadrant (RUQ), left upper quadrant (LUQ), pelvic assessment, and overall e-FAST performance. These findings are suggestive that the nurses were able to detect and identify the life-threatening injuries promptly and necessary intervention could be

done immediately. Similar studies have reported that participants demonstrated increased confidence and proficiency following structured ultrasound training programmes (De Lorenzo and Holbrook-Emmons, 2014; Blehar et al., 2015).
The time taken to perform the scan was impressive in the present study findings. It was noted that there was significant time reduction in almost all the domains. The total scanning time decreased from 20 minutes to just over 3 minutes after the intervention. This is suggestive of a remarkable transition from a new learner performer to a skilled performer acquiring the required acumen to perform the scan. It also reflects that with continued assistance and supervision the nurses made a remarkable improvement and efficiency. In the previous systematic review, it was found that there is limited evidence in regard to time required to achieve the competency in performing the ultrasound scans. Therefore, the present study findings shows that the structured and planned intervention can improve the efficiency, confidence and technical competency. The findings of De Lorenzo and Holbrook-Emmons (2014), who demonstrated that nurses could accurately obtain ultrasound measurements of the inferior vena cava, further support the present results. Similarly, the ability of nurses in the current study to perform multiple e-FAST views accurately suggests that ultrasound assessment can be effectively integrated into nursing practice following appropriate training.
Overall, the findings of the study shows that the Nurse Initiated Sono triage not only improved the skill acquisition of the nurses but also the time to scan the patient for any positive or negative findings. This combination of efficiency and accuracy is very necessary to rule out the patient's outcome in terms of mortality and morbidity. Early recognition of the fatal outcome is very significant in assuring the patients trust, safety and most importantly saving lives of the injured and trauma patients. Similar studies have reported that nurse-performed ultrasound contributes to earlier recognition of clinical deterioration and facilitates prompt management of trauma patients (Singh et al., 2022; Yaqoob et al., 2025).
The findings strengthen the fact that both traditional trauma triage and point of care ultrasound are both are great combination to provide efficient and effective care to the patients with emphasis on early assessment, prioritization and timely intervention and management of the trauma victims. The nurses provide patient centric care engaging in blending the skills with the technology for a better patient outcome and improved quality care.

Limitations

The present study has certain limitations that should be considered while interpreting the findings.

- It is a one group pretest and post-test design without a control group.
- Confounding variable may have impacted the outcome
- Small sample size of the nurses may limit the generalizability of the findings
- Direct patient centered outcome is not measured.
- Hawthorne effect: There was a possibility of observer bias during outcome evaluation

Despite these limitations, the study has several important strengths. It is among the first studies in the Indian context to evaluate a structured Nurse-Initiated Sono Triage training programme for emergency nurses. The intervention combined a standardized teaching module with supervised hands-on bedside training, providing participants with both theoretical knowledge and practical experience. The current study assessed competency development during 600 supervised real-patient examinations, in contrast to many educational studies that only use simulation or immediate post-training assessments. This allowed for a thorough understanding of learning progression under real-world clinical conditions. Additionally, the use of Linear Mixed Model analysis allowed for a reliable assessment of competency acquisition while taking participant-level variability and repeated measures into account. These methodological features add significant evidence to the developing field of competency-based point-of-care ultrasound education for emergency nurses and strengthen the findings' trustworthiness.
The findings demonstrated significant improvements in nurses' knowledge, technical skills, confidence, and efficiency in performing Sono Triage. These results highlight the feasibility of integrating ultrasound-based triage into emergency nursing practice and support the potential role of trained nurses in strengthening trauma assessment and decision-making in busy emergency departments.

CONCLUSION

The Nurse led intervention represents that the nurses are always ready for a task shifting role engagement in the busiest emergency catering to hundreds of patients every day. The findings of the present study highlight that a planned and supervised hands-on training on conducting Sono triage has improved and a better patient outcome. Its findings showed that the nurses were able to independently perform Sono triage after the intervention and a supervised practice session on the real patients.
By integrating point-of-care ultrasound into routine triage practice, nurses are equipped with objective, real-time clinical information that complements traditional assessment methods and supports more informed decision-making. The observed improvements in both competency and scanning efficiency suggest that nurses can successfully incorporate Sono Triage into emergency care workflows following appropriate training and support. The study also highlights an important gap in formal ultrasound education among emergency nurses, emphasizing the need for greater investment in competency-based training programmes. Sustained educational support, clinical mentorship, and opportunities for supervised practice are likely to be critical for maintaining proficiency and ensuring safe implementation in clinical settings.
Overall, Nurse-Initiated Sono Triage has the potential to strengthen trauma assessment, enhance emergency nursing practice, and contribute to more timely identification of critically injured patients. As emergency departments continue to face increasing patient volumes and resource constraints, innovative approaches such as NISt may help improve both the quality and efficiency of care while supporting nurses in an expanded clinical role. In multidisciplinary trauma teams,

Nurse-Initiated SonoTriage should be viewed as a adjunctive clinical assessment method that could improve early patient evaluation and speed up communication.

Instruction for AI Assistance Declaration

The authors have used the AI tools Microsoft Co-pilot in language enhancement and grammar correction during manuscript preparation. However, I have reviewed and revised the content thoroughly and take full responsibility for the final version of the manuscript.

Conflict of Interest

The authors affirm that there are no conflicting objectives

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