# Effect of Simulation-Based Ventilator Alarm Management Training on Nurse's Knowledge and Practices in a Tertiary Care Hospital

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**Abstract**

*This study aimed to evaluate the effectiveness of simulation-based ventilator alarm management training on knowledge and practice among nurses. It was conducted among 50 nurses of neurosurgery department AIIMS, New Delhi. Assessment of knowledge and practice regarding ventilator alarm management was done using researcher-developed knowledge questionnaire and observational checklist. Didactic teaching of 15- 20 minutes was done regarding various ventilator alarms following the baseline assessment. Hence, simulation-based teaching on managing ventilator alarm was conducted in a group of 3-4 participants which consisted of pre-brief (3-5 min explanation regarding the situation the participant was to experience), scenario run (7-10 min where the response and measures of managing different ventilator alarms are performed) and debrief (15-20 min of discussing the positive and right performance of participants followed by different areas requiring improvement). A low tech manikin (half body Laerdal manikin) was used for the simulation and the simulation was conducted in neuro ward of AIIMS, New Delhi. The entire intervention lasts for 40-45 min after which immediate post-test was done for knowledge and skill. Retention of knowledge was assessed 7 days after the intervention. Nurse's knowledge range regarding mechanical ventilator alarm management in pre-test was 11 (8, 15) MED (IQR), post-test 1 was 15 (13, 17) MED (IQR), post-test 2 range was 15 (13.16) MED (IQR). Thus, there was significant improvement in the knowledge level of nurses regarding the ventilator alarm management after the intervention ($p < 0.001$). The pre-practice score of nurse's skill in managing mechanical ventilator alarm management was 3.5 (2, 5) MED (IQR) and post-practice score minimum maximum range was 10.5 (2, 14) MED (IQR). There was significant improvement in the skill level of nurses regarding the ventilator alarm management after the intervention ($p < 0.01$). Simulation-based education improves nurse's knowledge and practice in recognising and managing the ventilator alarms.*

**Key words:** Simulation-based training, ventilator alarm, mechanical ventilation

Mechanical ventilation is a lifesaving technique in several forms of acute respiratory failure. Extensive studies have demonstrated that the inappropriate application of mechanical ventilation can worsen/induce lung injury, so-called 'ventilator-induced lung injury' (Fialkow et al, 2016). The study found that the false-alarm or provider-induced burden can be as high as 95 percent (Yee et al, 2016).

The audible burden can lead to a decreased alertness of health care professionals and alarm fatigue. According to a previous study, 3 percent (40% of healthcare workers) indicated they had never used many of the monitoring functions of a monitor. Also, there is a paucity of data regarding simulation and mechanical ventilation training in the medical education literature (Han et al, 2018).

In another previous study, it was found that there were limited ICU nurses who correctly identified alarm sounds, which is only 39 percent. This evidence shows the gap in the knowledge of nurses regarding the ventilator alarms.

## Objectives

This study sought to:

1. Assess the baseline knowledge and practices of nurses working in Neurosurgery department regarding the ventilator alarm management.
2. To assess the effect of simulation-based ventilator alarm management training on (a) knowledge and (b) practice of nurses working in neurosurgery department.
3. To associate the (a) pre-test knowledge and (b) post-practice scores with selected demographic variables.

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4. To find out the corelation between knowledge and practice among the nurses regarding ventilator alarm management.

### Hypotheses

**$H_1$:** There will be a significant difference between pre-test and post-test knowledge scores of nurses regarding ventilator alarm management as measured by Knowledge Questionnaire at 0.05 level of significance.

**$H_2$:** There will be a significant difference between pre- and post-practice scores of nurses regarding ventilator alarm management as measured by observational checklist at 0.05 level of significance.

### Review of Literature

Castro et al (2022) did a quasi-experimental study in Saudi Arabia on the impact of high-fidelity simulation (HFS) exposure of nursing students with their objective structured clinical examination. The findings revealed that the HFS exposure in addition to clinical training enhances the students' OSCE performance.

Filomeno et al (2020) undertook a non-experimental pre-test post-test study on effectiveness of clinical simulation on nursing students on their critical care knowledge; 60 nursing students of the Campus Docent Sant Joan de Déu, attending critical care subjects, were enrolled in the study. Pre-test questionnaire was administered after students received five weeks of theoretical lectures on critical care subjects. Post-test was administered after students performed the theoretical classes and the simulation-based learning activity on critical care subjects. The statistical analyses performed showed a significance of the intervention in the post-test p=0.01) and that the students improved on average by 1 point after the intervention, passing from 11.94 in the pre-test to 12.94 in the post-test.

Casolla (2021) did simulation-based training for neurology in acute setting and beyond. A manuscript was provided with a brief overview on the general principles of simulation techniques and their potential application in neurology training, in the acute setting and beyond. Multidisciplinary sessions with different team members (nurses, physician associates, specialist trainees, technicians) were conducted. Based on the learning objectives different types of simulation technique were used. It is understood that continuous evaluation of the simulation programme is essential for identifying strengths and weaknesses of training, for highlighting the points to be improved, and for suggesting solutions and for quality management.

Han et al (2018) conducted a quasi-experimental one-group, pre- and post-test design study in Japan on the effects of a simulated emergency airway management education programme on the self-efficacy and clinical performance of intensive care unit nurses. Thirty-five nurses were enrolled for the study. The simulation education programme included lectures, skill demonstration, skill training, team-based practice, and debriefing. The score for self-efficacy was 3.40±0.33 before education and 3.98±0.38 after education. The score after education was 0.58 higher than before. There were statistically significant differences (t=6.79, 95% confidence interval: 0.45–0.71, p<0.001). The score for clinical performance was 3.90+0.47 before education and 4.23±0.45 after education. The score after education was 0.33 higher than before. There were statistically significant differences (t=3.09, 95% CI: 0.21–0.45, p = 0.003). There is effective improvement in self-efficacy and clinical performance of nurses working in ICU after the simulation education.

Jansson et al (2017) did a randomised control trial study in USA on effects of simulation education on oral care practices to evaluate the longitudinal effects of single dose simulation education with structured debriefing and feedback in selected nurses on their adherence level to knowledge and skills in relation to the current oral care recommendations. Data was collected in a single academic centre in a 22-bed adult, mixed, medical-surgical intensive care unit. The effectiveness of simulation education was evaluated through the validated Ventilator Bundle Questionnaire and Observation Schedule at baseline (n = 30) and 24 months (n = 17) after simulation education. The average knowledge score in the intervention group increased significantly (44.0% to 56.0% of the total score) in the final post-intervention measurement ($p_t = 0.51$, $p_g = 0.002$, $p_{t*g} = 0.023$). There was increase in awareness, but no significant difference in oral care practices between the study groups after simulation education.

## Materials & Method

This study is a quantitative research approach with pre-experimental research design, conducted in Neuro Surgery Department of all India Institute of Medical Sciences, New Delhi (during October 2022 to 6 December 2022).

**Sample:** Nurses working in Neuro Surgery Department and taking care of patients on mechanical ventilation of AIIMS New Delhi constituted the sample. Convenient sampling technique was used in the study.

**Sample size:** Sample size 50, A SD 4.3, using an effect size of 0.2 power of 80 and assuming co-relation of 0.5 between the repeated measurements, a sample size of 42 was calculated. Assuming an accounting lost to follow-up of 10 percent recruited were Sample size was calculated with G Power version 3.1.9.4.

### Tools for Data Collection

**Tool 1** was the socio demographic profile of the participants. It included the name, age, sex, educational qualification, clinical experience.

**Tool 2** was a structured Knowledge questionnaire developed by the authors; it consisted of 20 questions.

The knowledge scores were categorised as:

- Adequate knowledge (15-20) (>75%)
- Moderate knowledge (10-14) (50-75%)
- Inadequate knowledge (<10) (<50%)

**Validity:** Validity of tool was established by three experts in neuro science and four Nursing experts from College of Nursing. CVI score was 0.78.

**Reliability:** Reliability was established by split half method (0.74).

**Tool 3** was an Observation Checklist developed by authors. Five observation checklists were made for as many types of alarm: High pressure alarm, Low pressure alarm, High minute volume alarm, low tidal volume alarm, Apnoea alarm.

Each checklist contained around 10-15 steps. Each correct step was given 1 mark and missed/ wrongly done was given a mark of 0.

**Validity:** Validity of tool was established by three medical experts in Neuro science and four Nursing experts from College of Nursing. CVI Score was 0.76.

**Reliability:** Reliability was established by Interrater reliability (0.7).

**Ethical consideration:** Ethical clearance was obtained from the institute ethical committee, AIIMS, New Delhi. Confidentiality of the information provided by the subjects and anonymity maintained. This trial was registered under clinical Trial registry- India (CTRI Reference no. REF/2022/04/053130).

**Data collection procedure:** The study was conducted among 50 nurses of neurosurgery department from October 2022 to 6 December 2022. Written informed consent taken from the participants. During pre-test conducted, demographic details were collected. Baseline knowledge was assessed using the knowledge questionnaire. Baseline practice was inadequate as ventilator management was mainly done by technicians.

The participants received knowledge-based PowerPoint teaching consisting of lecture on mechanical ventilation using different modes of ventilation, ventilator settings, important alarms and its identification and management. The session was followed by simulation-based teaching for 15-20 minutes involving management of different ventilator alarms in a simulated environment. The simulation-based ventilation alarm management training was conducted using a case scenario on a clinical situation that involved managing different ventilator alarms.

The intervention consisted of pre-brief, simulation and debriefing.

In the pre-briefing, participants were oriented to simulation-based teaching and purpose of the study. They were instructed to feel as real as they can and suspend their disbelief. They were given orientation to the manikin and the ventilator. under simulation, clinical scenarios on various conditions where ventilator alarm management can be used, was given (example High Pressure alarm, Low pressure alarm etc) to them on a low fidelity manikin. Script of the scenarios was prepared and validated by the experts.

In debriefing, the participants were guided through the scenario to reflect on their actions and what they did right and where they needed improvement. Finally, each participant was told to list down learning points.

All the participants completed the study. One week retention was also assessed. The mean age of subjects was 31± 5.38 years (mean ±SD); 39 (78%) of the subjects were female; 40 nurses had BSc Nursing qualification (Table 1).

Most of the nurses (48%) fell in the moderate knowledge level category in baseline which changed to good knowledge category (34%) and in moderate category (60%) after the intervention (Table 2). There was significant improvement in the knowledge level of nurses regarding the ventilator alarm management after the intervention ($p<0.001$).

There was significant improvement in the practice level of nurses regarding the ventilator alarm management after the intervention (p value of <0.01) (Table 3).

**Table: 1 Demographic data of Nurses (n=50)**

| Variables | Frequency (%) |
|---|---|
| *Gender Age (years) mean ± SD* | 31.83±5.38 |
| Male | 11 (22) |
| Female | 39 (78) |
| *Qualification* | |
| GNM | 4 (8) |
| BSc Nursing | 40 (88) |
| MSc Nursing | 6 (12) |
| *Experience (years)* | |
| 1-2 | 4 (8) |
| 2-5 | 17 (34) |
| 5-10 | 20 (40) |
| >10 | 9 (18) |

**Table 2: Baseline knowledge of nurses on ventilator alarm management (n=50)**

| Level of knowledge | Frequency (%) | Mean ±SD | Range |
|---|---|---|---|
| Good Knowledge | 5 (10) | 11.2±3.61 | 3-17 |
| Fair Knowledge | 24 (48) | | |
| Poor Knowledge | 21 (42) | | |

Minimum score: 10, Maximum score 20

**Table 3: Baseline practice score of nurses on ventilator alarm management (n=50)**

| Compliance to ventilator alarm management practice (Domain) | At baseline Frequency (%) | Mean ± SD |
|---|---|---|
| Inadequate compliance | 50 (100) | 3.64±0.82 |

Table 4 shows that all the nurses had inadequate practice scores on ventilator alarm management.

(Adequate compliance > 75 %, Moderate compliance 50%-75%, Inadequate compliance <50%)

**Table 4: Effectiveness of simulation-based ventilator alarm management on nurses' knowledge(n=50)**

| Knowledge score | Med (IQR) | p values* | | |
|---|---|---|---|---|
| Pre-test | 11 (8, 15) | Pre-test Post-test 1 | Pre-test, Post-test 2 | Post-test 1, Post-test 2 |
| Post-test | 15 (13, 17) | 0.001* | 0.01* | 0.99 |
| Post-test 2 | 15 (13, 16) | | | |

*Significant at 0.05 level, *Friedman's two-way analysis test.

**Table 5: Effectiveness of nurse's practice regarding ventilator alarm-management training(n=50).**

| Practice score | MED (IQR) | p values* |
|---|---|---|
| Pre-Practice | 3.5 (2,5) | 0.01* |
| Post-Practice | 10.5 (2,14) | |

Significance level of p value is 0.05*, Wilcoxon signed rank test.

Table 5 shows that there is a significant difference in the pre- and post-practice scores of nurses (p<0.01) regarding ventilator alarm management. There is significant improvement of p value (< 0.01) for the practice.

**Table 6: Association of pre-test knowledge with gender (n=50)**

| Demographic variable | Gender | Mean± SD | t value | p value |
|---|---|---|---|---|
| Gender | Male | 12.27± 3.036 | -1.310 | 0.196 |
| | Female | 10.67±3.723 | | |

Significant p value of 0.05*, Test applied is independent of t test

The mean difference of male is 12.27±3.036 (mean± SD) and in female is 10.67±3.723 (mean±SD). Therefore, there is no significant association of pre-test knowledge with gender (p=0.196) (Table-6).

**Table 7: Co-relation of baseline knowledge with age (n=50)**

| Variable | MED (IQR) | Co-relation coefficient value | p value |
|---|---|---|---|
| Age(years) | 30.5 (27, 35) | -0.120 | 0.407 |

Significance level of p value is 0.05*, Spearman's rho co-relation applied

Table 7 describes the co-relation value of baseline knowledge of nurses with age. Since age was a continuous variable, co-relation was analysed by applying Spearman's rho corelation. There is no significant co-relation between baseline knowledge and age.

**Table 8: Association of pre-test knowledge with other demographic variables (n=50)**

| Demographic variable | | MED (IQR) | P Value |
|---|---|---|---|
| Qualification | GNM | 9 (5.50,14) | 0.664 |
| | BSc Nursing | 11 (8,15) | |
| | MSc Nursing | 10 (8.25,14) | |
| Experience | 1-2 years | 11 (8, 13) | 0.684 |
| | 2-5 years | 12 (3, 14) | |
| | 5-10 years | 11.5 (3, 14) | |
| | >10 years | 10 (6, 13) | |

Significance level of p value is at 0.05*, Mann Whitney U test

Table 8 shows the association of pre-test knowledge of subjects regarding ventilator alarm management with socio demographic variable such as qualification, experience. No significant association was found for qualification and experience with a p values of 0.664 and 0.684 respectively.

**Table 9: Association of the practice scores with selected demographic variables (n=50)**

| Demographic variable | Practice scores Frequency (%) | | | p Value |
|---|---|---|---|---|
| **Gender** | Adequate | Moderate | Inadequate | |
| Male | 7 (63.63) | 4 (36.36) | 0 | 0.407 |
| Female | 24 (61.53) | 12 (30.76) | 3 (7.69) | |
| **Qualification** | | | | |
| GNM | 2 (50) | 2 (50) | 0 | |
| BSc. Nursing | 23 (57.5) | 14 (35) | 3 (7.5) | 0.867 |
| MSc. Nursing | 5 (83.33) | 1 (16.66) | 0 | |
| **Experience** | | | | |
| 1-2 years | 3 (75) | 1 (25) | 0 | |
| 2-5 years | 11 (64.7) | 4 (23.52) | 2 (11.76) | 0.869 |
| 5-10 years | 13 (25) | 6 (20) | 1 (5) | |
| >10 years | 4 (44.44) | 5 (55.5) | 0 | |

Significance level of p value is at 0.05*.

**Table 10: Co-relation between knowledge and practice among the nurses regarding ventilator alarm management in different settings (n=50)**

| | Correlation value | p value |
|---|---|---|
| **Knowledge and practice** | 0.081 | 0.57 |

Significance level of p value is 0.05*, Spearman's rho co-relation.

There was no significant association between knowledge score and demographic variables as well as practice scores and demographic variables.

There was no co-relation between the knowledge and practice of nurses regarding the ventilator alarm management (r=0.081, p=0.57) (Table 10).

## Discussion

The present study was undertaken to evaluate the effectiveness of simulation-based ventilator alarm management training on knowledge and practice among Nurses working in Neurosurgery department. Quantitative research with a pre-experimental research design (pre-test post-test one group design) was adopted depending on the objectives and conceptual framework.

Similar studies have been conducted in support of the current study. Filomena (2020) conducted a non-experimental pre-test post-test study regarding effectiveness of clinical simulation on nursing students' critical care knowledge. This study was carried out with a questionnaire. The statistical analysis showed a significant improvement in the post-test. The p value was 0.01 and the students improved on average by 1 point after the intervention.

Further study in agreement is by Norouzrajabi, (2021) was a pre-test, post-test interventional study carried out in Iran to assess the effects of feedback and education on nurses' clinical competence in mechanical ventilation and accurate tidal volume setting. The topic was related to feedback and education given to conveniently selected 75 nurses. In the results the mean score

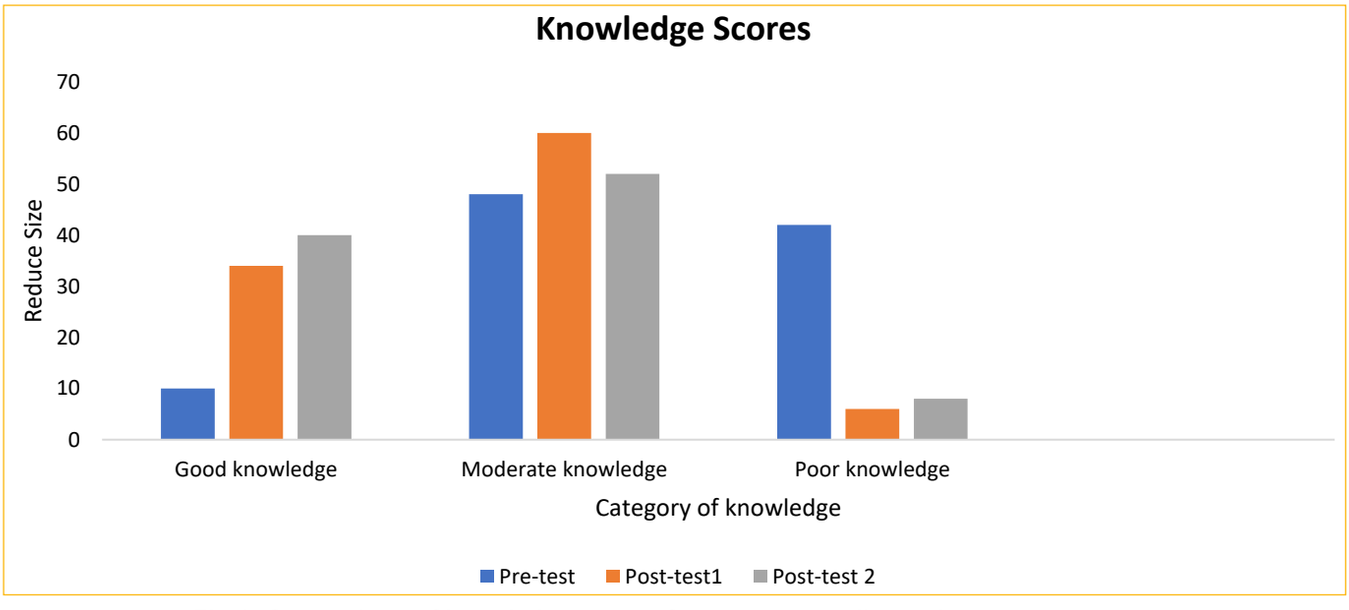


**Fig 1: Comparison of knowledge score of nurses on ventilator alarm management.**

of nurses' clinical competence increased from the 8.27±3.09 at pre-test to 10.07±3.34 at post-test ($p < 0.001$). There are other studies which support the present study such as a systemic review conducted by Guillermino et al (2018) based on the education given to intensive care nurses on mechanical ventilation. This kind of education to nurses brought better patient outcome such as statistically significant reductions in hospital length of stay, length of intubation, ventilator-associated pneumonia rates, failed weaning trials and improvements in lung-protective ventilation compliance.

Simulation study is effective to uplift the knowledge and practice in all health persons. Yee et al (2016) conducted a simulation-based study on mechanical ventilation in doctor resident. The residents were assessed using knowledge questionnaire and checklist. The mean change in test score was 26.8%, and a median score increased by 25 percent.

There was a contradictory RCT study findings in relation to the present study by Jansson et al (2017) on effects of simulation education on oral care practices in USA. The effectiveness of simulation education was evaluated using questionnaire after simulation education. The average knowledge score in the intervention group increased significantly (44.0% to 56.0% of the total score) in the final post-intervention measurement ($p_t = 0.51$, $p_{g.} = 0.002$, $p_{t*g} = 0.023$). But there was no significant difference in oral care practices between the study groups after simulation education. When comparing the knowledge in post-test 1 and post-test 2 of nurses regarding mechanical ventilator alarm management there was a decrease from 60 percent to 52 percent in moderate knowledge category level. So, it highlights the requirement of continuing education for nurses (Fig 1).

Simulation based study is the strength of the current study. Its limitations are: selecting convenient sampling technique, lack of control group, lack of generalisability of the findings, failure to assess the retention of practice and opting the chance to assess the real time practice. However an innovative advanced method of simulation ventilator alarm management is the strength of current study.

### Recommendation

- Simulation based ventilator alarm management training improves the nurse's knowledge and practice and service outcome.
- Simulation training on various clinical practices can be incorporated in the nursing syllabus.
- Standard protocol can be developed for mechanical ventilator alarm management.
- A study can be carried out on real time practice assessment.

## Conclusion

This study evaluated the effectiveness of simulation-based ventilator alarm management training on improvement of knowledge and practice among Nurses working in Neurosurgery department. Simulation-based education was found to be an effective method to increase the knowledge and practice of nurses caring patients on mechanical ventilation. There was a significant improvement in the knowledge and practice of nurses.

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