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Effectiveness of training programme on knowledge regarding ABG sampling technique and its interpretation among ICU nurses in Medanta Hospital, Gurugram, Haryana: A review

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***Abstract*---Background:** Arterial Blood Gas (ABG) analysis is an essential tool in intensive care for assessing oxygenation, ventilation, and acid–base balance. ICU nurses are frequently responsible for ABG sampling and interpretation; however, gaps in knowledge may compromise patient safety. **Objective:** To assess the pre-test level of knowledge regarding ABG sampling and interpretation, evaluate the effectiveness of the training programme, compare pre- and post-test knowledge scores, and identify associations with selected demographic variables. **Methods:** A quasi-experimental one-group pre-test post-test design was employed. The study involved 100 ICU nurses selected via simple random sampling at a tertiary care hospital in Gurugram. A self-structured knowledge questionnaire was administered before and after a structured training intervention on ABG sampling and interpretation. Descriptive and inferential statistics, including paired t-tests and chi-square tests, were used. **Results:** A quasi-experimental

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one-group pre-test post-test design was employed. The study involved 100 ICU nurses selected via simple random sampling at a tertiary care hospital in Gurugram. A self-structured knowledge questionnaire was administered before and after a structured training intervention on ABG sampling and interpretation. Descriptive and inferential statistics, including paired t-tests and chi-square tests, were used. **Conclusions:** The structured training programme effectively enhanced ICU nurses' knowledge of ABG sampling and interpretation. Institutionalizing such educational interventions is recommended to reduce clinical errors and improve patient safety in critical care settings.

***Keywords*---**ABG analysis, ABG interpretation, ICU nurses, training programme, knowledge, nursing education.

1. Introduction

Arterial blood gas (ABG) analysis is one of the most vital diagnostic tools in intensive care units (ICUs), providing essential information about a patient's respiratory efficiency, oxygenation, ventilation, and acid-base balance (Gomes et al., 2024). The accuracy of ABG sampling and correct interpretation are crucial, as misinterpretation may delay or misguide treatment and place critically ill patients at risk. Although ABG testing is routinely performed, nurses often face knowledge and skill gaps, particularly those who are newly employed or lack structured training (Fatma Alzahraa et al., 2024).

In India, ICUs remain heavily nurse-dependent in terms of patient monitoring. While physicians typically provide definitive treatment decisions, nurses' interpretation of ABG results enables earlier identification of life-threatening imbalances. Unfortunately, several studies have reported inadequate training in ABG analysis among ICU nurses. For instance, Kulvi et al. (2023) demonstrated significant improvements in nurses' knowledge following a structured teaching programme, highlighting the effectiveness of targeted educational interventions.

A study by Ragab Bayomi and Taha (2022) showed that self-learning packages significantly improved nurses' knowledge and practices regarding ABG analysis for critically ill patients. Similarly, Pakkirisamy et al. (2021) revealed substantial increases in post-test knowledge scores following a structured programme. These findings reinforce the importance of implementing evidence-based training to address knowledge deficits among ICU staff.

The need for this study stems from the increasing complexity of ICU care and the expanding role of nurses in critical decision-making. As ICU environments demand rapid interventions, lack of knowledge in ABG sampling and interpretation poses a significant barrier to patient safety. By evaluating the effectiveness of a structured training programme, this study aimed to generate evidence supporting standardized training initiatives in Indian tertiary hospitals.

Aim

This study assessed the effectiveness of a structured training programme on nurses' knowledge regarding ABG sampling and interpretation among Nurses in selected hospitals.

Methodology

Data Sources and Search Strategy

A comprehensive literature search was conducted using electronic databases including PubMed, Google Scholar, Scopus, CINHAL, ResearchGate, and ScienceDirect. The search covered publications from 2000 to 2024. Keywords used were: "Arterial Blood Gas," "ABG sampling," "ABG interpretation," "nurses' knowledge," "ICU nurses," "structured teaching program," "training programme," and "competency." Boolean operators such as AND, OR, and NOT were used to refine the search. Both peer-reviewed articles and relevant grey literature were included. Reference lists of retrieved articles were also screened manually to identify additional studies. Only studies focusing on ICU nurses and educational interventions related to ABG sampling and interpretation were selected.

Eligibility Criteria

Inclusion Criteria: Studies were included if they met the following criteria:

- Participants: Registered nurses working in ICUs
- Intervention: Educational programs that explicitly included training on ABG sampling techniques and its interpretation.
- Outcomes: Improvement in knowledge scores, Change in skill level regarding ABG sampling, Accuracy in interpretation of acid–base balance, Reduction in sampling errors
- Setting: Hospital-based settings (ICUs, critical care units).
- Published in English.

Exclusion Criteria: Studies were excluded if they were:

- Non-ICU settings, physician-only studies, editorials, and conference abstracts without data.
- Studies without full text available.

Data Extraction

A standardised data extraction sheet was used to capture relevant data from each included study. Extracted information included:

- Author(s) and year of publication
- Study location and setting
- Study design and sample size
- Characteristics of participants
- Description of the hands-on skill training intervention (content, duration, delivery mode)
- Outcome measures (knowledge scores, skill assessment, practice changes)
- Key findings related to effectiveness

Quality Assessment

The methodological quality of the included studies was assessed using standardized appraisal tools appropriate for the study design. For quasi-

experimental and pre-test/post-test studies, the **Joanna Briggs Institute (JBI) Critical Appraisal Checklist** for quasi-experimental studies was used. This tool evaluates key elements such as clarity of cause-and-effect relationships, similarity of participants, use of control groups, reliability of outcome measures, and completeness of follow-up.

Study Design

This review adopted a **narrative review design**, synthesizing evidence from experimental, quasi-experimental, and observational studies that evaluated the effectiveness of educational or training interventions aimed at improving nurses' knowledge and skills related to arterial blood gas (ABG) sampling and interpretation. The review followed a structured approach that included defining the research question, identifying relevant literature, applying eligibility criteria, critically appraising the included studies, and summarizing key findings.

Study Selection

A total of all records identified through database searching were screened in accordance with PRISMA recommendations. After removing duplicates, titles and abstracts were evaluated to determine initial eligibility. Full-text articles were then assessed based on the inclusion criteria (participants, intervention, outcomes, and setting). Studies were excluded if they lacked ABG-related educational content, did not involve nurses, had incomplete outcome reporting, or were not available in full text.The final set of studies included only those that met all methodological requirements and reported measurable outcomes related to ABG knowledge or competency.

The study selection process is illustrated in the PRISMA flow diagram (Figure 1).

Records identified through database searching (n = 210)
⬇
Duplicates removed (n = 32)
⬇
Records screened (n = 178)
⬇
Records excluded (n = 133)
⬇
Full-text articles assessed for eligibility (n = 45)
⬇
Full-text articles excluded (n = 31)
⬇
Studies included in the final review (n = 14)

Results

1. **Effect on Nurses' Knowledge regarding ABG sampling technique and its interpretation**

   Studies consistently demonstrated a significant improvement in post-test knowledge scores following various training interventions. Key findings include:

   - Nurses showed 30–45% improvement in ABG interpretation knowledge after structured teaching programmes.

- Understanding of pH, $PaCO_2$, HCO_3^-, base excess, and compensation mechanisms improved markedly.
- Many studies reported a shift from "inadequate knowledge" to "adequate/satisfactory knowledge" after training.
- Training enhanced nurses' ability to identify acid–base disorders, including mixed imbalances.
- Improvement was observed across all demographic groups, indicating that training is effective regardless of previous experience.

2. Effect on Practical Skills and Competency

Interventions significantly enhanced nurses' technical proficiency in ABG sampling and handling. Key improvements included:

- Increased accuracy in arterial puncture technique and syringe handling.
- Reduction in common errors such as:
    - air bubble contamination
    - insufficient heparinization
    - improper sample mixing
    - delayed sample transport
- Nurses demonstrated improved competency after 5–7 supervised practice attempts.
- Enhanced ability to operate point-of-care ABG analyzers with fewer errors.
- Better preparedness to handle complications such as hematomas and arterial spasm.
- Simulation-based training especially improved confidence and hands-on competence.

3. Impact on Routine Practice, Adherence and Care Processes

Increased compliance with ABG sampling protocols, including site preparation, aseptic technique, and proper disposal.

- Higher adherence to guidelines for sample transport, such as placing samples on ice when required.
- Enhanced awareness of institutional ABG policies and care pathways.
- Knowledge retention remained moderately high up to 4–12 weeks after training.
- Skills related to sampling and handling remained consistent for several months, especially when periodic refresher sessions were conducted.
- In facilities with ongoing training, nurses maintained long-term competency with minimal performance decline.
- Lack of ongoing reinforcement led to **partial decline in interpretation skills** over time, highlighting the need for continuous education.

4. Sustainability of Knowledge, Skills and Practice Change

Studies that conducted follow-up assessments revealed sustained improvements, though some areas required reinforcement:

- Knowledge retention remained moderately high up to 4–12 weeks after training.
- Skills related to sampling and handling remained consistent for several months, especially when periodic refresher sessions were conducted.

- In facilities with ongoing training, nurses maintained long-term competency with minimal performance decline.

Discussion

The findings of this review demonstrate that educational and training interventions significantly enhance nurses' knowledge, practical skills, and confidence in arterial blood gas (ABG) sampling and interpretation. Across all included studies, nurses showed marked improvement in understanding ABG parameters, acid–base disorders, and compensatory mechanisms, highlighting the effectiveness of structured teaching and self-learning modules. Hands-on and simulation-based training further strengthened technical competency, reducing common procedural errors such as air bubble contamination and improper sample handling. Improvements were not only theoretical but translated into routine clinical practice, with nurses demonstrating quicker identification of ABG abnormalities, better communication with physicians, and more timely interventions. Training also improved adherence to sampling protocols and documentation standards, contributing to safer and more standardized care processes.

Practical Implications

The review highlights that regular, structured ABG training programmes can significantly improve nurses' competency, leading to safer and more accurate patient care in critical settings. By strengthening knowledge, technical skills, and adherence to protocols, such training enables nurses to identify abnormalities earlier, support timely clinical decisions, and reduce errors in ABG sampling and interpretation. Integrating periodic refresher sessions, simulation-based practice, and standardized guidelines into routine nursing education can ensure sustained competency and enhance overall quality of care in ICU environments.

Limitations

This review has several limitations. First, many of the included studies had small sample sizes and were conducted in single-center settings, which may limit the generalizability of the findings. Second, most studies relied on quasi-experimental or pre-test/post-test designs with limited use of randomized controls, reducing the strength of causal conclusions. Third, follow-up assessments were either short-term or absent in several studies, making it difficult to evaluate the long-term sustainability of knowledge and skill improvement. Additionally, variations in training methods, outcome measures, and assessment tools across studies created inconsistencies that may affect comparability. Finally, only studies published in English were included, which may have led to the exclusion of relevant research published in other languages.

Directions for Future Research

Future research should focus on conducting large-scale, multi-center studies using stronger experimental designs, such as randomized controlled trials, to more accurately determine the effectiveness of ABG-related training interventions

for nurses. Long-term follow-up assessments are needed to evaluate the sustainability of knowledge and skill improvements over time. Studies should also explore the impact of simulation-based training, digital learning platforms, and blended educational models on clinical performance and patient outcomes. Additionally, developing and validating standardized competency assessment tools for ABG sampling and interpretation would enhance comparability across studies. Research examining organizational factors—such as workload, staffing patterns, and institutional support—would further clarify their influence on training effectiveness and routine practice.

Conclusion

This review demonstrates that structured educational and training interventions significantly improve nurses' knowledge, practical skills, and competency in arterial blood gas (ABG) sampling and interpretation. Enhanced proficiency leads to safer patient care, quicker identification of abnormalities, and more accurate clinical decision-making in critical care settings. While the evidence supports the effectiveness of these training programmes, ongoing reinforcement through refresher courses and standardized institutional protocols is essential to maintain long-term competency. Strengthening ABG education within nursing practice and integrating simulation-based and competency-driven learning approaches can further improve patient outcomes and elevate the quality of care provided by ICU nurses.

Overall, the findings from this review highlight the critical importance of continuous, structured training in ensuring nurses' preparedness to perform accurate ABG sampling and interpretation. As ABG analysis plays a central role in guiding treatment decisions for critically ill patients, enhancing nurses' competency directly contributes to improved patient safety and clinical outcomes. Training programmes not only strengthen theoretical understanding but also build confidence and technical proficiency, reducing pre-analytical errors and supporting evidence-based practice. To maintain these gains, healthcare institutions should prioritize regular skill updates, integrate ABG competencies into routine in-service education, and promote a culture of continuous professional development within critical care environments.

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