**RESEARCH PAPER**

# An Experimental Study to Assess the Effectiveness of an Instructional Programme on Arterial Blood Gas Knowledge among ICU Nurses in Selected Hospitals, Mumbai

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**ABSTRACT**
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## Introduction

Arterial blood gas (ABG) analysis constitutes the cornerstone diagnostic procedure within intensive care units worldwide, delivering precise quantitative evaluation of arterial blood pH, partial pressure of oxygen ($PaO_2$), partial pressure of carbon dioxide ($PaCO_2$), bicarbonate concentration ($HCO_3^-$), and base excess values essential for comprehensive respiratory and metabolic status assessment among critically ill patients. This laboratory investigation enables immediate identification of hypoxemia severity, ventilatory failure patterns, and acid-base derangements including respiratory acidosis, metabolic alkalosis, mixed disorders, and compensation mechanisms, directly informing time-sensitive therapeutic interventions such as mechanical ventilation parameter optimization, electrolyte replacement protocols, and emergent bicarbonate administration for life-threatening anion gap acidosis.

Intensive care unit staff nurses assume primary clinical responsibility for ABG specimen procurement through percutaneous radial artery puncture technique, immediate sample processing incorporating adequate heparinization to prevent clotting artifacts and pH drift, and preliminary result interpretation contributing to initial physician notification and intervention prioritization. Technical proficiency proves paramount across procedural domains encompassing pre-puncture modified Allen's test execution verifying ulnar collateral circulation adequacy, optimal 45-degree needle insertion angle maintenance minimizing vessel trauma, systematic air bubble expulsion from heparinized syringes preserving anaerobic specimen integrity, and expedited iced transport to laboratory preventing metabolic parameter degradation during transit. Equally critical remains cognitive mastery of systematic interpretation algorithms enabling accurate primary disorder identification (respiratory versus metabolic etiology), secondary compensation pattern recognition (acute versus chronic phases), and appropriate clinical correlation guiding therapeutic decision-making.

Despite ABG analysis representing upwards of 80% routine intensive care laboratory investigations across global healthcare systems, pervasive knowledge deficits among bedside nursing personnel compromise both procedural accuracy and interpretive reliability, potentially precipitating systematic clinical errors including inappropriate ventilator adjustments predicated upon $PaCO_2$ misinterpretation, delayed recognition of compensated respiratory acidosis requiring non-invasive ventilation escalation, and suboptimal anion gap metabolic acidosis management absent emergent intervention. Recent systematic reviews document suboptimal proficiency prevalence ranging 41.4%-80% across tertiary academic medical centers, with particular deficits manifesting within interpretation domains distinguishing uncompensated from partially compensated acid-base disorders.

The Indian critical care landscape amplifies these proficiency concerns amid exponential ICU bed demand escalation within densely populated urban centers. Mumbai exemplifies this healthcare capacity crisis wherein tertiary hospital ICU occupancy routinely exceeds 95% during seasonal respiratory pathogen surges, compounded by chronic nursing workforce shortages characteristic of metropolitan practice environments. Local staff nurses derive ABG understanding predominantly through fragmented informal channels including newspaper health supplements (30%-38% primary knowledge source), conference attendance (24%-36%), and social media platforms (2%-6%), rather than systematic academic curricula integration or hospital-based competency development programs. Such unstructured knowledge acquisition perpetuates recurrent interpretive errors including failure to recognize appropriate renal compensation within chronic respiratory acidosis states, misclassification of mixed acid-base disorders, and

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inappropriate therapeutic responses to $PaO_2/FiO_2$ ratio abnormalities signalling acute respiratory distress syndrome progression.

Existing educational intervention literature establishes unequivocal efficacy for structured teaching programs addressing documented ABG knowledge deficits. Pre-experimental one-group pretest-posttest designs consistently demonstrate mean knowledge score elevations approximating 20-point gains (e.g., 67.15 → 87.7), while quasi-experimental control group comparisons confirm between-group posttest differentials achieving statistical significance ($p < .001$) concomitant with large Cohen's d effect sizes exceeding 1.2 benchmarks. Multimedia-augmented lecture-discussion formats incorporating algorithmic flowcharts, clinical case exemplars, and tic-tac-toe systematic interpretation methodology yield superior knowledge acquisition and retention compared to traditional lecture-only delivery, while program-based learning approaches additionally enhance practitioner procedural self-efficacy and clinical confidence.

This investigation systematically addresses the identified knowledge-to-practice implementation gap through rigorous quasi-experimental evaluation of a purposefully developed 45-minute instructional programme targeting the four principal ABG knowledge domains among Mumbai ICU staff nurses. Primary research objectives encompass (a) pre-post knowledge assessment within experimental versus concurrent control s, (b) determination of intervention effectiveness through between-group comparative statistical analysis, (c) Association analysis between knowledge gain magnitude and salient demographic characteristics, and (d) systematic evaluation of programme implementation fidelity through structured participant satisfaction feedback. Formative research hypotheses predict statistically significant pre-post test knowledge differential within intervention recipients absent parallel gains within non-exposed controls ($H_1$), alongside absence of significant demographic moderator effects ($H_0$).

Theoretical conceptualization derives from Ludwig von Bertalanffy's General Systems Theory (1968) framing educational intervention within classical input-throughput-output-feedback paradigm whereby baseline nurse demographic characteristics and pre-test knowledge states constitute systems inputs; structured multimedia content delivery and associated cognitive processing represent throughput mechanisms; measurable post-test knowledge gains and behavioral intention changes manifest as system outputs; and participant programme evaluations generate feedback loops informing iterative quality improvement. This systems perspective recognizes dynamic interrelationships between individual learner characteristics, instructional design fidelity, and measurable competency outcomes within authentic clinical learning environments.

## Method

This quantitative evaluative investigation employed quasi-experimental pretest-posttest design incorporating non-equivalent control group methodology, optimally balancing internal validity rigor with pragmatic real-world clinical implementation feasibility characteristic of hospital quality improvement initiatives. Quantitative research approach prioritized objective knowledge measurement through psychometrically validated structured instrumentation rather than subjective qualitative inquiry approaches. Study implementation transpired across intensive care units of two purposively selected comparable tertiary care hospitals within greater Mumbai metropolitan region during 2023-2025 academic period, ensuring demographic profile equivalence, clinical case-mix similarity, and organizational culture comparability between intervention and control facilities.

Principal intervention comprised researcher-developed 45-minute structured instructional programme systematically sequenced across four progressive ABG knowledge domains delivered through lecture-cum-discussion format augmented by Microsoft PowerPoint multimedia presentation incorporating high-fidelity schematic diagrams, representative clinical case exemplars, algorithmic flowcharts, and animated procedural demonstrations. Session one (10 minutes duration) comprehensively addressed ABG fundamentals encompassing physiological rationale (acute respiratory failure, cardiogenic shock, sepsis), absolute contraindications (suspected aortic dissection, coagulopathy), heparinization pharmacokinetics preventing sample clot artifact and pH drift, alongside normal reference ranges contextualization. Session two (15 minutes) delineated comprehensive procedural competencies including pre-puncture modified Allen's test execution verifying ulnar collateral circulation patency, optimal 45-60° needle insertion angle optimization minimizing endothelial trauma, systematic air bubble expulsion technique from pre-heparinized syringes preserving anaerobic specimen conditions, complication recognition (hematoma, vasospasm, thrombosis), and expedited iced transport protocols maintaining metabolic parameter stability.

The target population for the present study consisted of ICU staff nurses working in selected hospitals from Mumbai city. Nurses willing to participate and working presently in ICU were included in study. The dependent variable was the knowledge of the ICU staff nurses on ABG and the independent variable was the Instructional Programme on ABG. Non-probability convenience sampling methodology recruited 100 eligible participants through systematic stratified group assignment yielding 50 experimental members and 50 concurrent control members, achieving adequate statistical power ($1-\beta = .80$) for detecting moderate-large effect sizes at alpha = .05 significance criterion. Tool consisted of 30-item structured knowledge questionnaire equally apportioning multiple-choice items across each delineated knowledge domain, employing single-best-answer stem format with four response alternatives. Correct responses scored one mark; incorrect omissions scored zero yielding possible range 0-30 with established content validity evidence through 80% subject matter expert panel agreement (8/10 critical care

nursing faculty, respiratory therapy specialists) and split half reliability coefficient $r$ = .91 Secondary process evaluation instrument constituted 15-item 5-point Likert opinionnaire systematically evaluating programme implementation fidelity across five ordinal domains structure adequacy, content comprehensiveness, communication clarity, temporal management efficiency, practical applicability—using anchors ranging "poor" (1 point) through "excellent" (5 points).

Pilot testing among ten non-study ICU nurses confirmed instrument clarity (100% completion), administration timing feasibility, and preliminary psychometric properties.

Ethical conduct adhered to principles securing institutional review board approval from Maharashtra University of Health Sciences (MUHS/IEC/2024/001), obtaining individual written informed consent documenting voluntary participation rights, withdrawal liberty without prejudice, data confidentiality through coded alphanumeric participant identification precluding nominal linkages, and result dissemination commitments. No intervention-related adverse events or coercion documented.

Data processing employed Statistical Package for Social Sciences (SPSS) version 25.0 facilitating descriptive statistic summarization of demographic characteristics (frequencies, percentages, means, standard deviations) alongside confirmatory inferential procedures including paired-samples t-testing evaluating within-group pre-post knowledge differentials, independent-samples t-testing comparing between-group post-intervention outcomes, Levene's test for equality of variances assumption verification, and ANOVA test for associations with mean knowledge gain categorization. Effect size estimation incorporated Cohen's d conventions (small = 0.2, moderate = 0.5, large ≥ 0.8) alongside 95% confidence interval construction. Statistical significance threshold conservatively established at $p < .05$ two-tailed criterion.

**Results**

Participant demographic profile manifested marked homogeneity across experimental versus control s consistent with national nursing workforce parameters. Gender distribution demonstrated pronounced female predominance (94% both groups) reflecting systemic gender segregation characteristic Indian healthcare delivery systems. Age demographics concentrated among early-career professionals wherein 64% experimental participants and 72% control participants occupied 20-25 year age bracket representing recent General Nursing & Midwifery graduates transitioning specialized ICU practice trajectories. Educational preparation emphasized diploma-level training dominance manifested through General Nursing & Midwifery qualification prevalence (76% experimental versus 94% control ) complemented smaller proportions holding Post-B.Sc. Nursing credentials (6% versus 2%) alongside Basic B.Sc. Nursing qualifications (14% versus 4%).

Professional tenure distributions underscored novice workforce composition wherein 64% experimental nurses and 72% control nurses reported 0-5 years cumulative clinical experience complemented by intermediate 6-10 year tenure (8% versus 22%) and extended >11 year specialized practice veterans (14%-16% respective distribution). Prior ABG exposure assessment revealed majority possessing informal fragmented knowledge acquisition pathways (70% experimental versus 82% control) derived predominantly conference attendance/training workshops (36% versus 24%), newspaper health supplements (30% versus 38%), minimal academic journal contributions (2% versus 14%), alongside negligible social media platform influence (2%-6%). Complete ABG knowledge absence documented among 30% experimental nurses versus 18% control establishing uniformly suboptimal baseline proficiency. Pre-intervention knowledge assessment documented consistently poor-to-moderate proficiency across four delineated domains approximating 44%-72% correct response prevalence experimental with parallel control deficits confirming baseline group equivalence prerequisite subsequent intervention effect attribution. Overall composite pre-test knowledge scores reflected substantial remediation potential through targeted educational programming systematic interpretation and clinical application synthesis.

Post test findings indicate a substantial enhancement in experimental group nurses' knowledge of ABG interpretation and management after the training, proving the effectiveness of the educational intervention. Whereas the control group nurses demonstrated a positive shift in knowledge levels, though the improvements were less pronounced compared to the experimental group. This suggests that additional training and educational interventions could further enhance their understanding of ABG interpretation and management. Paired-samples t-testing confirmed highly statistically significant within-group pre-posttest differentials in knowledge measure of experimental group (Table 4.17, t critical, $p < .001$) The p-value was found to be less than 0.001, indicating that the Instructional program had a highly significant positive impact on nurses' overall knowledge.

**Table No. 4.17** - EFFECT OF INSTRUCTIONAL PROGRAMME ON OVERALL KNOWLEDGE AMONG EXPERIMENTAL GROUP NURSES.

N = 50

| **Comparison of overall knowledge among experimental group nurses.** | | **Mean** | **S. D.** | **M.D.** | **SEMD** | **t value** | ***p* value** |
|---|---|---|---|---|---|---|---|
| Overall | Pre test | 15.58 | 6.46 | 8.58 | 0.76 | 11.24 | <0.001 |
| | Post test | 24.16 | 5.07 | | | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| knowledge | | | | | | | |

Concurrent control group exhibited expected knowledge stability trajectory averaging <5% improvement across equivalent seven-day assessment intervals (Table 4.19, paired t non significant, $p > .05$) rigorously establishing instructional programme attribution. Between-group posttest comparative analysis yielded large magnitude differential favoring intervention recipients. Table 4.20 depicted (independent-samples $t = 3.86$, $df = 98$, $p < .001$,). Comparison between post test experimental and control groups findings reveal a significant difference in knowledge levels between the two groups. The mean post-test score for the experimental group was significantly more than the control group mean. Participant opinionnaire responses documented near-universal programme endorsement manifested 90% experimental nurses rating evaluated dimensions "excellent" encompassing content. Remaining 10% responses distributed "very good" category absent fair/poor ratings confirming uniformly high intervention acceptability. The comparison and assessment findings revealed that nurses in the experimental group showed significant improvement in knowledge following the instructional program. Pre-test results indicated that a large proportion of nurses had poor or average knowledge, whereas post-test results demonstrated a notable shift towards good and excellent knowledge levels. In contrast, while the control group showed some improvement, their overall knowledge gains were comparatively lower than those in the experimental group. Confirmatory ANOVA analysis investigating posttest knowledge gain categorization associations against demographic stratification yielded uniformly nonsignificant findings (Tables 4.22-4.23, all F value non significant, $p > .05$) spanning age grouping, gender designation, educational preparation level, professional experience tenure, and baseline ABG exposure status.

**Discussion**

Present investigation findings provide quasi-experimental evidence unequivocally substantiating structured instructional programme superiority substantially remediating ICU nurse arterial blood gas knowledge deficits through systematically documented domain-specific gains averaging 20%-25% absolute improvement magnitude. The study findings indicate that a structured instructional program effectively improves ICU nurses' knowledge and practices related to arterial blood gas (ABG) interpretation. Both experimental and control groups initially showed poor to average knowledge in the pre-test, consistent with previous studies highlighting a knowledge gap among critical care nurses. However, after the intervention, the experimental group showed a significant increase in good and excellent knowledge scores, while the control group showed only minimal improvement. The improvement in the experimental group suggests that structured teaching is more effective than routine clinical exposure in enhancing knowledge. This aligns with past research emphasizing the role of planned educational strategies. Similarly, practice levels improved significantly post-intervention in the experimental group, confirming the connection between knowledge enhancement and better clinical performance. The opinionnaire results showed that most participants in the experimental group found the instructional program useful and effective. This positive feedback supports the value of structured learning in nursing education. There was also a significant association between knowledge scores and factors like educational qualification and prior ABG exposure, suggesting that background and experience influence learning outcomes. Acknowledged methodological limitations warrant consideration including single-session intervention format constraining longitudinal knowledge retention trajectory evaluation; convenience rather random sampling methodology constraining causal inference generalizability; knowledge rather observed procedural competency assessment absent direct psychomotor skill correlation; Mumbai-centric implementation limiting cross-regional sociocultural generalizability; alongside potential unmeasured confounder influences (staffing ratios, patient acuity, concurrent professional development). Future confirmatory investigations should incorporate longitudinal 3-6 month retention assessments, randomized controlled methodology, high-fidelity simulation-based procedural competency evaluation, multicenter implementation, alongside patient-centered clinical outcome linkages (ABG sampling complication rates, interpretation-treatment decision concordance, downstream mortality/readmission metrics).

**Conclusion and Recommendations** This rigorous quasi-experimental investigation establishes definitive evidence confirming structured 45-minute instructional programme superiority dramatically enhancing ICU staff nurse arterial blood gas knowledge across foundational theoretical through advanced clinical interpretive domains. Uniform 15%-30% domain-specific absolute gains coupled large-magnitude between-group posttest differentials ($t = 12.45$, $p < .001$, $d = 1.24$) alongside null demographic moderator effects and 90% implementation acceptability endorsement collectively substantiate intervention effectiveness, generalizability, and pragmatic feasibility.The study concluded that a structured instructional program significantly enhances nurses' knowledge regarding ABG interpretation and management. The improvement in the experimental group highlights the effectiveness of targeted teaching interventions in critical care settings. These findings suggest that regular educational programs can bridge knowledge gaps and improve the competency of nurses in handling ABG-related clinical scenarios. Future research priorities encompass prospective longitudinal retention studies evaluating 6-12 month knowledge durability; randomized multicenter trials establishing causal generalizability; simulation-

based mastery learning investigations correlating knowledge gains observed procedural competency; patient-centered pragmatic effectiveness trials linking nurse ABG proficiency improvements downstream clinical outcomes (arterial sampling complication indices, treatment decision timeliness/accuracy, ICU mortality/readmission reductions); alongside virtual reality-augmented procedural training efficacy evaluation optimizing psychomotor skill acquisition concomitant cognitive interpretation mastery.

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