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Data Analysis Course in Competency-Based Medical Curriculum-A Workshop-Based Approach

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ABSTRACT

Background: Mastery of data analysis is essential for evidence-based medicine; nonetheless, medical students frequently encounter difficulties in biostatistics. This study assessed the efficacy of a one-day, practical workshop in enhancing biostatistical knowledge and application skills in medical students.

Methods: A pre-post intervention study was undertaken involving fifth-year medical students. Participants undertook a pre-test, participated in a 6-hour data analysis session utilising Microsoft Excel, and subsequently performed an immediate post-test and a second post-test after 15 days. The program highlighted the actual implementation of statistical tests. Knowledge ratings were analysed using Friedman and Wilcoxon signed-rank tests.

Results: All 110 students participated, with 90.9% being female. A notable elevation in mean scores was recorded: Pre-test (4.12±1.83), Post-test 1 (7.37±1.06), and Post-test 2 (8.35±2.01) ($p<0.0001$). The passing percentage (≥70%) increased from 9.1% in the Pre-test to 80% in Post-test 1 and 77.3% in Post-test 2. Post-hoc analysis revealed significant differences among all test pairings (Pre vs. Post-1: $z=-8.74$, $p<0.0001$, $r=0.83$; Pre vs. Post-2: $z=-8.64$, $p<0.0001$, $r=0.82$).

Conclusion: An intensive, practical data analysis workshop resulted in a substantial and enduring enhancement of medical students' biostatistical expertise. Incorporating practical sessions into the medical curriculum can successfully connect theoretical knowledge with practical application, thereby enhancing students' preparedness for evidence-based practice and research.

Key-words: Competency-Based Medical Education (CBME), Data analysis, Medical students, Pre-test, Post-test, Statistical tests

INTRODUCTION

Biostatistics and data analysis constitute the foundation of clinical research and evidence-based medical treatment [1,2]. A robust foundation in these areas is essential for medical graduates to become discerning consumers of literature and proficient researchers [3]. Conventional, didactic approaches to teaching statistics frequently fail to captivate medical students, leaving them with theoretical information they find challenging to apply [4,5]. The worldwide transition to Competency-Based Medical Education (CBME) underscores the need for graduates to understand and apply analytical skills [6]. Medical educators are investigating innovative, student-centered pedagogical approaches. Research indicates that interactive, hands-on methods—such as workshops utilising statistical software—can markedly enhance students' comprehension, attitudes, and self-assessed proficiency in statistics [7-9]. The use of accessible tools such as Microsoft Excel for training has been recognised as a platform-independent advantage over proprietary software [10].

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The research underscores the importance of practical training; however, additional data, especially in the Indian context, is required regarding the immediate and short-term effectiveness of intensive, workshop-based interventions. This study sought to address this deficiency by developing and accessing a practical data analysis workshop for medical students.

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MATERIALS AND METHODS

A quasi-experimental pre-post intervention study was done with fifth-year medical students at the College of Medicine and Health Sciences, National University. All 110 students at the college were invited to participate in the study.

Intervention- The Data Analysis Workshop

The intervention consisted of a one-day, six-hour workshop with a thirty-minute interval. The workshop was intended to be exceptionally engaging and pragmatic.

Group Formation- Students were organised into 19 small groups of 5-6 participants each to enhance teamwork.

Tools and Software- Microsoft Excel.

The curriculum encompassed: data entry in Excel, assessment of normality, independent-samples t-test, paired-samples t-test, Z-test, pivot table construction, F-test, correlation coefficient, one-way ANOVA, and simple linear regression.

Pedagogy- Each statistical test was initially elucidated, followed by a structured practical session. Course facilitators promoted group discussions and offered prompt, comprehensive clarification of enquiries.

Data Collection and Measurement

Knowledge was evaluated at three intervals through scenario-based multiple-choice questions (MCQs) conducted on the Blackboard platform:

1. Preliminary assessment: Before the workshop.
2. Post-test 1: Immediately following the workshop.
3. Post-test 2: Fifteen days after the workshop.

The authors designed the assessment tool, which was evaluated for content validity by two senior biostatisticians and tested on a small group of interns for clarity. The test's internal consistency, measured by Cronbach's alpha, was 0.78, signifying acceptable reliability.

Statistical Analysis- The analysis of data was conducted utilising SPSS version-20. The data, gathered through convenience sampling and found to be non-normally distributed by the Kolmogorov-Smirnov test, necessitated the use of nonparametric tests. Descriptive statistics were presented as mean±standard deviation (SD) and percentages. The Friedman test was employed to compare scores among all three assessments. Post-hoc analysis was performed using the Wilcoxon signed-rank test with a Bonferroni correction, establishing the significance threshold at $p<0.025$ when applicable. Effect sizes (r) for Wilcoxon tests were computed to ascertain the extent of the change.

Ethical Considerations- Informed permission in writing was acquired from all subjects. The Institutional Ethics Committee approved the study protocol.

RESULTS

The average test results demonstrated a notable and significant enhancement from the pre-test to both post-tests (Table 1). The Friedman test indicated a statistically

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significant difference in scores among the three time points ($\chi^2(2)=137.96$, $p<0.0001$).

Table 1 illustrates the comparison of test scores acquired in the Pre-test, Post-test 1, and Post-test 2. The mean score, standard deviation (SD), and 95% confidence interval (CI) for each assessment are presented to illustrate performance enhancement over time. Pre-test: The mean score was 4.12 (SD=1.83), with a 95% CI ranging from 3.77 to 4.66, reflecting a relatively low baseline performance before the intervention- Post-test 1: The mean score rose to 7.37 (SD=1.06), with a 95% CI between 7.17 and 7.57, indicating a significant improvement in scores immediately following the intervention or training. Post-test 2: The mean score further increased to 8.35 (SD=2.01), with a 95% CI of 7.96 to 8.73, suggesting sustained learning or retention of knowledge over time. Overall, the data demonstrate a progressive improvement in test performance from pre-test to post-test, underscoring the efficacy of the implemented intervention or educational program.

Table 1: Comparative Analysis of Examination Scores (Out of 10)

Test	Mean Score	SD	95% CI
Pre-test	4.12	1.83	3.77 – 4.66
Post-test 1	7.37	1.06	7.17 – 7.57
Post-test 2	8.35	2.01	7.96 – 8.73

The proportion of students attaining the passing grade (≥7/10) surged significantly from 9.1% in the pre-test to 80% in the initial post-test. The gain was predominantly preserved in the second post-test (77.3%) (Table 2).

Table 2 presents the passing and failing rates of students in the Pre-test, Post-test 1, and Post-test 2. The data illustrate improvements in performance and knowledge retention among participants after the intervention. Pre-test: Merely 10 students (9.1%) achieved a passing score, whereas 100 students (90.9%) did not, signifying a low initial level of knowledge or comprehension before the intervention. Post-test 1: The passing rate markedly rose to 88 students (80.0%), with only 22 students (20.0%) failing. This indicates a significant enhancement in performance following the intervention or training. Post-test 2: The passing percentage marginally declined to 85 students (77.3%), while 25 students (22.7%) failed, implying a slight reduction in performance; however, overall knowledge retention remained elevated. Collectively, the data suggest that the educational intervention was successful in improving student performance, as evidenced by the considerable increase in passing rates from the pre-test to the post-test.

Table 2: Proportion of Successful Candidates

Test	Passed n (%)	Failed n (%)
Pre-test	10 (9.1%)	100 (90.9%)
Post-test 1	88 (80.0%)	22 (20.0%)
Post-test 2	85 (77.3%)	25 (22.7%)

The Wilcoxon signed-rank test confirmed that score improvements were statistically significant across all pairwise comparisons, with large effect sizes (Table 3).

Table 3: Results of the Post-hoc Wilcoxon Signed-Rank Test

Comparison	Z-value	p-value	Effect Size (r)
Pre-test vs. Post-test 1	-8.74	<0.0001	0.83 (Large)
Pre-test vs. Post-test 2	-8.64	<0.0001	0.82 (Large)
Post-test 1 vs. Post-test 2	-3.94	<0.0001	0.37 (Medium)

This study demonstrates that a one-day, intensive, hands-on data analysis workshop can yield a significant improvement in medical students' statistical understanding, with this improvement showing strong retention over a 15-day interval. The substantial effect sizes obtained suggest that the intervention was not only statistically significant but also practically influential.

DISCUSSION

This study demonstrates that a one-day, intensive, hands-on data analysis workshop can produce a substantial enhancement in medical students' statistical understanding, with this improvement showing strong retention over a 15-day interval. The large effect sizes recorded in all pairwise comparisons indicate that the intervention was both statistically robust and educationally meaningful. These findings reinforce the growing global evidence that practical, activity-based learning strategies are far superior to traditional lecture-based biostatistics teaching [8,9,12].

Our results are consistent with the literature advocating for interactive, participation-driven teaching approaches. Rubio *et al.* [8] demonstrated that participatory learning significantly enhances students' perception of competence in epidemiology and statistics. Similarly, Kiekkas *et al.* [9] reported that structured biostatistics

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sessions improved examination results and student attitudes toward statistics. The success of our Excel-based course aligns with LaPolla's [10] observations that freely available, platform-independent software fosters better engagement and accessibility than specialized statistical packages.

Moreover, Excel-based practical sessions have been shown to reduce learner anxiety and improve conceptual clarity in statistical reasoning, particularly among undergraduate medical populations [13,14]. The notable increase in post-test passing percentages mirrors the findings of Malini *et al*. [11], who used a pre–post-test design to evaluate the effectiveness of interactive educational interventions.

The minor decline observed between Post-test 1 and Post-test 2 is expected and aligns with established learning theories on knowledge decay. Research suggests that without reinforcement, learners experience predictable short-term attrition of newly acquired skills [15]. Despite this, the fact that Post-test 2 scores remained markedly higher than baseline demonstrates meaningful retention rather than superficial recall. Prior studies examining pre–post workshops in physiology and research methods report similar trends, with initial gains sustained over short- to medium-term follow-up [16,17].

Importantly, this study contributes valuable Indian evidence to the Competency-Based Medical Education (CBME) framework, which emphasizes the development of analytical and research-oriented skills [6]. Indian data on short-term learning outcomes related to statistical training remain sparse; therefore, this study helps fill a critical gap and supports the integration of structured, practice-oriented biostatistics modules into the undergraduate curriculum.

Collectively, the findings affirm that an intensive, application-based workshop is an effective pedagogical strategy for improving biostatistical competence among medical students. By bridging the gap between theoretical concepts and practical application, such workshops can significantly enhance students' preparedness for evidence-based clinical practice and research activities.

STRENGTHS

The principal strength of this study is its rigorous pre-post design, complemented by a follow-up examination to assess knowledge retention. The elevated participation rate and the utilisation of an established, trustworthy assessment instrument further reinforce the findings.

LIMITATIONS

Nevertheless, numerous restrictions must be recognised. The research was conducted at a single institution, utilising a convenience sample, which may have constrained the generalisability of the findings. The significantly imbalanced gender distribution hindered any substantive examination of gender-related disparities. The absence of a control group precludes the complete exclusion of exogenous influences. Ultimately, although we evaluated knowledge and application, we did not quantify alterations in student attitudes or the enduring effects on research output.

CONCLUSIONS

In conclusion, a workshop-based introduction to teaching data analysis is an effective strategy for improving medical students' biostatistical knowledge and application skills. This paradigm effectively connects theoretical knowledge with practical skills. We advocate incorporating practical, software-oriented workshops into the fundamental medical curriculum. Subsequent investigations ought to utilise controlled methodologies, incorporate qualitative elements to comprehend student viewpoints, and monitor the enduring effects of such training on research output and critical evaluation abilities.

Future studies should focus on effective methods for integrating statistics instruction with other disciplines and examine whether multiple-choice questions, despite their convenience for large cohorts, can adequately assess deep conceptual understanding. Longitudinal studies are essential to assess the enduring effects of these seminars on research proficiency in clinical practice.

CONTRIBUTION OF AUTHORS

Research concept- Dhaval Mahadevwala, Ashish Kumar Goyal

Research design- Dhaval Mahadevwala, Amit Agarwal

Supervision- Dhaval Mahadevwala

Materials- Dhaval Mahadevwala, Amit Agarwal, Ashish Kumar Goyal

Data collection- Amit Agarwal, Ashish Kumar Goyal

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Data analysis and interpretation- Dhaval Mahadevwala
Literature search- Amit Agarwal, Ashish Kumar Goyal
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Critical review- Dhaval Mahadevwala
Article editing- Dhaval Mahadevwala, Ashish Kumar Goyal
Final approval- Dhaval Mahadevwala

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