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Original article

Designing and assessing the impact of a competency-based training program in transfusion medicine among MBBS interns

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ABSTRACT

Introduction: It has been widely recognized that there is a pressing need to strengthen transfusion medicine education for both undergraduate and postgraduate medical trainees across various clinical specialties to enhance patient safety. In response to this, the National Medical Commission (NMC) of India implemented a competency-based medical education (CBME) framework in 2019 for undergraduate MBBS students across all medical colleges in the country. The present study aimed to assess the impact of a training program designed for medical interns, developed in alignment with the CBME curriculum prescribed by the NMC.

Materials and methods: This was a questionnaire-based cross-sectional study conducted among MBBS interns undergoing rotatory training in different departments of a tertiary care teaching hospital. A structured two-day educational program was organized, comprising six modules—three focusing on bedside transfusion practices and three addressing blood donation and laboratory-based transfusion medicine. Each module was designed to reflect the competencies outlined in the CBME curriculum and included pre- and post-training assessments to evaluate knowledge improvement. A pre-test was conducted to assess the knowledge of transfusion medicine among the participants and the post-test was conducted to assess the impact of the training program.

Results: Overall, the pre-test score in the present study was 14.1 (47%) which increased to 22.3 (77.6%) in the post-test. Analysis of the pre-test scores showed that 80% of the interns had weak knowledge of blood transfusion reactions and its management. 55.6% of the interns had weak knowledge of indications of blood component therapy whereas 32.2% of the interns had weak knowledge of bedside transfusion medicine practices. 73.3% of the interns had weak knowledge of blood donor selection and counselling. 62.3% of the interns and 73.3% of the interns had weak knowledge of transfusion transmitted infections and basic blood banking including compatibility testing and storage conditions for various blood components, respectively. Post-training results showed a significant improvement across all domains. Effect size analysis using Cohen's *d* indicated that the training program was highly effective in five out of six domains, with moderate effectiveness observed in the domain of immunohematology.

Conclusion: Although transfusion medicine knowledge is essential for routine practice in core medical and surgical specialties, a substantial knowledge gap exists among medical interns. This study demonstrates that a structured, CBME program is an effective strategy to improve transfusion medicine knowledge among MBBS interns.

1. Introduction

Resident doctors and interns are the closest point of contact to patients in a tertiary healthcare setting. They are involved in blood requisition, blood transfusion and management of any adverse transfusion reaction in the patients [1]. A medical intern must have a fundamental knowledge of the field of transfusion medicine to ensure patient safety [2]. It has been advocated that there is a need for enhancing the education in transfusion medicine for both undergraduates and postgraduates undergoing training in various clinical specialties [3]. The first comprehensive curriculum for teaching of transfusion medicine to undergraduates and postgraduates was designed by the Transfusion Medicine

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Academics award group in the year 1989 [4]. The European and Mediterranean initiative in transfusion medicine for medical student education in transfusion medicine has proposed a detailed competency-based medical education of transfusion medicine [2,5,6].

The National Blood Policy of India has also advocated for integrating transfusion medicine education into the undergraduate training of doctors to ensure clinically appropriate utilization of blood [7]. In 2019, the National Medical Commission (NMC) implemented competency-based medical education (CBME) for teaching various subjects to undergraduate MBBS students in all medical colleges in India [8]. Transfusion medicine education is imparted through 15 different competencies spread throughout the course. Out of these, six competencies are taught in the second year under the subject of pathology. Three competencies are included under the subject of general surgery, and six competencies are included under the subject of internal medicine. Horizontal and vertical integration has been done so that the competencies can be collaborated with a final objective that the student can demonstrate the clinical and lab side skills of transfusion medicine in practice and not just in theory. Herein, a training program was conducted for medical interns based on the competency-based medical education curriculum of NMC.

2. Material and methods

2.1. Study design, setting and study population

Following approval from the Institutional Research and Ethics Committee (SRHU/HIMS/RC/2023/188, dated 18/08/2023), a questionnaire-based cross-sectional study was conducted in August 2023 by the Department of Transfusion Medicine at a postgraduate teaching medical college in North India. The study participants comprised MBBS interns undergoing rotatory training across various clinical departments of the hospital.

2.2. Questionnaire designing

The questionnaire was designed by a group of five transfusion medicine specialists. The Content Validity Index (CVI) was used to determine which questions to include and which to exclude [9]. Each faculty member had to rate the question as relevant or not relevant. A question with CVI = 1 has been included in the final questionnaire [10].

The questionnaire consisted of six modules: Module I – Indication of blood component therapy, Module II – Immunohematology, Module III – Blood Banking, Module IV- Bedside transfusion practices, Module V – Transfusion reaction and Management, and Module VI – Transfusion transmitted Infection (TTI). Modules have been created based on the CBME curriculum of transfusion medicine for undergraduates and topics that an MBBS intern should know to ensure quality-driven best blood transfusion practices. Each module contained five questions, making a total of 30 questions. All the questions were of the multiple-choice type with a single best answer.

2.3. Study procedure

All participants underwent a pre-training test in which they were allotted 20 min to complete the test, then it was followed by a competency-based medical education training program. At the end of the program post-test was taken with the same questions used in the pre-test. The scoring was done module-wise separately for both pre- & post-tests. The training was spread over 2 days, and the total duration of the program was 6 h.

2.4. Outcome measures studied

The primary aim of this study was to evaluate the effectiveness of a CBME training program in enhancing the knowledge of transfusion medicine among medical interns. The secondary aim of the study was to assess the knowledge of transfusion medicine among medical interns.

2.5. Statistical analysis

The data generated was entered electronically and analyzed using the Statistical Package for Social Sciences (SPSS) software version 21 (Armonk, NY, USA: IBM Corp). The data was analyzed for mean score, level of knowledge on each module before and after the CBME-based training workshop program using SPSS software by entering the test scores. For each module, a knowledge score of ≤2 was categorized as weak knowledge and a score of ≥3 as adequate knowledge for that domain. Statistical tests were performed at a significance level of 0.05. Cohen's *d* test was used for measuring the effectiveness of the training program.

3. Results

Out of the total of 113 interns, 90 (79.6%) participated in the training program, and 23 (20.4%) did not show up for the workshop thus were not included in the study. The average age of participants was 23.7 ± 1.3 years old, with a female-to-male ratio of 50:41. Overall, the scores of participants before and after the training program (Table 1) were 14.1 ± 0.7 and 23.3 ± 0.7 out of 30, respectively, and there was a significant difference between the two scores ($p < 0.00001$). In each module, the mean pre-test and post-test scores were as follows: module I (2.3 ± 0.2 vs 3.7 ± 0.2, $p < 0.00001$), module II (3 ± 0.2 vs 3.7 ± 0.2, $p < 0.00001$), module III (2 ± 0.2 vs 4.1 ± 0.2, $p < 0.00001$), module IV (2.9 ± 0.3 vs 4.6 ± 0.1, $p < 0.00001$), module V (1.7 ± 0.2 vs 3.4 ± 0.2, $p < 0.00001$) and module VI (2.2 ± 0.2 vs 3.8 ± 0.2, $p < 0.00001$). Candidates with weak pre & post-test knowledge score (Table 2) was 55.6% ($n = 50$) and 10% ($n = 9$) respectively in module I; 28.9% ($n = 26$) and 7.8% ($n = 7$) respectively in module II; 73.3% ($n = 66$) and 6.6% ($n = 6$) respectively in module III; 32.2% ($n = 29$) and 2.2% ($n = 2$) respectively in module IV; 80% ($n = 72$) and 15.6% ($n = 14$) respectively in module V; 62.2% ($n = 56$) and 11.1% ($n = 10$) respectively in module VI. The effectiveness of each training module and overall training program is given (Table 3). Overall, the Cohen's *d* value was 2.62, signifying that the training program was highly effective.

4. Discussion

A two-day education program was conducted for medical interns. The program had 6 different modules, which were based on the recently introduced competency-based medical education curriculum for undergraduate MBBS students implemented by NMC in India. While 3 modules were based on bedside transfusion medicine, 3 mod-

Table 1
Module-wise improvement in knowledge scores among MBBS interns.

Parameter	Pre-test	Post test	*P* value
Module I: Indications of blood component therapy	2.3 ± 0.2	3.7 ± 0.2	$P < 0.00001$
Module II: Immunohematology	3 ± 0.2	3.7 ± 0.2	$P < 0.00001$
Module III: Blood Banking	2 ± 0.2	4.1 ± 0.2	$P < 0.00001$
Module IV: Bedside transfusion practices	2.9 ± 0.3	4.6 ± 0.1	$P < 0.00001$
Module V: Transfusion reaction and its management	1.7 ± 0.2	3.4 ± 0.2	$P < 0.00001$
Module VI: Transfusion transmitted Infection (TTI)	2.2 ± 0.2	3.8 ± 0.2	$P < 0.00001$
Total mean score	14.1 ± 0.7	23.3 ± 0.7	$P < 0.00001$

Table 2
Proportion of MBBS interns with weak knowledge scores in each module.

Parameter	Pre-test	Post test
Module I: Indications of blood component therapy	50 (55.6%)	9 (10%)
Module II: Immunohematology	26 (28.9%)	7 (7.8%)
Module III: Blood Banking	66 (73.3%)	6 (6.6%)
Module IV: Bedside transfusion practices	29 (32.2%)	2 (2.2%)
Module V: Transfusion reaction and its management	72 (80%)	14 (15.6%)
Module VI: Transfusion transmitted Infection (TTI)	56 (62.2%)	10 (11.1%)

Table 3
Effectiveness of the competency-based training program.

Parameter	Cohen's *d* score*
Indications of blood component therapy	1.39
Immunohematology	0.78
Blood Banking	1.52
Bedside transfusion practices	1.12
Transfusion reaction and its management	1.54
Transfusion transmitted Infection (TTI)	1.61
Total	2.62

*Interpretation of Cohen's *d* score:
<0.2 = small impact.
0.2–0.8 = moderate impact.
>0.8 = significant impact.

ules were based on blood donation and lab side transfusion medicine practices.

In this present study, analysis of results of the three modules based on clinical transfusion medicine showed that 80% of the interns had weak knowledge of blood transfusion reactions and its management. 55.6% of the interns had weak knowledge of indications of blood component therapy, whereas 32.2% of the interns had weak knowledge of bedside transfusion medicine practices. As already mentioned, medical interns and resident doctors are actively involved in blood requisition, blood transfusion and management of adverse blood transfusion reactions in the patients [1]. As per the Serious Hazards of Blood Transfusion (SHOT) 2019 report, 30.7% of the incorrect blood transfusion reactions occurred at the time of blood requisition [11]. Arinsburg et al. concluded that knowledge of transfusion medicine among clinicians strongly correlated with the quality of medical care delivered to the patients [12].

Analysis of the results of the three modules based on blood donor selection and lab side transfusion medicine practices showed that 73.3% of the interns had weak knowledge of blood donor selection and counseling. Voluntary non-remunerated blood donation program forms the cornerstone of safe quality blood transfusion services in any country [13]. The European and Mediterranean Initiative in Transfusion Medicine have proposed a bottom-up approach for imparting transfusion medicine education at the undergraduate level [2]. It has been concluded in this international forum that general practitioners and even physicians who rarely prescribe blood transfusion may be enquired by patient's attendants about the risks of blood donation and hence they should have basic knowledge about voluntary blood donation program [2]. In clinical settings, particularly among residents in surgical specialties, questions regarding blood donation and transfusion are commonly raised by the attendants of patients scheduled for elective procedures. In response to this educational need, the NMC has incorporated a core competency titled "Counsel patient and family/friends for blood transfusion and blood donation" into the surgery curriculum. This competency is designated to be taught during the third and fourth years of undergraduate MBBS training [14].

A significant proportion of interns demonstrated inadequate knowledge in key areas of transfusion medicine, with 62.3% lacking sufficient understanding of transfusion-transmitted infections and 73.3% showing weak knowledge in basic blood banking practices, including compatibility testing and the storage conditions of various blood components. These two domains are critical components of transfusion safety and have been emphasized in the bottom-up educational strategy proposed by the European and Mediterranean Initiative in Transfusion Medicine [2]. Recognizing their importance, these topics have been integrated into three specific competencies within the NMC driven CBME curriculum. These competencies are distributed across the subjects of pathology, internal medicine, and general surgery, and are scheduled to be taught during the second, third, and fourth years of the MBBS program, respectively [14].

Analysis of the Cohen's *d* test revealed that the competency-based training program was highly effective for 5 of the 6 domains and moderately effective for the domain "immunohematology". This signifies that the foundation of interns in basic immunohematology domain, which is a labside domain might be weak and there is scope of improvement in curriculum of this specific domain. Overall, the Cohen's *d* value was 2.62, signifying that the training program was highly effective.

The total teaching duration of the education program was 6 h spread over 2 days. Haspel et al. in a study involving resident doctors has demonstrated that there is a significant direct correlation between the knowledge of transfusion medicine and the curriculum time allocated to teaching of transfusion medicine in medical schools and those resident doctors who received more than 2 h of TM training scored better than those who received less than 2 h of TM training [15].

In the present study, the mean pre-test score was 14.1 out of 30 (47%), which significantly improved to 22.3 (77.6%) in the post-test, reflecting the positive impact of the training program. Similar trends of inadequate baseline knowledge in transfusion medicine among medical interns have been observed globally. A study by Farah et al. involving 210 interns from Saudi Arabia and Lebanon reported that 48% of participants had poor knowledge of transfusion medicine [16]. In India, Kaur et al. found that only 51% of responses from 25 interns were correct [17]. Likewise, a study by Shafiee et al. in Iran, involving 90 interns, reported an average assessment score of 54.7% [18]. A study by Peedin et al. in the United States, conducted among 63 interns, revealed an even lower average score of 27.5% [19]. These findings collectively underscore a global gap in transfusion medicine education during undergraduate medical training, highlighting the urgent need for structured, competency-based curricula for improved clinical practices.

A competency-based curriculum for teaching transfusion medicine at the undergraduate level has already been established in countries such as the United States, Canada, and the United Kingdom [2]. However, the extent of its implementation remains limited. An evaluation in the United States revealed that only 16% of medical schools provided at least six hours of dedicated education in transfusion medicine [4]. In a global survey conducted by Panzer et al., it was concluded that transfusion medicine education is inconsistent across medical schools, with a lack of standardized national curricula in most countries surveyed [5]. Similarly, Muller et al. reported that transfusion medicine was incorporated into the medical curriculum in only 12 out of 17 countries assessed [20]. Furthermore, no unified or standardized curriculum currently exists at the European level for transfusion medicine education [2]. These findings highlight the global variability and inadequacy in the teaching of transfusion medicine at the undergraduate level. There is a clear need for standardization and enhancement of educational frameworks to ensure that all future physicians are equipped with essential knowledge and skills in this critical area of clinical practice.

5. Conclusions

Although the application of transfusion medicine knowledge is routinely required across core medical and surgical specialties, a signifi-

cant gap persists in the transfusion-related competencies of medical interns. This shortfall is further compounded by the considerable variation in transfusion medicine curricula across different countries. The findings of this study reinforce that a CBME approach serves as an effective strategy to bridge this knowledge gap and enhance the proficiency of medical interns in transfusion medicine.

Disclosure of potential conflicts of interest

Authors declare no conflict of interest.

Research involving human participants and/or animals: Human participants.

Ethical approval

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional ethics committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. The institutional research and ethics committee approval was sought and obtained [(IEC-SRHU/HIMS/RC/2023/188) dated 18/08/2023].

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Informed consent

An informed consent was obtained from all participants as part of the training program.

CRediT authorship contribution statement

Manish Raturi: Conceptualization, Methodology, Investigation, Resources, Writing – review & editing, Supervision, Project administration. **Yashaswi Dhiman:** Investigation, Resources, Formal analysis. **Naveen Bansal:** Conceptualization, Methodology, Resources, Writing – original draft, Visualization, Validation, Project administration. **Basanta Khatiwada:** Investigation, Formal analysis. **Dushyant Singh Gaur:** Resources, Writing – review & editing, Validation. **Poonam Rawat:** Resources, Writing – review & editing.

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