

Original Article



Competency-based medical education and anemia in pregnancy: A mixed-methods intervention study among medical students in India

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Anemia, Pregnancy, Evaluation,
Assessment**Abstract**

Background: Traditional medical education in India emphasizes theoretical knowledge, with limited focus on competency-based outcomes that integrate clinical skills, decision-making, and interprofessional collaboration. Effective management of anemia during pregnancy requires a comprehensive understanding of pathophysiology, timely recognition of complications, and multidisciplinary interventions. This study was designed to deliver competency-based modules and to compare objective and subjective assessment outcomes.

Methods: A mixed-methods, intervention (pre-post test) design was used. Purposive sampling was utilized to select a batch of 40 undergraduate medical students among all students enrolled that year. A faculty panel designed five competency modules and assessments covering 15 areas. Nine areas were assessed objectively, and six were assessed subjectively. Assessment areas were classified using Miller's pyramid and revised Bloom's taxonomy. Objective assessments measured knowledge and understanding, scored as 1 for correct and 0 for incorrect answers. Scores were summed per domain; means and standard deviations were calculated. Subjective assessments evaluated higher-order competencies, scored 0–5 by faculty, with independent mean and standard deviation calculations.

Results: Objective assessments showed significant improvement in metabolism and physiology ($P < 0.001$), recognition of complications ($P = 0.04$), management strategies ($P < 0.002$), and multidisciplinary collaboration ($P < 0.001$), while the monitoring and follow-up domain showed no significant change. Subjective assessments revealed significant gains in all areas except recognition of complications.

Conclusion: Competency-based medical education (CBME) implementation significantly improved medical students' competencies in key domains related to anemia in pregnancy, in both objective and subjective assessments. The results underscore the importance of diverse assessment methods and continuous evaluation. This study provides a blueprint for naive settings adopting CBME, promoting cross-learning to standardize and enhance medical education and patient care quality.

Introduction

Competency-based education is emerging as the de facto standard globally. The adoption process of competency-based medical education (CBME) has been evolving over decades, and adoption timelines have varied in medical institutions across countries. There remain variances in terminologies, definitions of competencies, implementation, assessment, and evaluation. Despite calls for the development of a CBME model from the 1970s and 80s, there was a three-decade-long gap between initiation of the movement and widespread adoption.¹ The lead time

between the paradigm shift from a structure and process-based curriculum to a competency based curriculum was substantial. This delay can be attributed to ambiguities in defining benchmarks for specific competencies, modes for assessment of these competencies and evaluation of the competency based model in its entirety. Following the adoption of the Canadian Medical Education Directives for Specialists (CanMEDS) framework and the Outcome Project of the Accreditation Council for Graduate Medical Education (ACGME) in the USA in 2000, there has been widespread global adoption of the paradigm shift.^{2–5} The

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advancement of CBME in graduate medical education in US continues to be emphasized by the release of revised milestones (Milestones 2.0), and in Canada with the adoption of the Competence by Design framework.⁴

India formally adopted the model in 2019, with the release of three volumes of the CBME curriculum, five broad-based competency roles, a foundational course, a focus on early clinical exposure, ethics and communication skills, horizontal integration of subjects, and formative assessment models.⁶ This was a change from a model which relied predominantly on didactic lectures, unidirectional flow of lower order knowledge and stress on factual recall rather than comprehension, skills and application.^{7,8}

There remain numerous variances in the definition, terminology, components, approach, and implementation modalities in the CBME model.^{2,3,9} A large part of this variation stems from the need for the model and competencies to be contextual and meeting the local needs.⁹ However, key themes in a CBME model include a focus on the outcome and intended competencies to be achieved, assessment of these competencies based on criteria, a flexible learner-centered approach, and a de-emphasis on time-based learning. A focus on the outcome to design the curriculum, rather than the processes, enables a systems thinking approach with the end goal in mind. A flexible, learner-centered approach with a de-emphasis on fixed time for learning ensures a more personalized, engaging learning experience with opportunity for varied, individual progression and pathways for learning. Measurable competencies ensure accountability in the patient care process.

CBME models also follow these key principles. Competence is a demonstrable set of individual competencies in varied areas of knowledge, skills, and attitudes. Competencies are not static and may vary by time and context. There is a gradual progression of competence from “novice” to “expert”. A competency in one domain may not compensate for a competency in another domain. CBME requires assessments that are frequent and continuous. CBME also requires documentation and ongoing evaluation.^{1,10,11}

Despite these advantages, CBME models are considered to be continuous work in progress^{3,10} and implementing change in medical curricula require several years even with a coordinated, resourced and collaborative approach.² Disruptions such as the COVID pandemic require rapid restructuring and adaptation of the model.⁴ Despite CBME being the predominant model for medical education globally, there remain several instances wherein the CBME curriculum is established on paper alone and competencies are neither defined, nor assessed.^{2,4} There are global variations in medical education standards, assessment of competencies, and patient care.¹⁰

The current study aims to outline the experience of implementing a CBME curriculum module for the

management of anemia in pregnancy. The study was conducted in a naive setting, embarking on the transition to a CBME model. The goal was to document the process, implementation, learning, challenges, and perceptions of the learners of the model to facilitate a shared understanding and global dialogue.

Methods

Study design

The study, utilizing a mixed-methods, intervention (pre-post test) design, was conducted to develop a competency-based curriculum, teaching modules for management of anemia during pregnancy, and assess the performance on competency domains before and after the administration of the module. The satisfaction and self-perceived gain in knowledge among students were also assessed.

The intervention consisted of delivering five competency-based modules on anemia in pregnancy, after which pre- and post-assessment data were collected. The intervention period, including module delivery and assessments, took place over a month in November 2022. Follow-up assessments were conducted immediately after the intervention to evaluate changes in competency.

Study setting, participants, and consent

The study was conducted among undergraduate medical students attending clinico-social rotations in the department of Community Medicine of a tertiary medical college. The questionnaire and methodology for this study were approved by the Human Research Ethics Committee of the ESIC Medical College, Sanathnagar, India. (Ethics approval number: 799/U/IEC/ESICMC/F538/11/2023). Written informed consent was obtained from all participants before their involvement in the study. Forty students attending the department were approached for the study, and consent was sought. Consent was voluntary, and students were assured that participation in the study would not reflect on their academic performance or assessment in any way.

The sample size for this study was determined based on the ability to detect a meaningful change in student competency scores using a pre-post intervention design. Assuming a medium effect size (Cohen's $d=0.5$), a significance level of 0.05, and a power of 80%, the calculated minimum sample size required was approximately 32 students. Eligibility was based on enrollment as an undergraduate medical student at the institution during the academic year. A total of 40 students who consented to participate were included, representing one complete batch out of six batches enrolled that year. Participants were selected purposively as an entire group from this batch, reflecting a census approach within the selected group.

Development of competencies and teaching modules

For the development of the competencies, curriculum, and

modules, a multi-disciplinary team from the departments of Medicine, Obstetrics and Gynecology, and Community Medicine was involved. Five major competency domains, viz., metabolism and physiology, monitoring and follow-up, recognition of complications, management strategies, and multidisciplinary collaboration, were identified based on literature review and expert input from faculty. Teaching modules and self-directed learning exercises were developed for each of the topics under the five competency domains. Modules addressed knowledge domains aligned with Miller's pyramid and Bloom's taxonomy, incorporating clinical skills, decision-making, and interprofessional collaboration elements. Delivery was through interactive sessions integrating didactic teaching, case-based discussions, and self-directed learning.

Competency assessment

Formative and summative assessments were developed. For each of the competency domains, objective and subjective exercises were developed for assessment by the faculty panel. A total of 15 areas of assessment were included in the first formative assessment. Each assessment area was classified using Miller's pyramid and revised Bloom's taxonomy to understand which domain of learning was involved.³ The objective assessment largely measured knowledge and understanding, while the subjective assessment measured understanding, analysis, and creation competencies. Among the 15 areas of assessment, 9 were assessed objectively and 6 were assessed subjectively. Objective assessments were scored as zero for incorrect and one for correct. The scores of the objective assessments in each competency domain were summed, and the mean and standard deviations were calculated. Subjective responses were scored by a faculty panel on a scale of 0-5, and means and standard deviations

were calculated independently for each assessment area. Longitudinal follow-up, summative assessments, simulated clinical scenarios, and measurement of competencies have been planned, but the results are not presented in the current study.

Statistical analysis

Descriptive and inferential analyses were performed using R Statistical Software (version 4.3.2). Means and standard deviation were calculated for the objective and subjective assessments, and paired t-tests were conducted to assess improvement in assessment score before and after the delivery of the competency modules. Satisfaction with the module among students and self-perceived improvement of knowledge and skills were measured on a five-point Likert scale, and counts and percentages are presented.

Potential confounders include variations in baseline knowledge and clinical exposure among students. To control for these effects, pre-test scores were used as baseline measures, and changes in scores were analyzed using paired statistical tests comparing pre- and post-intervention results, thereby accounting for individual baseline differences.

Results

Among the 40 students who consented to participate in the study, 38 attended all the modules and completed both the pre- and post-test. The results and analysis are presented for 38 students. The students were all studying in the third year of MBBS (Phase 1), and 32 (84.2%) were female and 6 (15.8%) were male.

Table 1 presents the 5 competency domains and the 15 areas of assessment. It also includes the number of areas assessed objectively, 9 (60%) and the areas assessed subjectively, 6 (40%). The areas of assessment are ranked on

Table 1. Competency domains and method of assessment

Competency domain	Area of assessment	Method of assessment	Hierarchy of Miller's pyramid	Level on revised Bloom's taxonomy
Metabolism and physiology	Sources of iron	Objective	Knows	Understand
	Iron requirement in pregnancy	Objective	Knows	Understand
Monitoring and follow-up	Screening tests	Objective	Knows	Remember
	Diagnosis of anemia	Objective	Knows How	Understand
Recognition of complications	Complications of anemia	Objective	Knows	Understand
	Complications of anemia	Subjective	Knows How	Analyze
Management strategies	Iron supplementation and fortification	Objective	Knows	Remember
	Prevention strategies in the community	Objective	Knows How	Understand
	Management of anemia in pregnancy	Subjective	Knows How	Understand
	Management of side effects of therapy	Subjective	Knows How	Analyze
	Counseling	Subjective	Knows How	Create
	Adherence	Subjective	Knows How	Create
Multidisciplinary collaboration	Government initiatives	Objective	Knows	Remember
	Community approaches and counseling	Objective	Knows	Understand
	Lifecycle approach	Subjective	Knows How	Create

Miller's pyramid, which assessed progression of knowledge on hierarchies, including "Knows" and "Knows how". The areas are also ranked on the revised Bloom's taxonomy ranking understanding on various cognitive levels, viz., remember, understand, apply, analyze, evaluate, and create. The competency areas comprehensively covered all the ranks on the revised Bloom's taxonomy.

Table 2 presents the results of the objective assessment. The competency domains of metabolism and physiology, monitoring and follow-up, management strategies, and multidisciplinary collaboration comprised two summed areas of assessment with a maximum score of two and a minimum score of zero. The recognition of complications competency domain comprised only one area of assessment with a maximum score of one and minimum score of zero. There were significant differences in the mean scores among the competency domains of metabolism and physiology (P value < 0.001), recognition of complications (P value = 0.04), management strategies (P value < 0.002), and multidisciplinary collaboration (P value < 0.001). There was no significant difference in the mean scores on the competency domain of monitoring and follow-up (P value = 0.23).

Table 3 presents the results of the pre- and post-test for the subjective assessment. Scores were assigned on a scale of 0-5 by faculty, and the mean scores and standard deviation are presented. The management strategies domain had four areas of assessment (management of anemia in pregnancy, management of side effects of therapy, counseling and adherence) and the recognition of complications and multidisciplinary collaboration had one area of assessment. All areas of assessment, except recognition of complications, had significant differences in mean on a paired T test.

Table 2. Objective assessment

Competency	Pretest scores (Mean $\pm$ SD)	Post-test scores (Mean $\pm$ SD)	P value (paired T test)
Metabolism and physiology	1.34 $\pm$ 0.67	1.74 $\pm$ 0.45	0.000978
Monitoring and follow-up	1.53 $\pm$ 0.51	1.66 $\pm$ 0.53	0.23
Recognition of complications	0.50 $\pm$ 0.51	0.71 $\pm$ 0.46	0.04
Management strategies	0.82 $\pm$ 0.65	1.24 $\pm$ 0.79	0.002309
Multidisciplinary collaboration	0.76 $\pm$ 0.43	1.32 $\pm$ 0.74	< 0.0001

Table 3. Subjective assessment

Competency	Pretest scores (Mean $\pm$ SD)	Post-test scores (Mean $\pm$ SD)	P value (paired T test)
Management strategies			
Management of anemia in pregnancy	3.00 $\pm$ 1.39	3.76 $\pm$ 1.53	0.0003523
Management of side effects of therapy	2.53 $\pm$ 1.87	3.26 $\pm$ 1.87	0.02011
Counseling	2.87 $\pm$ 1.73	3.55 $\pm$ 1.69	0.01036
Adherence	1.05 $\pm$ 1.52	1.97 $\pm$ 1.59	0.002257
Recognition of complications	3.37 $\pm$ 1.85	3.84 $\pm$ 1.72	0.1068
Multidisciplinary collaboration	1.50 $\pm$ 1.56	2.79 $\pm$ 1.88	0.0008129

The satisfaction levels of the students were assessed on a five-point Likert scale ranging from very dissatisfied to very satisfied, and the results are presented in Table 4. Most of the students (27, 71.06%) indicated that they were either satisfied or very satisfied with the modules. The self-perceived gains in knowledge and skills were also assessed on a five-point Likert scale, and the results are presented in Table 5. Most of the students (26, 68.42%) rated that their knowledge gain was high or very high following completion of the modules.

Discussion

The current study was designed to document the blueprint of CBME practice in a setting with limited prior experience; to measure improvement in competencies and learner attitudes towards the approach.

Frank et al¹² outlined the criticism of medical education systems, including variability in medical competence, patient safety risks, inadequate supervision and observation, concerns with promotions, and inequity in clinical assessments. CBME designs can address these issues, and their study recommends following the five core elements as outlined by Van Melle et al¹³ for the design of a CBME program. The five core elements include training outcomes organized as a competency framework, progression of training from novice to expert, tailored learning experiences to meet the needs of learners, teaching focused on competency achievement, and programmatic assessment. Defining the levels and types of competencies to be achieved at the outset enables a shared mental model between the teacher and the learner.¹²

The current study identified five major competency domains required for management of anemia in pregnancy through a combination of literature review and input from subject experts from a multi-disciplinary team from the departments of medicine, obstetrics and gynecology, and community medicine. The five competency domains identified included physiology and metabolism, monitoring and follow up, recognition of complications, management strategies and multidisciplinary collaboration. This approach enabled the study to utilize a trans-disciplinary approach with horizontal integration of subjects as recommended by the national policy.⁶ This was a contrast to the earlier approach, where these topics were taught in isolation and in disconnected timelines in pre-clinical

Table 4. Satisfaction levels with the module

Satisfaction level with the module	Count	Percent
Very dissatisfied	1	2.63
Dissatisfied	3	7.89
Neither satisfied nor unsatisfied	6	15.79
Satisfied	16	42.11
Very satisfied	11	28.95
Did not respond	1	2.63
Grand total	38	100.00

and clinical years. Additionally, the trans-disciplinary approach ensured that the competencies developed were relevant to real-world skills. A learner-centric approach was utilized, and teaching methods varied between discussion modules and self-directed learning to ensure that a range of learning styles of students were catered to. Assessment of competencies was parallelly designed, and assessment questions were ranked on Miller's pyramid and revised Bloom's taxonomy³ to ensure that assessment measures progression of knowledge across higher orders of the cognitive domain, and competencies measure critical thinking and creativity. This enabled the model to overcome the reliance of the earlier system, which was largely based on factual recall.^{7,8} A mix of objective and subjective questions was also utilized to balance between recall, comprehension, and application.

On objective assessment, students showed a significant improvement in post-test scores on the competency domains of metabolism and physiology, monitoring and follow-up, management strategies, and multidisciplinary collaboration. The improvement in the competency domain of recognition of complications was not significant. In contrast, post-test improvement in the domain was significant on a subjective assessment. Plausible reasons for this include improved understanding of complications, but poor recall of laboratory values for the diagnosis of complications. This once again underlines the importance of utilizing multiple modes of assessment in CBME models. Similar studies by Borgaonkar and Patil,¹⁴ Sangam et al,¹⁵ and Tejeshwini and Kanyakumari¹⁶ obtained uniform improvement in all post-test scores; however, they utilized only objective methods of assessment. Learner satisfaction and self-perceived knowledge gain were higher with CBME in Borgaonkar and Patil,¹⁴ similar to the current study.

Another crucial determinant of success of CBME models is faculty preparedness for the transition to CBME. In India, 61.7% of medical faculty had been trained/sensitized on CBME in a study by Mahajan et al,⁸ a gap which has policy-level implications on CBME roll out. Bogie et al¹⁷ recommend sensitization of both teachers and learners as a policy-level change to facilitate national-level rollout of CBME.

While several countries have been rolling out national CBME programs, there is a dearth of documentation

Table 5. Self-perceived gains in knowledge and skills

Self-perceived gain in knowledge and skills	Count	Percent
Low gain	1	2.63
Some gain	2	5.26
Moderate gain	8	21.05
High gain	19	50.00
Very high gain	7	18.42
Did not respond	1	2.63
Grand Total	38	100.00

and literature on these efforts.¹² Ongoing policy changes in medical education models require research to identify implementation challenges.¹⁷ The need of the hour is sharing CBME: praxis. Sharing of real-life examples of CBME practice and lessons learned will dispel the notion that CBME is a theoretical premise and will also simplify the complex task of translating theory into practice.¹⁸

There were limitations to the study. The study was conducted in a setting where CBME rollout has been recent, and not all facets may apply to countries where CBME is a more mature and established model. Students participated from a single institution, which precludes generalizability. CBME models are inherently varied with divergences in terminology, application, assessment, and evaluation, which precludes uniformity.

Conclusion

CBME is globally being adopted as the preferred approach for medical education. Models and policies are continually evolving and require ongoing research and documentation for identifying and resolving implementation challenges. Dissemination of processes and practices from varied settings will help develop a shared language and understanding of these efforts to inform educators and policymakers. Key principles including a focus on outcomes, de-emphasis of time based learning, learner centered-ness, faculty preparedness, continual assessment through varied modalities and evaluation were reinforced through the experiences outlined in this study. Effective implementation of CBME models will ensure quality, standards, and accountability in medical education and patient care.

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Authors' Contribution

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Competing Interests

All authors declare no conflict of interest.

Ethical Approval

This study was conducted in accordance with the principles of the Declaration of Helsinki (2013) and was approved by the Human Research Ethics Committee of the ESIC Medical College, Sanathnagar, India. (Ethics approval number: 799/U/IEC/ESICMC/F538/11/2023).

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